How does the technological innovation limit or foster the economic growth of Kazakhstan?

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1 Background information of the concepts

1.1 Economic growth

Economic growth is an increment within the generation of merchandise and administrations in an economy over a given period, more often than not measured by development in gross domestic product (GDP). It could be a key marker of financial wellbeing, reflecting the capacity of an economy to deliver riches and give a better standard of living for its citizens. Economic growth is frequently related with a number of positive results, counting higher business, expanded pay levels, made strides open administrations, and expanded common well-being.

There are a few components of the concept:

1. Capital Accumulation: This includes the venture in physical capital, such as apparatus, foundation, and buildings. Expanded capital stock improves an economy's profitable capacity, leading to more effective generation forms and higher yield.

2. Labor Force Expansion: Development within the labor constrain, either through populace development or higher labor constrain cooperation rates, contributes to financial development. A bigger workforce implies more human assets are accessible for generation.

3. Technological Advancements: Developments and improvements in technology boost efficiency by empowering more proficient utilize of assets and making unused items and administrations. Mechanical advance may be a key driver of long-term financial development.

4. Human Capital Development: Investment in instruction, preparing, and wellbeing moves forward the quality of the workforce. A more gifted and more advantageous workforce can create products and administrations more proficiently and adapt to modern advances and forms.

5. Institutional and Policy Environment: Compelling administration, steady political frameworks, and sound financial arrangements make an environment conducive to financial development. Arrangements that advance free markets, secure property rights, and energize venture and business enterprise are especially imperative.

This paper is going to be focused on the analysis of the effect of technological advancements on the economic growth of Kazakhstan.

One of the key questions is "How to measure the Economic?". The reply is that financial development is most commonly measured by the alter in genuine GDP, which alters for expansion to reflect the genuine increment in esteem of merchandise and administrations delivered. Other measurements incorporate Gross National Product (GNP), which incorporates the value of products and administrations delivered by a country's inhabitants, and GDP per capita, which partitions GDP by the populace, giving a degree of person financial well-being.

Moreover, it can be measured by the HDI, which is Human Development Index that incorporates the life anticipation, instruction level, and pay per capita. The Gini coefficient that tracks into how the income is distributed among the country. Innovation and Technological Advancements, which are measured through patents filed and the adoption of new technologies, indicate how a country is progressing in terms of innovation. One of the most important ones is well-being and happiness indices, which assess the quality of life and satisfaction of the citizens. This kind of data is made by World Happiness Report.

1.2 Economic Growth of Kazakhstan

Kazakhstan, the largest economy in Central Asia, has experienced critical financial development since gaining autonomy from the Soviet Union in 1991. The country's development has been largely driven by its abundant natural assets, especially oil, natural gas, and minerals, which have attracted significant foreign investment. Kazakhstan's vital region connecting Europe and Asia has also played a key role in its financial development, making it an important link in territorial exchanges and framework projects such as China's Belt and Road Initiative.

In the early 2000s, Kazakhstan experienced rapid economic growth, with GDP growth rates regularly exceeding 8% per year. This development was fueled by high global commodity prices and an active energy sector. The government implemented a number of financial changes aimed at moving from a centrally organized economy to a more market-oriented structure. These changes included privatizing state-owned enterprises, improving the trade climate, and attracting foreign direct investment (FDI). As a result, Kazakhstan has become one of the most attractive destinations for FDI in the region, especially in oil and gas units.

However, Kazakhstan's reliance on conventional assets has left its economy vulnerable to external shocks, especially fluctuations in global oil prices. The sharp decline in oil prices in 2014-2015 exposed these vulnerabilities, leading to a slowdown in financial development and a critical devaluation of the national currency, the tenge. In response, the government gained more flexibility in managing trade rates and sought to expand the economy without depending on extractive industries.

