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Formation of the optimal portfolio of insurer's services of the voluntary types of insurance

Abstract

The article studies the possibility of using optimization modelling to form the optimal structure of insurance services' portfolio of insurance companies. Based on the data of net insurance payments and profitability of the voluntary types of insurance in 2005-2015, the authors conducted their analysis according to the possibility to be included in the general insurance portfolio of the insurance company. The optimization model is based on the approach developed by G. Markowitz. The formation of insurance services portfolio is conducted by solving the optimization problem to maximize the portfolios' profitability or to minimize the portfolio's risks. The obtained results can be used in making strategic decisions by the management regarding the development of insurance companies.

Keywords: insurance company, insurance service, insurance portfolio, portfolio optimization.

Introduction

The activity of insurance companies in the current conditions could be described as a rethinking of the ways of the future development. Uncertainty of the course of economic development, financial market's stagnation and significant problems of banking institutions do not contribute to the formation of a clear development strategy and the insurance market, especially when it comes to the sales of insurance products. Deterioration of financial performance of individual insurers, as well as the new possibilities that have to appear along with the gradual recovery of the insurance market, bring to the fore the issue of choosing a new development strategy, a key element of which should be the choice of the optimal set of insurance services that will ensure maximization of profits based on acceptable risk levels. Insurance companies need to define a list of optimization tasks according to which insurance services should be given priority.

Significant contribution to the study of the nature of insurance portfolio and its impact on the financial reliability of insurers was made by the following domestic scientists: V. Bazylevych (1997), N. Vnukova (2009), O. Vovchak (2005), S. Osadets (2002), as well as foreign researchers – S. Yefimov (1998), R. Doff (2011), T. Fyodorova (2004), V. Shakhov (2011). Issues dedicated to portfolio optimization are largely disclosed in the classical works of Markowitz (1952) and William Sharpe (2001), which received worldwide recognition, while their authors became Nobel Prize winners in economics.

Without denying the contribution of the leading researchers to this perspective, it is appropriate, within this article, to show what should be the

optimal portfolio of insurance services in the contemporary Ukrainian realities of the insurance market's development.

This problem will be solved by analyzing the performance indicators of insurance companies in Ukraine in terms of the provided insurance services and the use of the principles of G. Markowitz optimization model for the formation of the optimal portfolio of insurance services.

1. Literature review

The study of the insurance market and the role of adequate levels of insurance management is done in the works of many scientists. Each of them noted key aspects of quality management of insurance companies. For example, Bomhard (2005) notes that particularly relevant in conditions of financial instability is to harmonize the requirements of state regulations of the insurance industry, to use separate management of risks of certain types of insurance, paying special attention to the placement of insurance reserves.

Krenn & Oschischnig (2003) identify a number of key factors that must be taken into account by insurance companies in the management of insurance portfolios. They include underwriting risk, market risk, credit risk, liquidity risk, operational and other risks.

Ungureanu, M.A., Gruiescu, M., Ioanăș, C., Morega, D. (2010) proposed an approach that makes it possible to assess the individual risk of separate assets or assets portfolio taking into account the specifics of activities of insurance companies. Their method is based on the use of Value at Risk (VaR) methods.

Fwu-Ranq Chang (2008) shows how the connection between the property insurance and the portfolio choice of the insurer is realized, emphasizing their interdependence. The researcher notes that the size of the premium for the contract of property

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insurance plays a key role in making investment decisions, as its increase leads to this type of insurance becoming dominant in the portfolio, while the general approach of the insurer to the choice of insurance types becomes more conservative.

N. Dolhosheya (2010) emphasizes that the analysis of insurance portfolio of the insurer should start with determining the number of insured objects, the total insurance amount, and the size of collected insurance payments. The very structure of the portfolio determines the financial stability of the insurance company, and the study of unprofitableness of the insurance amount should solve the problem of identifying the actual level of unprofitableness and its comparison with the level of insurance rates used by the insurance company.

N. Yashina (2013), examining the types of insurance portfolios, creates their classification, within which she distinguishes a conservative portfolio with the risk level of 1-5% and the yield of 5.10%, a classic portfolio (5-15% and 15-30%, respectively), a specific portfolio (15-25% and 35-50%, respectively), a combined insurance portfolio (5-25% and 10-40%, respectively).

