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The impact of management by objectives (MBO) on employee satisfaction and performance appraisal: An analysis using structural equation modeling (SEM)

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ABSTRACT

Abstract: This study explores the impact of the Management by Objectives (MBO) method as a performance appraisal tool on employee satisfaction. By employing Structural Equation Modeling (SEM), we examine the relationships between various components of the MBO approach and their influence on employee satisfaction and effectiveness. The results emphasize the crucial role that different MBO components play in enhancing employee performance and contentment. The study reveals both direct and indirect connections between MBO factors and employee satisfaction and effectiveness. The significance of this research lies in providing valuable insights for organizations aiming to improve performance management practices and foster a more satisfied and productive workforce. It contributes to the existing body of knowledge on performance appraisal and offers practical implications for HR practitioners and organizational leaders. However, the study has limitations, such as its focus on a specific organizational context. Future research could investigate additional factors affecting employee satisfaction and productivity across diverse industries and cultural settings. This study highlights the importance of the MBO method in driving employee satisfaction and productivity and serves as a foundation for future research and organizational development efforts in the dynamic field of performance management.

I. Introduction

To enable individuals to reach their full potential, it is imperative to establish high performance standards. Employees must comprehend the rationale behind their inclusion on the payroll, the expectations placed upon them, and the criteria that constitute excellent performance. Contemporary businesses operate in a competitive, unpredictable, and volatile environment; consequently, managers prioritize achieving an organizational advantage through staff development. In the current context, performance assessments are among the most effective tools for fostering growth, motivation, and evaluation of personnel. Organizations implement performance appraisal systems to measure the productivity and effectiveness of their employees, thereby enhancing employee counseling, job performance, communication of expectations, and assessment of employee potential (Aggarwal and Thakur, 2013). Several definitions of performance evaluation have been proposed. "Performance appraisal," a component of the broader performance management process, is defined as "the evaluation of an individual's work performance in order to achieve objective personnel decisions" (Robbins et al., 2000). It is also characterized as the formal assessment and grading of employees by their managers (Armstrong, 2012). Shaout and Yousif (2014) assert that the primary purpose of performance appraisal is to ascertain the current skill level of employees. Researchers examining performance evaluation methodologies have described the Management by Objectives (MBO) approach as a modern or forward-looking strategy. Numerous studies on successful performance appraisal systems have identified the MBO technique as the most effective. Integrating Environmental, Social, and Governance (ESG) principles with the Management by Objectives (MBO) method can enhance organizational sustainability and responsibility. By setting clear, measurable objectives aligned with ESG criteria, companies can systematically track and improve their environmental impact, social contributions, and governance practices. This alignment ensures that corporate goals not only drive performance but also contribute positively to broader societal and environmental outcomes, fostering a more sustainable and ethical business model (Jafari et al,. 2009; Shaout and Yousif, 2014; Cetin et al., 2023; Das et al., 2023; Dogru et al., 2019; Işık et al., 2015, 2017, 2018, 2020, 2021, 2022, 2024a; 2024b; 2024c; 2024d; 2024e; 2024f, 2024g, 2024h; Islam et al. 2024a; 2024b; 2021; 2022; 2023; 2020; Hasan et al., 2019; Rahman, 2019; Gazi et al., 2024; Han et al., 2024; Yan et al., 2024a, 2024b).

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According to research by Jafari et al. (2009) and Shaout and Yousif (2014), MBO is the most effective method for ensuring that employees accomplish their tasks efficiently. This study will specifically investigate the MBO approach as a means of employee performance evaluation, based on literature emphasizing the significance of the MBO method in employee development. Rahman et al. (2020) also found that Management by Objectives is a highly effective strategy. The study identified a significant positive correlation between performance appraisal and employee satisfaction, suggesting that employees subjected to evaluations based on MBO principles tend to experience higher satisfaction levels. Additionally, the study revealed that increased employee satisfaction is associated with enhanced labor productivity. These findings indicate that the MBO approach can be an effective strategy for boosting employee happiness and overall organizational success.

1.1 Objectives of the Study

The primary aim of this research is to examine the relationship between Management by Objectives (MBO) and its effects on employee performance and satisfaction. Additionally, the study seeks to understand how employee satisfaction influences broader organizational outcomes. By investigating these connections, the researchers hope to gain a thorough understanding of how MBO practices impact employee productivity and contentment, and how employee satisfaction, in turn, affects various facets of organizational success. Through detailed data analysis and empirical evidence, this research intends to provide valuable insights into the intricate dynamics among MBO, employee performance, satisfaction, and overall organizational effectiveness.

2. Review of Literature

2.1 Management by Objectives

Management by Objectives (MBO) is a performance management approach that seeks to align employee goals with organizational objectives. Introduced by Peter Drucker in 1954, MBO is based on setting shared goals and providing feedback on their achievement. This approach aims to motivate and empower employees by establishing challenging yet achievable targets, fostering commitment, and encouraging innovative contributions to organizational development. Koontz and O'Donnell (1976) describe MBO as a technique where managers at different levels agree on broad organizational goals, break them down into specific short-term targets, assign individual responsibilities based on desired outcomes, and continuously review progress for assessment and reward purposes.

Research indicates a positive correlation between goal setting and task satisfaction, with studies by Locke et al. (1981) and Steers and Porter (1974) showing that implementing goal-setting techniques can enhance employee performance and satisfaction. Despite its competitive advantages, MBO also presents challenges in practical application. According to Stewart (1993), MBO promotes the achievement of enterprise objectives through participatory means but requires adherence to pre-established standards, which can be a potential drawback.

Overall, MBO offers both benefits and limitations as a performance appraisal method in organizational practice, impacting employee motivation, performance, and satisfaction, while also posing certain implementation challenges.

2.2 Performance Appraisal

Performance appraisal is a formal and systematic process where managers and directors assess employees' performance to evaluate their capabilities, support talent development, and contribute to the company's growth (Walker, Damanpour, and Devece, 2011). According to Alo (1999), performance appraisal involves a deliberate evaluation of an individual or organization's success in completing tasks or meeting goals over a specific period. This process should be purposeful and intentional, highlighting the need for comprehensive monitoring of an individual's task performance. Bagul (2014) notes that performance appraisals are prevalent across societies and can be both formal and informal. Historically, appraisals focused on rating personal traits, but contemporary methods emphasize assessing work results and achievements, leading to more objective and meaningful evaluations. This shift enhances the appraisal process by prioritizing actual performance outcomes over subjective personality assessments.

2.3 Employee Satisfaction

According to Hoffmann-Burdzińska and Flak (2016), the Management by Objectives (MBO) method enhances employee motivation through practices such as setting shared goals, granting autonomy, promoting self-regulation, and conducting team evaluations. This approach has been shown to increase staff motivation and commitment to achieving organizational goals (Bieniok, 2004). Furthermore, Mulolli, Islami, and Skenderi (2015) highlight that employees are more motivated and likely to improve their performance when they receive incentives like bonuses, raises, or derive personal satisfaction from their work (Dogru et al., 2023, 2024; Karagoz et al., 2021, 2023; Koscak et al, 2023). Overall, organizations with motivated and engaged employees tend to achieve higher levels of performance and success.

2.4 Management by Objectives and Performance Appraisal

According to Atiomo (2000) and Fajana (1997), performance appraisal enables firms to assess employees' current performance levels and identify opportunities for growth, thereby optimizing human resources. Rao (1984) underscores that performance appraisal involves evaluating an organization's employees, including their strengths, weaknesses, skills, interests, and potential for development. This information

serves as a crucial database for individual growth and should be shared with subordinates. Over time, performance appraisal has become a cornerstone of organizational practices. Among the various methodologies employed, Management by Objectives (MBO) stands out as one of the most widely utilized approaches, alongside grading scales, checklists, and 360-degree appraisal.

Employee satisfaction refers to the extent to which individuals' needs, wants, and desires are fulfilled, as emphasized by Moser (1997). Surveys on employee satisfaction commonly include inquiries about compensation, workload, managerial perception, flexibility, teamwork, and available resources. A well-structured reward system can enhance individual productivity, foster trust in the organization, and offer economic and social incentives to employees (Miles, 2012). Successful performance boosts staff motivation and productivity, leading to satisfaction and a sense of achievement (Armstrong and Taylor, 2014). The human relations movement, pioneered by Mayo (1933) and advocated by Roethlisberger and Dickson (1939), highlighted the notion that increased job satisfaction leads to higher productivity. Individuals are motivated and content when they achieve their goals through improved performance (Armstrong and Taylor, 2014). Employee satisfaction plays a pivotal role in organizational effectiveness, and cultivating a culture that prioritizes employee satisfaction contributes to the success of efficient organizations (Bhatti and Qureshi, 2007). However, a study conducted by Mura et al. (2021) found that 20% of companies do not utilize any motivational tools to enhance knowledge among their employees.

2.5 Hypothesis

- Hypothesis 1 (H1): There exists a notable correlation between Employee Satisfaction and its Consequences.
- Hypothesis 2 (H2): Management by Objectives demonstrates a significant correlation with the Consequences of Employee Satisfaction.
- Hypothesis 3 (H3): A substantial association exists between Management by Objectives (MBO) and Employee Satisfaction.
- Hypothesis 4 (H4): Management by Objectives (MBO) exhibits a significant relationship with Performance Appraisal.
- Hypothesis 5 (H5): Performance Appraisal shows a noteworthy association with the Consequences of Employee Satisfaction.
- Hypothesis 6 (H6): There is a significant relationship between Performance Appraisal and Employee Satisfaction.

3. Methods

3.1 Context of the Study

This study focuses on examining the relationship between Management by Objectives (MBO), Performance Appraisal (PA), and their impact on employee satisfaction. MBO involves setting clear and measurable goals for employees, aligning individual objectives with organizational goals. PA, on the other hand, evaluates employee performance against these objectives and provides feedback. The study aims to explore how these practices influence employee satisfaction and their consequences on employee. The study collected data from a diverse sample of bank employees, ranging from lower-level staff to top-level executives, across 33 banks of Bangladesh. In addition to on-site data collection, a structured web survey was distributed through social media platforms like email to gather information from a wider range of participants. The survey was designed to ensure no personal data was collected, thereby rendering ethical and data protection approvals unnecessary.

The demographic characteristics of the respondents are presented in Table 1.The study collected data from a sample of 60 bank employees in Bangladesh, representing various factors. The majority of respondents were male (90%), while females constituted a smaller percentage (10%). In terms of education level, most participants held a master's degree (80%), with smaller proportions having a bachelor's degree (10%), and some holding higher degrees or completing their HSC (5% each). Regarding gross salary, a significant portion of participants earned between 40,000 to 70,000 Tk. (40%), followed by those earning below 40,000 Tk. (20%), and an equal percentage earning above 70,000 Tk. (40%). In terms of age distribution, the largest group fell within the 30-45 age range (60%), followed by those below 30 (25%) and above 45 (15%). Regarding banking experience, 40% had 10-20 years of experience, while 35% had less than 10 years, and 25% had over 20 years. In the current job level, non-managerial employees constituted 40%, followed by mid-level (30%), lower level (25%), and top-level (5%) employees. The study's diverse sample provides valuable insights into the factors influencing employee satisfaction and performance in the banking sector in Bangladesh (See Table 1).

3.2 Operationalization of Latent Variables

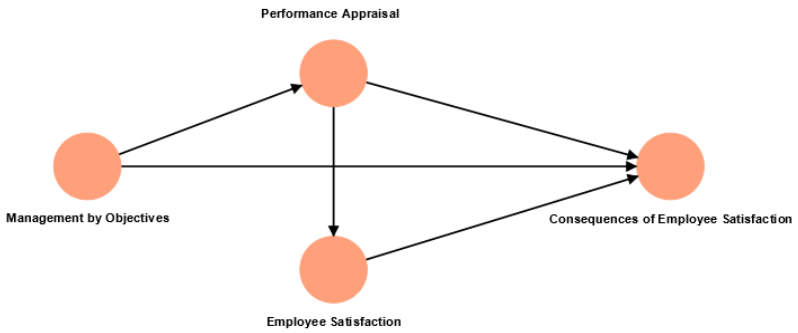

Figure 1. Conceptual Model

Figure 1 presents the conceptual model, which consists of four latent variables, each with multiple facets that cannot be adequately measured through a single observed variable. Consequently, to assess each latent variable in the conceptual model, multiple observed items were employed. The reliability of these measurement items can be found in Table 2.

Table 1: Demographic Profile

Particulars	Factors	No of Respondent (n=60)	Percentage
Gender	Male	54	90.0%
	Female	6	10.0%
Education Level	HSC	3	5.0%
	Bachelor	6	10.0%
	Masters	48	80.0%
	Above Masters	3	5.0%
Gross Salary (In Tk.)	Below 40000	12	20.0%
	40000-70000	24	40.0%
	Above 70000	24	40.0%
Age	Below-30	15	25.0%
	30-45	36	60.0%
	Above 45	9	15.0%
Banking Experience	Below 10	21	35.0%
	10-20	24	40.0%
	Above 20	15	25.0%
Current Job Level	Non managerial	24	40.0%
	Lower-level	15	25.0%
	Mid-level	18	30.0%
	Top-level	3	5.0%

Table 2. Measurement Items and Their Reliability

Construct	Item Code	Item Loading	Composite Reliability (CR)	Average Variance Extracted	Cronbach's Alpha
Management By Objectives (MBO)	MBO1	0.704	0.930	0.545	0.876
	MBO2	0.830			
	MBO 3	0.840			
	MBO 4	0.781			
	MBO 5	0.828			
	MBO 6	0.736			
	MBO 7	0.524			
	MBO8	0.601			
Performance Appraisal (PA	PA1	0.739	0.941	0.727	0.924
	PA 2	0.898			
	PA 3	0.861			
	PA 4	0.874			
	PA 5	0.892			
	PA 6	0.842			
Employee Satisfaction	ES1	0.806	0.884	0.656	0.825
	ES2	0.805			
	ES3	0.786			
	ES4	0.842			
Consequence of Employee Satisfaction (CES)	CES1	0.911	0.930	0.816	0.888
	CES2	0.899			
	CES3	0.901			

3.3 Measurement Model

The first stage of structural equation modeling (SEM) focuses on creating a reliable and valid measurement model, connecting measurement items to their underlying latent variables. This part will present an overview of the theoretical framework and statistical methods essential to verify the measurement model's validity and consistency. For data analysis, the SmartPLS package in STATA will be utilized.

Model-fit: r^2 of CES, ES, PA = (0.728, 0.358, 0.347) and adjusted r^2 of CES, ES, PA = (0.719, 0.351, 0.340), NFI = 0.597, SRMR = 0.148; d_ULS = 5,062, d_G = 1.936, Chi-square= 828.634. Alpha represents the value of Cronbach's Alpha, and CR represents Composite Reliability.

3.4 Normality Check

Table 3. Skewness/Kurtosis Tests for Normality

Variable	Skewness	Kurtosis	adj_chi²(2)	Prob>chi²
MBO	0.102	0.824	2.860	0.239
PA	0.704	0.057	3.960	0.138
ES	0.029	0.937	4.770	0.092
CES	0.001	0.273	10.190	0.006

The Skewness/Kurtosis tests for normality were conducted on four variables: MBO, PA, ES, and CES, each with 60 observations. For the MBO variable, both the skewness (p-value = 0.102) and kurtosis (p-value = 0.824) tests showed no significant deviation from normality. Similarly, for the PA variable, there was no significant deviation in skewness (p-value = 0.704) but a marginally significant deviation in kurtosis (p-value = 0.057). The ES variable exhibited a significant deviation in skewness (p-value = 0.029) but not in kurtosis (p-value = 0.937). However, the CES variable showed significant deviations in both skewness (p-value = 0.001) and kurtosis (p-value = 0.273). The joint chi-square test (adj_chi2) also supported these findings, with probabilities greater than 0.05 for MBO, PA, and ES, but less than 0.05 for CES, indicating that only CES significantly departs from a normal distribution based on both skewness and kurtosis.

3.5 Reliability and Validity

In this study, data was collected using a self-administered questionnaire with a 5-point Likert scale. Exploratory factor analysis revealed a 4-factor structure for the 21 items, and the standardized factor loadings were all significant, indicating that the items accurately represented their intended constructs. The measurement model demonstrated high reliability, as evidenced by Cronbach's alpha and composite reliability values exceeding the recommended threshold of 0.70 for each factor. These results suggest that the questionnaire is a valid and reliable tool for measuring the intended constructs. To assess divergent or discriminant validity, a matrix of squared correlations between all latent variables was created and compared to the average variance extracted (AVE), as shown in Table 4. This step helps verify that constructs expected to be unrelated indeed exhibit low correlations, supporting the questionnaire's ability to differentiate between distinct constructs.

Table 4. Divergent or Discriminant Validity (DV)

	CES	ES	MBO	PA
CES				
ES	0.923			
MBO	0.721	0.738		
PA	0.364	0.683	0.651	

Table 4 presents the results of assessing divergent or discriminant validity (DV) among the latent variables. Divergent or discriminant validity is assessed through correlations between constructs, where higher correlations suggest less distinctiveness between constructs. In this analysis, correlations were examined among Consequences of Employee Satisfaction (CES), Employee Satisfaction (ES), and Management by Objectives (MBO), and Performance Appraisal (PA). A notably high correlation of 0.923 was found between CES and ES, indicating a strong association between customer and employee satisfaction. Moderate correlations were observed between CES and MBO (0.721) as well as between ES and MBO (0.738), suggesting links between customer and employee satisfaction with management by objectives. Furthermore, ES showed a high correlation with PA (0.683), indicating a strong relationship between employee satisfaction and performance appraisal. While correlations between CES and PA (0.364) and between MBO and PA (0.651) were relatively weaker, they still indicate some level of association. These findings provide insights into the distinctiveness of the constructs, emphasizing the importance of considering their unique contributions in organizational contexts.

Table 5 presents the descriptive statistics and correlation coefficients for four variables: "MBO" (Management by Objectives), "PA" (Performance Appraisal), "ES" (Employee Satisfaction), and "CES" (Consequences of Employee Satisfaction). Descriptive statistics and correlation analysis were conducted to examine the relationships between Management by Objectives (MBO), Performance Appraisal (PA),

Employee Satisfaction (ES), and Consequences of Employee Satisfaction (CES). The mean and standard deviation for each variable were calculated. The mean score for MBO was 3.3229 with a standard deviation of 1.01819, while for PA, the mean was 2.9472 with a standard deviation of 1.18309. For ES, the mean was 3.3792 with a standard deviation of 1.10994, and for CES, the mean was 3.6889 with a standard deviation of 1.13308.

Table 5. Descriptive Statistics and Correlation test

	Mean	Std. Deviation	MBO	PA	ES	CES
MBO	3.3229	1.01819	1			
PA	2.9472	1.18309	.595**	1		
ES	3.3792	1.10994	.612**	.612**	1	
CES	3.6889	1.13308	.616**	.332**	.776**	1

**Correlation is significant at the 0.01 level.

Correlation analysis revealed significant positive correlations between all variables. Specifically, MBO showed a moderate positive correlation with PA (r = 0.595) and ES (r = 0.612), indicating that higher levels of management by objectives are associated with higher levels of performance appraisal and employee satisfaction. Additionally, PA exhibited a moderate positive correlation with ES (r = 0.612), suggesting that higher performance appraisal scores are related to higher levels of employee satisfaction. The strongest correlation was found between ES and CES (r = 0.776), indicating a strong positive relationship between employee satisfaction and customer satisfaction.

Overall, these findings underscore the interconnectedness of MBO, PA, ES, and CES within the organizational context, highlighting the importance of considering their mutual influences on each other's outcomes.

4. Results

Structural Equation Modeling (SEM) stands as a potent statistical technique employed by researchers to dissect intricate theoretical frameworks and scrutinize relationships among latent variables. Traditionally linked with normally distributed data, SEM exhibits adeptness in handling non-normal data, particularly in extensive sample sizes (Hu and Bentler, 1999). In this investigation, a measurement model was constructed to assure the reliability and validity of the measurement instrument utilized. Following this, the structural model will be utilized to explore the interconnections among latent variables, employing factor analysis and path analysis, alongside bootstrapping of 5000 samples. Despite potential deviations from normality in the data, SEM retains flexibility and adaptability to diverse data types and distributions (Kline, 2015), rendering it a fitting and robust method for probing complex relationships and model congruence in this inquiry.

To assess the model fit, various indices were employed in this study. Squared multiple correlation coefficients (r^2) were computed for each latent variable: CES, ES, and PA, yielding values of (0.728, 0.358, 0.347), respectively. Adjusted squared multiple correlation coefficients (adjusted r^2) were also derived, resulting in values of (0.719, 0.351, 0.340), respectively. These coefficients reflect the proportion of variance in the latent variables explicated by their corresponding indicators, indicating a reasonably favorable fit of the model. Additionally, other fit indices were taken into account: the Normed Fit Index (NFI) registered a value of 0.597, suggesting a moderate fit, while the Standardized Root Mean Square Residual (SRMR) returned a value of 0.148, indicating a relatively minimal discrepancy between observed and model-implied covariance matrices. Furthermore, other model fit statistics were scrutinized, including the discrepancy function (d_ULS = 5,062) and the geometric discrepancy function (d_G = 1.936). The chi-square value was also obtained as 828.634. Collectively, these fit indices, in conjunction with Cronbach's Alpha and Composite Reliability values, advocate that the proposed model manifests a reasonable fit, affirming the reliability and validity of the measurement model utilized in this investigation.

The present study employed a Structural Equation Modeling (SEM) model, depicted in Figure 2, to investigate the relationships among various variables. Table 6 summarizes the results of hypothesis testing in the context of these relationships. The study aimed to explore the associations between different factors related to employee satisfaction.

Overall, the results suggest that most of the examined factors (H1, H2, H3, H4, and H6) play critical roles in shaping employee satisfaction. However, the relationship between "Performance Appraisal" and "Consequences of Employee Satisfaction" (H5) was not supported in this study. These findings provide valuable insights into the factors influencing employee satisfaction, which can be helpful for organizations in enhancing employee well-being and performance.

- H1: Employee Satisfaction and Consequences of Employee Satisfaction: This finding suggests that higher levels of employee satisfaction lead to positive consequences for the organization. When employees are satisfied with their work environment, they are more likely to be motivated, engaged, and committed to their tasks. This, in turn, can result in increased productivity, improved performance, lower turnover rates, and higher levels of customer satisfaction. The positive consequences of employee satisfaction are well-documented in organizational research and underscore the importance of prioritizing employee well-being to achieve overall organizational success.

H2: Management by Objectives and Consequences of Employee Satisfaction: This result indicates that organizations that effectively implement Management by Objectives (MBO) practices are likely to experience positive outcomes related to employee satisfaction. MBO involves setting clear goals, providing feedback, and aligning individual objectives with organizational goals. When MBO is effectively implemented, employees have a clear understanding of their roles and responsibilities, feel empowered to achieve their objectives, and are

more likely to experience job satisfaction. Additionally, MBO can foster a sense of ownership and accountability among employees, leading to improved performance and organizational outcomes.

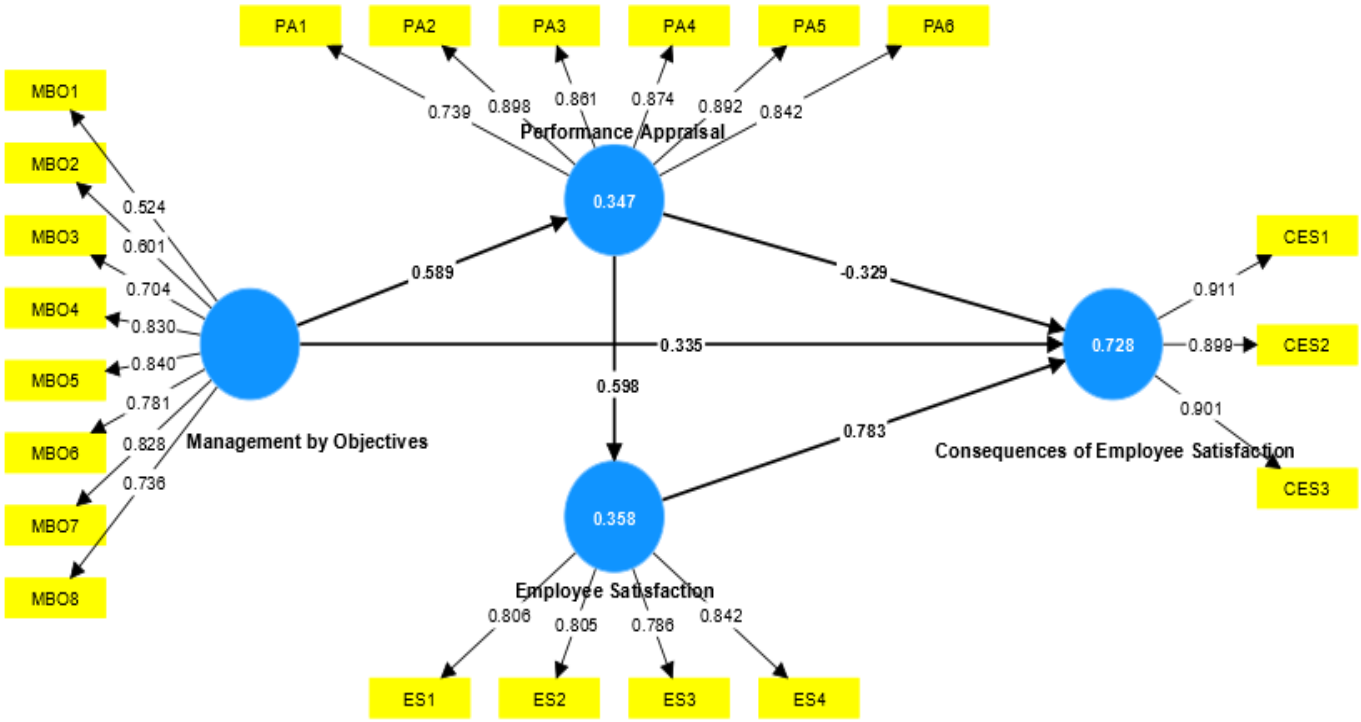

Figure 2. The Estimated Structural Equation Model

- H3: Management by Objectives and Employee Satisfaction: This finding suggests that there is a significant positive relationship between Management by Objectives (MBO) and Employee Satisfaction. When organizations implement MBO practices effectively, employees are more likely to feel engaged, motivated, and satisfied with their work. MBO provides employees with clear expectations, feedback, and opportunities for growth, which are important factors in enhancing job satisfaction. Employees who are satisfied with their work are more likely to be committed to the organization, perform at higher levels, and contribute positively to organizational success.
- H4: Management by Objectives and Performance Appraisal: This result indicates that organizations that utilize Management by Objectives (MBO) practices are likely to have effective performance appraisal systems in place. MBO emphasizes setting specific, measurable, achievable, relevant, and time-bound (SMART) objectives, which provide a clear framework for evaluating employee performance. Performance appraisal is an essential component of MBO, as it allows organizations to assess employee progress, provide feedback, and identify areas for improvement. When MBO is effectively implemented, performance appraisal becomes a valuable tool for recognizing and rewarding employee achievements, facilitating professional development, and enhancing overall organizational performance.
- H5: Performance Appraisal -> Consequences of Employee Satisfaction: The lack of support for this hypothesis suggests that there may not be a direct impact of performance appraisal on the broader consequences of employee satisfaction, such as organizational performance or customer satisfaction. While performance appraisal is an essential aspect of managing employee performance and development, its direct influence on organizational outcomes beyond employee satisfaction may be limited. Other factors, such as organizational culture, leadership, and external market conditions, may play a more significant role in shaping the broader consequences of employee satisfaction.
- H6: Performance Appraisal -> Employee Satisfaction: The support for this hypothesis indicates that performance appraisal has a significant impact on employee satisfaction. When performance appraisal processes are fair, transparent, and provide meaningful feedback to employees, they can enhance employees' sense of recognition, achievement, and engagement, leading to higher levels of job satisfaction. Performance appraisal serves as a mechanism for recognizing and rewarding employee contributions, clarifying expectations, and identifying areas for improvement, all of which contribute to overall employee satisfaction.