To achieve this improvement, Kazakhstan focused on building up non-oil units such as agribusiness, manufacturing, and management. The government initiated the "Kazakhstan 2050 Procedure", which outlines long-term goals for sustained financial development, emphasizing industrialization, development, and speculation in human capital. Kazakhstan has also worked to better coordinate with the global economy, joining the World Monetary Organization in 2015 and seeking closer financial ties with its neighbors through the Eurasian Financial Union.

Despite the challenges, Kazakhstan's economy has proven itself to be versatile, with straightforward growth rates over the long term. The spread of COVID-19 in 2020 briefly disrupted this development, but recovery efforts have

been supported by rising commodity prices and government shock measures. Moving forward, Kazakhstan faces the challenge of continuing its financial expansion while addressing issues such as depreciation, wage inequality, and natural repairability. Winning in these areas will be vital to maintaining sustainable long-term financial development and improving the overall quality of life of its citizens.

1.3 Linear regression

Linear regression is a basic quantifiable strategy used to demonstrate the relationship between a dependent variable and one or more independent variables. It is widely used in fields such as finance, foundation, science, and social sciences to predict outcomes, discern patterns, and obtain the strength of relationships between variables.

The simplest form, simple linear regression, involves one independent variable and models the relationship as a straight line with the condition:

$$Y = \beta_0 + \beta_1 X + \epsilon \tag{1}$$

where Y is the dependent variable, X is the independent variable, β_0 is the intercept, β_1 is the slope, and ϵ is the error term. The intercept appears as an estimate of Y when X is zero, while the slope indicates the change in Y for a one-unit change in X.

When multiple independent variables are included, the procedure is extended to multiple linear regressions, where the relationship is modeled with the condition:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n + \epsilon \tag{2}$$

Here, each independent variable $X_1, X_2, \ldots, X_n$ has its own coefficient that quantifies its specific effect on the dependent variable.

Preparing for the model involves estimating the coefficients $\beta_0, \beta_1, \ldots, \beta_n$ using a least squares strategy that minimizes the squared differences between observed and predicted values. The resulting model can be used to generate expectations by feeding new independent variable values into the regression equation.

Key assumptions of linear regression include linear relationships between variables, independence of errors, homoscedasticity (constant variance of errors), and normally distributed errors. When these assumptions are met, the model yields reliable estimates and predictions. However, violating these assumptions can lead to biased results, requiring alternative approaches to modeling or data transformations.

Despite its simplicity, linear regression remains an effective tool due to its ease of interpretation and broad applicability. It serves not only as a standalone strategy but also as a foundation for more complex machine learning models and algorithms, making it a basic technique in both predictive and explanatory data analysis.

1.4 Python

Python plays an important role in creating and using linear regression models, thanks to its flexible libraries and user-friendly syntax. The process usually starts with data preparation, where Python is used to collect data from various sources, such as CSV files, databases, or APIs. Libraries such as `pandas` and `numpy` are essential for cleaning and preprocessing this data, performing tasks such as managing missing values, encoding categorical variables, and normalizing the data to ensure it is suitable for analysis. Python also helps in exploring the data, with visualization libraries such as `matplotlib` and `seaborn` allowing you to explore the relationships between variables, which is crucial in modeling.

The actual creation of a linear regression model in Python is made easier by libraries such as `scikit-learn` and `statsmodels`. `Scikit-learn` is particularly known for its simplicity and efficiency, offering easy-to-use functions for initializing and fitting linear regression models. For example, you can quickly create a model by importing `LinearRegression` from `sklearn.linear_model` and fitting it to your training data. This library is ideal for those who want to run models with minimal coding. On the other hand, `statsmodels` is preferred when a more in-depth statistical analysis is required. It provides detailed output, including p-values and confidence intervals, which are vital for understanding the statistical significance of your model coefficients.