Thus, the contemporary works, which investigate insurance services portfolios, work out in detail various impact factors and their peculiarities. Nevertheless, the problems of optimizing insurance portfolios in modern conditions require further research. This paper offers one way to solve them.

2. Methodology

At the present stage of development of the insurance market in Ukraine, insurers have accumulated sufficient information on the volumes of insurance activities, which to a certain extent, continue to grow. Therefore, insurance companies can make forecasts of their activities and assess their potential.

The logic of the study involves the solving of practical problems of building an optimized portfolio of insurance services by the insurer based on the profitability of their provision. The general methodology requires the following steps:

- ◆ to make a selection of those types of insurance, which have a significant specific weight in insurance payments; exclude from the study those types of insurance that do not give significant amounts of insurance premiums;
- ◆ to calculate the profitability of the types of insurance using statistical data of the National Commission for the State Regulation of Financial Services Markets;
- ◆ to calculate statistical key indicators for portfolio optimization;

- ◆ to carry out portfolio optimization based on the approach of G. Markowitz;
- ◆ to make conclusions about the results of the study.

This approach is built on the principles, which take into account the current market importance of certain types of insurance. Calculations are made by using the general statistical information of the insurance market in Ukraine. They serve as the basis for the extension of this approach to the specific activities of a particular insurer.

As for the Markowitz optimization model, which is traditionally used to optimize the structure of the securities portfolio, it can also be applied to insurance. It is not only a matter of the insurance company's investment activity, but also of its insurance activities, such as optimization of the insurance services' portfolio. Indicators used by Markowitz model to calculate the optimal investment portfolio, have their counterparts in insurance business. The profitability of securities is similar to insurance profitability. The risk of securities in the model is calculated as a standard deviation of profitability. It is possible to calculate such indicator for a particular type of insurance.

The Markowitz model, which is based on the fact that the data for the previous periods used to calculate profitability and the risk of securities, fully reflects future values of profitability, is also acceptable for insurance, because the development of the insurance market, in general, is characterized by certain stability.

The extent and the nature of the relationship between the securities, which is expressed by the coefficients of linear correlation, can also be calculated for the types of insurance.

The Markowitz model is based on the fact that indicators of the profitability of securities are interdependent, which means that one can observe an increase in profitability of one type of securities with a simultaneous increase for other securities, while the third one remain the same, and the fourth one is generally reduced. This situation is inherent to the insurance market, where the profits of insurance products may grow in some categories and decrease in others.

Therefore, in our opinion, the Markowitz model in its basic approach is fully acceptable for selecting the optimal portfolio of insurance services.

3. Results

For the analysis, we collected statistical data on the voluntary types of insurance, which were provided by insurance companies in the period 2005-2015.

Indicators of insurance companies engaged in life insurance were not included in the analysis due to the nature of their activities, limited types of their insurance, which are present in statistical reporting of the relevant insurers. The preliminary analysis of state insurance and compulsory insurance has shown that these types are not connected to significant insurance claims and provide very high profitability. The paper does not contain relevant statistical data. It can be viewed on the website of the National Commission for the State Regulation of Financial Services Markets (Doff, 2011).

Based on the above-mentioned arguments, the paper will focus on the voluntary types of risk insurance. In order to assess their profitability, we will use the data of net income of insurance premiums (Table 1, see Appendix) and net insurance payments (Table 2, see Appendix). The preference is given to them, not to the gross indicators, because the net values of indicators are adjusted for the amounts, which are actually withdrawn from the insurance company through operations with a partial transfer of risks to other insurers as a result of reinsurance.

The types of voluntary insurance have undergone a procedure of additional selection by excluding the types of insurance with zero (or actually zero) indicators of the obtained net insurance premiums and insurance payments. As a threshold indicator of the selection we have taken 1% of the total amount of premiums and payments. This makes it possible to avoid working with such insurance services, which actually do not have volumes or the market of their consumption is limited to a small number of customers. These types of insurance are shown in Tables 1, 2 in gray color (see Appendix).

