

ASSESSMENT OF THE EFFICIENCY OF USE OF EPS BY BUSINESS

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ABSTRACT

As the world became more digitalized thanks to the Internet, it led to the creation of Electronic Payment Systems that are now used to seeing all over the world, but there is a need for estimation the return on development and implementation of EPSs. The research goal is to develop an approach based on optimization modeling for the assessment of the efficiency of implementation and the use of electronic payment systems by Ukrainian and international businesses for their day-by-day operations. The article also analyzed different classifications of EPS and determined several types of methodology for the evaluation of the effectiveness of the EPS (absolute and relative to business results and costs). Using the optimization model and system analysis, the authors proposed the algorithm for the estimation of profit from EPS implementation (both separate EPS or portfolio of EPSs) and make an experiment for one of the EPS for the period of 2023-2026. The optimization model includes revenue from EPS, as well as salary, rent, and infrastructure costs, which helps to improve the results of EPS implementation by adapting of transaction's tariff. Authors also described the process of solving optimization task for determining effective tariff per 1 transaction, taking into account marketing information.

Keywords: *electronic payment systems, efficiency, optimization, evaluation, implementation.*

1. INTRODUCTION

Today rapid development of information technology is leading to significant digitalization and digital transformation, which contributes to the development and expansion of e-commerce in many countries around the world. New economic trends and paradigms emerge in the digital era (De la Poza & Jódar, 2019). At the same time, the spread of electronic payments in the field of e-commerce contributes to the actualization of the use of electronic payment systems (Bobro et al., 2021).

Since the beginning of the 2000s, this topic has been increasingly popular amongst the academic community, as indicated by the number of articles published discussing Electronic Payment Systems which peaked during the last 5 years. More than 350 papers discussed electronic payment systems in the last 5 years and in 2019 and 2021 it was higher than 400 papers (Fig. 1).

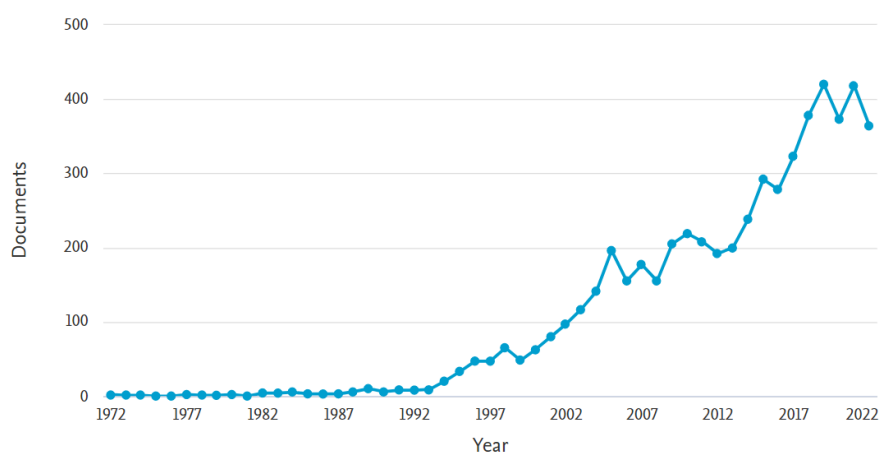
As the world became more digitalized throughout the years thanks to the Internet, we see millions of merchants shifting towards e-commerce, as of today many businesses start on the Internet as it is much more cost-effective, which in turn helps create an incredibly competitive environment on the market. Among the main challenges for enterprises is how to implement strategic growth

innovation along with executing traditional business model and operational excellence (Mašić et al., 2018).

As a result of all these processes, a serious need was created for platforms that would allow to process thousands of financial operations all at once, at the same time making it a reliable and safe environment, which led to the creation of Electronic Payment Systems that are now used to seeing all over the world.

Abrazhevich D. (2004) in his book explains that Electronic Payment System (EPS) is a reliable mechanism of paying for goods and services online using electronic money. It is based on modern technological solutions that meet all safety requirements. There are a couple of reasons as to why EPS became more popular. Technology becomes more affordable, and the number of people who resorted to e-commerce has increased and that created a demand for operational processing, which current technology is able to satisfy for a cheaper price, these are the main reasons that helped propel the development of EMS to the level we have today.

Figure 1. The number of articles published that discuss Electronic Payment Systems in Scopus from 1972 to 2022.



Source: Scopus search analyzer.