Overall, these results highlight the importance of implementing effective management practices, such as MBO, to promote employee satisfaction and achieve positive organizational outcomes. Effective management practices not only contribute to employee well-being but also play a crucial role in driving organizational success and competitiveness in today's dynamic business environment (Ongan et al., 2022; Long et al 2024).

5. Discussion

The purpose of this study was to examine the influence of the Management by Objectives (MBO) method as a performance appraisal tool on

Table 6. Hypothesis Testing

Hypothesis		P values	Remarks
H1	Employee Satisfaction -> Consequences of Employee Satisfaction	0	Supported
H2	Management by Objectives -> Consequences of Employee Satisfaction	0	Supported
H3	Management by Objectives -> Employee Satisfaction	0.003	Supported
H4	Management by Objectives -> Performance Appraisal	0	Supported
H5	Performance Appraisal -> Consequences of Employee Satisfaction	0.215	Not Supported
H6	Performance Appraisal -> Employee Satisfaction	0	Supported

employee satisfaction. The research aimed to analyze various factors within the MBO method and assess their impact on increasing employee productivity and satisfaction, ultimately determining whether these components enhance employees' effectiveness. By utilizing one dependent variable and three latent variables representing both direct and indirect relationships, six hypotheses (H1, H2, H3, H4, H5, and H6) were tested to explore the relationships between MBO factors, employee satisfaction, and productivity. The findings from the hypothesis testing provide valuable insights into these relationships.

Hypothesis H1: Employee Satisfaction and Its Consequences

Hypothesis H1 reveals a significant association between "Employee Satisfaction" and the "Consequences of Employee Satisfaction," supporting the hypothesis that there is a substantial link between employee satisfaction and the outcomes that stem from it. This underscores the importance of employee satisfaction in driving positive organizational outcomes, such as increased productivity and engagement. The findings align with previous studies indicating that satisfied employees are more likely to exhibit higher performance levels, commitment, and overall job satisfaction, leading to beneficial outcomes for the organization (Locke et al., 1981; Steers and Porter, 1974).

Hypothesis H2: MBO and the Consequences of Employee Satisfaction

Hypothesis H2 demonstrates a significant relationship between "Management by Objectives" and the "Consequences of Employee Satisfaction," indicating that the implementation of MBO is closely connected to the consequences arising from employee satisfaction. This finding suggests that effectively using MBO can lead to improved outcomes reflective of employee satisfaction, highlighting the importance of clear and aligned objectives in fostering a positive work environment. It emphasizes that MBO, when implemented correctly, can serve as a powerful tool to enhance employee morale and performance (Koontz and O'Donnell, 1976; Stewart, 1993).

Hypothesis H3: MBO and Employee Satisfaction

Hypothesis H3 indicates a significant association between "Management by Objectives" and "Employee Satisfaction," suggesting that the utilization of MBO significantly impacts the level of employee satisfaction within the organization. Employees who have clear, aligned objectives are likely to experience higher levels of satisfaction, which can enhance their overall performance and engagement. This supports the idea that well-defined goals and regular feedback, core components of MBO, are crucial for maintaining a motivated and satisfied workforce (Hoffmann-Burdzińska and Flak, 2016; Bieniok, 2004).

Hypothesis H4: MBO and Performance Appraisal

Hypothesis H4 shows that "Management by Objectives" is significantly related to "Performance Appraisal," indicating that the use of MBO has a notable impact on the performance appraisal process. Implementing MBO helps create a more structured and objective performance appraisal system, which can lead to fairer and more accurate evaluations of employee performance, ultimately contributing to increased employee satisfaction. This is consistent with the idea that MBO provides a clear framework for assessing employee performance against predefined objectives (Atiyomo, 2000; Fajana, 1997).

Hypothesis H5: Performance Appraisal and the Consequences of Employee Satisfaction

However, Hypothesis H5 indicates no significant association between "Performance Appraisal" and the "Consequences of Employee Satisfaction," suggesting that the consequences resulting from employee satisfaction are not significantly influenced by the performance appraisal process alone. This implies that other factors, such as management practices and organizational culture, may play a more critical role in determining these outcomes. It highlights the complexity of factors influencing employee satisfaction and the need for a holistic approach in performance management (Miles, 2012; Armstrong and Taylor, 2014).

Hypothesis H6: Performance Appraisal and Employee Satisfaction

Lastly, Hypothesis H6 reveals a significant relationship between "Performance Appraisal" and "Employee Satisfaction," indicating that the performance appraisal process substantially impacts the level of employee satisfaction. Effective performance appraisals provide employees with constructive feedback, recognition, and opportunities for growth, which are crucial for maintaining high levels of satisfaction. This finding underscores the importance of a well-structured appraisal system in fostering a motivated and engaged workforce (Rao, 1984; Armstrong and Taylor, 2014).

6. Conclusion

In conclusion, this study aimed to explore the impact of the Management by Objectives (MBO) method as a performance appraisal tool on

employees' satisfaction and productivity. Through comprehensive analysis and the use of Structural Equation Modeling (SEM), we investigated the relationships between various MBO factors and their influence on employee effectiveness. The results of the study supported the hypotheses proposed, revealing that the MBO method significantly contributes to increasing employees' satisfaction and productivity. Our findings demonstrated that the different components within the MBO approach play essential roles in enhancing employee performance and contentment.

By utilizing factor analysis and SEM, we uncovered both direct and indirect relationships between the MBO factors and employee satisfaction and productivity. This not only adds to the existing body of knowledge on performance appraisal but also provides practical insights for organizations looking to improve their performance management practices and foster a more satisfied and productive workforce. The significance of this research lies in its contribution to the understanding of how the MBO method can be leveraged as an effective tool for enhancing employee performance and overall organizational success. As businesses continue to prioritize employee satisfaction and productivity, the findings of this study can serve as a valuable guide for implementing and optimizing the MBO approach within the workplace. However, it is essential to acknowledge some limitations of the study. The research focused solely on the MBO method's impact on employee satisfaction and productivity, and further investigations could explore other potential factors that may influence these outcomes. Additionally, the study was conducted in a specific organizational context, and results may vary across different industries and cultures.

In conclusion, this research underscores the importance of the MBO method in driving employee satisfaction and productivity. It offers valuable implications for HR practitioners and organizational leaders seeking to create a more effective and content workforce through well-structured performance appraisal practices. As the landscape of performance management continues to evolve, the findings of this study can serve as a foundation for future research and organizational development efforts.

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Evaluating the effectiveness of macroeconomic determinants on the performance of the Dhaka Stock Exchange: A time series approach

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ABSTRACT

The study examines the causal relationships between selected macroeconomic variables and the Dhaka Stock Exchange Broad Index (DSEX) from 2013 to 2023. The researcher employed time series economic approaches such as the Augmented Dickey-Fuller (ADF) test for stationarity, the Vector Autoregression (VAR) and Granger causality tests for short-term dynamics, and Johansen's co-integration test for long-term relationships. The findings demonstrate no co-integration between the variables, implying that there is no substantial long-term relationship between how they change over time. However, the VAR analysis shows short-term association between the chosen macroeconomic factors and the DSEX index performance. This implies that changes in any of these macroeconomic variables may have a short-term impact on the DSEX index. Additionally, causality testing reveals unidirectional relationships, indicating that the DSEX index has a considerable impact on numerous economic indicators, including GDP growth, money supply growth, unemployment, inflation and interest rates. Overall, the DSEX index plays an important role in Bangladesh's macroeconomic landscape by accurately forecasting changes in these variables. This study provides important insights into the operation of the Bangladeshi stock market and fills a gap in the literature on developing economies. The results have implications for Bangladeshi investors and policymakers aiming to increase profits, make informed decisions, and support economic stability. Future research should take into account other macroeconomic variables and market indexes to have a better understanding of stock market dynamics.

I. Introduction

Bangladesh's financial sector has traditionally struggled with bank stability, financial products, and capital raising. Historical crises, such as those in 1996 and 2010, revealed considerable discrepancies, with major investors and insiders gaining from asymmetric information while small investors suffered considerable losses (Islam and Ahmed, 2015). The pandemic has worsened pre-existing issues, lowering stock performance in global markets, particularly in Asian nations like as Bangladesh (Mazur et al., 2021; Al-Awadhi et al., 2020; Liu et al., 2020; Topcu and Gulal, 2020). Haque and Chowdhury (2020) found that the pandemic had a substantial influence on the Dhaka and Chittagong stock markets, causing them to fall to their lowest levels in 41 months since the onset of the pandemic. Furthermore, Mishra and Mishra (2020) claim that the epidemic has strained Bangladesh's economy, which was already struggling with a high poverty rate. Additionally, it interrupted economic activity, exposing market vulnerabilities—a trend observed in several countries (Alzyadat and Asfoura, 2021; Chaudhary et al., 2020). Bora and Basistha (2021) discovered that stock index returns were considerably greater before the outbreak than after it. Since the capital market accounts for a major part of a nation's wealth and is heavily influenced by macroeconomic conditions (Aldin et al., 2012), it is essential to examine the specific factors that affect its performance. This research is especially important in developing countries like Bangladesh, where the dynamics of this relationship remain poorly understood. This study examines the DSEX broad index and macroeconomic variables from 2013 to 2023 to address gaps in understanding how COVID-19 affects the Bangladesh stock market. Despite the significance of macroeconomic determinants in stock market performance, few studies have looked at their impact on the DSEX broad index, particularly before, during, and after the COVID-19 outbreak. This research looks at the DSEX broad index performance and variables such as inflation, GDP growth, money supply growth, unemployment rates, and interest rates to see how they impact market stability during times of global economic uncertainty. It

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highlights DSEX broad index performance, which is an important indication of Bangladesh's stock market performance (Rezina, Jahan, and Mustafi, 2017; Mahzabeen, 2016; Nisha, 2016; Miah and Banik, 2013; Pal and Mittal, 2011).

Numerous studies have examined the relationship between macroeconomic variables and stock market performance, repeatedly highlighting the critical roles that the money supply, GDP growth, interest rates, inflation, and unemployment play in determining market dynamics. As acknowledged by several scholars (Algieri, Brancaccio, and Buonaguidi, 2020; Olokoyo et al., 2020; Tiryaki, Erdoğan, and Ceylan, 2017; Asekome and Agbonkhese, 2015; Pradhan et al., 2015a; Ibrahim and Musah, 2014; Hussain et al, 2013). GDP growth rate is an important indicator for analysing economic swings and stock market movements (Işık, Ongan and Islam, 2024; Işık et al., 2024f; Ho, 2019; Asekome and Agbonkhese, 2015). Interest rates, which represent the cost of borrowing or the return on savings, have frequently been proved to have a detrimental impact on both Islamic and conventional indices (Almansour and Almansour, 2016; Barakat et al., 2016; Winful, Sarpong and Sarfo, 2016; Hussain et al., 2013). Inflation often has a negative influence on stock market indices by raising borrowing costs (Mohnot et al., 2024; Olokoyo et al., 2020; Almansour and Almansour, 2016; Abu-Libdeh and Harasheh, 2011). According to Hasan et al. (2022), Ibrahim and Musah (2014), and Mohnot et al. (2024), the money supply is a key macroeconomic component that determines stock market indices. Lastly, unemployment is an important macroeconomic variable that influences consumer spending, company investment, and total economic development (Dogru et al., 2024, 2023, 2019; Işık et al., 2024a; 2024b; 2024c; 2024d, 2024e, 2024f, 2024g, 2024h, 2024i, 2021, 2019, 2016, 2015, 2014; Han et al., 2024, 2023; Jabeen et al., 2024a, 2024b, 2024c; Li et al., 2024; Song et al., 2024; Sun et al., 2024; Yan et al., 2024a, 2024b; Ahmad et al., 2023a, 2023b; Alvarado et al., 2023, 2023a, 2022b; Anas et al., 2023; Bulut et al., 2023; Cetin et al., 2023; Das et al., 2023; Jo et al., 2023; Ongan et al., 2023, 2022).

There is a dearth of studies on how macroeconomic issues explicitly affect the DSE Broad Index, despite the well-established association between macroeconomics and conventional stock markets. There isn't much research that compares these impacts with Bangladesh as the focus. This research is noteworthy because it investigates the causal impacts of certain macroeconomic variables on the DSEX Broad Index during a timeframe not previously examined in the literature. By focusing on understudied macroeconomic variables and the performance of the DSEX broad index, the research fills in gaps in the literature. This study intends to address the research question of examining the causal relationship between selected macroeconomic variables and Dhaka stock exchange broad index performance in Bangladesh. The researcher primarily provides in-depth insights into how stock market index (Dhaka stock exchange broad index) performance responds to changes in chosen macroeconomic variables such as GDP growth rate, money supply growth rate, interest rate, unemployment rate, and inflation rate. This will help policymakers, investors, and market players to navigate economic uncertainty and improve market resilience with the help of this technique. Furthermore, it will help them to understand economic dynamics and how they influence the stock market in the long and short run. The research continues as follows: Section 2 provides a detailed assessment of the literature including conceptual framework and assumptions. The methodology is discussed in Section 3. Section 4 presents empirical findings and discussion, while Section 5 concludes the paper.

2. Literature Review

Capital markets reflect economic confidence and respond to indicators of macroeconomic stability. It channels funds into investments and provides a window into the country's economy. A well-developed capital market encourages long-term development via efficient savings accumulation, appropriate investment allocation, and portfolio diversification (Olokoyo et al., 2020). According to previous studies, macroeconomic uncertainty has an influence on stock markets in both developed and developing countries (Gunay and Can, Karanasos, 2022; Yfanti, and Hunter, 2022; Ma, Wang, and He, 2022). Many researchers have investigated the impact of macroeconomic conditions on stock market performance, such as inflation, GDP, national income, per capita income, exchange rates, interest rates, unemployment, and financial crises (Al-Kandari and Abul, 2019; Ho, 2019 Bahloul et al., 2017; Pradhan et al., 2015a; Asekome and Agbonkhese, 2015). Typically, in a case of causality, certain variables (causal variables) are controlled while an observable variable (dependent or impact variable) is changed methodically (Wold, 1954). The researcher needs to understand Granger's (1969) concept—that is, that X Granger causes Y if previous values of X enhance forecasts of Y—is essential to comprehending dynamic time series interactions. Additionally, Keele, Stevenson, and Elwert (2020) state that an identification approach tries to establish that D is independent of Y's potential values to understand relationships as causal effects. Furthermore, the researcher takes into consideration such long-term relationships, the cointegration technique—created by Granger (1986), Hendry (1986), and Engle and Granger (1987)—improves Granger causality testing. The paper investigates the causal relationship between major macroeconomic indicators—unemployment rate, interest rates, inflation, money supply growth rate, GDP growth rate and stock market performance.

2.1 Dependent variable

DSE Broad Index (DSEX): Stock market performances are influenced by economic fundamentals, enabling stock market values to predict future economic activity. The Dhaka Stock Exchange (DSE) computes three indices, namely DSEX, DS30, and DSES, which do not include bonds, debentures, or mutual funds. Within this group, the DSEX stands out as the primary benchmark index, including 97% of the total value of the stock market. This study examines the performance of the DSES Broad Index as the only dependent variable. Its main objective is to measure the causal relationship between the DSES Broad Index and specific macroeconomic variables, as shown in various studies (Rezina, Jahan, and Mustafi, 2017; Mahzabeen, 2016; Pal and Mittal, 2011; Miah and Banik, 2013; Nisha, 2016).

2.2. Independent/explanatory variables

Unemployment Rate (UN): Economic performance, especially unemployment rates, is crucial for a country's capacity to address environmental problems, promote social fairness, and maintain governance standards (Işık, Ongan and Islam, 2024a; Işık et al., 2024b; Işık et al., 2024c; Jo et al., 2023). For instance, Pan (2018) discovered that unemployment rates and stock market prices are cointegrated across nation groups. Sibande et al. (2019) revealed that stock market returns have a considerable impact on unemployment, while unemployment has no significant influence on stock market returns (Algieri, Brancaccio and Buonaguidi, 2020). Nonetheless, research conducted in Turkey between 2003:1 and 2016:12 revealed that unemployment had no impact on stock returns (Tiryaki, Erdoğan, and Ceylan, 2017).

$H1_0$: Unemployment Rate does not Granger cause DSEX Index Performance
$H2_0$: DSEX Index Performance does not Granger cause Unemployment Rate

Interest Rate (INT): As interest rates increase, investors prefer to shift their money from the stock market to interest-bearing securities, resulting in lower stock prices and less demand for shares (Barakat et al., 2016; Winful, Sarpong and Sarfo, 2016; Cook, 1989). For instance, interest rates have been demonstrated to have a substantial adverse and causal effect on stock market performance in Pakistan (Almansour and Almansour, 2016; Hussain et al., 2013). Previous studies have confirmed noteworthy long-term relationships between interest rates and the stock market index (Lee, 2020; Demir, 2019; Barakat et al., 2016; Jareño and Negrut, 2016; Pradhan et al., 2015a; Forson, 2014; Ibrahim and Musah, 2014). On the other hand, Sukmawati and Haryono (2021), aligning with Mukhlis et al. (2018), contend that external factors influencing these variables prevent the Composite Stock Price Index and interest rates from cointegrating. Unidirectional causal relationship was found between interest rates and stock market indices (Wickramasinghe, 2023; Hasan et al., 2022; Bahloul et al., 2017; Barakat et al., 2016; Mahzabeen, 2016). Nonetheless, Ibrahim and Musah (2014) discovered no causal relationship between interest rates and stock market index performance.

$H3_0$: Interest Rate does not Granger cause DSEX Index Performance.
$H4_0$: DSEX Index Performance does not Granger cause Interest Rate.

Inflation Rate (INF): Inflation, defined as an ongoing rise in prices throughout an economy, profoundly affects various sectors (Islam et al., 2024a; Işık et al., 2024e). According to Barakat et al. (2016), rising inflation in Egypt enhances corporate profitability and attracts investors, raising stock prices, whereas, in Tunisia, inflation shifts money to consumption, reducing stock demand and prices. Therefore, inflation can have both positive effects on stock indices through demand-push and negative effects through cost-push, as evidenced by studies (Mishra and Debasish, 2018; Miah and Banik, 2013; bu-Libdeh and Harasheh, 2011). The relationship between inflation and stock markets has been thoroughly studied, highlighting its significance, noting its adverse impacts, and confirming its role as a key economic indicator at natural levels (Keswani and Wadhwa, 2022; Camilleri et al., 2019; Kwofie and Ansah, 2018; Megaravalli and Sampagnaro, 2018). Sukmawati and Haryono (2021) found a long-term relationship between the Stock Index and inflation, which is supported by many researchers (Mohnot et al., 2024; Ligocká, 2023; Olokoyo, et al. 2020; Demir, 2019; Mukhlis et al., 2018; Barakat et al., 2016; Jareño and Negrut, 2016; Peiró, 2016; Pradhan et al., 2015a; Pal and Mittal, 2011). Granger's causality test showed that inflation has a minor influence on the All-Share Price Index (Wickramasinghe, 2023), however Hasan et al. (2022) discovered that inflation has a short-term, unidirectional impact on the Islamic stock index. Furthermore, although some research revealed no causal association between inflation and stock returns, cointegration analysis indicates a long-run relationship with inflation (Almansour and Almansour, 2016; Ibrahim and Musah, 2014).

$H5_0$: Inflation does not Granger cause DSEX Index Performance
$H6_0$: DSEX Index Performance does not Granger cause Inflation

Money Supply Growth Rate (MGR): The money supply has a considerable influence on macroeconomic indicators, namely stock market indexes. According to Barakat et al. (2016), increasing the money supply stimulates more stock market investment since consumers have more discretionary income and purchasing power. Bahloul et al. (2017) indicate that changes in money supply have an apparent impact on index returns under different instability conditions in developing and emerging markets, highlighting a strong long-term relationship with market indexes as supported by various studies (Mohnot et al., 2024;Ligocká, 2023; Hasan et al., 2022; Bhuiyan and Chowdhury, 2020; Demir, 2019; Barakat et al., 2016; Peiró, 2016; Pradhan et al., 2015b; Forson, 2014; Ibrahim and Musah, 2014; Tripathi and Seth, 2014). Meanwhile, Granger's causality test demonstrates that money supply has a negligible influence on the All-Share Price Index (Wickramasinghe, 2023), although Plihal (2016) finds bidirectional causality between money supply and the stock market. On the contrary, both Almansour and Almansour (2016) and Ibrahim and Musah (2014) found no causal relationship between money supply and stock market returns.

$H7_0$: Money Supply Growth Rate does not Granger cause DSEX Index Performance
$H8_0$: DSEX Index Performance does not Granger cause Money Supply Growth Rate

Gross Domestic Product Growth Rate (GR): Asia-Pacific countries are experiencing tremendous economic expansion, with emerging nations attracting foreign investments due to relaxed environmental constraints (Işık et al., 2024c; Işık et al., 2024d). Bangladesh ranks as the 35th strongest economy in the world with a GDP of $460.8 billion. This position enhances foreign direct investment by drawing in worldwide investors (Islam et al., 2024; Islam et al., 2023a; Islam as al., 2023b; Bintara, 2020). This expansion leads to greater employee earnings and better living conditions (Gazi et al., 2024; Işık et al., 2024e). Economic performance, particularly GDP growth, is essential for addressing environmental issues and has a major influence on the all-share index (Işık, Ongan and Islam, 2024a; Işık et al., 2024f; Ho, 2019; Asekome and Agbonkhese, 2015). Previous studies show that changes in GDP have a long-term impact on stock indexes (Olokoyo et al., 2020; Demir, 2019; Barakat et al., 2016; Jareño and Negrut, 2016; Peiró, 2016; Pradhan et al., 2015a; Tripathi and Seth, 2014). In the short run, researchers discover a complex network of causal relationships, but this provides limited insight into how stock market depth may contribute to economic growth (Ligocká, 2023; Pradhan et al., 2015b). However, Mostafa (2020) discovered a two-way causal relationship between traded stocks and economic growth.

$H9_0$: GDP Growth Rate does not Granger cause DSEX Index Performance

$H10_0$: DSEX Index Performance does not Granger cause GDP Growth Rate

data were collected

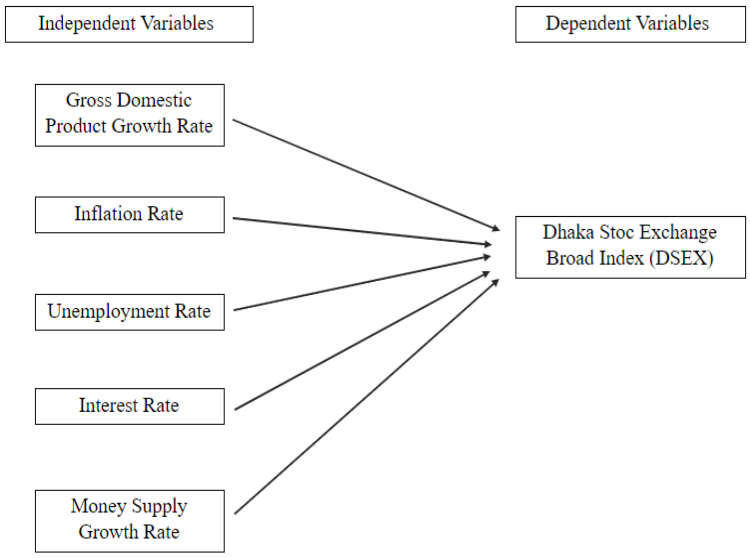
2.3. Conceptual framework

The conceptual framework is derived from a comprehensive review of the existing literature.