What is left includes 11 types of voluntary insurance. For each of them, we have made calculations for the indicators of profitability in the period 2005-2015 (Table 3, see Appendix).

Calculations of profitability of a specific type of insurance are made according to formula (1) and the obtained results are presented in Table 3 (see Appendix).

$$\Pi p_i = 1 - \frac{\mathcal{Y}CB_i}{\mathcal{Y}C\Pi_i}, \tag{1}$$

where Πp_i – profitability of the i -th type of insurance; $\mathcal{Y}CB_i$ – net insurance payments according to the i -th type of insurance, UAH; $\mathcal{Y}C\Pi_i$ – net income of insurance premiums according to the i -th type of insurance, UAH.

Indicators of profitability of the selected types of insurance were used in the Markowitz model (1, 2), which is formalized by formula 2.

$$\begin{cases} \sum_{i=1}^N w_i r_i \rightarrow \max \\ \sqrt{\sum_{a=1}^N \sum_{b=1}^N (w_a w_b cov_{ab})} \leq \sigma_{req}, \\ 0 \leq w_i \leq 1 \\ \sum w_i = 1 \end{cases} \tag{2}$$

where w_i – the share of the i -th type of insurance in the portfolio of insurance services;

r_i – profitability of the i -th type of insurance;

N – number of the types of insurance;

cov_{ab} – coefficient of covariance between the pairs of specific types of insurance;

σ_{req} – the maximum allowable risk of the insurance services portfolio.

Other options for formulating the problem are also possible, namely, the achievement of minimal risks at a certain level of profitability. However, in this article, we confine ourselves to maximization of profitability that can be achieved at different values of the general risk of insurance services portfolio.

For each type of insurance, we calculated indicators that are necessary for the formalized model, namely the average value of profitability, variance and standard deviation, which are actually a normal risk for each type of insurance (Table 4). These calculations are made on the basis of the profitability data of a particular type of insurance in the period 2005-2015 presented in Table 3 (see Appendix).

Table 4. Estimates of the average profitability and risk (standard deviation) according to the types of insurance services

№	Types of insurance	Average value of profitability	Variance	Standard deviation
1	Accident insurance	0.879	0.002	0.048
2	Medical insurance	0.267	0.011	0.106
3	Health insurance	0.745	0.008	0.087
4	Land transport insurance	0.461	0.009	0.097
5	Cargo and baggage insurance	0.964	0.000	0.018
6	Insurance from fire risks and risks of natural disasters	0.878	0.006	0.077

Table 4 (cont.). Estimates of the average profitability and risk (standard deviation) according to the types of insurance services

No	Types of insurance	Average value of profitability	Variance	Standard deviation
7	Property insurance	0.897	0.005	0.068
8	Third-party liability coverage	0.935	0.003	0.056
9	Credit insurance	0.680	0.027	0.166
10	Insurance of financial risks	0.297	0.649	0.806
11	Insurance of medical expenses	0.603	0.006	0.074

For the final use of the model, it is necessary to obtain the values of pairwise covariance coefficients for all types of insurance services, which was done by using the standard functions of MS Excel 2010.

The obtained results were presented in matrix form (Table 5), where the numbers from 1 to 11 are the symbols of the corresponding types of insurance from Table 4.

Table 5. Covariance matrix of insurance services portfolio

	1	2	3	4	5	6	7	8	9	10	11
1	0.053	0.043	0.037	0.031	0.041	0.035	0.055	0.035	0.042	0.043	0.032
2	0.043	0.047	0.045	0.053	0.072	0.084	0.061	0.039	0.039	0.038	0.034
3	0.037	0.045	0.049	0.064	0.085	0.104	0.065	0.041	0.038	0.038	0.033
4	0.031	0.053	0.064	0.109	0.158	0.218	0.084	0.043	0.032	0.029	0.035
5	0.041	0.072	0.085	0.158	0.253	0.363	0.113	0.047	0.028	0.023	0.038
6	0.035	0.084	0.104	0.218	0.363	0.542	0.134	0.044	0.012	0.002	0.031
7	0.055	0.061	0.065	0.084	0.113	0.134	0.098	0.059	0.058	0.057	0.051
8	0.035	0.039	0.041	0.043	0.047	0.044	0.059	0.044	0.044	0.044	0.038
9	0.042	0.039	0.038	0.032	0.028	0.012	0.058	0.044	0.050	0.050	0.038
10	0.043	0.038	0.038	0.029	0.023	0.002	0.057	0.044	0.050	0.052	0.039
11	0.032	0.034	0.033	0.035	0.038	0.031	0.051	0.038	0.038	0.039	0.034