Similar ideas are portrayed in a O'Mahony D., Pierce M., & Tewari H. (2001) book where authors describe the evolution of the market. World Wide Web has significantly solicited the growth of this technology. Since 1999 the number of active users on the Internet grew exponentially, which was initially an opportunity to grow a new market online in a business-to-consumer form. Later the same systems were actively used in a business-to-business form, which led to a simplification of the relationship between businesses and suppliers. All these factors cumulatively contributed to the further growth of e-commerce and the development of EPS which further proves the relevance of this topic.

As e-commerce grew, so did the plethora of EPS, which vary in different protocols, methods, and schemes. In their work Ureche O. and Plamondon R. (2000) explain that consumers don't really care what kind of standard of EPS is used as long as they can do business online because of its convenience. Hence there is a need for a proper classification of diversified system types. This is important as it will allow the user to make a weighted decision as the competition is high and different payment systems will suit different e-commerce needs respectively, which we will discuss later.

Taking into account the current development of EPS, the goal of current research is to develop an approach for the assessment of the efficiency of implementation and the use of such systems by Ukrainian and international businesses for their day-by-day operations.

2. LITERATURE OVERVIEW

In modern economic literature, there are many studies devoted to the issues of definition, classification, detailed characteristics, as well as the choice of electronic payment systems by companies.

In the study by Ureche O. and Plamondon R. (2000), the authors break down EPS classification initially into two classes: the ones that require subscription; the ones that don't (table 1). After that both groups can be broken down into subgroups that would include security protocols, which will help distinguish reliable and protected payment systems. For example, EPS without a subscription broken down into 2 classes – with and without a protected transfer model and EPS with a subscription broken down into 3 classes: with the “authentication” model, with the “debit / credit” model and with the “cash” model.

Table 1. Electronic Payment System classification.

Category	Class	Group
EPS without subscription	With a protected transfer model	Credit card based
	Without a protected transfer model	Check based
		Credit card & check based
EPS with subscription	With the “authentication” model	Password-based
		Escrow based
	With the “debit/credit” model	Password/PIN based
		Electronic check based
		Billing based
	With the “cash” model	Digital bill based

Source: Ureche O. and Plamondon R. (2000).

Yang, Q., Cheng, Z., and Song, P (2007) describe a different classification method of Electronic Payment Systems. According to the authors they can be also broken down into two general categories. The first category is the one that includes Internet Banking Payment Gateway, this way is pretty direct as it happens via the client's direct payment to the e-commerce business using their platform that is connected to some kind of external banking system, and the client is aware of that. The second type uses an external payment platform. In this case, the money from the client's account is transferred to the seller's account by such a system. The difference is that Internet Banking Payment Gateway adds banks into the equation and is basically designed for security reasons and authorization but tends to be a more costly option compared to the second type.

In particular, H. Yu, K. His, and R. Kuo (2002) identify four main categories of electronic payment systems, and also consider the advantages and disadvantages of each of them. More specifically they distinguish 4 groups: online card payment, electronic cheques, electronic cash, and small payments. Each group can be assessed through the economic, social, technological, and even legislative aspects. The authors also focused attention on the requirements that companies and consumers put forward to such systems, as well as the prospects for further expansion of their use. S. Hsieh (2001) believes that the development of electronic commerce has contributed to the emergence of various payment tools to facilitate transactions, although most of them did not receive sufficient support among companies initially. The author examines the characteristics of several major electronic payment tools, and possible problems with their use, and also offers practical strategies to reduce the possibility of fraud when using them.

The main examples of e-payment tools that the author describes are:

- electronic cash – the first peer-to-peer way of transferring money which bypasses intermediaries, this is especially helpful as it allows for a way to pay with anonymity like cash yet be meet all the requirements of the network security and comfort;
- CAFE (Conditional Access For Europe) – a project in Europe that would include the use of a digital wallet in the EU and help create a unified system which could hold identification and service information and could even prevent issuers from fraud;
- electronic wallet – which would function much like a physical one, holding owners credit cards, identification, contact information, e-cash, etc.

Such technology becomes more prevalent today as many tech companies inherit this EPS and implement it into their software ecosystems (Microsoft Wallet), making it heaps easier to use for consumers.

