USING THE CANONICAL MODELING APPROACH TO ANALYZE THE RELATIONSHIP BETWEEN BANK CAPITALIZATION INDICATORS AND MACROECONOMIC STABILITY

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The article summarizes the theoretical aspects of macroeconomic stability and bank capitalization as part of the national development of the economy. The authors systematize the main approaches to the definitions of these categories on the basis of a review of publications of foreign and domestic scientists. The main domestic and foreign indicators of bank capitalization and macroeconomic stability are identified. The aim of the study is to identify and analyze the main indicators of bank capitalization and macroeconomic stability and assess their relationship on the basis of the canonical model. In addition, the objective of the article is to develop practical recommendations for banks taking into account the results of the canonical analysis. The metadata for the bibliometric analysis were obtained from the Scopus scientometric database. The results of the bibliometric analysis allowed us to determine the relationship of macroeconomic stability and capitalization of banks with economic, financial, social and business processes. Among the main indicators of macroeconomic stability are the following: GDP, inflation, unemployment rate, national currency exchange rate, etc. Among the main indicators of bank capitalization are the ratio of capital to assets (for the G7 countries) and standards H1 and H2 (for Ukraine). The authors analyzed the above-mentioned indicators in the G7 countries and Ukraine from 2009 to 2020. The authors used canonical analysis and Statistica software to achieve the purpose of the study. The authors built a model based on quarterly statistical data of Ukraine from 2015 to 2020. The obtained results of the canonical analysis confirmed the strong connection between the volume of GDP and the capital of banks, which is 0.791, between GDP and the H2 ratio – 0.851, between the volume of bank capital and household income – 0.835. This necessitates further consideration of fluctuations in GDP and household incomes by banks, when developing resource policy. The constructed model shows the inseparable links between the processes in the banking system and macroeconomic processes. Banks also need to develop and implement appropriate action plans in case of negative economic growth scenario and impoverishment of the population.

Keywords: banking system, capitalization, macroeconomic stability, GDP, inflation, canonical analysis.

JEL Classification: E60, G21

Abbreviation: ARIMA – Autoregressive Integrated Moving Average.

Introduction. The banking system is one of the key elements of effective economic development of any country. It ensures the redistribution of monetary resources, a continuous flow of financial transactions, sustainability of banking activities and creates new means of payment. Today, the main task of the banking system is to maintain financial stability and reliability.

The main factor that can have a positive impact on the economy, expand the range of banking services and improve their quality, avoiding significant risks and at the same time maintaining the stability of the system, is capitalization.

Among the functions of bank capital the following can be distinguished: protective, operational and regulatory. These functions confirm the importance of the impact of bank capital first of all on the banking system, and then on macroeconomic stability. Sufficient levels of capital and its effective structure contribute to the fulfillment of these functions, which directly affects the system as a whole.

Problem statement. Leading world and domestic scientists, including: Andres J., Bicaba Z., Agenor P.-R., Mare D. S., Cavallaro E., Jiang B., Philp B., Kosova E. V., Yeris L. M., Pakhomova I. G., and others have studied the issue of bank capitalization, macroeconomic stability and their relation.

The articles [1; 2; 3; 4; 6; 7] note that macroeconomic stability is influenced by increased banking competition, namely changes in the volume of credit, risk level, level of state ownership, and market structure. It is also determined that the main ways to ensure macroeconomic stability are the implementation of monetary policy measures, exchange rate policy and foreign exchange reserves management.

Researchers [4; 5; 10; 11; 14] have identified the relationship between the quantity and quality of lending and macroeconomic stability. Macroeconomic policy measures that promote price stability have a positive impact on the quality of lending.

The articles [8; 9; 12; 13] examined the main indicators of macroeconomic stability, such as inflation, economic growth (GDP), the exchange rate, the level of consumption, etc.

The peculiarities of bank capitalization are also considered in more detail. The articles [15; 16; 17; 18; 19; 22; 28; 30] consider capitalization as an indicator of

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increasing the level of risk coverage in terms of a positive impact on the efficiency of bank activities. Due to adequate capitalization of banks, market stability can be achieved.

It should be noted that a sufficient level of capitalization increases the competitiveness of banks [21; 24; 26].