The search of the optimal portfolio of insurance services is done by using the functions of MS Excel 2010 “Search of Solutions” from the packet “Analysis” (Markovitz, 1952). In doing so, restrictions were imposed in accordance with model (2). The values of the specific weight of a particular type of insurance were limited to 15%, which, in our opinion, will make it possible to include the maximum number of selected insurance services. The search of a decision was conducted for a class of nonlinear problems by using the method of generalized consolidated gradient. Two variants of optimized portfolio were proposed: according to the criterion of profitability maximization (3) and the criterion of risk minimization (4). The obtained results are presented in Table 6.

$$\begin{cases} \sum_{i=1}^N w_i r_i \rightarrow \max \\ \sqrt{\sum_{a=1}^N \sum_{b=1}^N (w_a w_b cov_{ab})}, \\ 0 \leq w_i \leq 0,15 \\ \sum w_i = 1 \end{cases} \quad (3)$$

$$\begin{cases} \sum_{i=1}^N w_i r_i \rightarrow \max \\ \sqrt{\sum_{a=1}^N \sum_{b=1}^N (w_a w_b cov_{ab})} \rightarrow \min. \\ 0 \leq w_i \leq 0,15 \\ \sum w_i = 1 \end{cases} \quad (4)$$

Table 6. The optimal portfolio of insurance services of the voluntary types of insurance at maximum restrictions set at 15% for the share of one type of insurance

No	Types of insurance	Effective portfolio structure	
		Profitability maximization	Risk minimization
1	Accident insurance	0.150	0.150
2	Medical insurance	0.000	0.007
3	Health insurance	0.150	0.088
4	Land transport insurance	0.000	0.000
5	Cargo and baggage insurance	0.150	0.150
6	Insurance from fire risks and risks of natural disasters	0.150	0.150
7	Property insurance	0.150	0.150
8	Third-party liability coverage	0.150	0.150

Table 6 (cont.). The optimal portfolio of insurance services of the voluntary types of insurance at maximum restrictions set at 15% for the share of one type of insurance

№	Types of insurance	Effective portfolio structure	
		Profitability maximization	Risk minimization
9	Credit insurance	0.100	0.075
10	Insurance of financial risks	0.000	0.000
11	Insurance of medical expenses	0.000	0.080
	Total	1.000	1.000
	Risk of insurance services portfolio	0.0008	0.0007
	Profitability of insurance services portfolio	0.863	0.850

The obtained results demonstrate that the indicators of profitability and riskiness of portfolios are almost identical for the portfolio of profit maximization and the portfolio of risk minimization. A characteristic feature of these portfolios is the exclusion of such types of insurance as insurance of financial risks and ground transport insurance.

They are risky and do not give high levels of profitability. Within the existing restrictions, the portfolio includes such types of insurance as accident insurance, cargo and baggage insurance, insurance from fire risks and risks of natural disasters, property insurance and third-party liability insurance.

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Conclusion and recommendations

One could argue that the obtained results, like the used methodology, can be used by the managers of insurance companies or developing their strategies. The choice of the voluntary types of insurance gives insurers sufficient flexibility not to conclude high-risk insurance contracts or, in some cases, an opportunity to transfer reinsurance contracts. It is clear that the realities of specific regions, the existing developments, customer base and additional risks, which are inherent to a particular type of insurance, may affect the final choice, and the final version of insurance services portfolio may differ from the one obtained in this article, but certain guidelines could prove to be quite useful.