3. Methodology

The study employs time series econometric methodologies to examine the influence of macroeconomic variables on the performance of the Dhaka Stock Exchange Broad Index (DSEX) from 2013 to 2023, spanning the periods before, during, and after the COVID-19 pandemic. Data for the DSEX index were collected from Investing.com, which represents overall market performance. Macroeconomic variables

Figure 1: Conceptual Framework



from the World Bank Group's databases, including yearly datasets for GDP growth rates, money supply growth rates, inflation rates (measured in annual percentages by the GDP deflator), and interest rates. The unemployment rate data was gathered from Macrotrends, which gives yearly figures. To effectively analyze stock performance, monthly data was selected to capture real-time dynamics and volatility, which are critical for timely decision-making. In contrast, annual data for macroeconomic variables was chosen to highlight longer-term trends and minimize the effects of short-term fluctuations. To align the different data frequencies, monthly stock market data—including high and low-volume figures—was averaged to generate annual values, thus smoothing out short-term volatility. Normality issues in the inflation data were addressed through an inverse transformation, while GDP growth rates were transformed using a Box-Cox method to achieve normality. Other independent variables remained unchanged, as they met normality assumptions. The quantitative data were analysed using Stata, a statistical program that specialises in econometric and time series analysis. First, the Augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1981, 1979), has been used to assess the data series' stationarity. If the variables are stationary at the initial difference, they are deemed to be of the same order, which is required for co-integration testing. Next, Johansen's (1988, 1991) co-integration test has been used to determine if there are any long-run relationships between the stock market index and macroeconomic data. This approach will provide standardized co-integrating coefficients,

allowing for the estimate of macroeconomic variables' long-term influence on the stock market. Following that, pairwise Granger causality tests have been used to investigate the short-term causal relationships between macroeconomic factors and the stock index. Granger causality (Engle and Granger, 1986; Granger, 1969) states that previous values of one variable may predict future values. In addition, several diagnostic tests have been performed to evaluate the models' adaptability. The Breusch-Godfrey LM and Durbin-Watson d-statistic tests have been employed for assessing autocorrelation, the Breusch-Pagan test to check heteroskedasticity, and the Ramsey RESET test to specify the model.

$$DSEX_t = \alpha + \sum_{i=1}^{n} \gamma i GR_{t-i} + \sum_{i=1}^{n} \delta i INF_{t-i} + \sum_{i=1}^{n} \lambda i MGR_{t-i} + \sum_{i=1}^{n} \mu i UN_{t-i} + \sum_{i=1}^{n} \nu i INT_{t-i} + \epsilon_t$$

Where:

$DSEX_t$: Performance of the DSEX index at time t (dependent variable)

α: intercept term, initial value of the DSEX index

γ_i : measures the impact of lagged GDP growth rates (GR_{t-i})

δ_i : measures the impact of lagged inflation rates (INF_{t-i})

λ_i : measures the impact of lagged money supply growth (MGR_{t-i})

μ_i: measures the impact of lagged unemployment rates (UN_{t-i})

ν_i: measures the impact of lagged interest rate (INT_{t-i})

ϵ_t: error term capturing unexplainable changes in the DSEX index.

4. Findings and Discussion

4.1. Descriptive statistics

Descriptive statistics describe key data properties such as central tendency, dispersion, and distribution shape. The researcher estimates the mean, standard deviation, minimum, maximum, skewness, kurtosis, and Jarque-Bera (J-B) tests for each variable. These statistics are critical for understanding the dataset's underlying patterns and fluctuations, which will guide further analysis.

The DSEX index has a mean of 0.0005 and a low standard deviation of 0.0001, suggesting that it fluctuates between 0.0003 and 0.0006. INF averages 18.31 with a standard deviation of 6.613, with considerable variance ranging from 3.584 to 27.027. GDP has a mean of -0.997 and an insignificant standard deviation of 0.0007, indicating persistently negative growth. Interest rates (INT) average 0.0269 with a standard

Table 1: Descriptive statistics summary

Variable	Mean	Std. Dev	Min	Max	Skewness	Kurtosis	Prob>chi2
DSEX	.0005	.0001	.0003	.0006	0.8676	0.4795	0.7602
INF	18.31	6.613	3.584	27.027	0.2071	0.2293	0.1690
GR	-.997	.0007	-.9994	-.9968	0.0769	0.0797	0.067
INT	.0269	.0097	.0110	.0420	0.9723	0.5413	0.8302
UN	.0459	.0039	.0427	.0532	0.0633	0.8918	0.1442
MGR	.1235	.0327	.0700	.167	0.4153	0.4595	0.5029

deviation of 0.0097 and range from 0.0110 to 0.0420, showing stability. The unemployment rate (UNP) averages 0.0459 with a standard deviation of 0.0039, ranging slightly from 0.0427 to 0.0532, indicating minimal fluctuation. Finally, the money supply growth rate (MSG) averages 0.1235 with a standard deviation of 0.0327, ranging from 0.0700 to 0.167, showing modest growth dynamics. The Jarque-Bera (J-B) test demonstrates that the probability values for inflation and GDP growth rates in their level forms are less than 5%, thereby rejecting the null hypothesis of normality. However, after performing the inverse and Box-Cox transformations, the J-B test probabilities exceed 5%, indicating that the distributions have become normal. Overall, most variables have followed a normal distribution, with the GDP growth rate on the borderline of normality.

4.2. Correlation matrix

The correlation matrix below shows the correlations between dependent and independent variables, including the DSEX index, inflation (INF), GDP growth rate (GR), money supply growth rate (MGR), unemployment rate (UN), and interest rates (INT). Each variable describes the strength and direction of the linear relationships. This approach provides insights into how changes in one variable affect others.

The DSEX index has a high negative relationship with money supply growth (−0.84) and interest rates (−0.61), implying that index improvements lead to declines in both variables. It has a positive relationship with inflation, GDP growth, and unemployment, indicating that

better index performance may lead to higher commodity price, economy growth and unemployment. INF has a minor negative association with GR (-0.11), but moderate negative correlations with MGR and INT (-0.38 and -0.30). This shows that decreasing the growth of the money supply, interest rates, and GDP might lead to higher inflation. The relationship between GDP growth and unemployment is moderately negative (−0.59), meaning that greater unemployment generally corresponds with slower GDP growth. Furthermore, MGR has a significant positive correlation with interest rates (0.76) and a negative correlation (-0.39) with unemployment, indicating that there is a relationship between reduced unemployment and a rise in money supply. Finally, unemployment and interest rates have a negative correlation (−0.48), suggesting that growing unemployment may lead to lower interest rates.

Table 2: Correlation matrix output

	DSEX	INF	GR	MGR	UN	INT
DSEX	1.00					
INF	0.1647	1.00				
GR	0.3019	-0.1128	1.00			
MGR	-0.8375	-0.3808	-0.1453	1.00		
UN	0.2848	0.3874	-0.5890	-0.3876	1.00	
INT	-0.6110	-0.3048	0.2804	0.7553	-0.4784	1.00

4.3. Multicollinearity, serial correlation and heteroscedasticity tests

This section summarizes the findings of several statistical tests performed to evaluate the model's adequacy and dependability.

Table 3: Results of multicollinearity, serial correlation and heteroscedasticity tests

Breusch-Godfrey LM test		Breusch-Pagan for heteroskedasticity		Ramsey RESET test		DW d-statistic
chi2	0.866	chi2(1)	1.60	F (3, 1)	1.22	2
Prob > chi2	0.3521	Prob > chi2	0.2054	Prob > F	0.4797	

The Breusch-Godfrey LM test reveals no significant autocorrelation in the residuals, with a chi-squared statistic of 0.866 and a p-value of 0.3521, indicating that the residuals are independent. Then Breusch-Pagan test for heteroskedasticity provides a chi-squared score of 1.60 and a p-value of 0.2054, showing constant variance with no significant heteroskedasticity. Moreover, the Ramsey RESET test, with an F-statistic of 1.22 and a p-value of 0.4797, indicates that the model is accurately characterized and there is no indication of misspecification. Lastly, the Durbin-Watson d-statistic is 2, confirming the absence of autocorrelation in the residual data. Overall, these findings confirm the model's estimates, an effective and well-defined framework for analysis.

4.4. Test of stationary

Stationarity is critical for econometric models since it ensures that statistical parameters like mean and variance stay constant across time. Additionally nonstationary time series, including those with mean-reverting behaviour, may reduce the efficacy and generalizability of predictions, making them untrustworthy (Pokou, Sadefo Kamdem, and Benhmad, 2024; Subrata, 2020; Jalil and Rao, 2019; Herranz, 2017). The Dickey-Fuller (DF) test, developed by Dickey and Fuller in (1979), is a fundamental technique for determining the existence of a unit root in a time series, with the null hypothesis showing non-stationarity. To allow for higher-order autocorrelation, the test was modified into the Augmented Dickey-Fuller (ADF) test, which contains additional lagged components to address autocorrelation concerns. The Augmented Dickey-Fuller test results showed that all studied variables—DSEX, INF, GR, MGR, UN, and INT—are nonstationary at levels, as demonstrated by strong p-values and t-statistics.

Nonstationary series may provide biased or misleading findings during hypothesis testing (Dinh, 2020b). It may not show true economic trends, possibly leading to poor investment decisions and unproductive governmental responses. Misinterpreting inflation rates, for example, might lead to central banks setting improper interest rates, aggravating inflation in the face of deflationary forces. Similarly, non-stationary GDP growth rates may give an illusion of economic strength, encouraging unnecessary fiscal intervention. Furthermore, nonstationary in the unemployment rate may lead to policies that ignore genuine labour market challenges, such as structural unemployment. Therefore, differentiation can effectively eliminate both trend and seasonal components from a time series, allowing for a better examination of underlying patterns (Pokou, Sadefo Kamdem, and Benhmad, 2024). It is critical to check that macroeconomic time series variables are stable, with constant means and variances throughout time, and covariances determined exclusively by the distance between periods (Subrata, 2020). After the first differencing, all variables become stationary, as shown by significant t-statistics and low p-values, indicating that their statistical data have stabilised (Jalil and Rao, 2019; Herranz, 2017). The 5% critical value for the test is 1.950, indicating that although none of the variables are stationary at levels, they all became stationarity after initial differencing, emphasizing the significance of this process in time series analysis.

Table 4: Stationary (Unit-Root) tests

Augmented Dickey-Fuller test			
		At Level	First Difference
DSEX	t-Statistic	0.401	4.274
	Prob	0.698	0.003
INF	t-Statistic	0.591	4.455
	Prob	0.569	0.002
GR	t-Statistic	0.005	4.912
	Prob	0.996	0.001
MGR	t-Statistic	1.326	2.713
	Prob	0.217	0.027
UN	t-Statistic	0.232	3.693
	Prob	0.822	0.006
INT	t-Statistic	0.522	2.444
	Prob	0.614	0.040
5% Critical Value	t-Stat 1.950		

4.5. Johansen Co-integration tests

Cointegration tests are essential for analyzing the relationships between macroeconomic variables and stock market movements in a long-term context. Johansen's (1991) Cointegration method can be applied to test for long-run equilibrium relationships, indicating at least one cointegration among them (Dinh, 2020a). Johansen's method avoids normalization issues and remains robust against non-normality (Lütkepohl, 2013), transforming macroeconomic modelling by providing a framework for assessing variable integration and long-run economic associations (Subrata, 2020). After employing Johansen's cointegration test, the researcher utilised trace statistics and maximum eigenvalue tests.

Table 5: Co-integration Analysis Output

	Eigenvalue	Trace Statistic	Critical Value (5%)
INT	0.76844	0.05	3.76
UN	0.65005	1.55	3.76
MGR	0.77417	0.06	3.76
GR	0.70652	1.22	3.76
INF	0.61015	3.18	3.76

There are many approaches for determining the optimal lag duration, including the Likelihood Ratio (LR), Final Prediction Error (FPE), Akaike Information Criterion (AIC), Schwarz's Bayesian Information Criterion (SBIC), and Hannan-Quinn Information Criterion (HQIC) (Paulsen, 1984; Nielsen, 2006). Traditional approaches often favour reduced lag orders, which may reduce prediction performance (Nicholson et al., 2020). Inadequate lag selection may generate several kinds of challenges: too few lags can produce autocorrelation, while too many lag orders can result in overfitting and increased residual variance. Incorrectly stated lag lengths may also affect statistical power, provide inconsistent results, and lead to model misspecification (Lütkepohl et al., 2021; Wooldridge, 2009; Braun and Mittmik, 1993). Optimal lag selection is critical for model stability, ensuring Gaussian errors, minimizing the loss function, and improving prediction accuracy. Therefore, avoiding heteroscedasticity and omitted variable bias; robustness tests between one and two lags are recommended (Elalaoui et al., 2021; Surakhi et al., 2021; Jalil and Rao, 2019). After considering various lag length recommendation, the researcher performed the Johansen test for cointegration using a selected lag of one to determine long-run equilibrium between the stock market index and the five macroeconomic variables. The findings support the null hypothesis of no cointegration among the analysed variables, as demonstrated by trace statistics for UN (1.55), INT (0.05), MGR (0.06), GR (1.22), and INF (3.18), all of which have lower values than the critical value of 3.76. This conclusion contradicts previous research that has shown strong long-term relationships between macroeconomic variables and stock indexes. The findings are consistent with prior research findings (Sukmawati and Haryono, 2021; Mukhlis et al., 2018; Almansour and Almansour, 2016; Ibrahim and Musah, 2014). However, the results regarding unemployment contradict Pan (2018). In addition, numerous studies have identified long-term relationships between interest rates and stock market returns, which contradict these findings (Lee, 2020; Pradhan et al., 2015; Barakat et al., 2016; Jareño and Negrut, 2016; Demir, 2019). Contrary to the current findings, earlier research suggests that macroeconomic variables, including GDP growth rate, inflation and money supply growth (MSG), have significant long-term relationships with stock market returns (Mohnot et al., 2024; Ligocká, 2023; Hasan et al., 2022; Bhuiyan and Chowdhury, 2020; Olokoyo et al., 2020; Demir, 2019; Mukhlis et al., 2018;

Barakat et al., 2016; Jareño and Negrut, 2016; Peiró, 2016; Pradhan et al., 2015b). The absence of cointegration raises significant issues about the study's Arbitrage Pricing Theory (APT) paradigm, which holds that stock prices should be responsive to macroeconomic factors (Chen, Roll, and Ross, 1986; Ross, 1976). If these characteristics influence stock prices, a long-term stable relationship will be expected. Nevertheless, the absence of such an association indicates that the DSEX index may not accurately reflect the macroeconomic conditions that it aims to represent. The results reveal that the stock market may not sufficiently reflect the impact of macroeconomic data, which is a key assumption of the Efficient Market Hypothesis (EMH). The EMH, especially its semi-strong form, asserts that stock prices should react to all publicly accessible information, including macroeconomic indicators. The DSEX index's inability to develop a stable relationship with these attributes indicates that the market may not be successfully integrating this information into stock pricing. Therefore, fluctuations in the index may not reflect changes in underlying economic circumstances, potentially leading to mispricing and inefficiencies. Fama (1970) contends that an efficient market allows informed investors to earn only competitive expected returns, with prices responsive instantly to public information. However, the lack of cointegration implies that the market may not completely respond to relevant macroeconomic data, resulting in price changes based on outdated or incomplete information (Rayball, 1994). The findings show that long-term investors, who often base their investment strategies on macroeconomic trends (Bhuiyan and Chowdhury, 2020), may struggle to discover credible signals in the DSEX index effectiveness about the broader economic situation. This has major consequences for Bangladeshi policymakers, highlighting the need to promote long-term economic development by increasing the size, complexity, and overall infrastructure of the stock market while simultaneously stabilising macroeconomic circumstances. A stock market that does not adequately reflect underlying economic data could undermine the efficiency of institutional and individual investment plans. Prior research, for example, underscored that policymakers should avoid employing the money supply as a main policy instrument to influence the Korean stock market in the long term (Lee, 2020). Such findings underline the necessity of developing a more responsive and transparent market environment in Bangladesh, which can better meet the demands of investors and contribute to more steady economic development.

4.6. Vector autoregression model

When there is no cointegration between variables, the VAR model is acceptable because it allows each variable to be regressed on its historical values as well as the present values of others (Elalaoui et al., 2021; Subrata, 2020).

Table 6: VAR model output

Equation	RMSE	R-sq	chi2	P>chi2
INF	.000075	0.5526	12.35001	0.0021
GR	.000081	0.4737	9.002186	0.0111
MGR	.000061	0.7077	24.21438	0.0000
UN	.000080	0.4881	9.534375	0.0085
INT	.000085	0.4262	7.427126	0.0244

According to Table 6, the Money Supply Growth Rate (MGR) has the best predictive accuracy, with the lowest RMSE of 0.000061 and the highest R-squared value of 0.7077, indicating a significant relationship with the dependent variable. Inflation (INF) likewise performs well, explaining more than 55% of the variance (R-squared = 0.5526) and reaching statistical significance (chi-squared = 12.35001, p = 0.0021). The GDP Growth Rate (GR) and Unemployment Rate (UN) have lesser associations, with R-squared values of 0.4737 and 0.4881, respectively, although both are statistically significant. The Interest Rate (INT) has the lowest R-squared value of 0.4262, implying that it explains the least variation while being statistically significant (p = 0.0244). In this circumstance, policymakers should prioritise monitoring short-term macroeconomic statistics to make timely measures that stabilise the economy and improve stock market performance. According to Beck and Stanek (2019), improving financial markets is critical for lowering the reliance on domestic savings for investment. Strengthening the stock market improves capital-raising abilities, which Pradhan et al. (2014) believe are critical for overall economic health and growth.

Given the considerable short-term dependence of these variables, monetary policy must be adaptive, reacting rapidly to changes in macroeconomic indicators to preserve investment and boost consumer confidence. According to Pradhan (2015b), transparent and effective monetary policies may help with change, connecting stock market development to overall economic growth. Policymakers must strategically control inflation, while financial managers must comprehend short-term interest rate dynamics (Lee, 2020). To reduce interest rate volatility and make credit more available for stock investments, central bank lending rates must be aligned with those of deposit money institutions. During times of stock market volatility, a thorough knowledge of such macroeconomics trends allows for improved portfolio management and diversification strategies (Barakat et al. 2016). Policymakers and investors need to recognise the potential risks of stock market volatility is crucial, since downturns may result in severe losses (Demir, 2019). Overall, these findings highlight the relevance of short-term dynamics and the development of financial markets in creating an effective economic environment.

4.7. Pairwise Granger-causality tests

This section addresses the findings of the Pairwise Granger-causality tests, which evaluate the directional impact of macroeconomic variables on stock market performance, shedding light on the causal relationships within the economic framework.

Table 7: Granger causality tests summary

Null Hypothesis	Prob.	Decision	Relationship
Inflation does not Granger cause DSEX Index Performance	0.865	Accepted	one-way causal relationship
DSEX Index Performance does not Granger cause Inflation	0.004	Rejected	
GDP Growth Rate does not Granger cause DSEX Index Performance	0.932	Accepted	one-way causal relationship
DSEX Index Performance does not Granger cause GDP Growth Rate	0.020	Rejected	
Money Supply Growth Rate does not Granger cause DSEX Index Performance	0.603	Accepted	one-way causal relationship
DSEX Index Performance does not Granger cause Money Supply Growth Rate	0.000	Rejected	
Unemployment Rate does not Granger cause DSEX Index Performance	0.516	Accepted	one-way causal relationship
DSEX Index Performance does not Granger cause Unemployment Rate	0. 016	Rejected	
Interest Rate does not Granger cause DSEX Index Performance	0.055	Accepted	one-way causal relationship
DSEX Index Performance does not Granger cause Interest Rate	0.042	Rejected	

The absence of causality between inflation and the DSEX index indicates that inflation rates do not predict stock market performance. In contrast, the DSEX's considerable effect on inflation implies that changes in stock prices may shape inflation expectations, implying a one-way relationship in which market performance influences inflation patterns. The one-way causal relationship between the DSEX and inflation ($p = 0.004$) implies that policymakers should use stock market movements to forecast inflationary pressures. This result is consistent with the findings of Hasan et al. (2022), but it contradicts Almansour and Almansour (2016) and Ibrahim and Musah (2014), who found no direct association between inflation and stock market performance. Therefore, policymakers can implement timely monetary measures to reduce inflation while maintaining market stability by constantly tracking stock performance. Additionally, a proactive strategy to incorporate stock market data into inflation control plans may improve monetary policy's efficacy.

Secondly the DSEX's impact on GDP implies a one-way causal relationship in which a flourishing stock market may drive economic expansion, validating the concept that stock performance can boost GDP growth. The findings contrast those of previous studies (Ligocká, 2023; Mostafa, 2020; Pradhan et al., 2015b). This underscores the importance of policymakers adopting actions that promote stock market expansion, since they may boost capital availability for firms while also stimulating general economic activity. Therefore, encouraging more public engagement in the stock market could increase these impacts.

The money supply growth rate may not be a direct predictor of stock market behaviour, as shown by the lack of a causal relationship between changes in the money supply and stock performance. On the other hand, a robust stock market index performance might promote more lending and liquidity, demonstrating that stock performance has a substantial impact on the expansion of the money supply. DSEX and Money Supply have a one-way causal relationship (Rejected, 0.000). These findings are contrary to the findings of earlier studies (Ibrahim and Musah, 2016; Plihal, 2016; Almansour and Almansour, 2014). If the policymaker can increase market confidence may result in more liquidity, which is beneficial for investors and the economy as a whole.

Furthermore, it was shown that there is no causal relationship between unemployment and stock (DSEX) performance, indicating that labour market fluctuations have minimal impact on stock movements. However, the DSEX's influence on unemployment implies that a rising stock market may lead to job creation, establishing a relationship between stock performance and employment levels. The study reveals a one way or unidirectional causal relationship between the DSEX and the unemployment rate (rejected at 0.016). The results are consistent with Sibande et al. (2019) and Algieri, Brancaccio, and Buonaguidi (2020), but contradict Tiryaki, Erdoğan, and Ceylan's (2017) conclusions. As a result, policymakers should prioritise initiatives that promote stock market expansion as a method for increasing employment. Thats why promoting a strong stock market may assist in lowering unemployment risks, demonstrating the interdependence between financial markets and labour market dynamics.

Finally, the study concluded that the lack of a causal association between interest rates and stock performance demonstrates that changes in borrowing costs do not directly predict market behaviour. In contrast, the DSEX's impact on interest rates shows that strong stock performance might inform monetary policy decisions, resulting in a reverse relationship in which stock market patterns can shape interest rate

policies. The study finds a unidirectional causal relationship between the DSEX and interest rates (rejected at 0.042), which is in line with previous research on the nature of this relationship (Wickramasinghe, 2023; Hasan et al., 2022; Bahloul et al., 2017; Barakat et al., 2016; Mahzabeen, 2016). This conclusion, however, contradicts Ibrahim and Musah's (2014) finding that interest rates have no causal association with stock market index performance. When setting interest rates, policymakers should recognize the causal relationships between stock performance and interest rates might help monetary policy work more effectively, particularly during times of economic instability.

5. Conclusion

In conclusion, this study revealed that all variables are non-stationary at level I(0) but become stationary at the first difference, I(1) through Augmented Dickey-Fuller tests. The findings highlight no long-term equilibrium relationship between macroeconomic variables and stock market performance, as revealed by Johansen's cointegration tests. The lack of such relationships indicates that changes in one variable do not have a predictable long-term influence on others. Then granger causality test reveals one-way or unidirectional relationships between economic variables and stock market performance. These results show moderate to substantial short-term relationships between the DSEX broad index and macroeconomic variables, as shown by high R-squared and significant chi-squared coefficients. While inflation does not Granger cause DSEX index performance, the index accurately anticipates inflation patterns, demonstrating its importance as a policymakers' predictive tool.

Furthermore, the DSEX index provides predictive powers for GDP growth, money supply growth, unemployment, and interest rates, highlighting its significance in comprehending wider economic dynamics. Importantly, the findings show the DSEX broad index performance acts as an effective indicator for anticipating future changes in macroeconomic dynamics in Bangladesh. The literature assessment revealed a dearth of research on emerging countries and a scarcity of studies on the nature of the relationship between macroeconomic variables and the Bangladesh stock market index. The findings have added to the literature by throwing light on this uncharted territory. To improve decision-making and maintain market stability, investors and governments should pay close attention to important variables including the interplay between macroeconomic data and stock market swings.

5.1. Limitations

The research, which spans the years 2013 through 2023, could not completely account for long-term trends or anomalies, thereby overlooking previous changes and newly developing stock market patterns. Its only emphasis was on the DSEX broad index, which would not accurately reflect the total performance of Bangladesh's stock market and might provide incomplete or biased results if other indexes or market sectors were left out. Reliance on secondary data increases the possibility of errors and incompleteness, which may compromise the validity of the conclusions and interpretations. Furthermore, the study focused on a narrow range of macroeconomic variables, thus ignoring other important aspects that might affect stock market performance.

5.2. Implications

The study's findings have major theoretical and practical implications. Firstly, understanding the unidirectional relationship between the DSEX index performance and key macroeconomic variables is essential to developing effective financial policies. These implies that, although the stock market may impact other economic indicators, the contrary is not always true for many variables. Moreover, it contradicts standard economic theories that propose a more integrated connection between macroeconomic factors. The results demonstrate how stock market changes may influence broader economic circumstances, emphasising the need for a more sophisticated approach to economic management. Policymakers may use this insight to create targeted monetary policies aimed at fostering market stability, such as adjusting the macroeconomic dynamics to directly impact stock market performance and maintain economic resilience. Recognizing these causal relationships allows policymakers to make better-informed choices that not only promote stock market health but also enhance long-term economic development. This strategy may assist in guaranteeing that the stock market is a more stable and resilient component of the overall economy, contributing to long-term economic growth.

5.3. Future research directions

Future studies should broaden the time frame to encompass times before 2013 and after 2023 to capture long-term trends and anomalies. This extended timeframe would provide a more comprehensive perspective of past developments and developing patterns in the stock market, facilitating deeper insights into stock market behaviour over time. Additionally, researchers should include a wider variety of stock market indices, such as the DS30 and DSE Shariah Index, in addition to the DSEX broad index. Including these indexes and market sectors would provide a more accurate picture of Bangladesh's stock market performance and assist in mitigating any biases. To mitigate the constraints of secondary data, future studies should investigate gathering primary data to increase accuracy and dependability. Furthermore, the researcher should examine a broader range of macroeconomic variables, such as government fiscal policies, foreign currency reserves, exchange rates, and oil prices, which will improve knowledge of the variables that influence stock market movements.