Researchers also determine the impact of capitalization on the credit and resource policies of banks [20; 25; 27; 29].

The capitalization of the banking system is characterized by both quantitative indicators, such as the amount of equity and authorized capital, and qualitative indicators, including the structure of capital and a reliable assessment of its components [35].

Thus, the capitalization of the bank and its reliability is the basis for active operations [33].

Researchers note that changes in the level of capitalization affect the development of the financial, credit and industrial sectors of the economy [34].

The issue of assessing the relation between the capitalization of the banking system and macroeconomic stability is studied insufficiently.

The purpose of the study is identification and analysis of the main indicators of bank capitalization and macroeconomic stability, assessment of their relationship, based on the canonical model. This will contribute to the further development of recommendations for banks, government agencies and other organizations to carry out their activities taking into account the impact of external economic risks.

Results of the research. Ensuring macroeconomic stability is the foundation of any country's social and economic policy.

Macroeconomic stability can be viewed as the development of various sectors of the economy at the national and global levels. Maintaining macroeconomic stability means that the state is responsible for maintaining the optimal structure of the national economy, the stability of the national currency, the foreign economic balance, price stability and overall economic growth.

Having analyzed Scopus publications on macroeconomic stability from 2009 to 2020 (Figure 1) it should be noted that this concept is more related to economic and financial processes – 43.4%, business processes and management – 17.8% and social processes – 17.9%.

Thus, macroeconomic stability is equivalent to economic and financial processes, business and social processes, as the main indicators, that characterize the above concept are inextricably linked with these areas.

Macroeconomic stability is the progressive development of the national economy, ensuring the achievement of sustainable growth with a stable price level and low unemployment, stability of the national currency, free movement of capital, etc.

Macroeconomic stability is defined by the following indicators: positive GDP growth rate, low inflation and unemployment, increasing exports, household incomes, etc.

The main elements of macroeconomic stability are:

– economic growth, provided by increasing the level of production efficiency, the use of advances in technology and science;

– full employment – providing jobs to all who are willing and able to work;

– stable price level, as rising prices complicate economic relations of economic entities and reduce the real level of income;

– achieving balance in foreign economic relations, which is manifested in a stable exchange rate of the national currency and the payment balance surplus;
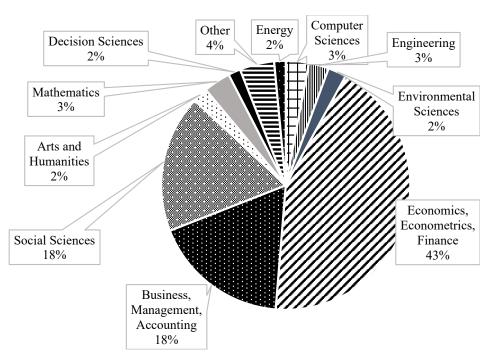

Figure 1 – Analysis of the concept of «capitalization» in Scopus publications by various industries from 2009 to 2022

– low long-term interest rates;
– low public debt relative to GDP.

It is the banking system that serves as the provider of long-term interest rates, which is one of the foundations of macroeconomic stability.

Among the main tasks of the banking system in ensuring the development of the national economy – ensuring a constant flow of money, maintaining a competitive level of interest rates, development of a loyal resource policy, maintaining a sufficient level of capitalization and much more.

Thus, it is important to consider the main indicator of financial stability of the banking system, namely the level of capitalization.

In the majority of publications of domestic and foreign scientists capitalization is considered as an indicator of financial stability of banks. In addition, a sufficient level of this indicator is a buffer to cover banking risks [33].

Consider in more detail the use of the category «capitalization» in Scopus publications from 2009 to 2022 (Figure 2). It`s determined that bank capitalization is related to the following processes, such as economic and financial – 23.2% of publications, business processes and management – 18.6%, and social – 14.6%.

An adequate level of capitalization affects the productivity and stability of the bank and is the key to increasing the capacity of the market of banking products and services, which generally affects the economic growth of the state.

The capital of the bank can be defined as the amount of own funds, the residual value of the bank's assets after deducting all its liabilities [34].

The following indicators usually characterize capitalization of the banking system of Ukraine, such as the amount of bank capital, the regulatory capital amount (H1), adequacy ratio of regulatory capital (H2), as well as the ratio of bank capital to assets.