Table 1. Net income of insurance premiums for certain types of insurance in 2005-2015, thousand UAH

Voluntary types of insurance	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Accident insurance	111793.9	184561.0	276146.5	417808.1	287792.3	348881.7	346727.3	756377.8	990870.6	637974.5	309443.7
Medical insurance	253962.4	353157.2	452830.0	636346.6	724128.6	809363.9	736311.5	1280060.8	1395662.6	1507146.9	1441852.1
Health insurance	81261.0	93659.3	111264.5	165034.1	126797.7	138908.2	121643.2	316343.2	372076.5	300943.7	201558.9
Railway transport insurance	232821.7	4348.9	13608.2	72358.5	25077.4	18712.6	58006.7	68805.0	54511.0	41941.5	41814.5
Land transport insurance	1039177.7	1900058.7	3403873.0	4887040.2	3448112.1	3064987.5	1800307.1	3243068.8	3270423.0	3059813.4	2571611.4
Air transport insurance	5848.5	8222.0	7488.4	10187.0	18443.7	18202.3	2863.5	5575.5	9649.8	11079.6	14489.3
Water transport insurance	18380.9	21509.9	34081.9	31423.5	33909.8	28211.3	8596.4	32615.4	22812.7	21326.9	12907.9
Cargo and baggage insurance	582942.8	483278.9	532950.2	699678.1	378596.7	801675.9	657462.3	948702.4	965656.2	860404.2	1197636.6
Insurance from fire risks and risks of natural disasters	759564.4	927128.1	1142878.7	1204612.7	930997.5	1156295.8	1015813.4	1830040.0	1649286.7	1250366.3	980147.4
Property insurance	984700.4	1194267.8	1534129.7	1630413.4	1489866.3	1680822.1	1027353.8	2606524.6	2489676.7	2045130.4	1617323.1
Civil liability insurance of the owners of land transport	45715.2	46898.7	68262.2	71886.5	56854.4	81488.9	42464.7	80386.7	92746.2	105934.1	148631.9
Liability insurance of the owners of air transport	1954.5	1453.6	-225.3	1624.1	16407.9	22627.1	-19144.8	5010.5	595.0	2544.3	8348.5
Liability insurance of the owners of water transport	6652.1	7620.4	7562.2	8122.5	7212.4	6798.6	644.4	7040.2	5208.0	6409.6	4849.0
Third-party liability coverage	190157.6	226778.9	283125.6	434077.2	485832.5	505916.5	313921.8	940289.0	1033863.0	671720.9	745788.6
Credit insurance	371683.4	336574.9	598682.6	1178680.0	744296.6	256445.2	185209.6	498020.7	683963.5	388209.1	214979.2
Investment insurance	13385.3	2109.0	2141.9	65.3	-14.7	2.0	-40628.1	4.9	6168.4	9.5	1.0
Insurance of financial risks	1473505.0	1494939.7	1658365.6	1395588.3	905077.3	755681.4	1257832.3	2098397.2	2401323.2	2019078.3	1811564.4
Insurance of court expenses	45.9	39.9	7.2	0.2	2.0	0.6	0.2	0.4	9.1	2730.1	1248.4
Insurance of the given and accepted guarantees	16187.4	13507.3	5211.4	-13476.4	-90127.5	-77990.6	-2734.3	28063.0	-64674.2	-354368.7	-35254.1
Insurance of medical expenses	28803.8	50348.2	85117.9	142588.5	167797.5	213867.0	223448.5	317915.3	323416.6	321667.8	351768.1

Source: Data of the National Commission for the State Regulation of Financial Services Markets (Bazylevich, 1997).

Table 2. Net insurance payments for certain types of insurance in 2005-2015, thousand UAH

Voluntary types of insurance	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Accident insurance	27360.3	19841.2	28750.3	44622.8	37414.7	39314.9	42524.8	51038.7	73862.9	67483.2	48543.1
Medical insurance	169959.9	226709.6	324971.4	461004.4	550694.6	632899.6	744149.6	900811.4	1010135.1	1108512.8	861246.1
Health insurance	35857.9	32589.6	29574.3	32822.2	33348.1	38026.6	35746.7	40662.9	66584.7	68365.0	36631.0
Railway transport insurance	175.2	17.0	5.2	1.8	-125.9	0.0	224.0	6480.9	2293.8	3375.3	0.0
Land transport insurance	510901.4	846639.8	1647280.1	2828225.2	2377013.0	1693035.6	1333441.2	1440177.3	1514356.0	1617455.8	1313892.1
Air transport insurance	1814.8	6334.3	772.4	703.7	2879.3	2856.4	1119.7	9022.0	7193.9	450.5	0.0
Water transport insurance	4526.0	6300.2	2435.0	21639.6	12138.6	5069.9	12433.3	28016.7	8927.7	5245.5	1436.6

Table 2 (cont.). Net insurance payments for certain types of insurance in 2005-2015, thousand UAH.