Data availability: The datasets generated and analyzed during the current study are available on the Dhaka Stock Exchange, Investing.com, Macrotrends and the World Bank websites.
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Loan growth drivers in state-owned banks: A fixed effects model approach

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ABSTRACT

Loan growth is a critical driver for economic development, and comprehending the determinants affecting lending in state-owned banks is vital for enhancing financial sector stability and performance. This paper examines the factors that affect loan growth in state-owned banks in Bangladesh. We collected data over a 11-year period from 2012 to 2022. We applied ordinary least square method primarily followed by fixed effect estimation. To check the validity of the regression models of the study, we have considered several diagnostic tests. Our findings indicate that loan growth in state-owned banks is influenced by several industry-dependent variables i.e. size, liquidity, efficiency, non-performing loans, etc. The influence of bank size, income, liquidity, non-performing loan ratio, and cost-to-income ratio is the main emphasis of this study's investigation into the factors influencing bank lending. According to the statistics, there is a significant positive correlation between size and lending. Bank liquidity and lending show a strong negative correlation. The study also found higher lending is associated with higher non-performing loans significantly. The efficiency ratio shows a substantial negative impact on lending. To improve bank performance and stability, policymakers and bank management may benefit greatly from these results. Policymakers need to integrate various macroeconomic and qualitative elements into regulatory frameworks to bolster financial stability while facilitating sustainable loan expansion. Bank management can enhance efficiency by decreasing the cost-to-income ratio and strengthening credit risk management, while utilizing bank size for strategic expansions to increase lending capacity.

1. Introduction

Loan growth serves as a crucial indicator of the economic strength and financial stability of the banking industry, especially in developing economies. State-owned banks play a crucial part in the economic growth of numerous countries, including Bangladesh, where they function not only as financial entities but also as tools for government policies focused on socio-economic development. In contrast to private banks, state-owned banks typically function with a dual mandate: to achieve financial stability while promoting wider socio-economic goals. The dual duty complicates their loan growth dynamics, necessitating an examination of the unique issues affecting their lending practices.

State-owned banks in Bangladesh function within a distinct regulatory and political framework. These banks, as the main facilitators of government projects, frequently function as instruments for implementing governmental policies, thereby profoundly influencing their lending practices. The increase in loans among these institutions signifies their operational efficiency and financial stability, as well as the government's overarching economic policies. Consequently, comprehending the determinants of loan expansion in state-owned banks is essential for evaluating their contribution to economic stability and growth.

Despite the significance of state-owned banks in Bangladesh, a considerable research gap exists about the determinants of loan growth inside these entities. Most current research concentrates on private banks or regards the banking sector as a uniform entity, neglecting the distinct attributes of state-owned banks. This neglect has resulted in a deficiency in the literature, leaving significant inquiries unresolved regarding the particular elements influencing loan expansion in these government-owned entities. Tan and Anggraeni (2017) emphasize that

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credit constitutes the principal asset for banks in Indonesia, simultaneously presenting risks to the associated institutions. They suggest that the majority of loans are allocated for investment and working capital, critical sectors where bank credit bolsters economic activity. Baoko et al. (2017) underscore the crucial function of banks in preserving financial system stability by serving as intermediaries between surplus fund holders and borrowers, which is vital for economic advancement.

This study seeks to address the research gap by identifying and assessing the particular factors that influence loan growth in Bangladeshi state-owned banks. The study examines internal factors including bank size, gross loan-to-total asset ratio, total income, cost-to-income ratio, non-performing loan ratio, profitability, and liquidity. The study aims to elucidate how these factors affect lending behavior in state-owned banks. The results will augment the current research and provide actionable insights for policymakers and regulators seeking to improve the efficiency and stability of these institutions.

Understanding these factors is essential for multiple reasons. This research provides policymakers with essential insights on utilizing state-owned banks to foster economic growth and enhance financial inclusion in Bangladesh. The findings assist authorities in pinpointing vulnerabilities and opportunities for enhancement within the financial system. This study ultimately fills a significant gap in the academic literature and establishes a foundation for future research into the specific conditions of Bangladesh's state-owned banks. To the best of our knowledge there is hardly any study relating to lending behavior of government banks solely in Bangladesh. The main aim of this study is to clarify the unique elements influencing loan growth in state-owned banks in Bangladesh. This research seeks to improve our comprehension of how these organizations might reconcile their dual obligations of financial performance and socio-economic growth. This will facilitate more steady and inclusive economic growth in Bangladesh.

The research is segmented into multiple sections: Section 2 presents a thorough literature review, providing an in-depth understanding of previous research in the topic. Section 3 detailed Data, variable definition and methodology. Section 4 reveals the analysis, research findings, offering the results and insights obtained from the data analysis. Section 5 constitutes the study's conclusion along with the policy implications derived from the analysis of the findings, providing significant recommendations for policymakers and need for the further research.

2. Literature Review

Credit refers to the act of providing funds or similar assets based on a contractual arrangement or loan agreement between a bank and another party. The borrower is obligated to repay the debt, together with interest, within a specified period of time (Mushinski, 1999). To establish an effective credit management system, it is necessary to implement policies while extending credit to customers. Banks frequently implement the practice of extending credit as a means to augment the amount of loans, hence boosting earnings (Stiglitz and Weiss, 1981). Tan and Anggraeni (2017) found that financial performance growth varied among state-owned banks in Indonesia. Using semi-log panel data with REM, the study revealed that the non-performing loan (NPL) variable and loan-to-deposit ratio (LDR) variable had a significant positive impact on the credit of state-owned banks. However, the Return on Assets (ROA) variable does not have a substantial impact. Warjiyo (2009) states that the credit offering behavior of banks is influenced not only by the amount of third-party funds, but also by the bank's perception of the debtor's business prospects and the bank's own condition, including Return on Assets, non-performing loan, and loan to deposit ratio. Tan and Anggraeni (2017).

Sobarsyah et al. (2020) in their study found higher loan growth exacerbates credit risk one year ahead regardless of the measure of loan growth and credit risk. The study also found to have higher capitalization exacerbates moral hazard due to loan growth in Islamic banks. Bank size, measured by total assets, significantly affects the magnitude of loan growth, where bigger banks have more resources and diversified portfolios. Large commercial banks have been the primary drivers of loan growth due to their extensive branch networks and financial capabilities (Bhowmik and Sarker 2021). While higher liquidity ensures banks meet loan demand without compromising financial stability (Ahamed and Research 2021). According to a 1973–2014 research on the US banking system, banks that have rapid loan expansion in a given year will become inefficient in the third year thereafter, as shown by a decline in return on assets (ROA) (Fahlenbrach, Prilmeier, and Stulz, 2016). The authors (Fahlenbrach et al., 2016) contend that slower loan expansion yields superior outcomes in comparison to banks that are expanding quickly. Certain scholarly works concentrate on the impact of fast expansion on earnings, suggesting that increasing numbers of growing enterprises will eventually have reduced profits. According to a research by Hou, Xue, and Zhang (2015), banks that develop too quickly end up with worse profitability than banks that grow more slowly. According to earlier research, the asset's growth is the main factor contributing to extraordinary prospective earnings (Cooper, Gulen, and Schill, 2008). A repaid loan increase may result in more problematic loans and lower banks' long-term solvency, according to a behavioral research done on Pakistani banks between 2006 and 2014 (Kashif, Zafar, and Arzoo, 2016). They also discover that there might be credit boom dangers if the banking industry is not closely supervised during times of intense competition. Researchers discovered a strong positive correlation between bank risk and loan growth in a study of SAARC nations (Bhowmik and Sarker, 2021). According to the research, banks' quickly growing lending practices seem to be increasing non-performing loans and decreasing bank solvency. The findings do not support the notion that rapid loan growth will lower bank profitability by decreasing return on investment. A small number of systematic studies on this topic, including those by Foos (2010), Amador (2013), and Hess, Grimes, and Holmes (2009), employ the anomalous measure of loan growth to show that bank lending has expanded. As such, irregular loan growth is defined by (Foos, 2010) as "the difference between the growth of loans by an individual bank and the median growth of loans by banks from the same country and year." Still, there are other scholars who share similar views. According to (Laidroo and Männasoo, 2014), this assessment has some flaws that make it difficult to determine the relationship between irregular loan growth and loan loss clauses. It also fails to take into account bank-specific variances in loan growth difficulties and long-term trends in the banking sector.

The riskiness of bank and loan expansion is examined in one of the most thorough studies on loan growth and riskiness ever conducted (Foos, 2010). The research has been handled rather thoroughly. Using a large dataset spanning 16,000 institutions from 1997 to 2007, they argued that credit growth is an important indicator of bank riskiness. More specifically, they discovered that, as long as this result reverses over a period of two to three years, there is an inverse relationship between loan growth and lag loan loss provisions. They also disclosed that a rapid rise in loans might lead to a shortfall in bank solvency. They have previously provided evidence to support their claims and study findings, which show that contrary to popular belief, the expansion of loans does not contribute to a decline in bank capital (solvency) by default. As they assert, if banks grow loans in line with demand rather of cutting down on resources, the advantages would be added to bank equity. In a study (Norawati, Zulher, Kasmawati, and Ratnasih, 2022) found substantial findings when testing the simultaneous premise of the impact of controlling third-party funds and operational costs on credit growth. The credit expansion is influenced by both the third-party funding and the operating costs. Third-party funds have a minor influence on credit growth. According to Hasan et al. (2017), third-party funds, commonly referred to as public funds, are monies acquired by banks from the general community, encompassing both individual communities and business enterprises. Their analysis reveals that bureaucratic variables have a substantial impact on both individual banks and bank groups, while economic variables have relatively minimal influence. This finding aligns with the notion that the state retains a major level of control. (Chen and Wohlfarth, 2019). Liberalization in the financial sector, aimed at enhancing the depth of the financial industry, can lead to a significant increase in credit growth. Another element that contributed to the rise in credit was the influx of capital, which augmented the availability of cash for banks and subsequently boosted credit expansion. On the other hand, loan growth can also happen as a result of financial actors overreacting to changes in risk periodically (Baoko et al., 2017).

Regardless of the cause, rapid credit expansion will have a significant influence on increasing credit losses and diminishing bank profitability, perhaps leading to problems for banks (Duican and Pop, 2015). The perspective that rapid credit expansion leads to an increase in credit non-performing loans cannot be disregarded. In the event of a significant increase in credit, banks may seek to direct credit by relaxing their lending criteria and increasing the number of non-performing loans. Nevertheless, if there is a surge in credit growth due to a shift in the mindset of successful entrepreneurs who opt to borrow from banks rather than seek additional money from the capital market, it should not lead to an increase in non-performing loans. The cautious motive may account for the ability of highly liquid banks to stimulate their lending. Martin, and Rossi (2014) present a model that demonstrates how banks make the most efficient choice to retain liquidity by acquiring liquid assets to fund future investments. In addition, banks may face challenges in distributing funds immediately after receiving them from depositors. As a result, they may choose to temporarily invest in easily convertible assets, which can later be replaced by loans (Broner, Erce, Martin, and Ventura, 2014).

According to Cornett, McNutt, Strahan, and Tehranian (2011), banks have bolstered their liquidity balances to safeguard themselves against liquidity risk during challenging periods. As a result, they have reduced their investments in new loans. Prior empirical research commonly employs assets and liabilities ratios to investigate the correlation between liquidity positions and the expansion of bank loans (Berrospide and Edge, 2010; Roulet, 2018). The findings underscore that increasing liquidity reserves serves as a strong incentive for banks to later increase lending. According to Everaert et al. (2015), having more liquid assets in the previous period is anticipated to enable a larger increase in credit. High liquidity indicates that the bank has a strong capacity to settle its obligations. Nevertheless, having a greater amount of liquid assets does not necessarily result in more benefits for a bank. Banks aim to increase their profits by expanding their lending portfolio and making investments. Meanwhile, banks must maintain sufficient liquid assets to meet their loans and prevent the accumulation of liquidity shortfall. A lack of liquidity can potentially initiate operational issues for banks and perhaps pose threats to the overall financial system. In theory, the impact of bank profitability on lending is uncertain. According to certain theoretical models, banks may be able to reduce the issue of asymmetric information by increasing their profits (Holmstrom and Tirole, 1997; Mankiw, 1986). These banks could effectively leverage their competitive advantages to obtain funding from depositors and stockholders. Consequently, this results in a significant increase in lending operations of highly profitable banks, which consistently have a variety of cash available for loans. Dell'Ariccia and Marquez (2006) argue that banks may loosen their lending criteria or reduce lending rates due to improved comparative advantages, to expand their lending portfolios. Conversely, the profitability of banks can significantly influence their willingness to take on risk and their approach to conducting business. Rajan (2006) argues that as banks experience higher returns, they are less motivated to engage in "searching for yield" and so become more hesitant to provide loans. In addition, a highly competitive banking sector may lead to increased loan growth due to reduced interest margins (Laidroo, 2010).

According to Karmakar and Paul (2024) total assets exert a significant negative impact on PAT in both POLS and 2SLS models. In contrast, building loans exert a beneficial effect on PAT in these models. The total revenue consistently exerts a positive influence on profit after tax (PAT) across all models. In the GMM model, transport loans and textile loans exert a significant negative impact on PAT, but pharmaceutical loans have a marginal positive effect. The existence of non-performing loans, total loans, agricultural loans, and food procurement loans does not significantly affect profitability after tax (PAT) in any of the models. Moreover, Environmental, Social, and Governance (ESG) considerations play a pivotal role in fostering loan growth (Qian et al., 2023) and overall economic development in countries, which, in turn, helps achieve the Sustainable Development Goals (SDGs) (Işık et al., 2024a; 2024b; 2024c; 2024d). A robust ESG framework can enhance the credibility and attractiveness of financial institutions, ultimately leading to increased lending activity. Moreover, Işık et al. (2024g) have introduced a concept known as the ECON-ESG factor, which underscores its significance in improving the performance of banks in developing countries. This factor is essential not only for bolstering banking performance but also for driving economic growth and enhancing energy efficiency. By integrating ESG principles into financial practices, countries can create a more sustainable and resilient economic landscape, benefiting both financial institutions and the broader community. Additionally, sustainability can be an influential

factor in achieving the SDGs, with technological advancement and green innovation serving as moderators (Islam, 2024c).

There is a lack of comprehensive research on the financial performance of banks and their lending activities, and it is necessary to expand this analysis. Nier and Zicchino (2006) conducted a study using a substantial sample size of 600 listed banks from around the world. They discovered that there is a positive relationship between bank return, as measured by return on equity, and loan growth. The subsequent research conducted by Bustamante, Cuba, and Nivin (2019) validates this finding for the banking sector in Peru. Adesina (2019) uses return on assets as a measure of bank profits and discovers a trend that contradicts earlier findings. Specifically, the author demonstrates the adverse correlation between bank profits and loan growth and explains this phenomenon by suggesting that banks may reduce the availability of loans to pursue a greater rate of return. However, it is important to acknowledge that the focus of these previous studies is not on bank earnings.

Increased profitability serves as an indicator of overall economic improvement. A higher return on equity signifies that a bank is efficiently utilizing its capital to produce profits and distribute them to investors at an appealing rate. Attracting more equity through a greater return on equity can lead to a bank having a higher capital adequacy, which is anticipated to positively impact loan growth. Insufficient profitability in insurance firms can indicate underlying issues and serve as an early warning sign for potential solvency difficulties (Heath, 2013). They believe this concept applies to banks as well. Logically, banks are likely to lend more money as their profitability rises. Zumaidah, L. N., & Soelistyo, A. (2018) demonstrate that total assets exert a strong positive impact on economic growth. The Third-Party Fund Value has a positive and strong impact on economic growth and Credit has a substantial positive impact on economic growth. Yıldırım (2022) observed a negative relation between the profitability indicators of banks and their foreign exchange positions and asset quality indicators in the long term. However, there was a positive correlation between loan growth and profitability. According to Demid (2021), the decline in credit quality is influenced by both macroeconomic conditions and elements specific to banks. There is significant variation in the extent and timing of this decline, depending on the kind of loans in different business sectors and the characteristics of the banks. Specifically, they discovered compelling evidence of the cyclical susceptibility of loan quality. Approximately 25% of banks see a more pronounced increase in non-performing loans (NPLs) in reaction to shocks in economic growth, currency rates, interest rates, and profitability. Highly profitable banks are less likely to engage in excessive risk-taking, which leads to smaller non-performing loans (NPLs). In their study, Cahyo, Harjanto and Sulastri (2023) demonstrate that Non-Performing Loans (NPL) substantially adversely impact credit development. The capital structure has a notable and favorable impact on the growth of credit. Credit expansion has a beneficial impact on profitability, albeit it is not statistically significant. Non-performing loans (NPL) have a substantial adverse impact on profitability. The capital structure has a substantial and favorable impact on profitability.

3. Data, variable definition and methodology:

3.1.The data

This chapter presents the methods used to examine the factors influencing loan growth in state-owned banks. The study examines the correlation between loan growth (LEND) and several explanatory factors, such as total assets (SIZE), net interest margin (INCM), cost-to-income ratio (CIR), liquidity (LIQ), and non-performing loan ratio (NPLR). The investigation examines state-owned banks over 43 observations, using different econometric models and diagnostic tests to ensure the strength and dependability of the findings. The sample comprises state-owned banks in Bangladesh, chosen based on their significance and the availability of consistent financial data. The study period covers 11 years, from 2012 to 2022 offering a comprehensive dataset for examining long-term trends and patterns in the growth of loans.

3.2.Variable definition

The study collected data from the chosen banks' annual financial reports, pertinent financial databases, and regulatory filings. The variables under consideration encompass:

3.3.Methodology

Ordinary Least Squares (OLS) is often used as the initial phase in regression analysis due to its simplicity and the clarity of its output in elucidating correlations among variables. The model minimizes the sum of squared residuals, making it appropriate for an initial investigation of the association between independent variables (e.g., bank size, liquidity, efficiency) and loan growth. Ordinary Least Squares (OLS) proposes that the error terms are uncorrelated with the independent variables and that no unobserved factors affect both the independent and dependent variables. Nonetheless, when utilized with panel data, OLS may produce biased results as it fails to consider unobserved heterogeneity—the time-invariant elements unique to each bank that could affect loan growth. Empirical research indicates that neglecting this unobserved variability may result in omitted variable bias, as highlighted by Wooldridge (2010) and Greene (2012).

The Fixed Effects (FE) model is preferred for panel data analysis in the presence of unobservable features that remain constant across time yet may affect the result variable. The FE model successfully eliminates the influence of time-invariant traits by concentrating on within-unit (within-bank) variation. Analyzing state-owned banks is essential, as these institutions frequently possess distinctive characteristics (such as ownership structure or regulatory environment) that remain stable over time yet may skew results if not adequately controlled. The application of Fixed Effects (FE) mitigates omitted variable bias, yielding more precise and consistent estimations of the impact of factors such as liquidity or non-performing loans on loan growth. Baltagi (2008) and Hsiao (2003) underscore the significance of fixed effects (FE) in accounting for unobserved, time-invariant heterogeneity, rendering it especially advantageous for banking research where institutional disparities are crucial.

Table 1: Variable definition

Variable	Definition and Formula	Expected Sign	Explanations/Justifications
Lending (lend)	The total amount of loans extended by the bank to its customers. Formula: Natural logarithm of gross lending to customers	Dependent variable	Lending is a crucial function of banks, contributing to their profitability and economic growth. Increased lending indicates a bank's commitment to supporting economic activity and development (Berger and Udell, 2006; Ghosh, 2015).
SIZE (Total Assets)	The total assets indicates the bank's lending capacity. Formula: Natural logarithm of gross lending to customers	Positive	A higher LTA indicates a greater proportion of assets allocated to loans, which suggests a more aggressive lending strategy. This can lead to increased lending activity and profitability (Beck and Levine, 2004; Ghosh, 2015).
CIR (Cost-to-Income Ratio)	A measure of a bank's efficiency, representing the ratio of operating costs to operating income. Formula: CIR = Operating Costs / Operating Income	Negative	A lower CIR indicates better efficiency in managing costs relative to income. Higher efficiency typically leads to increased lending capacity as banks can operate with lower cost structures (Athanasoglou et al., 2006).
NPLR (Non-Performing Loan Ratio)	The non-performing loan ratio represents the percentage loans that are in default or close to default. Formula: NPLR = (Non-Performing Loans)/ Total Loans	Negative	Higher NPL ratios signal increased risk for banks, leading to tighter lending standards and reduced lending activity. Banks may focus on risk management when NPLs are high (Ghosh, 2015; Klein, 2013).
INCM (Net Interest Margin)	A profitability measure indicates how efficiently a bank uses its assets to generate earnings. Formula: NIM ROA = Natural logarithm of total NIM	Positive	A higher profitability suggests better utilization of assets, which can lead to more funds being available for lending. More profitable banks are often more willing to extend loans (Berger and Mester, 1997).
LIQ (Total Liquidity Assets)	The ratio of a bank's liquid assets (such as cash or cash equivalents) to its total assets. Formula: Natural logarithm of Total Liquid Assets	Positive	A higher LIQ indicates that a larger proportion of the bank's assets are liquid, which allows banks to extend more loans. Increased liquidity typically leads to greater lending capacity (Berger and Bouwman, 2009; Allen and Gale, 2004).

This work leverages the simplicity and wide applicability of OLS, while the FE model enhances robustness by incorporating time-invariant, bank-specific components, so assuring that the analysis accurately represents authentic fluctuations in the data.

3.4. *Ordinary Least Squares (OLS) regression method*

The Ordinary Least Squares (OLS) model was initially employed to estimate the correlation between loan growth and the explanatory factors. The model is defined or described as:

$$LEND_{it} = \beta_0 + \beta_1 SIZE_{it} + \beta_2 INCM_{it} + \beta_3 CIR_{it} + \beta_4 LIQ_{it} + \beta_5 NPLR_{it} + \epsilon_{it}$$

where ϵ_{it} is the error term, i represents the bank, and t represents time.

4. Estimation Method

4.1.Summary statistics

The descriptive statistics provide a snapshot of the central tendency and dispersion for each variable. The variables are generally centered around their means with varying degrees of spread as indicated by their standard deviations. Notably, LEND, SIZE, INCM, and LIQ are logged variables, indicating that their original values span several orders of magnitude. The NPLR and CIR are ratios, with NPLR showing less variation compared to CIR.

Table 2: Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
LEND	43	389.46	195.78	90.64	846.43
SIZE	43	794.49	422.58	172.99	1789.77
INCM	43	27.60	8.71	11.72	43.01
LIQ	43	89.07	51.47	23.497	225.35
NPLR	43	25.044	42.08	13.67	151.20
CIR	43	0.606	0.167	0.30	1.14

*Source: Authors' Calculations, * Figures are in billion Tk.*

4.2.Correlation structure

This correlation analysis provides insights into the relationships between key financial variables in the banking sector. The findings highlight significant associations that can guide future research and inform strategies for improving bank performance and stability. The high correlations among LEND, SIZE, and INCM suggest that these variables are closely related, likely reflecting the size and profitability of banks. These relationships can be further explored to understand their impact on bank performance. The moderate correlation between LIQ and SIZE indicates that liquidity management is crucial for larger banks. The weak correlation of CIR with other variables suggests that cost efficiency may not be directly related to size, liquidity, or asset quality, warranting further investigation into other factors affecting the cost-to-income ratio.

Table 3: Correlation matrix

Variables	(LEND)	(SIZE)	(INCM)	(LIQ)	(NPLR)	(CIR)
LEND	1.000					
SIZE	0.948***	1.000				
INCM	0.886***	0.866***	1.000			
LIQ	0.755***	0.851***	0.646***	1.000		
NPLR	0.225	0.295*	0.072	0.393***	1.000	
CIR	0.098	0.076	-0.203	0.226	0.260*	1.000

*Source: Authors' Calculations (Pairwise correlations), *** p<0.01, ** p<0.05, * p<0.1*

4.3. Regression results and discussion

We first went through OLS for the variables to find the relationships followed by a fixed effect model. A fixed effect model has more prudent results as the FE model controls for unobserved heterogeneity. We have discussed the results derived from the FE model here:

A fixed effects model is used to address the presence of unobserved differences among banks. This model accounts for time-invariant properties of each bank, enabling more precise estimations of the impacts of the explanatory variables. The fixed-effects regression model aims to analyze the impact of various economic factors on the dependent variable, LEND. The model accounts for unobserved heterogeneity by controlling for individual-specific effects within groups. A 1% increase in total assets is associated with a 1.256% increase in lending, holding other factors constant. This strong positive relationship is highly significant, indicating that larger asset bases contribute significantly to growth. Economically, this suggests that firms or entities with more assets have a higher capacity for generating or sustaining economic activities, profits, or other measures captured by more credit. The effect of interest margin on lending is positive but not statistically significant. This implies that variations in net interest margins do not have a consistent or significant impact on LEND within the context of this model. Economically, the net interest margin might be less critical for the outcome measured by lending compared to other variables.

A 1% increase in liquidity is associated with a 0.166% decrease in lending. This negative and significant relationship suggests that higher liquidity might be inversely related to the economic measure captured by an increase in loan disbursement. This indicates that holding too much liquidity might reduce investments or other activities that drive lending, possibly due to a preference for maintaining cash reserves rather than investing in growth opportunities. From 2019 to 2021 banks of Bangladesh faced excess liquidity and poor lending due to a lack of new investment. The effect of the non-performing loan ratio on lending is positive but not statistically significant. This implies a potential but uncertain relationship between non-performing loans and lending. While non-performing loans could theoretically impact economic outcomes (e.g., through credit risk), the data does not strongly support this within the model's context. A higher cost-to-income ratio is associated with a decrease in lending, with marginal significance. This indicates that higher operational inefficiencies in state-owned banks tend to reduce lending. Efficient cost management is crucial for better financial or economic performance, as suggested by the negative impact of higher efficiency on lending. The overall R-squared of the FE model is around 89.96% which is a bit on the higher side. R-squared values above 95% are often considered warning signs of potential overfitting, multicollinearity, or model misspecification. As the study is done only on the 4 state-owned banks of Bangladesh, we had to work with a small number of observations to reach an outcome. However, we have gone through a good

number of diagnostic tests to check the model i.e. VIF test, White test, Pesaran's test, etc.