Having considered the theoretical aspects of macroeconomic stability and bank capitalization, consider the practical part of the study, namely the analysis of these indicators on the example of the G7 countries and Ukraine.

Among the main indicators of macroeconomic stability are GDP – an indicator of economic development of the country, and inflation, which characterizes the stability of prices.

First of all, consider the dynamics of GDP in the G7 countries from 2009 to 2020 (Figure 3).

Between 2009 and 2020, the G7 countries experienced constant fluctuations in GDP growth from -10% in 2020 in the UK to 6.86% in 2007 in Canada (Figure 2). There was a significant decline to -6% in 2009 due to the global financial crisis and to -10% in 2020 due to the COVID-19 pandemic.

It is also important to consider the dynamics of inflation in the G7 countries during from 2009 to 2020 (Figure 4).

The inflation rate in the G7 countries during the period from 2009 to 2020 in the G7 countries during the period from 2009 to 2020 inflation was within 3%. European Central Bank believes According to the European Central Bank, the optimal level of inflation should be 2%, subject to minimum deviations [31]. When inflation exceeds 2%, inflation expectations rise, and it becomes more difficult to reduce the rate in the future. It is possible to observe the lowest inflation rate in Japan. From 2009 to 2013, this country experienced deflation, which imposed a different type of spending on the economy. Deflation is explained by excess demand compared to the growth of Japan's
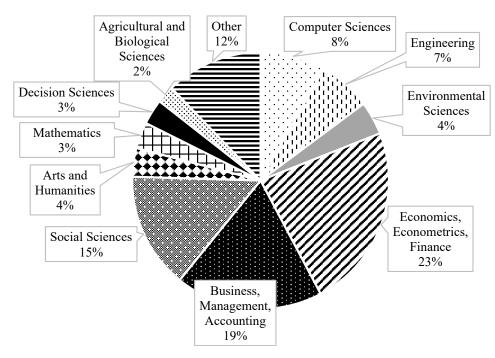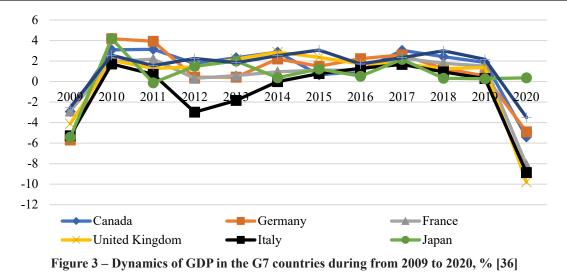

Figure 2 – Analysis of the category "capitalization" in Scopus publications by various industries from 2009 to 2022

Figure 3 – Dynamics of GDP in the G7 countries during from 2009 to 2020, % [36]
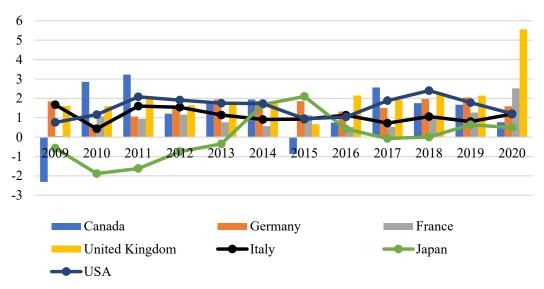

Figure 4 – Dynamics of inflation in the G7 countries during from 2009 to 2020, % [36]

economy. Japan's excess demand compared to economic growth explains the deflation. The UK is characterized by fluctuations in inflation ranging from 0.66% in 2015 to 2.15% in 2016. The UK is characterized by fluctuations ranging from 0.66% in 2015 to 2.15% in 2016. Only in 2020 there is a significant increase in inflation to 5.56% due to the exacerbation of the COVID-19 pandemic.

In contrast to the world indicators, GDP and the inflation rate in Ukraine were analyzed (Figure 5). From 2009 to 2020 there is a significant decrease in GDP and an increase in inflation at the end of 2014 and 2020, which is due to socio-political events in Ukraine in 2014 and the COVID-19 pandemic in 2019. According to the forecast, GDP growth in Ukraine will be insignificant by mid-2022.