Voluntary types of insurance	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Property insurance	83926.7	66734.2	73840.1	82047.0	109710.7	133825.2	266278.6	399751.2	137634.1	172508.5	302616.5
Cargo and baggage insurance	8677.6	3950.9	19122.9	13195.6	12690.4	27825.5	23784.3	50854.7	67280.6	30395.7	64990.7
Insurance from fire risks and risks of natural disasters	20998.5	42952.8	237563.7	321246.2	160026.0	176992.9	156681.8	143023.1	69072.3	161725.3	59624.1
Civil liability insurance of the owners of land transport	10861.8	11819.7	10294.9	10781.8	9532.6	12834.7	15527.1	16138.8	20608.2	19689.5	19882.0
Liability insurance of the owners of air transport	36.0	0.0	268.6	2.2	0.0	1192.9	0.0	399.7	26.7	2.7	25.2
Liability insurance of the owners of water transport	362.3	132.1	186.6	259.6	160.6	1829.5	31.4	43.9	1202.9	239.4	62.6
Third-party liability coverage	37270.1	22922.0	35735.0	23186.4	15773.6	10802.0	20661.6	24280.9	19664.0	36514.6	16699.6
Credit insurance	18888.7	97648.9	223225.0	616901.1	355114.6	151089.8	52318.7	163904.9	98812.5	59969.2	66149.4
Investment insurance	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	203.5	0.0	0.0
Insurance of financial risks	388884.4	644266.4	882411.0	1461676.8	1577866.5	1959133.9	840251.5	437977.8	89251.2	41639.9	331282.2
Insurance of court expenses	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Insurance of the given and accepted guarantees	281.7	23.2	0.0	0.0	0.0	848.1	1277.8	0.0	0.0	0.2	0.0
Insurance of medical expenses	15701.5	24544.0	34210.1	44810.7	72713.6	83834.2	97780.9	120485.2	101343.5	111065.6	113637.6

Source: Data of the National Commission for the State Regulation of Financial Services Markets (Bazylevich, 1997).

Table 3. Indicators of profitability of the voluntary types of insurance in 2005-2015, thousand UAH.

Voluntary types of insurance	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Accident insurance	0.755	0.892	0.896	0.893	0.870	0.887	0.877	0.933	0.925	0.894	0.843
Medical insurance	0.331	0.358	0.282	0.276	0.240	0.218	-0.011	0.296	0.276	0.264	0.403
Health insurance	0.559	0.652	0.734	0.801	0.737	0.726	0.706	0.871	0.821	0.773	0.818
Land transport insurance	0.508	0.554	0.516	0.421	0.311	0.448	0.259	0.556	0.537	0.471	0.489
Cargo and baggage insurance	0.985	0.992	0.964	0.981	0.966	0.965	0.964	0.946	0.930	0.965	0.946
Insurance from fire risks and risks of natural disasters	0.972	0.954	0.792	0.733	0.828	0.847	0.846	0.922	0.958	0.871	0.939
Property insurance	0.915	0.944	0.952	0.950	0.926	0.920	0.741	0.847	0.945	0.916	0.813
Third-party liability coverage	0.804	0.899	0.874	0.947	0.968	0.979	0.934	0.974	0.981	0.946	0.978
Credit insurance	0.949	0.710	0.627	0.477	0.523	0.411	0.718	0.671	0.856	0.846	0.692
Insurance of financial risks	0.736	0.569	0.468	-0.047	-0.743	-1.593	0.332	0.791	0.963	0.979	0.817
Insurance of medical expenses	0.455	0.513	0.598	0.686	0.567	0.608	0.562	0.621	0.687	0.655	0.677

Source: Calculated by the author based on the data of the National Commission for the State Regulation of Financial Services Markets (Bazylevich, 1997).