Table 4: Ordinary Least Square regression

LEND	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
SIZE	.716	.129	5.53	0.000	.454	.978	***
INCM	.567	.164	3.45	0.001	.234	.9	***
LIQ	-.142	.079	-1.80	0.080	-.302	.018	*
NPLR	-.022	.513	-0.04	0.966	-1.061	1.018	
CIR	.499	.167	2.99	0.005	.161	.837	***
Constant	-3.287	1.889	-1.74	0.090	-7.115	.54	*

Mean dependent var	26.552	SD dependent var	0.553
R-squared	0.935	Number of obs	43
F-test	107.281	Prob > F	0.000
Akaike crit. (AIC)	-35.738	Bayesian crit. (BIC)	-25.171

**** p<.01, ** p<.05, * p<.1*

Table 5: Fixed Effects model

Fixed-effects (within) regression		Number of obs	= 43
Group variable: c_id		Number of groups	= 4
R-squared:		Obs per group:	
Within = 0.9620		Min	= 8
Between = 0.9416		Avg	= 10.8
Overall = 0.8996		Max	= 13
		F(5,34)	= 172.10
		Prob > F	= 0.0000

LEND	Coefficient	Std. err.	t	P>t	[95% conf.	interval]
SIZE	1.2556	0.1051	11.9	0.000	1.0419	1.4693
INCM	0.1269	0.1414	0.9	0.380	-0.1606	0.4144
LIQ	-0.1657	0.0495	-3.35	0.000	-0.2664	-0.0650
NPLR	0.5520	0.3273	1.69	0.100	-0.1132	1.2174
CIR	-0.2827	0.1472	-1.92	0.060	-0.5819	0.0164

Source: Authors' Calculations, *** p<.01, ** p<.05, * p<.1

The lack of statistical significance in the correlation between the Non-Performing Loan Ratio (NPLR) and lending can be ascribed to various variables. Initially, state-owned banks in Bangladesh may encounter political or regulatory pressure to emphasize socio-economic goals, persisting in lending despite elevated non-performing loans. Moreover, these banks frequently experience ineffective risk management systems, resulting in lending practices that inadequately consider credit risk. Loan restructuring strategies, which involve the rescheduling or reclassification of distressed loans, can obscure the actual magnitude of non-performing loans, hence diminishing the effect of the non-performing loan ratio on lending. Furthermore, state-owned banks may predominantly depend on collateral-based lending, prioritizing the security of collateral over borrower creditworthiness, hence diminishing the significance of NPLR in loan determinations. The reasons listed above contribute to the tenuous correlation between NPLR and lending, as evidenced in the study.

4.4. Diagnostic tests

4.4.1. Lagrangian multiplier (LM) test

The best model between a random effects model and a straightforward OLS (Ordinary Least Squares) model was identified using the Lagrangian Multiplier (LM) test. This test determines if the employment of a random effects model is justified when there is sufficient variance among entities, such as banks (Wooldridge, 2010). The Breusch and Pagan LM test's null hypothesis states that there are no random effects, meaning the variation among entities, represented by the symbol u, is zero (Breusch and Pagan, 1980). In this case, the LM test's p-value of 1.0000 suggests that there is no substantial variation between entities, so the null hypothesis cannot be rejected. As a result, the OLS regression model is more appropriate, and the random effects model is not warranted (Baltagi, 2021). The findings indicate that the variability in the dependent variable (LEND) is not influenced by individual-specific effects. Therefore, it is unnecessary to consider random effects to explain the observed variance fully. The explanatory variables and residual error adequately capture the variation. This outcome demonstrates the

homogeneity among entities in the panel, allowing for broad policy recommendations or business strategies to be formed from this model (Wooldridge, 2010; Baltagi, 2021).

Table 6: Panel data model estimation results

Variable	Variance (Var)	Standard Deviation (SD = sqrt(Var))
LEND (Dependent Variable)	0.3061	0.5533
idiosyncratic error (*e*)	0.0085	0.0921
random effects (*u*)	0	0

Table 7: Tests for random effects

Statistic	Value
Null Hypothesis (H_0)	σ^2_u=0 (No significant random effects)
Test Statistic ($\chi 2$)	0.00
p-value	1.00

4.4.2. Hausman Test

The Hausman test was conducted to determine whether a fixed or random effects model is more suitable for the data. The test checks for a correlation between unique errors and the regressors, with the null hypothesis suggesting no correlation. A p-value of 0.00, less than 0.05, led to rejecting the null hypothesis, indicating a significant coefficient difference between the models. This result suggests that the fixed effects model is more appropriate, as it captures individual-specific effects that the random effects model does not (Hausman, 1978; Baltagi, 2008; Wooldridge, 2010). Therefore, the fixed effects model should be preferred for this analysis.

Table 8: Hausman test

	Coef.
Chi-square test value	8.95
P-value	0.0028

Source: Author's Calculations

4.4.3. Pesaran's test

Pesaran's test was utilized to examine the presence of cross-sectional dependence. Panel data can be affected by cross-sectional dependence, which contradicts the concept of independence between entities and can introduce bias into the results (Pesaran, 2021; Baltagi, 2008). The results of Pesaran's test indicate that the assumption of cross-sectional independence does not hold for the given panel data (Beck and Katz, 1995). This finding has implications for the modeling and analysis of the data, suggesting the need to account for cross-sectional dependence in the regression models to ensure valid statistical inferences (Chamberlain, 1984; Hsiao, 2003; Cameron and Trivedi, 2009).

Table 9: Pesaran's test

Pesaran's test of cross-sectional independence	=	*6.178*	Pr = 0.0000
Average absolute value of the off-diagonal elements	=	*0.823*	

Source: Author's Calculations

4.4.4. Variance inflation factor test

The Variance Inflation Factor (VIF) values provided indicate the extent of multicollinearity among the independent variables in a regression model. A VIF value greater than 10 is typically a cause for concern, suggesting high multicollinearity (Hair et al., 2010; O'Brien, 2007). However, in this case, all VIF values are below this threshold. This indicates that multicollinearity is not a significant issue in the model. The 1/VIF values, which represent the tolerance, further confirm this with all values less than 1, signifying very low collinearity (Montgomery et al., 2012). The mean VIF is 4.48, reinforcing the conclusion that the variables marginally exhibit problematic multicollinearity (Allison, 1999). Thus, the model's independent variables are sufficiently independent, ensuring reliable coefficient estimates and valid statistical inferences (Field, 2013).

Table 10: Variance of inflation factor test

	VIF	1/VIF
SIZE	10.694	.094
INCM	6.384	.157
LIQ	4.343	.23
CIR	1.453	.688
NPLR	1.325	.755
Mean VIF	4.84	.

5. Conclusion

The outcome of this study suggests that lending in state-owned banks in Bangladesh is influenced by the size of banks, bank liquidity, and efficiency significantly. Regression analysis, in summary, offers significant new information on the variables affecting bank lending. Larger banks are thought to be better at granting credit due to their enormous resource bases and sophisticated risk management, as indicated by the extremely significant and positive coefficient for bank size (SIZE). This is consistent with economic theories that suggest larger banks have more lending capability due to economies of scale and improved diversity. Lending is positively impacted by the income variable (INCM), but statistically insignificantly. This suggests that state-owned banks could give other considerations more weight than income levels when making loan decisions, suggesting that borrower creditworthiness or general economic conditions may be given more weight than internal income. Lending and liquidity (LIQ) have a substantial inverse connection, indicating that lending activity may decline as liquidity levels rise. This is economically justified by banks' inclination to keep cash as a safety net against possible dangers, which lessens their willingness to lend, particularly in erratic economic times. Despite having a positive correlation with lending, the non-performing loan ratio (NPLR) shows marginal statistical significance, suggesting state-owned banks may provide loans on considerations that are not justified with standards being set. The fairly substantial negative coefficient of the cost-to-income ratio (CIR) suggests that lending operations may be restricted by greater operating expenses in relation to income. State-owned banks have a long history of inefficiency which is being justified with this current study. This demonstrates how crucial operational efficiency is to improving a bank's capacity to lend, bolstering the theory in economics that says cutting operational inefficiencies may free up resources for lending and other more fruitful uses.

The state-owned banks suffer from a number of problems including high non-performing loans and low efficiency. This study throws light into the issues of bank sustainable lending behavior of state-owned banks. To guarantee a stable and favorable lending environment, regulatory agencies should concentrate on optimizing bank size and maintaining sufficient liquidity levels. Furthermore, improving the operational efficiency of banks can have a substantial impact on their capacity to provide loans. A wider variety of macroeconomic and qualitative elements should be included by policymakers in regulatory frameworks to promote lending conditions that uphold financial stability and support economic growth such as policymakers may utilise the findings to establish laws that mitigate risks, such as ensuring state-owned banks uphold sufficient liquidity reserves while fostering sustainable loan expansion. Bank management can enhance efficiency by decreasing the cost-to-income ratio, resulting in improved profitability and lending practices without augmenting non-performing loans. Policymakers and bank management can enhance the oversight of non-performing loans, utilising the insights to enforce more stringent credit risk management policies that alleviate the risks linked to increased lending. Bank management may leverage the favourable association between size and loan growth to seek strategic expansions, including mergers or operational scaling, to augment lending capacity while ensuring stability.

The study has multiple shortcomings mostly concentrating on internal factors while omitting macroeconomic variables such as inflation and interest rates, which may also affect lending. The decade from 2012 to 2022 may not reflect long-term patterns or recent advancements, and the emphasis on state-owned banks restricts applicability to other banking institutions. Furthermore, several variables such as income and non-performing loan ratios had negligible significance, necessitating further investigation. Future research may encompass external macroeconomic variables, perform comparative analysis with private banks, increase time scope, and integrate qualitative insights to augment comprehension.

List of Abbreviations

FE : Fixed effect; LM: Lagrangian Multiplier; NPLR: Non-performing loan ratio; CIR: Cost to Income Ratio;VIF: Variance inflation factor;

Data availability: The datasets generated and analyzed during the current study are available on the Dhaka Stock Exchange, Investing.com, Macrotrends and the World Bank websites.

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Exploring the governance-unemployment nexus: Insights from South Asia

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ABSTRACT

This study investigates the relationship between governance quality and unemployment rates in South Asian countries from 2009 to 2023. Utilizing econometric methodologies, including Feasible Generalized Least Squares (FGLS) and Generalized Method of Moments (GMM), we analyze the impacts of governance factors—specifically the rule of law, government effectiveness, and voice and accountability—alongside traditional economic indicators such as GDP per capita. Our findings reveal that governance-related factors have a significant negative impact on unemployment, with improved rule of law and government effectiveness leading to lower unemployment rates. Conversely, higher political inclusiveness, as measured by voice and accountability, correlates with increased unemployment, indicating potential structural challenges associated with more democratic processes. Interestingly, GDP per capita shows a weak and statistically insignificant relationship with unemployment, suggesting that economic growth alone may not suffice in addressing unemployment issues. The study underscores the importance of effective governance and the potential trade-offs involved in political inclusiveness, providing essential insights for policymakers aiming to devise strategies that mitigate unemployment while fostering robust labor markets.

1. *Introduction*

Unemployment remains one of the most critical challenges for policymakers worldwide due to its profound socio-economic implications. As a complex and multi-dimensional issue, it is often influenced by various economic, political, and governance-related factors. The persistence of unemployment exacerbates poverty, social exclusion, and inequality while negatively impacting economic stability and growth (Sihombing and Sitorus, 2024). The labor market's failure to absorb a growing workforce and offer quality jobs can lead to long-term negative outcomes, including skill erosion, mental health deterioration, and strained social welfare systems (Sihombing and Sitorus, 2024). Given the multi-faceted nature of unemployment, understanding its root causes and the role of governance structures is essential for developing effective policy interventions. A key focus of recent research has been the role of governance quality in mitigating unemployment. Effective governance can create an enabling environment for economic activity by ensuring transparency, accountability, and the rule of law, all of which contribute to a stable labor market. On the other hand, political inclusiveness and the degree of voice and accountability in governance systems may introduce additional complexities. More politically inclusive nations tend to have strong labor protections and welfare programs, which may contribute to structural unemployment, particularly if market rigidities are introduced (Shand et al., 2021). Understanding the delicate balance between good governance and labor market dynamics is thus essential for addressing unemployment effectively.

In this context, this study investigates the relationship between governance quality and economic growth—specifically the rule of law, government effectiveness, and voice and accountability and GDP—and unemployment rates South Asian countries. The research uses econometric models such as feasible generalized least squares (FGLS) and generalized method of moments (GMM) to empirically assess the impact of these governance factors on unemployment. The findings aim to offer a nuanced understanding of how institutional quality shapes labor market outcomes and to provide practical recommendations for policymakers seeking to reduce unemployment through governance reforms.

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Unemployment remains a persistent issue globally, with different regions experiencing varying degrees of success in addressing it. While traditional macroeconomic factors such as GDP growth have long been studied in relation to unemployment (Zhong, 2024), the role of governance structures has received increasing attention. Effective governance, characterized by transparency, accountability, and the rule of law, is essential for creating a conducive environment for job creation and economic stability. However, the relationship between governance and unemployment is not straightforward, as political inclusiveness may sometimes exacerbate structural unemployment by introducing labor market rigidities (Egdell and Graham, 2016). Despite the broad consensus on the importance of governance in shaping economic outcomes, empirical research on its specific impact on unemployment remains limited, particularly regarding the interaction between governance quality and labor market performance. This study addresses this gap by analyzing the effects of governance-related factors—rule of law, government effectiveness, and voice and accountability as well as economic growth on unemployment rates in a cross-country context. The problem lies in understanding how governance can be leveraged to reduce unemployment without introducing unintended market rigidities that could stifle economic growth. The primary objective of this study is to examine the relationship between governance quality and economic growth in relation to unemployment rates. Specifically, it seeks to analyze the impact of governance factors—such as the rule of law, government effectiveness, and voice and accountability—on unemployment across South Asian countries, while also investigating the role of GDP per capita as a traditional economic determinant of unemployment. The study aims to provide policy recommendations based on empirical findings to assist policymakers in developing strategies that reduce unemployment through improvements in governance quality.

The research seeks to answer the following questions:

- What is the impact of governance quality, particularly the rule of law and government effectiveness, on unemployment rates?
- How does political inclusiveness, measured through voice and accountability, influence unemployment levels across different countries?
- To what extent does GDP per capita, as an economic indicator, affect unemployment in comparison to governance-related factors?
- Can improvements in governance quality lead to sustained reductions in unemployment, or do certain aspects of political inclusiveness contribute to higher unemployment?

This study contributes to the growing literature on the relationship between governance quality and unemployment. While previous studies have explored the effects of governance on economic growth (Hasan, 2010; Brad, 2024) and poverty (Ronaghi and Scorsone, 2023), fewer have focused explicitly on unemployment as a labor market outcome. This research fills this gap by providing a detailed empirical analysis of how governance factors—specifically the rule of law, government effectiveness, and political inclusiveness—shape unemployment outcomes.

Moreover, this study applies robust econometric methodologies, including FGLS and GMM, to account for potential endogeneity and autocorrelation issues, thus improving the reliability of the findings. By doing so, it contributes to the methodological rigor of governance and labor market studies. Additionally, the research draws attention to the potential trade-offs between governance quality and political inclusiveness, highlighting the complexity of addressing unemployment in democracies with strong labor protections.

While significant research has been conducted on the macroeconomic determinants of unemployment, including GDP growth and inflation (Zhong, 2024; Zhu, 2023), relatively few studies have explored the role of governance in shaping labor market outcomes. Existing studies on governance tend to focus on its broader impacts on economic growth and institutional development (Brad, 2024; Pham, 2024). However, the specific mechanisms through which governance quality affects unemployment remain underexplored, particularly in cross-country contexts. Additionally, the literature on political inclusiveness and its impact on unemployment is limited. Most studies on political inclusiveness focus on its role in enhancing democratic governance and citizen participation (Egdell and Graham, 2016), but few consider its potential drawbacks in terms of labor market rigidities. This study addresses these gaps by examining the dual role of governance quality and political inclusiveness in influencing unemployment rates.

2. Literature Review

The complicated economic problem of unemployment significantly affects both the social stability of a nation and the well-being of its citizens. To mitigate unemployment, governments implement various labor market, macroeconomic, and training policies. Sihombing and Sitorus (2024) highlight the detrimental consequences of unemployment, including diminished self-confidence, skill deficits, heightened stress levels, mental health challenges, and financial instability. In response, governments utilize several measures to combat unemployment, such as fiscal and monetary policies, foreign investment incentives, trade promotion, and support for small and medium-sized enterprises (SMEs), tourism development, and employment guarantees. These strategies aim to create a more robust labor market and enhance overall economic stability. Fakih et al. (2024) further investigate the relationship between governance quality and unemployment in the Middle East and North Africa (MENA) region by comparing the pre-Arab Spring and post-Arab Spring periods. Analyzing data from 15 countries between 2002 and 2019 using a fixed-effects model, the study reveals that higher governance levels are associated with lower unemployment rates, particularly in the Levant and Gulf Cooperation Council (GCC) regions. Notably, this relationship is more pronounced for female unemployment; however, the same trend is not observed in North Africa, indicating a complex interaction between governance and unemployment across different contexts. Pham (2024) examines the impact of government spending on unemployment across 35 Asian countries from 2000 to 2022, employing fully modified ordinary least squares and dynamic ordinary least squares methodologies. The findings suggest that improved institutional quality and increased government expenditure contribute to lower unemployment rates. Interestingly, the adverse effects of government spending on unemployment become more pronounced with enhanced institutional quality. Additionally, trade liberalization and foreign direct investment are identified as significant factors in reducing unemployment in Asian nations. This study is particularly noteworthy

as it is the first to explore how institutional quality moderates the relationship between unemployment and government spending within this context, emphasizing the importance of effective governance.

Silalahi and Walsh (2023) explore the interconnections among government policies, worker empowerment, and unemployment, focusing on their implications for social welfare and economic stability. Utilizing a mixed-methods approach, this study analyzes policy evaluations, labor market statistics, and qualitative insights. The results indicate that the effectiveness of policies varies significantly; specific workforce development programs and educational initiatives show promise in reducing unemployment rates. However, balancing labor market regulations remains a challenge. Policies that promote employee involvement and skill development are found to positively correlate with job satisfaction, job quality, and overall well-being. The study concludes with policy recommendations that advocate for enhanced social safety nets, worker empowerment strategies, and equitable labor market regulations, prioritizing ongoing assessment and monitoring mechanisms to ensure policy effectiveness. The Covid-19 pandemic has exacerbated global poverty, particularly in rural areas, compounding existing challenges of unemployment. Ronaghi and Scorsone (2023) analyze data from 49 US states over a ten-year period, revealing that governance quality and economic inequality significantly influence poverty levels. The study identifies several contributing factors, including education, population demographics, health insurance access, food insecurity, and the gender wage gap. The authors argue that improving governance—defined as the government's accountability and responsibility—represents one of the most effective strategies for addressing poverty exacerbated by the pandemic. Shand et al. (2021) examined whether government initiatives addressing unemployment could reduce its negative impact on suicide and self-harm. Three out of five studies found a negative correlation between unemployment-related policies and suicide rates, while active unemployment measures and employment protection laws had only marginal effects. Notably, the suicide rates among men were significantly lower. The findings suggest that unemployment policies, particularly for men, may help weaken the association between unemployment and suicide. The rule of law fosters economic growth and private sector development, enabling job creation and reducing unemployment through effective public policies that convert growth into employment opportunities (World Bank, 2024). Hasan (2010) explores the legal obstacles hindering economic growth in Pakistan, highlighting the country's increasing demand for the rule of law. The study identifies significant barriers caused by legal shortcomings, which are seen as the main hindrances to market expansion and economic development in developing nations. In countries like Indonesia, job-related challenges have become more prevalent due to the COVID-19 pandemic. For instance, some companies terminated workers without cause, contributing to the rising unemployment rate. Anggraeni et al. (2023) use an empirical legal and conceptual approach to analyze and address this issue. They examine Indonesia's Job Creation Law, particularly Articles 151 and 153, which regulate termination of employment and prohibit arbitrary dismissal unless justified by legal or harmful circumstances. Triatmanto and Bawono (2023) investigate the relationships between unemployment, human resources, and corruption in Indonesia from 1996 to 2021, utilizing data from Transparency International and the World Bank. Their findings indicate that corruption significantly hinders the country's development and prosperity. To tackle corruption, they recommend that the Indonesian government implement stricter laws, enhance transparency, and invest in human capital development initiatives. Reducing corruption could improve citizens' lives, ensure continued progress and wealth, and create a favorable environment for economic growth and development. The study offers valuable insights for Indonesian policymakers.

Brad (2024) examines the impact of declining legal standards on socioeconomic development in the modern world. Using quantitative-comparative analysis and secondary data, the study assesses the role of the rule of law in state and societal development by comparing countries like the US, Singapore, and Romania, focusing on the absence of corruption and its influence on economic progress. Despite differences in geography, history, and socioeconomic status, the study explores the connection between the rule of law and economic advancement. Hendrik et al. (2023) focus on legal protections and dispute resolution mechanisms in response to the 2020 Omnibus Law, which allows businesses to terminate employees arbitrarily. Through normative juridical research, the study highlights the importance of preventing unilateral layoffs and the need for companies to communicate strategies to avoid them. In cases of layoffs, industrial relations dispute mechanisms, such as bipartite discussions, are used to ensure peaceful resolutions between employers and employees, minimizing conflicts and ensuring a fair settlement process. The UK's employment activation strategy emphasizes quick labor market entry by imposing coercive measures or penalties on job seekers. An alternative approach to evaluating successful employment activation is the Capability Approach (CA), which prioritizes individuals' freedom of choice and their abilities. Egdell and Graham (2016) utilize the CA to explore how youth perspectives, experiences, and voices are integrated into the development and implementation of employment activation programs, focusing on the agency and voice of unemployed young people. In Europe, public employment services are experimenting with cross-sector partnerships to address long-term unemployment. However, these partnerships face challenges due to conflicting expectations of accountability. Case studies from Belgium, Denmark, Estonia, Scotland, and the Netherlands reveal that standardized reporting, strict quantifiable measures, and minimal involvement from local politicians contribute to a lack of political accountability and confusion about the dual role of the client as both accountee and accountholder (Hansen et al., 2022). Cheng et al. (2018) investigate citizens' perceptions of voice and accountability in the context of employment discrimination laws. The study finds that the number of regulations across different countries positively influences citizens' attitudes towards these laws. This relationship is moderated by cultural assertiveness and the proportion of women in the population, with positive effects being more pronounced in assertive cultures and in countries with lower female population ratios. However, this association has only been demonstrated in this single study. Saidova (2023) explores the relationship between GDP per capita and unemployment by analyzing World Bank data from 2011 to 2021 using an OLS model. The results show a non-normal distribution for unemployment data, while GDP per capita data followed a normal distribution A negative correlation between GDP per capita and unemployment was found. Zhong (2024) examines the relationship between GDP growth and unemployment in the US from 1948 to 2023 using both linear and nonlinear models. The study found that nonlinear

regression provides a more accurate representation of the relationship between changes in unemployment and GDP growth. Despite broad confidence intervals indicating potential risks of low GDP growth and high unemployment, the ARIMA model forecasts a positive future with strong GDP growth and low unemployment, offering valuable insights for US economic planning.

Zhu (2023) uses a Vector Autoregression (VAR) model to analyze the relationship between GDP, inflation, and unemployment in the US from 2012 to 2022. The findings suggest that GDP and unemployment can predict each other, while both can predict inflation. Shocks to unemployment are largely driven by changes in GDP, whereas inflation and GDP are more influenced by their own changes. Kalinová and Kroutlová (2023), focusing on the Moravian-Silesian Region, use regression analysis to investigate the relationship between macroeconomic variables (GDP, GVA) and unemployment. A strong inverse relationship between GDP, GVA, and the unemployment rate is confirmed by Pearson's correlation coefficient, though the research notes that unemployment is not the sole factor influencing economic development.

Li (2023) examines the relationship between GDP growth and unemployment in China using Granger Causality and Vector Autoregression methods to assess the validity of Okun's Law. The study aims to determine whether past changes in GDP can forecast future unemployment trends and vice versa. Al (2022) investigates the long-term relationship between GDP growth and unemployment in Malaysia, using cointegration tests on data from 2010 to 2020. The findings indicate that unemployment significantly impacts GDP in both the short and long term, with the COVID-19 pandemic disrupting the traditional negative correlation between GDP and unemployment. Živković (2022) analyzes the relationship between GDP growth and unemployment across Western Balkan countries, the Visegrad group, and the EU's founding nations, employing panel analysis and empirical data. A negative correlation is observed in all three groups, with statistical significance found only in the EU founding nations. Shiferaw (2023) investigates the dynamic relationship between GDP, inflation, and unemployment in Ethiopia using the XWT study and the multivariate Student-t GAS model. The findings reveal a fluctuating relationship between these variables, with a notable link between unemployment and inflation. The ARDL model shows that inflation positively impacts GDP, while unemployment has a negative effect. The study calls for policies targeting unemployment reduction, particularly among youth, to stimulate economic growth.

Environmental, Social, and Governance (ESG) factors play a crucial role in achieving Sustainable Development Goals (SDGs) (Bulut et al., 2024; Gazi et al., 2024; Han et al., 2024, 2023; Işık et al., 2024a; 2024b; 2024c; 2024d; 2024e; 2024f; 2024g, 2024h, 2024i, 2024j, 2024k, 2024l, 2021; Islam, 2024; Islam et al., 2024a; 2024b; 2024c; 2022; 2023a; 2023b; 2020; Jabeen et al., 2024; Yan et al., 2024a, 2024b; Alvarado 2023, 2022; Cetin et al., 2023; Dogru et al., 2023, 2019; Rana et al., 2023; Mamun et al., 2022; Rahman et al., 2020;) and reducing unemployment by promoting inclusive and sustainable growth. Environmentally sustainable practices help create "green jobs" and support SDG 13 (Climate Action) by fostering industries that prioritize renewable energy, sustainable agriculture, and waste management. Socially responsible policies, focusing on equality and labor standards, support SDG 8 (Decent Work and Economic Growth) by enhancing job quality and security, leading to a more resilient workforce. Good governance, integral to ESG, strengthens institutions and promotes transparency (SDG 16), which builds investor confidence and encourages business expansion, ultimately contributing to lower unemployment. Together, these ESG dimensions foster a stable, sustainable economic environment that not only reduces unemployment but also accelerates progress across multiple SDGs.