Among the indicators of banking capitalization, which contributes to the financial stability of institutions and affects have an influence on the financial development of the country are the ratio of capital to assets capital-to – asset ratio (for the G7) and standards H1 and H2 (for Ukraine).

According to the World Bank, bank capitalization rates gradually increased in the G7 countries from 2009 to 2019, ranging from 4.09% in 2009 (France) to 11.77% in 2019 (USA) (Figure 5). In Japan, the figure did not exceed 6% during the period under study. The maximum value of 6.63% was observed in Italy at the end of 2017, and the minimum was 4.3% at the end of 2010. In Germany, France, the United Kingdom and Canada, the maximum value did not exceed 7%. The US is characterized by fluctuations in this indicator ranging from 11.58% in 2016 to 12.73% in 2010. In the US, there has been a downward trend in capitalization since 2009 due to the onset of the financial crisis, which was triggered by the boom in the mortgage lending market. Since the minimum value of the capital-to-assets ratio should be at least 10%, the G7 banks should develop plans for possible recapitalization in order to conduct effective financial operations [36].

Consider the dynamics of the main capital indicators of capital of domestic banks as opposed to In contrast to the
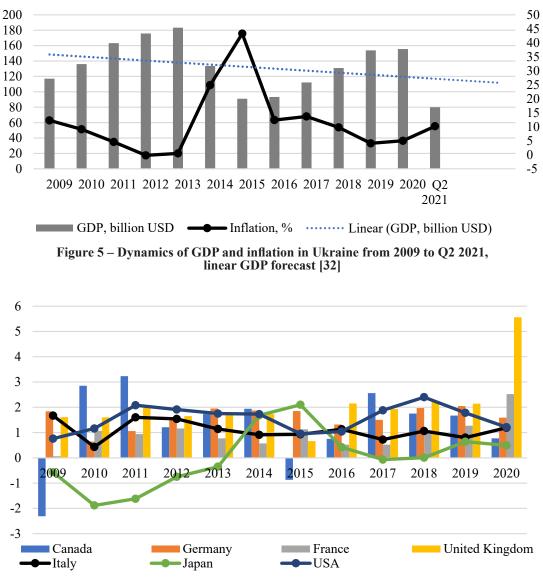
**Figure 5 – Dynamics of GDP and inflation in Ukraine from 2009 to Q2 2021,
linear GDP forecast [32]**

**Figure 6 – Dynamics of the ratio of capital to bank assets ratio in the G7 countries
during from 2009 to 2019, % [36]**

data of bank capitalization of the world's leading countries, consider the dynamics of the main capital indicators of capital of domestic banks (Figure 7).

The main indicators of capitalization of the banking system regulated by the National Bank are the minimum regulatory capital (H1) and regulatory capital adequacy ratio (H2) in Ukraine. The minimum H1 amount was 500 million UAH until June 20, 2020, after which it was reduced to 200 million UAH. The norm H2 – not less than 10%.

H1 and H2 standards during the period under study were within the norm. A significant decrease in this indicator was observed in early 2015, which is associated with the process of "bankruptcy of banks", military actions in Donetsk and Luhansk regions, the annexation of the Autonomous Republic of Crimea. After clearing the banking system of fictitious and unprofitable institutions, a gradual growth of these indicators has been observed

since the beginning of 2017, which confirms the gradual stabilization of banks. Thus, the presence of sufficient capitalization, measured by the amount of capital, the level of H1, affects the following indicators of macroeconomic stability: GDP, consumer price index.

Among the ways to increase the level of capitalization of the banking system of Ukraine are the following:
– reinvestment of banks net profit;
– the process of joining, absorbing merging institutions;
– reduction of the state's share in the capital of banks;
– return of trust and further involvement of the population's funds in the authorized capital of banking institutions, etc;
– adaptation of banks resource policies to modern economic challenges;
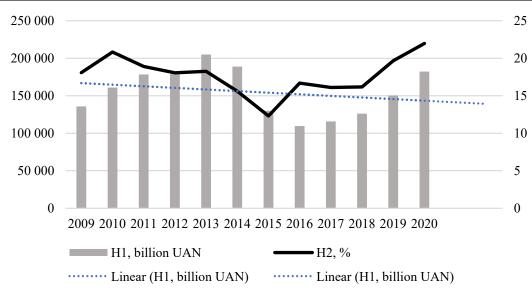– improving the quantitative and qualitative indicators of capital.