While such tools are gaining more popularity and more companies choose to adopt these technologies and use them in their own way, credit cards still are more favorable amongst users in today's financial system. There are a number of issues concerning the topic of problems associated with these technologies. The first and main one is probably Internet standards and to be more precise their absence. Globalization allowed for the world to be more intertwined which led to a competitive market and as it has been mentioned before EPSs are no different. There has been significant improvement in terms of the creation of these universal standards but as of yet it's far from perfect and some systems are not compatible with different services, which creates a gap in these legislations and standards. These tools are not always cheap as multiple authors in different articles have emphasized. Not just that but not being universally accessible for users and on top of that having possible security issues creates a mistrust in the clients. S. Hsieh (2001) states that creating federal legislation could help build more trust in users towards these systems; implementing a unified security protocol could not only protect users but also help diminish the number of fraud attempts.

R. Singh, N. Supriya, and M. Joshna (2013) help define electronic payment, define its main types, and also consider electronic payment systems from the standpoint of their recognition in the world. They tried to determine the reason for the relative popularity of different payment systems. In order to do that they considered the problems and challenges of each one of them, as well as possible solutions to these problems to improve the quality of EPS.

The fast growth of the number of users in Electronic Payment Systems compared to traditional payment methods was documented way back in 2003 by Federal Reserve Financial Services Policy Committee where payments in electronic systems cumulatively were 1.21 times more than in cheques. Not only that but Electronic Payment Systems create a more favorable environment for the banking system's prosperity. Automated payments in such systems help attract more deposits. Since such payments require a certain level of authentication and authorization as a consequence they help decrease the shadow economy (Masihuddin et al., 2017).

E. Oney, G. Guven, and W. Rizvi (2017) believe that EPSs lead to an improvement in the quality of life of consumers by simplifying making payments via the Internet. They point out that the impact of trust and security on the use of EPS no longer needs to be proven, as it is evident from previous research and is considered an established fact. But the authors emphasize that most studies have not considered this problem from the consumer's point of view, so they created a conceptual model to identify the factors that influence the perception of trust and security, as well as their influence on the choice of EPS. The authors established that the main factors for the consumer were the level of technical protection and previous experience of use. Chikhi et al. (2022) try to identify the most important factors determining companies' investment decisions.

Humphrey D.B., Kim M., and Vale B. (2001) also came to the conclusion that Electronic Payment Systems can be beneficial for both sides: the clients and businesses. For clients it is a much simpler way to go about purchasing goods and services every day, you don't need to worry about how much cash you have to carry around, it is reliable and there is virtually no need to go to the bank for routine financial issues. The same can be said about the banks as Electronic Payment Systems help save a lot of time and are way more accurate when it comes to calculations. Additionally, they can process way more transactions so it's also cost-effective.

There seems to be clear evidence that Electronic Payment Systems have an abundance of benefits that suit both sides. They are easy, fast, cheap, and reliable. But some also argue otherwise. Naturally, since users input their personal financial data every time, they want to make a purchase with a transaction through the Electronic Payment System there is a chance that this data may be leaked and used in an illegal manner.

The question of security in such systems is a real issue. N. Asokan, P. Janson, M. Steiner, and M. Waidner (1997) for example emphasize that the defining criterion of any system is its security because without it such a system can't be viable. At the same time, they emphasize that EPS, although it has additional risks that are not inherent in making payments in person, but has the potential to be more reliable if proper measures are taken.

In other studies by Sahi et al. (2022), Liu et al. (2019), and El Haddad et al. (2018) authors found out that one of the countries that has contributed towards the development of different Electronic Payment Systems and analysis of their security and privacy was China, which makes sense considering that aside from using world-famous EMPs they have their own unique ones that are actively being used. The least contribution to this topic has been provided by African countries. Interestingly authors concluded that since the majority of studies published used the unified theory of acceptance and technical standpoint, a cultural factor might be overlooked. Since a person's opinion is shaped through the social environment and cultural upbringing it can also affect the adoption of EPSs. Authors speculate that this might be the reason for contradictory evidence about EPSs security. For future research authors suggested analyzing how the risk of security problems could affect individuals' disposition towards EPSs, since for example people in smart cities are rarely using such technology for personal protections sake, but more so for convenience.

Each Electronic Payment System uses its own technology and algorithms in order to work. Each one of them can be a subject for potential cyber-attack. Solat S. (2017) assessed multiple transaction methods and their pitfalls.

More popularity is gained by electronic currency, especially by governments. Nández Alonso S., Echarte Fernández M., Sanz Bas D., and Kaczmarek J. (2020) explain that creating a system that would use this technology would create a near to completely transparent financial system in a country as each unit of such currency would have an authentication code or other type of information and could be tracked down to the very begging of existence rendering almost any fraudulent attempts essentially impossible.