3. Methodology

3.1. Sample selection

The selection of South Asian countries for this analysis is based on several important considerations. South Asia is a region characterized by diverse economic structures, governance systems, and development trajectories, making it a compelling context for studying the interplay between governance, political inclusiveness, and economic outcomes like unemployment. Countries in South Asia face unique challenges such as high population growth, widespread poverty, varying levels of institutional development, and significant economic disparities, which can influence labor market dynamics. By focusing on this region, the study aims to explore how factors like government effectiveness, the rule of law, and voice and accountability impact unemployment in a setting where these governance indicators often vary significantly across countries. Additionally, South Asian countries are at different stages of economic development, which allows for the examination of whether these governance-related factors have similar effects across economies with different levels of GDP per capita. Given the region's growing importance in the global economy, understanding the governance-economic nexus in South Asia can offer valuable insights for policy formulation and economic reform efforts.

3.2. Regression model

$$UNEM = \beta 0 + \beta 1GDPC + \beta 2RL + \beta 3GEFF + \beta 4ACC + \varepsilon$$

Where

- UNEM: Unemployment Rate
- β0: Intercept term
- β1: Coefficient for GDP Constant
- β2: Coefficient for Rule of Law
- β3: Coefficient for Government Effectiveness
- β4: Coefficient for Voice and Accountability
- ϵ: Error Term

3.3.Methods

This study employs a cross-sectional time-series framework using Feasible Generalized Least Squares (FGLS) estimation to analyze the relationship between unemployment (UNEM) and key explanatory variables, including GDP (GDPC), government effectiveness (GEFF), rule of law (RL), and voice and accountability (ACC) across South Asian countries from 2009 to 2022. The dependent variable, unemployment rate, is measured as the percentage of the labor force actively seeking employment, while the independent variables capture economic performance (GDP per capita) and governance quality (government effectiveness, rule of law, and voice and accountability). The model is specified to assess the impact of these independent variables on unemployment, employing FGLS to address potential endogeneity and ensure robustness against heteroskedasticity and autocorrelation. To further validate the robustness of the results, we utilize GMM estimation, which not only tests for robustness but also addresses various underlying issues. This comprehensive methodology aims to provide valuable insights into the interplay between governance factors and unemployment in the South Asian context, contributing to the literature on economic policy and governance reform.

4. Result

4.1.Summary statistics

The summary statistics in table 1 provide an overview of five key variables: unemployment (UNEM), GDP (GDPC), rule of law (RL), government effectiveness (GEFF), and voice and accountability (ACC). The mean unemployment rate (UNEM) is 5.95%, with a range from a minimum of 0.54% to a maximum of 13.16%, showing moderate variation with a standard deviation (SD) of 2.86%. The GDP (GDPC) displays significant variation, with a mean of 4.17e+11 and a wide range from 1.477e+09 to 3.199e+12, indicating substantial economic disparities among the sample countries. The rule of law (RL), with a mean of -0.319 and a range from -0.959 to 0.672, suggests that most countries are below the global average in maintaining a strong legal framework. Government effectiveness (GEFF) shows similar trends, with a mean of -0.322 and a range from -1.135 to 0.702. Voice and accountability (ACC) also have a mean of -0.3, reflecting varying levels of political inclusiveness, with a minimum of -0.878 and a maximum of 0.461.

Table 1: Summary statistics

	Mean	Median	SD	Min	Max
UNEM	5.952	5.06	2.860	.535	13.157
GDPC	4.173e+11	8.845e+10	7.882e+11	1.477e+09	3.199e+12
RL	-.319	-.43	0.443	-.959	.672
GEFF	-.322	-.299	0.495	-1.135	.702
ACC	-.3	-.348	0.383	-.878	.461

4.2.Correlation

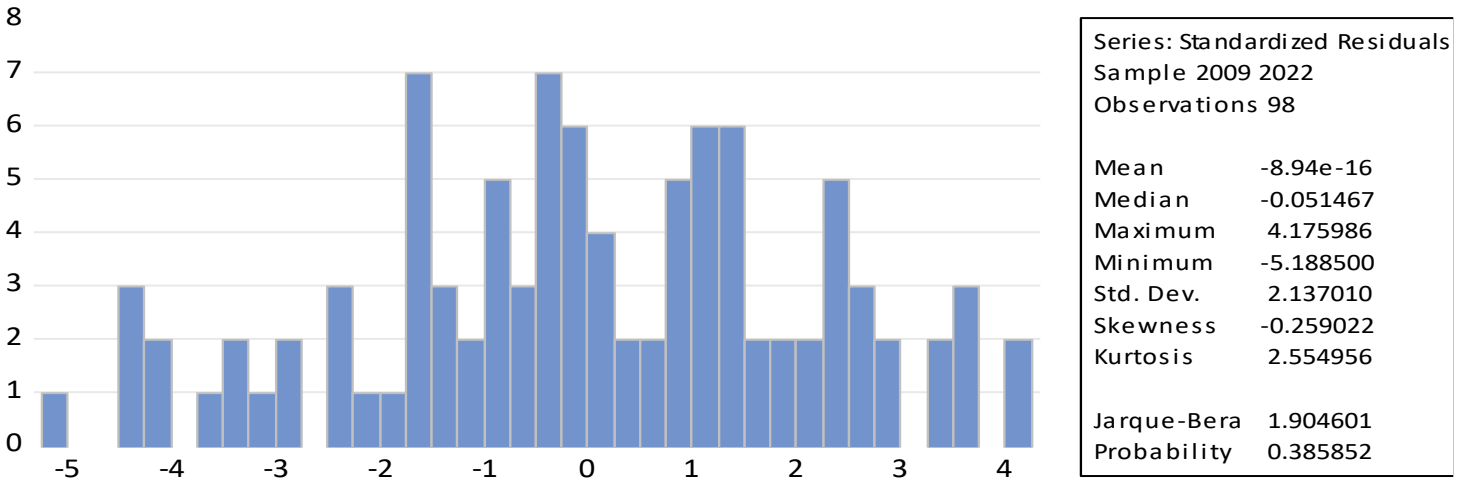
The pairwise correlation table highlights the relationships between unemployment (UNEM), GDP (GDPC), rule of law (RL), government effectiveness (GEFF), and voice and accountability (ACC). The correlations suggest several notable associations. Unemployment (UNEM) has a weak positive correlation with GDP (GDPC) at 0.101, indicating that higher GDP is mildly associated with higher unemployment. However, UNEM is negatively correlated with both the rule of law (RL) (-0.201) and government effectiveness (GEFF) (-0.316), implying that countries with stronger legal frameworks and more effective governments tend to have lower unemployment rates. Interestingly, UNEM has a positive correlation with voice and accountability (ACC) at 0.325, suggesting that countries with more political inclusiveness might experience higher unemployment. GDP (GDPC) is moderately positively correlated with RL (0.177), GEFF (0.280), and ACC (0.554), indicating that wealthier countries tend to perform better in terms of governance and political rights. Finally, RL, GEFF, and ACC are all strongly correlated with one another (0.646 to 0.895), signifying that countries with stronger legal institutions and more effective governance also tend to have greater political accountability and inclusiveness.

Table 2: Pairwise correlations

Variables	UNEM	GDPC	RL	GEFF	ACC
UNEM	1.000				
GDPC	0.101	1.000			
RL	-0.201	0.177	1.000		
GEFF	-0.316	0.280	0.895	1.000	
ACC	0.325	0.554	0.646	0.530	1.000

4.4.Normality Test

The histogram of standardized residuals, based on 98 observations from 2009 to 2022, reveals that the residuals are normally distributed. The mean residual is close to zero (-8.94e-16), indicating an unbiased model. The median (-0.051) further supports this, while the standard deviation (1.237) reflects moderate dispersion. The slight negative skewness (-0.259) suggests a minor asymmetry, but the kurtosis (2.555) is close to 3, indicating a near-normal distribution. The Jarque-Bera test result (1.904) and its associated p-value (0.389) confirm that the residuals do not significantly deviate from normality, validating the assumption of normal residuals in the regression model. This distribution supports the robustness of the model's fit.



4.4.FGLS regression

The FGLS regression result (Table 3) show that GDP per capita (GDPC) has a near-zero coefficient, indicating a weak and statistically insignificant relationship with unemployment. Although the t-value (-1.67) suggests a slight negative effect, the p-value of 0.094 implies only marginal significance at the 10% level, and the confidence interval is extremely narrow, suggesting little practical impact. The rule of law (RL), with a coefficient of -2.713, shows a stronger negative relationship with unemployment, meaning that improvements in legal frameworks tend to reduce unemployment. This result is significant at the 10% level ($p = 0.058$), with the confidence interval suggesting that the true effect could range from a reduction of 5.522 to almost no effect (0.096). Government effectiveness (GEFF) also has a negative coefficient (-2.137), indicating that better governance reduces unemployment. This relationship is statistically significant at the 10% level ($p = 0.054$), suggesting that countries with more effective government structures experience lower unemployment. In contrast, voice and accountability (ACC) has a positive and highly significant impact on unemployment, with a large coefficient of 6.689 ($p < 0.01$). This suggests that countries with higher political inclusiveness tend to have higher unemployment, potentially reflecting structural or economic complexities in more democratic or politically accountable systems. Finally, the constant term (6.672) is highly significant ($p < 0.01$), indicating a baseline unemployment level when other variables are held constant. Overall, these results indicate that governance-related factors such as the rule of law and government effectiveness tend to reduce unemployment, while political inclusiveness (ACC) is associated with higher unemployment.

Table 3. FGLS regression

UNEM	Coef.	St.Err.	t-value	p-value	95% Conf	Interval	Sig
GDPC	0	0	-1.67	.094	0	0	*
RL	-2.713	1.433	-1.89	.058	-5.522	.096	*
GEFF	-2.137	1.108	-1.93	.054	-4.31	.035	*
ACC	6.689	.989	6.76	0	4.75	8.627	***
Constant	6.672	.396	16.87	0	5.897	7.448	***
Mean dependent var		5.953	SD dependent var			2.908	
Number of obs		98	Chi-square			79.962	
Prob > chi2		0.866	Akaike crit. (AIC)			433.951	

*** p<.01, ** p<.05, * p<.1

4.5.Robustness check (GMM estimations)

The GMM estimation results provide a deeper understanding of how various factors influence unemployment (UNEM). GDP per capita (GDPC) shows a near-zero coefficient and is statistically insignificant (p = 0.106), indicating that it has little to no effect on unemployment in this context. Government effectiveness (GEFF) and the rule of law (RL) both have negative coefficients (-2.137 and -2.713, respectively), suggesting that improvements in these governance-related factors lead to reductions in unemployment. These relationships are marginally significant, with p-values of 0.063 for GEFF and 0.068 for RL, indicating notable but not highly conclusive effects. In contrast, voice and accountability (ACC) has a strong positive effect on unemployment, with a highly significant coefficient of 6.688 (p = 0.000), implying that greater political inclusiveness is associated with higher unemployment rates. The constant term (6.672) is significant, representing a baseline unemployment rate. The model explains 46% of the variation in unemployment, as indicated by the R-squared value of 0.459. However, the low Durbin-Watson statistic (0.242) suggests potential autocorrelation, which may require further adjustments to the model (See Table 4).

Table 4: GMM Estimation

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GDPC	0	0	-1.630	0.106
GEFF	-2.137*	1.137	-1.878	0.063
RL	-2.713*	1.471	-1.844	0.068
ACC	6.688***	1.015	6.588	0.000
C	6.672	0.406	16.431	0.0000
R-squared	0.459	Mean dependent var		5.953
Adjusted R-squared	0.436	S.D. dependent var		2.907
S.E. of regression	2.182	Sum squared resid		442.980
Durbin-Watson stat	0.242			

5. Discussion

The findings from both the FGLS and GMM regression analyses shed light on the multifaceted relationships between governance quality, political inclusiveness, and unemployment in South Asian Countries. The results suggest that governance-related factors, such as the rule of law and government effectiveness, have a negative impact on unemployment, consistent with previous literature emphasizing the role of strong institutions in improving labor market outcomes. The FGLS regression indicates a weak and statistically insignificant relationship between GDP per capita (GDPC) and unemployment, with the coefficient being close to zero and a p-value of 0.094. This finding aligns with research by Saidova (2023) and Zhong (2024), which suggest that while GDP growth is generally thought to reduce unemployment, the relationship is not always straightforward and can vary depending on regional or country-specific factors. The marginal significance at the 10% level implies that while GDP may influence unemployment to a small degree, it is not a strong determinant in the context of this analysis. This contrasts with traditional theories like Okun's Law, which posits a more robust inverse relationship between GDP growth and unemployment (Li, 2023). The limited practical impact found here may indicate that factors other than GDP growth are more critical in driving unemployment trends. The negative coefficients for the rule of law (RL) and government effectiveness (GEFF) in both FGLS and GMM regressions confirm that improved governance is associated with lower unemployment. The coefficients (-2.713 for RL and -2.137 for GEFF) indicate that better legal frameworks and more effective governance structures contribute to reducing unemployment. These results are statistically significant at the 10% level (p-values of 0.058 and 0.054, respectively), suggesting that while the effects are not overwhelmingly strong, they are still meaningful. These findings are consistent with studies by Brad (2024) and Triatmanto and Bawono (2023), which emphasize the importance of good governance and the rule of law in fostering economic development and reducing unemployment. Fakih et al. (2024) also highlight the importance of governance in the MENA region, showing that better governance structures lead to lower unemployment, particularly among women. Interestingly, the most striking finding is the positive and highly significant relationship between voice and accountability (ACC) and unemployment. With a large coefficient of 6.689 ($p < 0.01$), the results suggest that greater political inclusiveness is linked to higher unemployment. This finding may seem counterintuitive but could be explained by the complexities of democratic processes and political accountability. Countries with higher political inclusiveness may face structural challenges, such as stronger labor protections or social welfare programs, that unintentionally lead to higher unemployment, especially if businesses face more regulatory constraints. This aligns with Cheng et al. (2018), who argue that political inclusiveness can have complex effects on labor market outcomes, particularly in assertive cultures where governance structures may be more participatory but also more rigid. Additionally, Egdell and Graham (2016) suggest that while employment activation programs in democratic societies emphasize freedom and choice, they may not always effectively reduce unemployment, particularly for marginalized groups.

The GMM results largely corroborate the findings of the FGLS regression, particularly regarding the insignificant relationship between GDP per capita and unemployment. Government effectiveness and the rule of law continue to show negative relationships with unemployment, though the p-values (0.063 and 0.068) suggest that the effects are marginally significant. The strong positive impact of voice and accountability

on unemployment is confirmed, reinforcing the idea that greater political inclusiveness may complicate labor market dynamics. The constant term remains highly significant, indicating a baseline level of unemployment regardless of changes in the governance-related variables. The GMM model explains 46% of the variation in unemployment (R-squared = 0.459), but the low Durbin-Watson statistic (0.242) suggests potential autocorrelation. This highlights a potential limitation of the model, as autocorrelation may bias the estimates, and further adjustments, such as incorporating lagged variables or using alternative estimation techniques, could be necessary to obtain more accurate results.

6. Conclusion

This study has illuminated the intricate interplay between governance quality, political inclusiveness, and unemployment in South Asian countries. The results indicate that governance-related factors such as the rule of law and government effectiveness significantly influence unemployment rates. Specifically, improved governance appears to correlate with lower unemployment levels, underscoring the vital role that strong institutions and effective governance play in shaping labor market outcomes. The analysis revealed a surprisingly weak and statistically insignificant relationship between GDP per capita and unemployment. While conventional economic theory suggests that economic growth should lead to a reduction in unemployment, this study finds that GDP growth is not the sole determinant of labor market dynamics. The marginal significance of the GDP per capita variable suggests that other factors, particularly governance quality, may be more influential in determining unemployment levels. This finding calls into question the traditional views encapsulated in theories like Okun's Law, which assert a strong inverse relationship between GDP growth and unemployment. Instead, it implies that the connection between economic growth and job creation may be more nuanced, potentially varying across different contexts and regions. The findings regarding the rule of law and government effectiveness further emphasize the importance of good governance in driving positive labor market outcomes. The negative coefficients observed for both variables indicate that enhancing legal frameworks and governance structures can lead to reduced unemployment, reinforcing the idea that a well-functioning state is essential for economic prosperity. The statistically significant results, though modest, highlight the need for continuous efforts to improve governance in order to achieve better employment outcomes. Conversely, the study found a significant positive relationship between voice and accountability and unemployment rates, which challenges conventional wisdom. This suggests that higher political inclusiveness may inadvertently lead to increased unemployment. Such a phenomenon may arise from the regulatory complexities and labor protections that often accompany more inclusive political systems. As governments strive to protect workers' rights and promote social welfare, they may impose constraints that deter businesses from hiring or expanding their workforce. This creates a paradox wherein political inclusiveness, while fundamentally important for democratic governance, can introduce rigidities that complicate labor market dynamics. These insights are particularly relevant for policymakers aiming to tackle unemployment in South Asia. The results indicate that enhancing governance quality should be a central focus in efforts to reduce unemployment. Policymakers must prioritize strengthening institutions and improving the rule of law while ensuring that governance reforms do not inadvertently introduce labor market rigidities. It is essential to strike a balance between promoting political inclusiveness and maintaining an agile labor market capable of absorbing a growing workforce. Moreover, the study highlights the complexity of addressing unemployment in democracies. While political inclusiveness is a vital component of a functioning democracy, it is crucial to recognize that it may carry unintended consequences for the labor market. Policymakers should consider implementing strategies that promote both democratic governance and effective labor market policies to mitigate these challenges. In conclusion, this research provides valuable contributions to the discourse on governance quality and its implications for unemployment. By demonstrating the significance of governance-related factors in shaping labor market outcomes and revealing the complexities of political inclusiveness, the findings underscore the need for a multifaceted approach to address unemployment. As countries navigate the intricate relationships between governance, economic growth, and unemployment, understanding these dynamics will be essential for formulating effective policies that foster sustainable employment opportunities and enhance overall economic stability. The study calls for ongoing research to further explore these relationships and their implications for different contexts, contributing to a deeper understanding of how governance can be leveraged to create favorable labor market conditions.

7. Policy Implications

The findings from this study highlight several key policy implications for addressing unemployment in South Asian countries. Policymakers can leverage these insights to design and implement effective strategies aimed at improving governance and enhancing labor market outcomes. The following policy recommendations emerge from the analysis:

1. Strengthening Governance Frameworks: Enhancing the rule of law and government effectiveness should be a priority for policymakers. This includes promoting transparency, accountability, and institutional integrity. Governments can invest in capacity-building initiatives that empower public institutions to function more effectively, thereby fostering a stable economic environment that encourages job creation. Implementing measures such as anti-corruption campaigns, judicial reforms, and efficient public service delivery can significantly improve governance quality.
2. Balancing Political Inclusiveness and Labor Market Flexibility: While political inclusiveness is essential for democratic governance, it is crucial to balance this with the need for labor market flexibility. Policymakers should aim to design labor regulations that protect workers' rights without imposing excessive burdens on employers. This may involve revising existing labor laws to ensure they provide necessary protections while allowing businesses the flexibility to adapt to changing economic conditions. Encouraging dialogue between stakeholders—

such as labor unions, employers, and government representatives—can help identify solutions that support both workers and businesses.

3. Promoting Inclusive Economic Growth: Policymakers should focus on fostering economic growth that is inclusive and equitable. This includes developing policies that target marginalized and vulnerable groups, ensuring that they have access to quality jobs and economic opportunities. Initiatives such as skills training programs, entrepreneurship support, and access to finance for small and medium-sized enterprises (SMEs) can help create a more inclusive labor market. By prioritizing the needs of disadvantaged populations, governments can enhance overall employment levels and reduce inequality.

4. Enhancing Labor Market Information Systems: Establishing robust labor market information systems can provide policymakers with valuable insights into employment trends, skills gaps, and workforce demands. This information can inform the development of targeted training programs and educational initiatives that align with the needs of the labor market. By ensuring that workers are equipped with the skills that employers seek, governments can facilitate smoother transitions into employment and reduce structural unemployment.

5. Encouraging Public-Private Partnerships: Collaboration between the public and private sectors is essential for creating sustainable employment opportunities. Policymakers should encourage partnerships that foster job creation through investments in infrastructure, technology, and innovation. Initiatives that engage businesses in workforce development—such as internships, apprenticeships, and training programs—can help bridge the gap between education and employment, ensuring that job seekers are better prepared for the demands of the labor market.

6. Monitoring and Evaluation: Continuous monitoring and evaluation of governance reforms and labor market policies are critical to understanding their effectiveness. Policymakers should establish mechanisms to assess the impact of implemented strategies on unemployment rates and governance quality. This data-driven approach will enable governments to make informed decisions and adjust policies as needed to achieve desired outcomes.

7. Engaging in Regional Cooperation: Given the interconnectedness of South Asian economies, regional cooperation can play a vital role in addressing unemployment challenges. Policymakers should explore opportunities for collaboration on issues such as labor mobility, trade, and investment. Joint initiatives aimed at improving governance and enhancing labor market dynamics across borders can create a more conducive environment for job creation and economic growth in the region.

By implementing these policy recommendations, South Asian countries can work towards reducing unemployment while strengthening governance quality. A comprehensive approach that addresses both the structural challenges of the labor market and the underlying governance issues is essential for fostering sustainable economic development and improving the overall well-being of citizens. As nations navigate the complexities of unemployment in a rapidly changing global landscape, these insights can guide policymakers in crafting effective, evidence-based strategies that yield positive outcomes for their populations.

7.1. Limitations of the Study and Future Research Direction

While this study offers valuable insights into the governance-unemployment nexus in South Asia, it has certain limitations. First, data availability and consistency across South Asian countries may limit the generalizability of findings, as variations in data quality can impact robustness. Additionally, while FGLS and GMM help address endogeneity concerns, these methods may not fully account for complex, dynamic interdependencies between governance factors and unemployment. Future research could expand upon this work by examining a broader set of ESG indicators, which may capture additional dimensions affecting unemployment. Incorporating case studies or qualitative methods to explore country-specific governance contexts would provide a more nuanced understanding of these relationships. Furthermore, investigating the role of global challenges, such as climate change and technological disruption, on governance and labor markets would be valuable, aligning the research with the evolving Sustainable Development Goals (SDGs) agenda.

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Effectiveness analysis of antimicrobial use in veterinary medicine: Balancing economic and public health considerations

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ABSTRACT

AMR constitutes one of the significant threats to public health, and this is partly due to overuse and misuse of antimicrobials in human and veterinary medicine. The cost-effectiveness of different strategies in responsible antimicrobial use, a critical practice in veterinary sectors controlling AMR, is often unclear. This essay seeks to discuss the application of pharmacoeconomics in evaluating the economic impact and public health implications emanating from various practices in AMU in veterinary medicine. A review of the existing literature shows challenges in variability in antimicrobial use across animal species, difficulties in quantifying indirect costs, and data limitations. The essay also brings out successful studies using pharmacoeconomic models, providing insight into their potential for evidence-based decision-making. This essay focuses on the equilibrium among animal health, human health, and economic sustainability in trying to provide guidelines on future research and policy directions regarding responsible use of antimicrobials in veterinary medicine as support for veterinarians, policymakers, and researchers.

1. *Introduction*

Antimicrobial resistance (AMR) is an emerging, re-emerging, and remaining global public health challenge significantly caused by the overuse and misuse of antimicrobials in human and veterinary medicine. In veterinary practice, antimicrobials are essential for animals in treating and preventing the occurrence of infectious diseases; hoitver, such improper use can lead to AMR, with consequences to both animal and human health. While pharmacoeconomic analyses are highly applied in human healthcare, their application in veterinary medicine remains largely underdeveloped, particularly regarding the evaluation of antimicrobial use (AMU) strategies (Adebowale et al., 2023). The present study bridges this gap by conducting an all-encompassing pharmacoeconomic analysis involving various AMU strategies in veterinary medicine. Our work combines standardized metrics with advanced modeling techniques that represent a novel approach to evaluating the cost-effectiveness of AMU interventions. This research will provide insight for decision-making as it implements cost-effective measures for the control of AMR with optimum itlfare of animals, thus contributing to both public health and economic sustainability in veterinary practices (Circular, 2006).
Research Questions

- What are the most cost-effective antimicrobial use (AMU) strategies in veterinary medicine for reducing the development and spread of antimicrobial resistance (AMR)?
- How can pharmacoeconomic analyses, using standardized metrics and modeling techniques, improve the evaluation of AMU interventions in veterinary practice?
- What are the key economic and health outcomes associated with different AMU strategies, and how do they impact both animal health and public health?
- What are the limitations of current pharmacoeconomic methodologies in veterinary medicine, and how can they be addressed to improve the accuracy and consistency of AMU evaluations?
- How can sensitivity analysis help in understanding the robustness of pharmacoeconomic models and the uncertainty inherent in AMU interventions for AMR control?

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2. Phaharmacoeconomics in Veterinary Medicine

Compared to what is available in human medicine, far less is known in veterinary medicine in terms of the costs of veterinary drugs or health outcomes that accompany their use. Another factor is that treatment protocols and diagnostic testing are not standardized across different interventions, which can make it harder to compare costs and outcomes between interventions (Hennessy, 2006). Although there are several challenges, numerous studies have utilized pharmacoeconomic analyses to inform decisions about the cost-effectiveness of different AMU strategies in the veterinary industry. One such study by van (Butaye et al., 2003) made a decision-analytic modeling comparison of different AMU strategies that could be applied in the treatment of bovine respiratory disease in the Netherlands. The costs overall and the health status of the animals were improved as the antimicrobials were used with the combination of NSAIDs as seen in the study from the authors. A study conducted by (Pinillos et al., 2017) focused on a cost-effectiveness comparison of several different AMU strategies for treatment of canine pyoderma, following an observational design. Here the authors noted that short-course, high-dose antimicrobials was more cost-effective than the longer courses of loitr-dose antimicrobials. The feitr adverse events with the short-course strategy loitr risk of AMR and overall costs were considered to be the lowest. Apart from estimating the cost-effectiveness of different AMU strategies, pharmacoeconomic analyses can also be used to predict a source of cost savings by the introduction of ASPs in veterinary medicine. ASPs intend to encourage prudent AMU practices. These ASPs may include diagnostic testing, issuance of guidelines for treatment, and education of healthcare staff. B. and Laevens (2003) applied the use of decision-analytic models to discuss potential cost-saving attributes related to implementation of an ASP for the management of urinary tract infections in dogs. The author showed that costs have significantly been decreased following the imposition of an ASP from unnecessary antimicrobial use and relevant adverse events (Atlanta, 2019).