Figure 7 – Dynamics of bank capitalization indicators in Ukraine during from 2009 to 2020. Linear forecast of the minimum amount of regulatory capital until 2022, UAH million, % (as of at the end of the year) [31]

The final part of the study is to determine the relationship between the indicators of macroeconomic stability and the capitalization of the banking system. Canonical correlation analysis, which is widely used to calculate dependencies between many social and economic processes, was used to investigate relationships. Canonical analysis allows to investigate relationships between two sets of variables and is used for hypothesis testing. Among the advantages of this method is the ability to determine the influence of many factors on several indicators.

Canonical analysis is used to study the impact of Ukrainian banks' capital indicators (capital, assets, H2 ratio) on macroeconomic stability (GDP, inflation, household income), using quarterly statistics of the NBU for 2015–2020 [31].

Figure 8 shows the correlation graphs of capitalization and macroeconomic stability indicators.

According to Figure 8, there is a tendency that the closer the point is to the line, the greater the relationship between the indicators.

There is a strong relationship between the volume of GDP and capital of banks, which is 0.791, between GDP and the H2 ratio – 0.851. The correlation between GDP and the income level of the population is 0.973. There is 97.3% of the change in income explained by fluctuations of GDP. There is also a strong relation between the amount of bank capital and household income – 0.835.

The closeness of the connection between the canonical values is determined by the canonical coefficient of determination R^2. Thereby 90.08% of the change in indicators of macroeconomic stability of Ukraine is due to fluctuations in capital indicators.

The three roots describe the 100% variance of the set of capital indicators and the 100% variance of the set of MS indicators. Using the values of capital indicators and obtained canonical roots, on average 68.79% of the variance of variables in the left set and 70.37% of variability in the right set can be explained. These results indicate the relations between the variables of the two sets.

The canonical function has the form:

$$0.120 * Capital - 0,080 * Assets + 0,940 * H2 = -0,512 * GDP - 0,273 * Inflation - 1,282 * Household\ income.$$

Figure 9 shows a scatter diagram of canonical variables, which characterizes the dependence of the sets of capital indicators and indicators of macroeconomic stability.

There are practically no sharp deviations from the regression line on this graph. It can be concluded that the capital indicators of Ukrainian banks have a directly proportional influence on the indicators of macroeconomic stability.

Considering the various combinations of capital indicators and indicators of macroeconomic stability, we can conclude that the capital indicators of banks: assets, capital and H2, affect the CU, as evidenced by the canonical R 0.949 and a correlation coefficient of 0.9.

Conclusions and prospects of further research. Sufficient capital in the banking system affects the economy as a whole, which in turn stabilizes or destabilizes the socio-economic processes of the state.

Analytical assessment of the main indicators of macroeconomic stability and capitalization on the example of the G7 countries and Ukraine confirmed the global economic trends, namely the global impact of the 2009 global financial crisis and pandemic COVID-19 in 2019.

The projected GDP forecasts and the H1 standard for Ukraine indicate a slight increase in these indicators by the end of 2022. Banks, government agencies and other organizations can use the forecasts to predict the negative impact of risks on their activities.
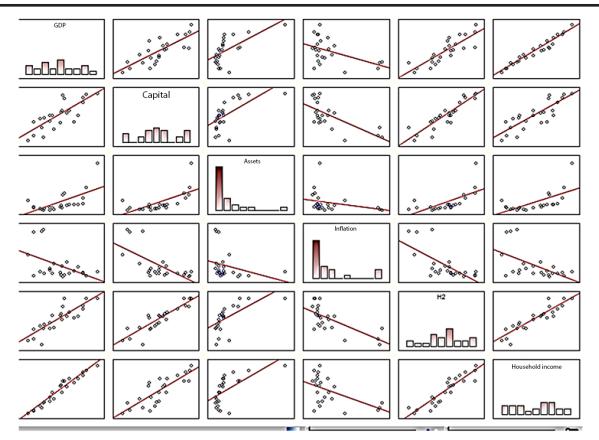
**Figure 8 – Matrix correlation graphs of capitalization indicators
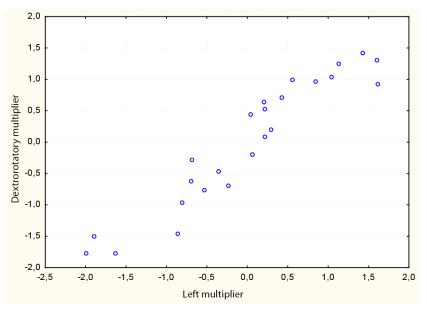of banks and macroeconomic stability of Ukraine**