NFC is becoming a more adopted practice in different companies. Using your phone for a quick transaction seems like an enticing thought as there will no longer be a need to use credit cards. This technology has existed for a while, since 2002, and is becoming more popular nowadays. The vulnerability of this technology is obviously in the wireless aspect which is its advantage at the same time. Attackers can try to steal and extract data from a device wirelessly. Thankfully as of today encrypting technologies implemented into NFC Data Exchange Format protocols have been added, which makes data transactions between devices with this method pretty secure (Ramos-de-Luna et al., 2016; Pal et al., 2015).

Blockchain technology becomes increasingly a topic of discussion in academic circles, it has a lot of potential and Electronic Payment Systems are one of the first that were associated with this technology. Multiple articles have analyzed this issue. Blockchain would create a completely decentralized anonymous and very reliable system, that would make it almost impossible to

interfere with. Since blockchain on its own is a decentralized database of transactions that are encrypted, and it's able to communicate with copies of each other ensuring the validity of each transaction, this already provides advantages of pretty much all the aforementioned security systems. Some argue that this system would not be ideal for governments as it essentially takes all the control over a financial system away from it. Moreover, the implementation of such systems and their maintenance is incredibly costly even with today's technological advancements. A very limited number of businesses can afford to sustain such a system, and scaling it further to national levels would create an immense need for computational power that is not yet sustainable. Multiple sources also pointed at its negative effects on the environment due to the demanding nature of such a system (Ahn et al., 2018; Hatefi, 2022).

When it comes to the analysis of the efficacy of Electronic Payment there isn't really a uniform set of features one should take into account when choosing such a system for business' sake. Some authors pay more attention to the security aspect of a system, while others are inclined toward its infrastructure. As we've mentioned before a lot depends on a geographical location of a system as this will determine not only the legal and regulatory framework to which it will need to abide, but it will also change the nature of even as simple as socio-cultural challenges, which will affect the choice of an Electronic Payment System. Some areas are more prone to fraudulent attempts, in others, people are severely lacking in trust towards such types of systems hence why they won't get used as much as intended initially and that would pose an issue with its profitability in the first place, other placements are just not well adept to these systems, etc.

For example, in the study by Antwi et al. (2015), the authors analyzed what key factors played into businesses acquiring and adopting Electronic Payment Systems and their respective use amongst clientele in Ghana. As some authors in the articles described above mention, it is a real issue for African countries to introduce Electronic Payment System technology into the masses, these countries have the least amount of trust towards them and have contributed the least when it comes to their research in academic fields. One payment system that has been introduced in this region is e-ZWICH, which would help fight high-cost business transactions that affect economic development, long queues, and even armed robbery. The problem is that this system isn't really as widespread as it would be preferable. This creates challenges like link failure, and machine breakdowns further stagnating Electronic Payment System infiltration in a region and potential economic growth. Authors suggest that in order to increase its efficacy banking and financial systems should create a more widespread net of this system installing more ATMs that would support e-ZWICH, and encouraging more shops, hotels, guest houses, and supermarkets to use this system. Authors conclude that the efficacy of a system can be assessed when it is widespread and can make a difference in a financial transaction preferences amongst clients because it can be a highly secured system with great profitability, but it won't matter unless it's in use.

In turn, N. Harris, V. Guru, and M. Avvari (2011) conducted an empirical analysis of the expectations of firms from Electronic Payment Systems, as well as the degree of satisfaction of these expectations. Although authors do acknowledge the fact that the study itself has flaws because of the amount of respondents and lack of generalization. The authors concluded that one of the decisive factors playing into the spread of the adoption of Electronic Payment Systems was the flexibility of the payment system, contrary to popular opinion that the functionality, data management, and security of the system were the most important. While they do play a crucial role in the financial sector and have significantly contributed to the growth of this technology in developed countries over the past years, the developing countries have a different outlook on these systems, which was also noted in other articles. According to the authors, the level to which Electronic Payment Systems are being in use in the region depends on the perceived level of functionality in the users (meaning clients) and secondly on the perceived level of security. People are more interested in the practicality of such systems, and even though as of today the prevalence of cash payments and the use of cheques in a country is still higher than that of Electronic Payment Systems, non

the less firms keep adopting these systems into their ecosystems and services, slowly growing the proportion of potential clientele.

In their study [Hassan M., Shukur, Z., and Hasan M. \(2020\)](#) have mentioned that in today's world, since Electronic Payment Systems have been introduced into major parts of our lives and a lot of people today start a business without physical office but on the Internet, as it is significantly more cost-effective, e-commerce has taken over the world. The authors highlight that security is also a paramount part of any Electronic Payment System and to be more precise a payment gateway. In simple terms, these payment gateways play the role of physical terminals in regular shops but in e-commerce. These gateways play a paramount role as they are responsible for maintaining security and anonymity during transactions all the while eliminating any exchange disputes.