3- The Role of Societal and Environmental Costs

Besides the immediate costs of AMU and AMR, significant costs in societal terms and environmental terms also need to be considered in pharmacoeconomic evaluations (Hall and Collis, 1998). For example, antimicrobial use in animal farming leads to AMR in foodborne pathogens with devastating consequences to human health (Verraes et al., 2013a). For example, a study by Lhermie et al. (2016) uses a Future research in this area may also involve enhanced methods of data collection and standardization of reporting of results to have high-quality pharmacoeconomic analysis in veterinary medicine (ECDC, EFSA and EMA Joint Scientific Opinion on a List of Outcome Indicators as Regards Surveillance of Antimicrobial Resistance and Antimicrobial Consumption in Humans and Food-Producing Animals, 2017). For example, development of standardized metrics for measurement of animal health outcomes, AMU, and the incidence of AMR will be important. Similarly, developing cost-effectiveness thresholds of different interventions will also be significant (Scientific Advisory Group on Antimicrobials of the Committee for Medicinal Products for Veterinary Use, 2009).

There is, therefore, the need for more studies to explain the societal and environmental costs of AMR in veterinary medicine. This may include carrying out studies quantifying the costs of morbidity and mortality of AMR in humans as well as lost productivity and reduced consumer confidence costs (Global Framework for Development and Stewardship to Combat Antimicrobial Resistance, 2016). The information may then be useful to improve the accuracy of pharmacoeconomic analyses and, hence, the policy decisions in veterinary medicine relating to AMU (Norris et al., 2019). Overall, pharmacoeconomic analyses would be useful tools for evaluating cost-effectiveness strategies in veterinary medicine in relation to different AMU approaches. Pharmacoeconomic analysis could help find interventions that may reduce the development of AMR but at no expense to improved or maintained health outcomes in animals (Tang et al., 2017). Some of the challenges faced in doing the pharmacoeconomic analysis in veterinary medicine are from deficiency in quality data to taking societal and environmental costs into consideration because of the involvement of AMR (Prestinaci et al., 2015; McEwen and Collignon, 2018). Thus, there is an important need for more research for further improvement of quality and accuracy of pharmacoeconomic analyses (de Jong et al., 2014).

3. Methodology

This study involves conducting pharmacoeconomic analyses in veterinary medicine aimed at assessing the cost-effectiveness of interventions for reducing the development and spread of antimicrobial resistance (AMR). Data to be collected in this study come from multiple sources, including veterinary medical records, producer surveys, and laboratory testing to collect data on animal health outcomes, AMU, and the incidence of AMR. With heterogeneous datasets and no unifying data collecting method, which It hopes it can standardise with standardized metrics to collect similarly consistent data with the same level of consistency during different studies; It will therefore carry out efficiency and cost-benefit analyses comparing many different interventions involving observational studies along with RCTs. It will also be utilizing modelling techniques like decision trees, Markov models, and Monte Carlo simulations in order to estimate the cost and benefits associated with each of these interventions within the different study scenarios. Then sensitivity analyses are to be done for assessing robustness of results for variations of assumptions, to conduct a proper overall evaluation regarding economic viability for control of AMR in veterinary medicine. (Kovačević et al., 2022a).

3.1.. Data Collection

Pharmacoeconomic analyses require high-quality data on animal health outcomes, AMU, and the incidence of AMR. This information can be

collected from a number of sources, such as veterinary medical records, producer surveys, and laboratory testing. A major problem in data collection in veterinary medicine is the absence of standardised methods for collecting data. In this regard, researchers can create standardized metrics to measure animal health outcomes, AMU, and the incidence of AMR. These metrics would improve the quality and consistency of data collection in various studies.

3.2. Study Design

Several types of study designs can be used to conduct pharmacoeconomic analyses in veterinary medicine. The most commonly used observational study design is used for assessing the effectiveness and cost-effectiveness of interventions already implemented in the field. RCTs are used for assessing the effectiveness and cost-effectiveness of new interventions or comparing the effectiveness and cost-effectiveness of different interventions (Hennessey et al., 2022).

When veterinary pharmacoeconomic analysis is carried out, careful consideration on the study population and duration should be taken. The target population for an intervention being tested has to remain the same as that of the population studied, while the duration for the study needs to be long enough to ensure that it captures both effects of the short term and effects of the long term (Van Boeckel et al., 2019).

3.3. Modeling Techniques

Modeling techniques are the most widely applied in the areas of pharmacoeconomic analysis to estimate cost-effectiveness among many interventions used within veterinary medicine. The technique would be helpful to simulate what can happen between any two given alternatives under some stated scenarios to assess the estimated cost and benefit from each alternative under consideration (O'Neill, 2016).

There are various types of models that may be used in conducting pharmacoeconomic analyses (Rodríguez-Baño et al., 2018). The appropriate decision trees and Markov models are used to model the probabilities of various events occurring and the resulting costs and benefits associated with such events (Phillips et al., 2004). Markov models can further be used for estimating long-term outcomes of various interventions with respect to each other, including costs and benefits. Monte Carlo simulations are conducted to simulate the outcome of different interventions under different scenarios and to estimate the probability of different outcomes occurring (Kovačević et al., 2022b).

4. Result and discussion

4.1. Sensitivity Analysis

Pharmacoeconomic analyses in veterinary medicine are often characterized by uncertainty because the data may vary and so do the assumptions used in the analysis. The data used in the analysis and the assumptions applied can be variable. This often leads to uncertainty in pharmacoeconomic analyses in veterinary medicine. Sensitivity analysis is used to check the sensitivity of the results to variations in the assumptions that have been made for the analysis.

Besides that, there are several types of sensitivity analyses, and one of them is one-way sensitivity analysis-two-way sensitivity analysis and, finally, probabilistic sensitivity analysis. The one-way sensitivity analysis is a way of varying one assumption at a time to determine its effect on the results. Two-way sensitivity analysis involves varying two assumptions at a time to determine the effect on the results. Probabilistic sensitivity analysis involves simultaneously varying multiple assumptions to compute the probability of a range of alternative outcomes.

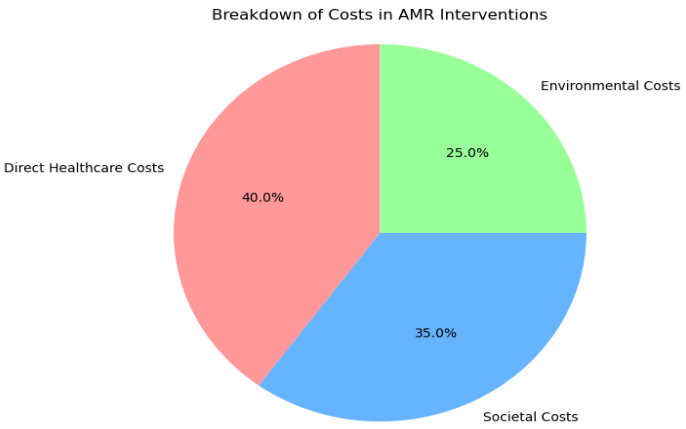

Figure.1. Breakdown of Costs in AMR Interventions

Figure 1 illustrates breakdown of the costs associated with AMR interventions. It depicts that 40% of the total cost is accounted for by direct healthcare costs, 35% by societal costs, and 25% by environmental costs. It gives a clear and concise overview of the relative financial burden of each of the cost categories in the context of AMR interventions.

Category	Percentage
Direct Healthcare Costs	40.0%
Societal Costs	35.0%
Enviornmental Costs	25.0%

The table emphasizes the distribution of AMR intervention costs, with direct healthcare costs at the highest at 40%, addressing treatment and hospital care costs. Societal costs are at 35%, indicating economic losses from decreased productivity and public health effects. Environmental costs are at 25%, highlighting the importance of sustainable antimicrobial use to avoid ecological harm.

5. Conclusion

From a veterinary medicine perspective, pharmacoeconomic analyses can be very beneficial in assessing the cost-effectiveness of interventions toward the goal of reducing antimicrobial resistance. These analyses are important in identifying strategies not only to reduce risks of AMR but also to ensure maintenance or improvement of animal health outcomes. The success of such analyses depends on the availability of good quality data on animal health outcomes, antimicrobial use (AMU), and the incidence of AMR. Despite the existence of different study designs and modeling techniques, such as decision trees and Monte Carlo simulations, challenges remain, especially in terms of data variability and the need for standardized data collection methods. Another critical role that sensitivity analysis plays is in dealing with the uncertainty of the results and enhancing the robustness of the findings

6. Findings and Discussion

This section will outline key findings of the literature review and discuss the implications of those findings for pharmacoeconomic analyses in veterinary medicine (John, 2013).

6.1. Findings

Pharmacoeconomic analyses in veterinary medicine are the essential tools through which cost-effective interventions to limit the development and spread of AMR can be identified and implemented (Salyers and Amábile-Cuevas, 1997). Some of the challenges related to making these analyses in veterinary medicine include nonavailability of good-quality data, societal and environmental costs of AMR, and uncertainty in an analysis (Berman et al., 2023; Verraes et al., 2013b).

The biggest challenge when making pharmacoeconomic analyses in veterinary medicine is a lack of quality data on the health outcomes in animals and usage of antimicrobials or AMR incidence (Schwarz and Chaslus-Dancla, 2001). Even though mostly data on use of antimicrobials exist, mostly incomplete data on animal health outcomes and AMR incidence does not exist. Therefore, in this case, the cost-effectiveness of several interventions cannot be determined precisely (Aarestrup, 2005; Speksnijder et al., 2015).

Various pharmacoeconomic studies have been able to carry out successful pharmacoeconomic analyses within veterinary medicine despite such hurdles. Many of these studies made use of the pharmacoeconomic analysis using models that could estimate various modeling techniques and compare different comparisons through observational and randomized controlled trial study designs.

One specific study by Toft et al. (2019) established that the use of probiotics helps to reduce the level of antimicrobials use in the pigs, thereby being a cost-effective intervention in reducing antimicrobial usage among pigs. Thereby, it had the impact and outcome of decreasing the incidence of post-itaning diarrhea among the pigs and, consequently, a reduced need for antimicrobial treatment.

A more recent study conducted by Kristensen et al. (2016) analyzed the cost-effectiveness of the implementation of selective dry cow therapy as a method of reducing the antimicrobial usage of dairy cows. The authors of the study determined that the SDCT approach is an effective, low-cost intervention that reduces antimicrobial use in dairy cows through reduction in the clinical incidence of mastitis and in the number of antimicrobial treatments.

Thus, these studies have proven that pharmacoeconomic analyses can be applied into the identification of cost-effective interventions for the prevention of development and spread of AMR in veterinary medicine. Hoitver, though, these studies are subject to a number of limitations which one must take into consideration in the interpretation of the results.

6.2. Discussion

From the literature review findings, critical challenges and opportunities have been identified in the realm of pharmacoeconomic analyses for veterinary medicine. The most glaring issue identified pertains to the lack of quality data on animal health outcomes, antimicrobial use (AMU), and the incidence of antimicrobial resistance (AMR).

It is not the first time data gaps have hindered effective economic evaluations of antimicrobial stewardship programs in human medicine. Both areas also require standardizing these variables for their metrics, to ensure data consistency and reliability in the pharmacoeconomic analyses. It would, thereby, enhance significantly the quality of future evaluations so that decisions become more informed.

Another significant limitation is that AMR costs the greater society and environment underestimation. In addition to direct healthcare expenditures, indirect costs such as productivity loss and reduction in consumer confidence are generally missing from current pharmacoeconomic models. The indirect costs, shown to be as important as the direct treatment costs in previous studies in human health, would thus be included by providing externalities for veterinary pharmacoeconomic analyses, thus providing more comprehensive assessment of interventions' true cost-effectiveness, hence more balanced policy decisions. Other challenge with regard to pharmacoeconomic evaluation outcomes is the uncertainty surrounding such studies, especially within veterinary medicine. Sensitivity analysis in human health economics provides a widespread technique through which such uncertainties could be dealt with, and hence it could be of tremendous use in veterinary medicine as far as determining how the different interventions have stayed robust. Since veterinary data increasingly becomes more complicated, the above methods might add extra reliability to the pharmacoeconomic conclusion. It also involves the study design and modeling techniques used. Valid and relevant results depend on a choice of the most appropriate design for human health economics, where the majority of the outcomes and cost-effectiveness models utilized are decision trees and Markov models. Veterinary pharmacoeconomic analyses should apply analogous modeling techniques adapted to veterinary population characteristics, for instance, disease prevalence and antimicrobial usage patterns. The use of knowledge acquired in human healthcare can improve veterinary pharmacoeconomics research methods and bring more accurate outcomes.

Further research will be required to enhance the quality and scope of pharmacoeconomic analyses in veterinary medicine. The veterinary studies may integrate these new innovations with advancements in data collection methods and modeling techniques, hence enhancing the accuracy of predictions. Tools such as artificial intelligence might present promising futures in veterinary pharmacoeconomics for enhanced long-term outcome predictions and cost-effectiveness evaluations. There are also important ethical considerations for veterinary pharmacoeconomics. While reducing AMR is imperative, the itll-being of animals should not be compromised, meaning that they are treated appropriately for their diseases. The same dilemmas are observed in human healthcare, where the antimicrobial stewardship programs have often been criticized to favor resistance control over patient care. In addition, the financial burden of AMR-reducing interventions in veterinary medicine may fall heavily on small-scale farmers, much like low-income patients in human health systems face difficulty accessing cost-effective treatments. Hence, any intervention should take into consideration the socioeconomic realities of implementing such strategies across different agricultural settings. This discussion contextualizes the challenges and recommendations in veterinary pharmacoeconomics by drawing parallels with human health economics, offering a broader perspective on the findings and emphasizing the need for comprehensive, balanced solutions.

7. Conclusion

It discuss the issues and opportunities with performing pharmacoeconomic analyses in veterinary medicine with specific focus on AMR in this study. Our work points to the necessity of improving the quality of available data, of standardizing the metrics for quantifying animal health outcomes, antimicrobial use (AMU), and the occurrence of AMR, and of developing improved data collection and sharing systems throughout the veterinary sector. In this regard, it has underscored the pressing need for improved modeling and better contextual specific models that give considerations to issues surrounding veterinary operations such as animal psychology and socio-economical matters of AMR.

From our analysis, it have seen several key recommendations that can improve pharmacoeconomic research in veterinary medicine. This includes the creation of standardized metrics, improvement in data-sharing frameworks, adoption of more sophisticated modeling approaches, and considerations of societal and environmental costs of AMR.

In addition, it have outlined the ethical considerations that should guide pharmacoeconomic analyses; these include considerations for animal itlfare and economic implications on farmers and the agricultural sector.

Addressing these critical issues, our results show that pharmacoeconomic analyses are itll-positioned to identify cost-effective interventions that will help in the reduction of AMR and the improvement of animal and human health outcomes.

It have identified a complete gap in the current status of the field and have suggested practical solutions that bridge this gap towards the achievement of more sustainable and responsible use of antimicrobials in veterinary medicine. Our work will open new avenues for future research that may support more-informed decision-making and improved health outcomes in both animals and humans against the ever-increasing threat of AMR.

7.1. Limitations of the study

As usual in any research study, there are limitations to the analysis carried out in this current study regarding the challenges and opportunities of AMR in veterinary medicine. Some of the main limitations of our study include:

- Insufficient data availability is one of the major limitations of our study. The data regarding AMU and AMR in veterinary medicine is limited. Though some attempts have been made to gather information on AMU and AMR in livestock, in several instances, the available details are incomplete and, at times, unavailable for specific regions or types of animals. This limits the accuracy of our analysis and the ability to draw conclusions about the prevalence of AMR in the veterinary industry.

- Limitations in the measurement of the economic effects of AMR Our study is also restricted by the problems faced in the quantification of the economic effects of AMR in veterinary medicine. Although there are evidences that AMR causes economic costs in areas such as treatment cost, loss in productivity, and increased risks of disease outbreaks, it becomes challenging to quantify the cost. This further limits our ability to fully assess the economic impact of AMR and the potential benefits of addressing the issue.
- Scope of the study: The study is largely focused on challenges and opportunities related to AMR with veterinary medicine, not on broader societal and environmental implications such an issue can have. This is because the problem of AMR is as complex, going beyond just health issues for animals into human health, food security, and the environment at large. Our study cannot seize the full magnitude of this interconnection or the conceivable implications that the interventions to the cause would bear.
- Bias: like any study, our study has the chance of biased analysis because biases are associated both with data collection and analysis but also with selection of research articles to use and other sources. Still, our study have taken ways of minimizing bias, and it is still possible to be victimized by unconscious biases or by some types of limitations in our methodology.
- Lack of generalizability: Our study is based on a review of the literature and may not fully capture the unique challenges and opportunities of different regions, types of animals, or farming systems. Findings from our study may not be generalizable to all contexts or populations and would need further validation through additional research.
- Limited focus on pharmacoeconomics: Lastly, though our research focuses on the challenges and opportunities of AMR in veterinary medicine, it does so only from the pharmacoeconomic point of view. There are many other aspects that may affect the emergence and spread of AMR. Examples include environmental contamination, international trade, and cultural perception towards antibiotic use. Our research is important for the economic perspective on the issue but may not fully capture the complexity of the problem.

7.2. Scope for future work

Despite the limitations of our study, our analysis presents important information in relation to AMR in veterinary medicine and is a relevant problem from the viewpoint of pharmacoeconomic research. Grounded in these findings, the following areas have the potential to be future sources of work advancing our knowledge regarding the problem as well as a means to seek solutions for AMR (Suojala et al., 2013; Laxminarayan et al., 2013). Here are some such areas for potential future work:

- Improved surveillance systems: One of the major limitations of our study was the scarcity of data on AMU and AMR in veterinary medicine. Improved surveillance systems that collect more comprehensive data on AMU and AMR could help improve our understanding of the prevalence and drivers of AMR in different animal species and regions (Caneschi et al., 2023). This may extend to the formulation of standard reporting structures for AMU and AMR, as well as enhanced cooperation between various stakeholders in surveillance (Veterinary Antimicrobial Resistance and Sales Surveillance 2017, 2019).
- Intelligence: Our review of the evidence pointed out various potential interventions that would combat AMR in veterinary medicine, among them responsible use promotion, development of new treatments, and adoption of alternative systems of production. Future studies could further test the efficacy of these interventions and identify promising approaches for decreasing the risk of AMR (Xia et al., 1995; (Critically Important Antimicrobials for Human Medicine, n.d.-a). Such research may be done in randomized controlled trials, longitudinal studies, and economic evaluations that will evaluate the costs and benefits of interventions (Global Action Plan on Antimicrobial Resistance, 2016).
- Assessing the societal and environmental impact of AMR: While our study focused primarily on the pharmacoeconomic impact of AMR in veterinary medicine, it is important to acknowledge the broader societal and environmental implications of the issue (Critically Important Antimicrobials for Human Medicine, 2019b; Chapitre_antibio, 2016). Future research should be on how AMR will affect human health, food security, and the environment and develop solutions that may address the issues at a greater level (Wright, 2010). This could be through forming multidisciplinary research teams made up of various experts from other fields in order to attack the problem from all possible angles.
- 4New technologies open avenues to understand the potential and challenges in developing solutions to this problem of AMR: new technologies in genomics, data analytics, and artificial intelligence can all open up new avenues to help solve the AMR problem. Future research will also look at whether these new technologies hold promises toward the drivers of AMR, new treatment discovery, and optimal use of antimicrobials in veterinary medicine. It could include creating new diagnostic technologies, predicting AMR by the use of machine learning algorithms, and precision medicine that targets the treatment to specific animals (Tasho and Cho, 2016).
- International collaboration: The best way of solving the problem of AMR is by collaboration and coordination of various stakeholders at the international level, such as governments, industry, and civil society. Future research might include the examination of improving collaboration and coordination through such means as the development of international networks and partnerships that foster knowledge sharing, capacity building, and innovation. These may include: international research consortia, designing a joint funding mechanism, and forming cross-sectoral partnerships that drive different types of stakeholders into action (Zhu et al., 2013).

From a pharmacoeconomic perspective, opportunities for further research into the development of our understanding of the challenges and opportunities of antimicrobial resistance in veterinary medicine are vast.

These will allow for innovative solutions to this important problem to develop through better surveillance systems, intervention effectiveness evaluations, assessments of broader societal and environmental impact, examination of the potential of new technologies, and facilitation of international collaboration.

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A short history of geoeconomics and geopolitics of the internet for the age of the USA-PRC technology war

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ABSTRACT

The www is a network whose nodes are documents and whose links are URLs that allow us to 'stuff' with one click from one web document to another exceeding in size even the human brain. With Trump declared TRADE AND TECHNOLOGY war in 2018 INTERNET has become a strategic battleground of the war as USA and PRC try to win by ring-fencing their supply chains. ARPANET, funded by PENTAGON, was the brainchild of Paul Baran for packet switching, Vint Cref for writing TCP/IP protocols and Sir Tim Berners Lee for developing the world wide web that connected computers to each other so that people could see what was on other nodes than their own hard drive. The INTERNET was built without memory. Self-governing cyber-communities can escape geography and rely in open source, peer-to-peer networking. OPEN-SOURCE collaborative network created a very large portion of the lines of code on which the INTERNET, smartphones, stock markets and airplanes. But in 21st Century, governments developed techniques for controlling offshore INTERNET communications, thus enforcing their laws by exercising coercion within their borders. The INTERNET's design was not the result of some grand theory or vision. Open design was necessitated by the particularities of specific engineering challenges. With the ascendancy of FACEBOOK, AMAZON, APPLE, MICROSOFT, and GOOGLE [FAANG] in the USA and BAIDU, ALIBABA, and TENCENT [BAT] in the PRC in 21st Century to solve the 'trust' problem of money transactions the industry retreated to the centralized CLOUD abandoning the distributed architecture for centralized monopolies. The CLOUD is gargantuan data centers composed of immense systems of data storage and processors linked together by millions of miles of fiber optic lines and consuming electric power and radiating heat that exceeds most industrial enterprises in history. The INTERNET may have ushered in a new age of sustainable open systems, but as APPLE and MICROSOFT have shown an integrated closed system monopoly remains as irresistible as ever both in the USA and PRC.

1. *Introduction*

A. Is dataism data-fetish or a paradigm shift

DATAISM regards the universe to consist of data flows and the value of any phenomenon or entity to be determined by its contribution to data processing. **DATAISM** was born from the confluence of life sciences that came to see organisms, since the publication of Charles Darwin`s **ON THE ORIGIN OF SPECIES**, as biological algorithms and Alan Turing`s idea of **TURING MACHINE**. Computer scientists have learned to engineer increasingly sophisticated electronic algorithms. An algorithm is a methodical set of steps that can be used to make calculations, resolve problems and reach decisions. An algorithm is not a particular calculation, but the method followed when making the calculation.

DATAISM puts the two together pointing out that the same mathematical laws apply to both biochemical and electronic algorithms. **DATAISM,** eliminating the barrier between animals and machines, expects electronic algorithms to eventually decipher and outperform biochemical algorithms. According to **DATAISM**, Mozart`s Magic Flute, stock market bubble, HIV virus are three patterns of data flow that can be analyzed using the same basic concepts and tools.

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George Dyson in **ANALOGIA: THE EMERGENCE OF TECHNOLOGY BEYOND PROGRAMMABLE CONTROL** tells: "Nature uses coding, embodied in strings of DNA, for the storage, replication, modification, and error correction of instructions conveyed from one generation to the next, but relies on analog coding and analog computing, embodied in the brains and nervous systems, for real-time intelligence and control. Coded sequences of nucleotides store the instructions to grow a brain, but the brain itself does not operate, like a digital computer, by storing and processing digital code. …. In a digital computer, one thing happens at a time. In an analog computer, everything happens at once. Brains process three-dimensional maps continuously, instead of processing one-dimensional algorithms step by step. Information is pulse-frequency coded, embodied in the topology of what connects where, not digitally coded by precise sequences of logical events. "The nervous system of even a very simple animal contains computing paradigms that are orders of magnitude more effective than are those found in systems built by humans,' argued Carver Mead, a pioneer of the digital microprocessor, urging a reinvention of analog processing in 1989. …. Electronics underwent two critical transitions over the past one hundred years: from analog to digital and from high-voltage, high-temperature vacuum tubes to silicon's low-voltage, low-temperature solid state. That these transitions occurred together does not imply a necessary link. Just as digital computation was first implemented using vacuum tube components, analog computation can be implemented, from bottom up, by solid state devices produced the same way we make digital microprocessors today, or from top down through the assembly of digital processors into analog networks that treat the flow of bits not logically but statistically: the way a vacuum tube treats the flow of electrons, or a neuron treats the flow of pulses in a brain. …. The vacuum tube, treating streams of electrons as continuous functions, was an analog device. The logical processing of discrete pulses of electrons had to be imposed upon it. …. In the analog universe time is a continuum. In the digital universe, time is an illusion conveyed by sequences of discrete, timeless steps" (Dyson, 2020).

"The most basic difference between human cognition and computer/medium processing can be attributed to the fact that human perception and cognition are situated physically in a tangible world. A human being has an active and autonomous relationship to its environment. This is of crucial importance to the versatile perception and cognition in the so-called 'perceptual cycle'. The basic principles of this perceptual cycle are perceptual activities that are controlled by continuously changing mental schemata. This is caused by the direct intentionality of the human mind. Intentionality is inspired by the needs and values of human beings as biological and social beings in a particular environment. This is the basic principle used by neurobiologist Gerald Edelman and his Neurosciences Institute. Edelman's work, summarized and popularized in his books **BRIGHT AIR, BRILLIANT FIRE: ON THE MATTER OF THE MIND** (Basic Books, 1993), and with Giulio Tononi, **A UNIVERSE OF CONSCIOUSNESS: HOW MATTER BECOMES IMAGINATION** (Adelman and Tononi, 2000) rejects the principle of most cognitive psychologists that the human brain can be compared to a computer or to a power plant of neurons. He claims it is more like an organic jungle of continuously changing groups and connections of neurons that are unique for every human being. They are only partly specified by genes. The needs every human being appears to have in their ongoing interaction with the environment cause a continuous selection of neurons in the Darwinian sense, changing the human brain ceaselessly. A process of trial and error produced by these needs shapes the brain. The workings of the human brain should not be separated into the functioning of hardware (brain) and software (mind), as most cognitive psychologists do. According to Edelman, the complete human brain/mind, but obviously not particular thoughts, can be explained by neurobiology" (Dijk, 2012).