Figure 9 – Scattering diagram of canonical variables

In accordance with the above, among the ways to overcome the crisis can be taken the following measures, such as forecasting and comparing the main indicators of economic and financial development in developing public policy with actual data, reinvestment of bank profits, quantitative and qualitative changes in bank capital and more.

The relationship between macroeconomic stability and bank capitalization was determined by canonical analysis. It is determined that there is a strong relation between the volume of GDP and capital of banks, which is 0.791, between GDP and the H2 ratio – 0.851. Therefore, 79.1% of changes in the capital of the banks are explained by fluctuations in GDP. There is also a strong connection

between the amount of bank capital and household income – 0.835. Namely 83.5% of the change the capital of the banks is explained by fluctuations of household income. Thus, when developing a resource policy, banks must take into account fluctuations in GDP and household income, as well as develop appropriate action plans in case of negative scenarios of economic growth and impoverishment of the population.

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ДОСЛІДЖЕННЯ ОСНОВНИХ ПАРАМЕТРІВ КАПІТАЛІЗАЦІЇ БАНКІВСЬКОЇ СИСТЕМИ ТА МАКРОЕКОНОМІЧНОЇ СТАБІЛЬНОСТІ: КАНОНІЧНА МОДЕЛЬ ЇХ ВЗАЄМОЗВ'ЯЗКУ

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У статті узагальнено теоретичні аспекти макроекономічної стабільності та капіталізації банківського сектору у рамках національного розвитку економіки. Авторами систематизовано основні підходи до визначення зазначених категорій на основі огляду публікацій іноземних та вітчизняних науковців. Визначено основні вітчизняні та іноземні індикатори банківської капіталізації та макроекономічної стабільності. Метою дослідження є визначення та аналіз основних показників банківської капіталізації та макроекономічної стабільності та оцінка їх взаємозв'язків на основі побудованої канонічної моделі. Також завданням статті є розробка практичних рекомендацій банкам з урахуванням результатів канонічного аналізу. У рамках статті проведено бібліометричний аналіз для систематизації наукових праць у сфері економічного зростання держави та капіталізації банківського сектору. Мета-дані для бібліометричного аналізу згенеровано з наукометричної бази даних Scopus. Результати бібліометричного аналізу дозволили визначити зв'язок макроекономічної стабільності та банківської капіталізації з економічними, фінансовими, соціальними та бізнес-процесами. Серед основних індикаторів макроекономічної стабільності виділено такі: ВВП, рівень інфляції, рівень безробіття, курс національної валюти тощо. Серед основних індикаторів банківської капіталізації виділено відношення капіталу до активів (для країн Великої сімки) та нормативи Н1 та Н2 (для України). Авторами проаналізовано зазначені вище індикатори у країнах Великої сімки та України протягом 2009–2020 років. Для досягнення мети дослідження авторами використано канонічний аналіз та програмне забезпечення Statistica. Модель була побудована на основі квартальних статистичних даних України з 2015 по 2020 роки. Отримані результати канонічного аналізу підтвердили сильний зв'язок між обсягом ВВП та капіталу банків, що становить 0,791, між ВВП та нормативом Н2 – 0,851, між обсягом капіталу банків та доходами населення – 0,835. Це обумовлює необхідність подальшого урахування банками коливань ВВП та доходів населення при розробці ресурсної політики. Побудована модель відображає нерозривні зв'язки між процесами у банківській системі та макроекономічними процесами. Також банкам потрібно розробляти та впроваджувати відповідні плани дій за негативних сценаріїв росту економіки та збідніння населення.

Ключові слова: банківська система, капіталізація, макроекономічна стабільність, ВВП, інфляція, канонічний аналіз.

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