Once the model is created, Python plays an important role in evaluating its performance. Predictions on new data can be made using the `predict` function of the model, and various performance metrics are available through Python libraries to evaluate how well the model fits the data. For example, metrics such as Mean Squared Error (MSE), Root Mean Squared Error (RMSE), and R-squared can be calculated to assess the accuracy of the model. Python also facilitates residual analysis through visualizations, which is important for verifying the assumptions of linear regression such as the independence and normality of errors.

Furthermore, Python's ability to easily extract and interpret the coefficients of the model makes it a valuable tool for understanding the relationships within the data. In the case of `statsmodels`, Python can provide a comprehensive summary of the model, including detailed statistical information. Finally, once a model is built and validated, Python supports deployment in production environments, whether through standalone scripts or integrated within web applications using frameworks such as Flask or Django. Overall, Python's extensive libraries and ease of use make it an indispensable tool for creating, evaluating, and deploying linear regression models.

2 Methods of research

2.1 SWOT analysis

Strengths

1. **Simplicity and Accessibility:** Linear regression is one of the most straightforward statistical models, making it highly accessible to those without a deep background in mathematics or statistics. Its ease of implementation means that it can be quickly deployed for basic predictive analysis in everyday situations, such as budgeting, health monitoring, or simple trend analysis. Because of its simplicity, it is also an excellent educational tool for teaching fundamental concepts in data analysis, helping to build a strong foundation for understanding more complex models in the future.

2. **Effective Predictive Power for Linear Trends:** When the relationship between the dependent and independent variables is linear, linear regression provides powerful predictive capabilities. In daily life, this might involve predicting future expenses based on past spending habits or estimating health outcomes based on measurable factors like diet and exercise. In economics, linear regression is used to forecast key indicators like GDP growth, inflation rates, or employment trends, providing valuable insights that help individuals and policymakers make informed decisions.

3. **Versatility Across Various Domains:** Linear regression is a versatile tool that can be applied across numerous domains, from finance and economics to biology and social sciences. It is used to model relationships in diverse scenarios, such as assessing the impact of marketing campaigns on sales, analyzing the effect of education level on income, or predicting stock prices based on historical data. This broad applicability makes linear regression a go-to method for many professionals, offering a reliable way to quantify relationships and make data-driven decisions in different fields.

Weaknesses

1. **Dependence on Assumptions:** Linear regression relies on several key assumptions, including linearity, independence of errors, homoscedasticity (constant variance of errors), and normality of residuals. If these assumptions are not met, the model can produce biased or inaccurate predictions. For example, if the relationship between variables is non-linear, forcing a linear model may oversimplify the dynamics, leading to incorrect conclusions. This dependency on assumptions limits the model's effectiveness in complex or real-world situations where these conditions might not hold true.

2. **Inadequacy for Non-Linear Relationships:** Linear regression is inherently limited to capturing linear relationships between variables. In cases where the true relationship is non-linear, the model may fail to provide accurate predictions or insights. For instance, in fields like biology or finance, where interactions between variables are often complex and non-linear, relying on linear regression can lead to oversimplified models

that do not capture the true nature of the data. This limitation necessitates the use of more advanced modeling techniques when dealing with non-linear data.

3. **Sensitivity to Outliers:** Linear regression models are highly sensitive to outliers, which are data points that deviate significantly from the overall pattern of the data. These outliers can disproportionately influence the regression line, leading to skewed results and misleading predictions. In economic data, for example, extreme events or anomalies, such as a financial crisis or a sudden market boom, can heavily impact the model's accuracy. Handling outliers often requires additional preprocessing or robust regression techniques, adding complexity to the analysis.

Opportunities

1. **Integration with Advanced Technologies:** As data collection and processing technologies advance, linear regression can be enhanced by integrating with big data, artificial intelligence, and machine learning tools. For example, combining linear regression with machine learning algorithms can improve predictive accuracy and model robustness, especially in complex datasets. In daily life, this integration could lead to smarter personal finance tools, health monitoring apps, or customized marketing strategies, all of which leverage the predictive power of linear regression enhanced by modern computational methods.