A lot of e-commerce shops resort to the use of third-party providers of these services. It makes it easy, fast and the price isn't steep. The problem is third party providers use cloud computing to host their services. Cloud computing on its own has been a debatable topic and a lot of people have argued that such services may be less secure than a traditional in-house hosting system since you give out an important function of your business to the net and there have been multiple reports that stipulated information theft ([Alouffi et al., 2021](#)). Authors have come up with a protocol for an Electronic Payment System that would have a payment gateway that would not interfere with the efficacy of a system meanwhile maintaining integrity, and confidentiality as well as providing proper authentication and authorization. In such a system these gateways would function essentially like a proxy in order to transmit data between a bank, a business, and a client. Such a system utilizes some of the developments in the security area of Electronic Payment Systems mentioned above, Tokenization and Blind Signatures.

As of now a lot of countries use Electronic Payment Systems, some are more universal, and some are used only in specific regions. The number of these systems grew largely over the past two decades which led to the saturation of the market. Almost any consumer today can confirm that they don't use any one specific Electronic Payment System as it would be inconvenient, they have different functionalities and not all of them are supported by all businesses or regions. And that is where a lot of academic literature is lacking, many articles focus on one system or one issue, disregarding the need for diversities in their portfolios. [Tounekti O., Ruiz-Martinez A., & Gómez A. \(2019\)](#) have analyzed this issue from the customer's point of view. They hypothesized that consumers largely choose multiple Electronic Payment Systems depending on functionality, familiarity, personal and situational factor, and the two latter were deciding factors that would force a customer to choose multiple systems instead of one. Authors came to the conclusion that the consumer's choice is made in a hierarchical manner, where first they look for ease of use (22.8%), then security (20.4%), convenience (13.3%), privacy (10.9%), and fees (10.3%). This research indicates that businesses that would adopt not one Electronic Payment System but a portfolio that would give consumers preferable choices to choose from when it comes to payment methods would be at a significant advantage. This can also help keep consumers in the shopping cart if their first payment choice wasn't available but there is an alternative available.

Pretty much every piece of literature on this topic confirms that with the introduction of Electronic Payment Systems, the use of cash and cheques is slowly fading away. The developed countries have adopted these systems quite a long time ago, they have the means and resources to support such systems and they simplify everyday routine actions. The developing countries, even though show less support towards them and are generally not as trusting, are still moving towards a complete digitalization of the financial sector, it's just a question of time. [Abdillah G., Harahap W., and Muda I. \(2019\)](#) argue that the future of the Electronic Payment System is in the e-cash. The experience of some countries that have adopted this technology shows that it can be a very convenient way of executing not only microeconomic and retail transactions but also on a larger macroeconomic scale as well, simplifying the transaction procedure and authorization, making the economy more transparent. Although it is not without its downsides. Authors state that central banks in the world

have decreased their profit due to diminished seigniorage, as there is no longer a need to produce so much paper money. Security and proper legislation also pose a potential problem.

Bezovski Z. (2016) has an alternative opinion. In the article, the author describes that more people use mobile payment systems as it's very convenient and becomes a more widely available method of financial transaction. Although this technology needs to be better integrated into present telecommunication and financial infrastructures, enhancing the compatibility of these systems with other technologies. This may also go beyond the use in the financial transaction field and go further into digitalizing our surrounding and automating processes.

Some argue that wireless payments would exclude people from the equation completely where you would only select goods and services that you would want to purchase and transactions will be processed by machines without humans inputting any information. Blockchain technology also has a lot of potential in this field as it has been mentioned before.

Kirana M., and Havidz S. (2020) analyzed how financial literacy could influence the adoption of Electronic Payment Systems into the masses. In their research, they were conducting a survey method. Using Slovin's formula (Slovin, 1960) they got the population size sample that would be representative, where n is a sample size to be determined; N is the actual population size; e is the margin of error required such as 1% or 5% from the normal distribution table.

Slovin's formula for choosing a representative population sample size for research

$$n = \frac{N}{1 + Ne^2} \quad (1)$$

After that researchers conducted a multiple linear regression to find out how exactly markers of financial literacy affected EPS adoption. The authors concluded that financial literacy directly correlates with EPS adoption in the region, which matches research results in more developed countries.

All in all, the analysis of previous studies allowed us to conclude that Electronic Payment Systems have been around for a while and have become a regular part of our everyday life. Different authors have different classification models for them. One classification would include criteria like whether the Electronic Payment System has a subscription service or whether it is a standalone system hosted within a single business. Another classification would include methods of transaction that such a system would be able to support. These systems were initially used by customers as a way to look through the services and goods that businesses online could provide, later they advanced and were able to support the actual transactions, which then created a separate market of e-commerce. Electronic Payment systems make life easier for both sides: merchants and customers, hence why this technology picked up in developed countries and spread very quickly. One of the main issues that are associated with Electronic Payment Systems are security and anonymity of customers and merchants. Multiple technologies were developed that would allow for undisclosed and protected transactions to take place, like Tokenization. More and more security technologies are created every day, one of the most promising is blockchain, which would be virtually impossible to bypass although it is very demanding when it comes to computational power.

Multiple authors have analyzed what key features play into the efficacy of these systems. The most prevalent are functionality where it should be able to work with different devices and support multiple financial systems, and accessibility which is actually closely linked with the region in question, the more accessible the system, the more it's going to be used. Security is of utmost priority for both sides, in terms of transaction transparency and the ability to avoid fraudulent attempts. One of the key factors that influence the effectiveness of these systems regardless of region, socio-economic environment, etc. is diversity. Since the market of Electronic Payment Systems is already saturated many customers resort to the use of multiple systems at once depending on the type of transaction, services, and other reasons. So, as a results, the diversity of the electronic payment systems can be

calculated by number of implemented EPSs and by total number of potential consumers of one of the used EPSs. Many businesses don't take this key factor into account which creates an issue. The more diverse a portfolio of Electronic Payment Systems is the more competitive the business is going to be, hence this factor significantly affects efficacy. For the successful functioning and development of e-business, companies should use Electronic Payment Systems, and form their effective portfolio for maximum satisfaction of customer needs and requests. To do this, it is necessary to analyze the existing systems and choose a portfolio that will be optimal for each specific company taking into account everything mentioned above.

3. METHODS

As the purpose of the research is to develop and generalize an approach for the assessment of the efficiency of implementation and the use of electronic payment systems by Ukrainian and international businesses for their day-by-day operations, the system analysis was used as the main method. To conduct the research a huge number of scientific papers and case studies were analyzed. Moreover, the main classification approaches for classifying electronic payment systems were defined.

To achieve the goals in this scientific paper general scientific methods were used:

- logical generalization – to identify trends in the development of electronic payment systems and propose a mathematical model for evaluating the efficiency of EPSs implementation;
- comparison – to analyze return on EPSs implementation;
- analysis and synthesis – to analyze the conditions for increasing EPSs profitability and to build a holistic understanding of the process for their determination;
- methods of optimization modeling – to determine the model for assessing EPS efficiency.

Overall, the study is conducted using system analysis, in particular generalization and systematization, classification, and evaluation.

4. RESULTS

Today, more attention should be paid to the issue of economic efficiency in the field of electronic payment systems. In this case, economic efficiency is a complex concept that encompasses the maximization of economic results (revenues), and the minimization of costs and losses while meeting all regulatory requirements, rules, safety standards, risk minimization, etc.

Integration and interaction with other systems (card, clearing, credit, settlement, etc.) forming a common payment infrastructure are also important factors in ensuring the economic efficiency of electronic payment systems. In this regard, the efficiency parameters of external systems and partners also significantly affect the economic efficiency of payment systems.

In accordance with the main goal of the EPS to ensure reliable, fast, safe, and timely transfer of funds between accounts, there are certain criteria for achieving and evaluating the effectiveness of the EPS and, in particular, the payment processor (or the provision of electronic payment services). Such factors can be estimated by speed of money transferring and by evaluation of their safety by expert and by implemented safety protocols. Additional criteria for achievement and evaluation of effectiveness may appear in accordance with the appearance and consideration of other EPS goals, for example, ensuring the population's access to payment services (financial inclusion). These goals create a complex understanding of the effectiveness of the provision of electronic payment services and determine the multiplicity of criteria for its achievement and evaluation, which are systematically detailed by the relevant parameters. Using these parameters, we can talk about the quality of payment services, the level of which to a certain extent characterizes their effectiveness.

In addition to the multiplicity of achievement and assessment criteria, the complexity of the effectiveness of providing electronic payment services requires taking into account a wide range of factors of a different nature, in particular: various standards, requirements, rules (state regulation), the level of fraud, etc.