2. **Personalized Decision-Making Tools:** The rise of personalized data tracking through smartphones, wearables, and other devices creates an opportunity to use linear regression in more tailored decision-making applications. For instance, individuals can use regression models to analyze their spending habits, health metrics, or productivity patterns, leading to more informed and personalized decisions. In economics, personalized financial planning tools that use linear regression could help individuals optimize their savings, investments, and spending based on historical data and future projections.

3. **Economic Policy Development and Analysis:** Linear regression can be a valuable tool for governments and organizations in developing and analyzing economic policies. By using regression models to forecast economic indicators such as unemployment rates, inflation, or GDP growth, policymakers can make data-driven decisions to promote sustainable economic development. Moreover, regression analysis can help evaluate the impact of past policies, providing insights that guide future policy adjustments. This application of linear regression supports more effective and evidence-based economic planning and decision-making.

Threats

1. **Data Quality and Reliability Issues:** The effectiveness of linear regression is highly dependent on the quality and reliability of the data

used. Inaccurate, incomplete, or biased data can lead to flawed models and unreliable predictions. In daily life, poor data quality might result from inconsistent tracking of personal metrics, while in economics, it could stem from incorrect or outdated economic indicators. These data quality issues threaten the accuracy and usefulness of linear regression models, potentially leading to poor decision-making.

2. **Over-Reliance on Linear Models:** There is a risk that individuals and organizations may become overly reliant on linear regression models, especially in complex situations where the relationships between variables are not truly linear. This over-reliance can result in oversimplified analyses and flawed strategies, particularly in fields like finance or healthcare, where outcomes are often influenced by a multitude of interacting factors. The threat here is that critical nuances may be overlooked, leading to suboptimal or even harmful decisions.

3. **Competition from More Advanced Techniques:** As more advanced statistical and machine learning techniques become widely available, linear regression faces competition from models that can handle more complex and non-linear relationships. Techniques such as decision trees, random forests, or neural networks often provide better predictive performance in complex datasets. This competition threatens the continued dominance of linear regression, especially in fields where higher accuracy and the ability to model intricate patterns are crucial for decision-making.

2.2 Survey

Questions for the survey:

1. Are you familiar with the concept of artificial intelligence (AI)?
   - Yes
   - No
2. Do you use any AI-powered tools or applications in your daily activities (e.g., virtual assistants, recommendation systems, etc.)?
   - Yes
   - No
3. In which sectors do you believe AI has had the most significant impact in Kazakhstan? (Select all that apply)
   - Education
   - Healthcare
   - Employment/Job Market
   - Public Services

- Finance
- Other (please specify)

4. Do you think the use of AI in education has improved the quality of learning in Kazakhstan?
    - Yes
    - No
    - Not Sure
5. Has AI automation affected job opportunities in your industry?
    - Yes, positively (more opportunities)
    - Yes, negatively (fewer opportunities)
    - No impact
    - Not sure
6. Do you think AI has made public services in Kazakhstan more efficient?
    - Yes
    - No
    - Not Sure
7. Overall, do you believe the adoption of AI has contributed to the economic growth of Kazakhstan?
    - Yes
    - No
    - Not Sure
8. Do you think AI will play a more significant role in the future economic development of Kazakhstan?
    - Yes
    - No
    - Not Sure

In order to fully get the answers to these questions, the survey was held among the representatives of all three generations: X, Y, and Z. Generation X includes people born between 1965 and 1980, Generation Y includes those born between 1981 and 1996, and Generation Z includes those born between 1997 and 2012. This audience will help identify the influence of technologies on different aspects of life, such as education, jobs, and daily activities, due to the fact that each of these groups spends their time differently.

2.3 Interview

The interviews were conducted with specialists in both economics and IT fields. The first interviewee was the director of the Center for Macroeconomic Research and Forecasting at the Economics Research Institute, and the second was the main IT specialist of the BI Group company.