The evaluation of the effectiveness of the EPS can be, in particular:

1. absolute, that is, to evaluate the overall results (evaluation of the dynamics of the parameters of the payment services market);
2. relative, i.e. evaluate the ratio of results to costs, which is more in line with the level of FinTech companies.
3. to be considered as the level of achievement of established goals, and target indicators;
4. as the level of perfection of a certain system, the quality of performance of its functions.

The absolute assessment is important for macro-, meso- and microeconomic analysis. Also, from the point of view of efficiency assessment, the following can be considered:

1. external and macro-efficiency of EPS is efficiency from the point of view of consumers, partners, national economy, and markets;
2. micro-efficiency is the efficiency of payment service provider companies (Khanin & Sopin, 2021).

These two areas of evaluation have certain difficulties (impossibility of taking into account all effects, their ambiguity for participants, different manifestation of effects over time, etc.).

Due to the fact that the EPS is integrated into external systems, it is necessary to take into account the relevant sources of creation of costs and revenues (for example, the costs of issuing banks and bank receivers). In addition, various types of risks that generate losses have a significant impact on the effectiveness of the payment service provider, and their minimization requires appropriate costs. Efficiency research is necessary for improving the methodology for creating EPS, as well as improving the level of quality of functioning of already existing ones.

To assess the effectiveness of the implementation of electronic payment systems, it is advisable to solve an optimization problem that involves maximizing the company's profit:

$$\text{Profit} = \text{Revenue from EPS} - \text{Costs for EPS} \rightarrow \max,$$

where

- *Costs or NPS per each period = Salary for EPS implementation specialists + rent + infrastructure support costs;*
- *Revenue from EPS = $\sum_{i=1}^n$ (Tariff per one transaction ast PLanned or Actual level of Transactions * in period i).*

Rent and infrastructure support costs also includes system maintenance cost.

Tariff per one transaction in the electronic payment system can be determined per planned salary for EPS implementation specialists' rent costs, infrastructure support costs as well as an average yearly number of transactions for previous n years:

$$\text{Tariff per one transaction} = \frac{\text{Salary} + \text{rent} + \text{infrastructure support costs}}{\text{average yearly number of transactions}} \quad (2)$$

As an example, let's consider the assessment of profit from EPS implementation with the next conditions:

- *Salary per month* = 65 500 UAH;
- *Rent+infrastructure support costs per month* = 30 000 UAH;
- *Average yearly number of transactions* = 130 000;
- *PLanned level of transactions for 2023* = 753 478;
- *PLanned level of transactions for 2024* = 956 858;
- *PLanned level of transactions for 2025* = 1 418 148;
- *PLanned level of transactions for 2026* = 1 787 794.

The tariff per transaction in these conditions, calculated by formula 2 will be at level 0.073 UAH. Costs for 2023 include three months of salary for the development of the implementation procedure and realization of each stage, organization of the correct technical work of the system, and 12 months for rent costs and infrastructure support costs. Costs for 2024-2026 include only rent and infrastructure support during the 12 months. Table 2 contains the expected revenue and costs for electronic payment system implementation. Such results show that the expected profit is negative (loss is more than 1 275 thousand UAH). So, in these conditions, it is not recommended to implement such EPS.

Table 2. Return from Electronic Payment System implementation.

Indicator	2023	2024	2025	2026	Total
Revenue	55 352	70 292	104 179	131 334	361 157
Costs	556 500	360 000	360 000	360 000	1 636 500
Profit					-1 275 343

Source: author's calculations.

To achieve a positive result and maximize profit, it is necessary to solve optimization tasks, considering market and transaction restrictions. Optimization model taking into account EPSs revenue and costs will be like following:

$$\text{Profit} = \text{Revenue from EPS} - \text{Costs for EPS} \rightarrow \max,$$

$$\sum_{i=1}^n (\text{Tariff per 1 transaction} * \text{Transactions in period } i) - \text{Salary} + \text{rent} + \text{infrastructure support costs} \rightarrow \max$$

$$\sum_{i=1}^n \frac{\text{Salary} + \text{rent} + \text{infrastructure support costs}}{\text{average yearly number of transactions}} * \text{Transactions in period } i) \quad (3)$$

$$- (\text{salary for EPS implementation specialists} + \text{rent} + \text{infrastructure support cost}) \rightarrow \max$$

$$\text{Tariff per 1 transaction} \leq \text{average market tariff} * 1,3$$

$$\text{Tariff per 1 transaction} \geq \text{average market tariff} * 0,7$$

Another way of profit maximization is to determine the minimal level of transaction cost, which will help to achieve positive business results. In the planned level of all indicators mentioned above and based on the model in Formula 3, we determined that the level of the tariff plan, which will generate zero profit is 0.333. So, to achieve positive profit the tariff level should be higher than the level of break-even.

Considering the specifics of the optimization process in the case of a portfolio of EPSs, the model in Formula 3 will include aggregation of revenue and costs per each EPS. Optimization model for the portfolio of EPSs:

$$\text{Profit} = \sum_{i=1}^n \text{Revenue_EPS}_i - \sum_{i=1}^n \text{Cost_EPS}_i \rightarrow \max$$

$$\text{Tariff_EPS}_i \leq \text{average market tariff} * 1,3 \quad (4)$$

$$\text{Tariff_EPS}_i \geq \text{average market tariff} * 0,7$$

As a next stage of the research, let's consider the main areas of improvement in the efficiency of electronic payment systems.

The development strategy of the payment service provider is the starting point for increasing economic efficiency because it defines its goals, the sphere of economic interests, and the target indicators that need to be achieved. That is, the strategy determines the results, the level of achievement of which is presented as efficiency. In accordance with the strategy, strategic management is formed, which covers all management functions, as well as in the conditions of the digital economy - the function of generating digital financial and technological innovations, and improving the digital system. Such a function must be carried out permanently.

As a way for improving the efficiency of EPSs it should be mentioned marketing activities. Marketing (and marketing management) is a defining component of the development strategy, which affects all other areas of efficiency improvement. Marketing takes priority because efficiency improvement begins with the value of the created "product" (payment service and payment system) and the recombination of available resources based on innovation.

The development of the payment service ecosystem includes expanding the functionality of the digital system, ensuring the provision of additional and related services, as well as generating information products that will be of interest to the consumer. This is related to the generation of financial innovations, and also calls for the improvement of the technological base of the digital system. The such improvement involves improving the quality of all algorithms and other intellectual developments (software, mathematical developments, neural networks, artificial intelligence, etc.) that ensure its work for better provision of all functions and procedures, as well as improvement of the company's organization and work practices. In this direction, it is necessary to single out the

intelligent analysis of data, which allows for obtaining knowledge for marketing and improvement of the digital system.

Summarizing all directions, the basic prerequisite for increasing economic efficiency should be considered to be the improvement of the quality of risk management, which is caused by the dynamism and aggressiveness of the environment, the complexity of meeting requirements, etc. Risk management is considered comprehensively, in addition to issues of profitability, covering: the technical side of the digital system; protection of consumer rights (minimization of consumer risks); protection of the interests of all parties to the operation (minimization of partners' risks); fulfillment of cyber security requirements. The level of income and profitability of the payment service provider directly depends on the minimization (mitigation) of risks, influencing the obtaining of benefits based on the effects of scale and increasing returns. Risk management covers quite complex tasks, only part of which can be worked out in the regulatory work.

5. CONCLUSIONS AND DISCUSSIONS

In modern conditions of digitalization, modernized payment systems are actively used and existing ones are being improved, society is being informatized, and the rapid development of electronic payment systems. The result of the current research was the substantiation of theoretical and methodological principles and practical recommendations for the assessment of the efficiency of EPS implementation for business. The peculiarities of EPS classification also were studied.

The economic efficiency in the field of electronic payment systems become a very important scientific issue, which needs to be solved due to the high level of EPSs implementation. In this case, economic efficiency is a complex concept that encompasses the maximization of economic results (revenues), and the minimization of costs and losses while meeting all regulatory requirements, rules, safety standards, risk minimization, etc. The evaluation of the effectiveness of the EPS can be absolute, that is, to evaluate the overall results or relative, i.e. evaluate the ratio of results to costs. During the research, the optimization model taking into revenue from EPS, as well as salary, rent, and infrastructure costs, which helps to improve the results of EPS implementation by adapting of transaction's tariff, was built. The experiment shows the algorithm of calculation the level of the tariff plan, which generate zero profit.

Using of the proposed optimization model and approach for assessing the EPS implantation efficiency can be useful for Ukrainian and International companies for achieving higher validity of investment decisions and by scientific society for further development of EPS and methodology for its evaluation.

Limitations of current research covers the including in proposed optimization model only cost indicators for salary, rent and infrastructure support. It is relevant to highlight area of future researches, which include development of the model, considering the transaction costs and variables indicated growth of sales and attraction of new clients.

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