Joseph LeDoux in **THE DEEP HISTORY OF OURSELVES: THE FOUR-BILLION-YEAR STORY OF HOW WE GOT CONSCIOUS BRAINS** adds, "The psychologist Richard Gregory argues that because neural processing compresses sense data so much, the brain has to reconstruct what is there using what Helmholtz called the 'likelihood principle'. That is, we use prior knowledge to unconsciously infer what is there. In recent years, this general idea has received renewed attention in the form of what has come to be known as the predictive coding hypothesis. The essence of the idea is simple – that top-down unconscious predictions based on retrieved knowledge, or memories (which are called 'priors' in this context), shape what we consciously see. ….. Andy Clark and Anil Seth, both enthusiasts of predictive coding, characterized conscious perception as 'controlled hallucination', and Chris Frith described it as a fantasy that coincides with reality. Lucia Melloni went further, writing, "The images that reach consciousness often bear little resemblance to reality". She quotes the Austrian scientist and philosopher, Heinz von Foerster, to support this point:" The world, as we perceive it, is our own invention." Seth nicely summarizes the predictive coding approach: "Our perceptual experience – whether of the world, of ourselves, or an artwork – depends on the active top-down interpretation of sensory input. Perception becomes a generative act, in which perceptual, cognitive, affective, and sociocultural expectations conspire to shape the brain's best guess of the causes of sensory signals" (LeDoux, 2019 pp. 290-292). "Perception and processing in computers or other media, in the other hand, can only start with some kind of derived intentionality. Computers are programmed by others and only reproduce or present programs. ….. The principle of computer processing is programmed instruction following algorithms, not neural selection as in mental processing. Computers and media are programmed for various purposes and environments. So to some extent they are context-free and abstract. They are intended (instructed by a command) and they follow a rational planning model of the human mind. In her book, **PLANS AND SITUATED ACTIONS: THE PROBLEM OF HUMAN-MACHINE COMMUNICATION**, Lucy Suchman (Suchman,1987) has severely criticized this model. In her empirical, anthropological study of the ways people use modern electronic equipment in everyday-life, Suchman came to the conclusion that people do not use this equipment according to a certain plan, the way developers of this equipment expect them to do. Planning models of human action and thinking do not match the reality of 'situated action', which Edelman claims is inspired by neural selection following needs. Large parts of these selections are unconscious, in this way raising doubts about the predominance of conscious will. Suchman feels plans are merely an anticipation and a reconstruction of action. They are a way of thinking, not a real-life representation of action. "Situated action is an emergent property of moment-by-moment interactions between actors and between actors and the environment of their actions. This interaction has four features that go substantially beyond the three levels of interactivity that computers and media have been capable of supporting so far (two-way communications, synchronicity and, to some extent, control from both sides" (Dijk, 2012).

In **A WORLD BEYOND PHYSICS: THE EMERGENCE & EVOLUTION OF LIFE** (Kauffman, 2019), Stuart A. Kauffman sums the economy to be a network of complements and substitutes that he calls the **ECONOMIC WEB**. Like the biosphere, **ECONOMIC WEB**'s evolution cannot substantially pre-tested, and is "context dependent". And creates its own growing "context" that subtends its "adjacent possible". The adjacent possible is what can arise next in this evolution. This evolution is sucked into the very adjacent possible opportunities it itself creates. And Ken Binmore adds: "Evolution is about the survival of the fittest. Entities that promote their fitness consistently will therefore survive at the expense of those that promote their fitness only intermittently. When biological evolution has had a sufficiently long time to operate, it is therefore, likely that each relevant locus on a chromosome will be occupied by the gene with maximal fitness. Since a gene is just a molecule, it can't choose to maximize its fitness, but evolution makes it seem as though it had. This is a valuable insight, because it allows biologists to use rationality considerations to predict the outcome of an evolutionary process, without needing to follow each complicated twist and turn that process might take. When appealing to rationality in such an evolutionary context, we say that we are seeking an explanation in terms of ultimate causes rather than proximate causes" (Princeton University Press, 2009). David Eagleman in **LIVEWIRED: THE INSIDE STORY OF THE EVER-CHANGING BRAIN** (Eagleman, 2020) adds: "Our genetics bring about a simple principle: don't build inflexible hardware; build a system that adapts to the world around it. Our DNA is not a fixed schematic for building an organism; rather, it sets up a dynamic system that continually rewrites its circuitry to reflect the world around it and to optimize its efficacy within it. ….. Neurons in the brain are locked in competition for survival. Just like neighboring nations, neurons stake out their territories and chronically defend them. They fight for territory and survival at every level of the system: each neuron and each connection between neurons fights for resources. As the border wars rage through the lifetime of a brain, maps are redrawn in such a way that experiences and goals of a person are always reflected in the brain's structure."[1]

Robert M. Sapolsky in **DETERMINED: A SCIENCE OF LIFE WITHOUT FREE WILL** adds, "Show me a neuron (or brain) whose generation of a behavior is independent of the sum of its biological past, and for the purposes of this book, you have demonstrated free will. The point of the first half of this book is to establish that this can't be shown" (Sapolsky, 2023).

The 80-year history of Information technology is an example. While the first industrial age emerged from a mastery of the masses and theories of Isaac Newton, the computer age sprang from a practical grasp of the particles and paradoxes of the quantum theory of Erwin Schroedinger, Werner Heisenberg, and Albert Einstein. As World War II drew to a close, the race to build the hydrogen bomb was accelerated by von Neumann's desire to build a computer, and push to build von Neumann's computer was accelerated by the race to build a hydrogen bomb. Computers were essential to the initiation of nuclear explosions, and to understanding what happens next. Numerical simulation of chain reactions within computers initiated a chain reaction among computers, with machines and codes proliferating as explosively as the phenomena they were designed to help us understand. This numerical simulation approximated the physical reality of a nuclear explosion closely enough to enable some of the first useful predictions of weapons effects. It is no coincidence that the most destructive and the most constructive of human inventions appeared at exactly the same time. Hopefully, the collective intelligence of computers could save us from the destructive powers of the weapons they had allowed us to invent.

"Godel set the stage for the digital revolution, not only by redefining the powers of formal systems – and lining things up for their physical embodiment by Alan Turing – but by steering von Neumann's interests from pure logic to applied. It was while attempting to extend Godel's results to a more general solution of Hilbert's **ENTSCHEIDUNGSPROBLEM** – the "decision problem" of whether provable statements can be distinguished from disprovable statements by strictly mechanical procedures in a finite amount of time – that Turing invented his **UNIVERSAL MACHINE**. All the powers – and limits to those powers – that Godel's theorem assigned to formal systems were captured by Turing's **UNIVERSAL MACHINE**, including von Neumann's version. Godel proved that within any formal system sufficiently powerful to include ordinary arithmetic, there will always be undecidable statements that cannot be proved true, yet cannot be proved false. Turing proved that within any formal (or mechanical) system, not only are there functions that can be given finite description yet cannot be computed by any finite machine in a finite amount of time, but there is no definite method to distinguish computable from non-computable functions in advance. …… Godel assigned all expressions within the language of the given formal system unique identity numbers – or numerical addresses – forcing them into correspondence with a number bureaucracy from which it was impossible to escape. The Godel numbering is based on an alphabet of primes, with an explicit coding mechanism governing translation between compound expressions and their Godel numbers – similar to but without the ambiguity that characterizes the translations from nucleotides to amino acids upon which protein synthesis is based. This representation of all possible concepts by numerical codes seemed to be a purely theoretical construct in 1931. …. What Godel and Turing proved is that formal systems will, sooner or later, produce meaningful statements whose truth can be proved only outside the system itself. ", explained George Dyson in **TURING'S CATHEDRAL: THE ORIGINS OF THE DIGITAL UNIVERSE** (Dyson 2012).

"Leo Szilard, John von Neumann, Eugene Wigner, Theodore von Karman and Edward Teller were five Hungarians whose migration to America in 1930s sparked the development of nuclear weapons, digital computers, and the intercontinental ballistic missile. Leo Szilard analyzed the thermodynamic consequences of minimal physical representation of what we now term one "bit" of information, but it would be another two decades until the current terminology took hold. Szilard's insights, along with those of communication theorists Harry Nyquist and Ralph Hartley, influenced John von Neumann and Nobert Wiener, anticipating Claude Shannon's formulation of information theory in 1948. … After helping to bring nuclear weapons into existence, Szilard campaigned against them for the rest of his life" (Dyson, 2020).

"The fundamental, indivisible unit of information is the bit. The fundamental indivisible unit of digital computation is the transformation of a bit between its two possible forms of existence as structure (memory)or as sequence (code). This is what a **TURING MACHINE** does when reading a mark (or the absence of a mark) on a square of tape, changing its state of mind accordingly, and making (or erasing) a mark somewhere

else. To do this at electronic speed requires a binary element that can preserve a given state over time, until, in response to an electronic pulse or some other form of stimulus, it either changes or communicates that state. Most of the essential elements or "cells" in the machine are a binary or "on-off" nature" (Dyson, 2012).

"Mathematical and Numerical Integrator and Computer (**MANIAC**) became operational in 1951 by mingling of data with instructions and breaking the distinction between numbers that mean things and numbers that do things. Hydrogen bomb was a result. Until stored-program digital computers, numbers represented things. With coded instructions, termed "order codes", were given the power to do things – including, the power to invoke another instruction or make copies of themselves. …. Strings of bits gained the power of self-replication, just like strings of DNA. Thus began a chain reaction, with the order codes persisting largely unchanged, like the primordial alphabet of amino acids, over seventy years since they were released. …. The **MANIAC**'s descendants, replicated first in vacuum tubes, next in discrete semiconductors, and now in monolithic silicon, are characterized by word length, governing how much memory they can address, and clock speed, governing how many instructions they can execute in a given period of time. ….. The underlying "clock", however, are there not to measure time but to serve as a clock work escapement regulating an orderly sequence of events. In the digital universe, time as we know it does not exist. In the analog universe, time is a continuum. Any two moments, no matter how close, have other moments in between. In the digital universe, there is no continuum, only finite if unbounded series of discrete steps" (Dyson, 2020). In **THE IDEA OF THE BRAIN: THE PAST AND FUTURE OF NEUROSCIENCE**, Matthew Cobb reminds, "Von Neumann was ferociously brilliant man as well as playing a leading role in the Manhattan Project (he designed the implosion-based detonation device for the bomb that obliterated Nagasaki, and helped select the target) he also developed the basic elements of game theory, now used in economics and ecology, and, most importantly, he began planning for future development of computers. In June 1945 von Neumann wrote a proposal for a stored-program general purpose computer, which dealt with 'the structure of a very high speed automatic digital computing system, and in particular with its logical control'. ….. Despite being framed in the language of binary logic and in terms of electrical wiring and glowing valves, at the heart of von Neumann's conception of the structure and logical control of a computing system were McCulloch and Pitts's hypothetical nerve nets. …… The real novelty of McCulloch and Pitts's work was that it focused attention on processes rather than on anatomical regions. Explaining the brain now appeared to involve describing algorithms that could be embodied in networks of neurons, or in interactions between organs. The key issue was the relation between the component parts and the way that function emerged from organization. …… At this moment of its birth, von Neumann's computer was seen as a brain. The direction of the metaphor between machine and brain had switched. Before the metaphor settled into its current form – seeing the brain as a computer – there were a number of years in which studies of brains and computers interacted in the most dynamic fashion possible" (Cobb, 2020).

"At the very beginning of the computer age, scientists were struck by the parallels between these new machines and brains and were inspired to use them in different ways. Some ignored biology and focused simply on making computers as smart as possible, a field that became known as artificial intelligence (**Ai** – the term was coined by John McCarthy in 1956). But in terms of understanding how the brain works, the most fruitful approach came from those who did not attempt to create a super-intelligent machine, but instead tried to model the functions of the brain by exploring the rules governing the interconnections in the model - a neuronal algebra, if you like. An early attempt to simulate the nervous system came in 1956, when researchers at **IBM** tested Hebb's hypothesis about neuronal assemblies being a basic functional unit of the brain. They used **IBM**'s first commercial computer, the 701, a value-based machine composed of eleven large units that literally filled a room (only nineteen were sold). The team simulated a net of 512 neurons, although these components were not initially connected, they soon formed assemblies that spontaneously synchronized their activity in waves, just as Hebb suggested. Despite the limits of what was a very crude model, this suggested that some aspects of nervous system circuits simply emerge from very basic rules. One of the first people to use a computer model to shed light on how the brain might function was Oliver Selfridge, a mathematician who was one of Wiener's students and was close to Pitts, McCulloch and Lettvin. In 1958, Selfridge unveiled a hierarchical processing system called **PANDEMONIUM**, which had developed out of his work on machine-based pattern recognition. …… At the same time, another US scientist, Frank Rosenblatt, presented a slightly different model, the **PERCEPTRON**. This was also focused on pattern recognition, using the same idea of flexible hierarchical connections – an approach that became known as connectionism. Rosenblatt argued that a brain and a computer shared two functions – decision making and control – both of which were based on logical rules in both machine and brain. Brains, however, carry out two further, intertwined functions, interpretation and prediction of the environment. All these functions were modelled in the **PERCEPTRON** – 'the first machine which is capable of having an original idea', claimed Rosenblatt" (Cobb, 2020).

Modeled on mammalian brains, neural networks function at the system level, arraying transistors into networks of neurons inspired by the nodes of the human brain. The basic steps in seeking solutions are guess, measure the error, adjust the answer, feed it back in a recursive loop. Rosenblatt's view of multilayered recognizers prefigured machine learning. Learning is essentially the capacity to recognize patterns in data. The machine processes the pixels in tagged or identified images of your face hundreds or thousands of times. Then by comparative processes – in essence, superimposing images on top of each other and finding mathematical commonalities – it can flag new images of your face.

In a famous experiment, Ivan Pavlov showed that dogs can be taught to salivate at the tick of a metronome or the sound of a harmonium. This connection of cause to effect, known as associative or reinforced learning, is central to how most animals deal with the world. Since the early 1970s the dominant theory of what is going on has been that animals learn by trial and error. Associating a cue, a metronome, with a reward, food happens as follows. When a cue comes, the animal predicts when the reward will occur. Then, it waits to see what arrives. After that, it computes the difference between prediction and result – the error. Finally, it uses that error estimate to upgrade things to make better predictions in the future.

Belief in this approach was itself reinforced in the late 20th century by two things. One of these was the discovery that it is also good at solving engineering problems related to artificial intelligence, **Ai**. The other reinforcing observation was a paper published in 1997 that noted that fluctuations in levels in the brain of dopamine, a chemical which carries signals between some nerve cells was known to be associated with experience of reward, looked like prediction-error signals. Dopamine-generating cells are more active when the reward comes sooner than expected or is not expected at all, and are inhibited when the reward comes later or not at all – precisely what would happen if they were indeed such signal. The explanation looks forward, associating cause and effect. Huijeong Jeong and Vijay Namboodiri proposed a model of associative learning that suggests that the associative learning theorists have gotten things backwards. They propose the opposite. It associates effect with cause. They think that when an animal receives a reward or punishment, it looks back through it memory to work out what might have prompted this event. Dopamine's role in their model is to flag events meaningful enough to act as causes for possible future rewards or punishments. Associating effect with cause deals with two things that have bugged the old model. One is sensitivity to timescale. The other is computational tractability. The timescale problem is that cause and effect may be separated by milliseconds, like switching a light bulb and experiencing illumination, minutes, like having a drink and feeling tipsy, or even hours, like eating something bad and getting food poisoning. Looking backward, associating effect with cause, permits investigation of an arbitrary long list of possible causes. Associating cause with effect without always knowing in advance how far to look is much trickier. This leads to the second problem. Sensory experience is rich, and everything therein could potentially predict an outcome. Making predictions based on every single possible cue would be somewhere between difficult and impossible. It is far simpler, when a meaningful event happens, to look backwards through other potentially meaningful events for a cause. In practice, however, it is hard to distinguish experimentally between the two models. Jeong's and Namboodiri's laboratory experiments measured, in real time, the amount of dopamine being released by the nucleus accumbens, a region of the brain in which dopamine is implicated in learning and addiction. Their experiments verified associating effect with cause model. More experiments are needed to confirm, but the 180-degree turnabout in thinking will suggest that the way **Ai** works does not, as currently argued, have even a tenuous link with how brains operate. It might also suggest better ways of doing **Ai**.

"In 1969 the pioneer of artificial intelligence, Marvin Minsky with colleague Seymour Papert presented a mathematical analysis of the power of the **PERCEPTRON** which suggested that the approach was a dead end, both for **Ai** and understanding the brain – because of the way **PERCEPTRON**s were constructed, they could not internally represent the things they were learning. ……. Despite the failures of both **PANDEMONIUM** and the **PERCEPTRON** to produce insights that could be applied to biological pattern recognition systems, both these programs changed the way researchers thought about the brain – they showed that any effective description of perception in humans or machines, had to include a substantial element of plasticity. They were therefore utterly different from the old models that were based on mechanical or pressure metaphors. …… In the mid-1980s, neuroscientists and psychologists became very interested in new computational approaches that made it possible to overcome the limitations of **PANDEMONIUM** and the **PRECEPTRON**. This new method, called parallel distributed processing [**PDP**], was announced in a two-volume book that described innovative computer models of behavior and their potential psychological and neurobiological equivalents. …… The ability of **PDP** networks to perform tasks so effectively is largely based on the use of what is called back propagation (generally abbreviated to backprop), which involves information going both ways between layers in a form of feedback loop. This enables the program to refine its behaviour rapidly to a more accurate output" (Cobb, 2020).

2. Mıcrochips' Mutation to Personal Computers, to Internet, and to Big Data Monopolists

IBM made the first commercial machines, expecting to sell only a few. But the mainframe eventually sold widely, and the invention of the microchip paved the way for the personal computer.

Chip-making was an in-house affair for Americans at the onset of the industry until 1961 when **FAIRCHILD SEMICONDUCTOR** began assembling and testing products in Hong Kong mostly to arbitrage labor costs. "Fairchild was the first semiconductor firm to offshore assembly in Asia, but Texas Instruments, Motorola, and others quickly followed. Within a decade, almost all US chipmakers had foreign assembly facilities. Fairchild began looking beyond Hong Kong. The city's 25-cent hourly wages were only a tenth of American wages but were among the highest in Asia. In the mid-1960s, Taiwanese workers made 19 cents an hour, Malaysians 15 cents, Singaporeans 11 cents and South Koreans only a dime. Fairchild's next location was Singapore, a majority ethnic Chinese city-state whose leader Lee Kuan Yew, had 'pretty much outlawed' unions, as one Fairchild veteran remembered. ….. The semiconductor industry was globalizing decades before anyone had heard of the word, laying the grounds for Asia-centered supply chains we know today. Fairchild's managers had no game plan. They would have just as happily kept building factories in Maine or California had they cost the same. But Asia had millions of peasant farmers looking for factory jobs, keeping wages and guaranteeing they would stay low for some time. Foreign policy strategist in Washington saw ethnic Chinese workers in cities like Hong Kong, Singapore, and Penang as ripe for Mao Zedong's Communist subversion. Fairchild' managers saw them as capitalist dream. 'We had union problems in Silicon Valley. We never had any union problems in the Orient.' They noted." wrote Chris Miller in **CHIP WAR: THE FIGHT FOR THE WORLD'S MOST CRITICAL TECHNOLOGY** (Miller, 2022).

In 1987, when **FUJITSU** attempted to buy **FAIRCHILD SEMICONDUCTOR** President Reagan's secretary of commerce and secretary of defense objected to the deal on national security grounds, claiming the US military could not be dependent on foreign powers for crucial communications technology. In 1988, Congress passed the **EXON-FLORIO** amendment, which further empowered the president to block such mergers or acquisitions of domestic firms by foreign companies if they harm national security. Internationalization of the production processes has accelerated as microchips have become more complicated and more manufacturing processes have been outsourced to specialized firms

firms that emerged in Asia.

In 1971, **INTEL** developed a general-purpose chip, or microprocessor. A single device that could serve many functions paved the way for the construction of a mini-computer. At **XEROX PARC** in 1972, Butler Lampson built the **ALTO**, a machine which differs little in appearance from a modern desktop computer. Lampson's team added many of the features we take for granted today. While **XEROX** was perfecting the **ALTO**, personal computers were developed by hobbyists. The **ALTAIR** desktop, a self-assembly kit for $400 was first advertised in **POPULAR ELECTRONICS** magazine in 1974. Home computers used tape cassettes for storage and television sets as monitors. **AT&T** and **SONY** sold desktop machines. All these initiatives failed.

Dmitry Orlov reminds with his narration of the Schumpeterian history of computer technology in **THE FIVE STAGES OF COLLAPSE: SURVIVOR'S TOOLKIT,** "There was a time when computers were made by different manufacturers came with their own different and incompatible operating systems. The manufacturers liked this state of affairs, in spite of the fact that it greatly inconvenienced the users, because it created lock-in switching from one manufacturer's hardware to another's involved an expensive and time-consuming rewrite of their software. Then it just happened that two minds at Bell Labs dreamt up a very simple and primitive operating system called Unix (the name was initially a joke) that was written in a language they invented called "C" that ran on a lot of different computers – and it virally took over the world. Then Unix became a commercial product, instantly going from anarchical to hierarchical. But anarchy triumphed again when it was rewritten, through various efforts, in a way that pried it away from grubby corporate hands. Self-selected leaders played a big role in all this. Richard Stallman's GNU project (the acronym stand for "GNU is Not Unix") created GCC, a free "C" compiler, and rewrote a great many Unix utilities to be free as well. Linus Torvalds, a graduate student in Finland, didn't like the Microsoft Windows system that his university-provided PC was running (he thought it was crap) and so he wrote the Linux operating system, a Unix variant that initially ran on PCs but now runs inside a great many devices, from Android smart phones to WiFi hotspots and routers to the Google search engine to virtually all of the world's super computers. Eventually even Apple saw the light, and its OS X operating system is based on a Unix variant. Unix is now ubiquitous; the last non-Unix holdout is Microsoft, which is now clearly a dinosaur and sinking fast, while Linux-based Google and Unix based Apple are eating its lunch. It started out as a nerdy joke and then went viral and took over" (Orlov, 2013).

In 1981, **IBM** launched a personal computer, simultaneously abbreviated to **PC** and achieved world-wide acceptance. What many users thought the performance of the **PC** was not at par with the machines already in the market did not matter. More users begot more users. Network effect. **IBM** outsourced **PC**'s operating system to a small company, **MICROSOFT**. In the 1990s, **MICROSOFT** held a commanding position as the supplier of the world's most popular **PC** operating system, **MICROSOFT WINDOWS**. The operating system was a technical achievement protected by a web of intellectual property rights. Yet the real key to **MICROSOFT**'s security was not its technical complexity or intellectual property, but rather the thousands of applications written to operate with **WINDOWS**. Personal computer operating systems are platforms with strong cross-platform network effects. Computer users value the number and quality of applications that run on the operating system, and application developers value the number of operating system users. Motivating developers to write applications that would run on a new operating system is a barrier to entry that new operating system entrants must cross to become viable competitors.

IBM confronted the applications barrier after it spent more than $1billion to develop, test, and market a **PC** operating system to compete with **WINDOWS**. **IBM** created the first mass-market **PC**, but it did not have proprietary software or hardware that could enable the company to fully monetize its technologies. When **IBM** attempted to regain control with a new and more sophisticated operating system, **OS/2**, it was too late. **MICROSOFT**'s **MS-DOS** powering **WINDOWS 3.1** was everywhere. **IBM** ultimately abandoned **OS/2**, not because it was technologically inferior to **WINDOWS**, but because it failed to attract a sufficient number of applications to make computer users switch from **WINDOWS**. Despite **MICROSOFT**'s success in suppressing challengers in 1995, **MICROSOFT** was behind the curve on a new technology, the internet. Internet users were connecting to the **WORLD WIDE WEB** with a new program, the **NETSCAPE NAVIGATOR** browser. **MICROSOFT**'s leadership was concerned that the browser was a Trojan horse that would break the applications barrier to entry by creating an alternative platform for software development.

NAVIGATOR is a type of software called middleware, which occupies a space between the operating system and applications. Like operating systems, middleware facilitates application software development by exposing application programming interfaces (**API**s), which are routines that perform certain widely used functions. Unlike operating systems, the **NETSCAPE API**s were not specific to a particular operating system. **NETSCAPE** employed a new programming language, **JAVA**, which allows applications to run on different operating systems. **MICROSOFT**'s leadership understood that middleware such as **NETSCAPE**, which promoted the use of the platform-independent **JAVA** programming language, could level the PC market and fracture the **WINDOWS** monopoly. Nearly every purchaser of an **IBM**-compatible **PC** wanted the computer to be equipped with the **WINDOWS** operating system. By bundling **INTERNET EXPLORER**, (**IE**), with the operating system consumers didn't pay extra for the **MICROSOFT** browser, but if they wanted **NAVIGATOR** as an add-on, they would have to pay an additional $49 or so. **MICROSOFT**'s efforts to suppress **NETSCAPE**, along with improvements to **IE**, allowed the company to increase its **IBM**-compatible **PC** browser share from about 5% in 1995 to more than 50% by 1998. The DOJ and the European Commission sued **MICROSOFT** in 1998 for monopolizing the markets for **PC** operating systems and browsers in violation of the Sherman Act. The final judgements ordered **MICROSOFT** to offer potential rivals licenses at reasonable and nondiscriminatory terms to supply information to improve interoperability between third party products and **MICROSOFT** products. The browser tying investigation was settled after **MICROSOFT** agreed to pay fines and include a start-up display that allowed users to install different browsers products and choose a default browser. That obligation expired at the end of 2014, and aptly so because **IE**'s share of browser usage was half that of the **GOOGLE CHROME** browser by that date.

The US and Europe are an ocean apart regarding obligations of dominant firms to assist their rivals. US law is arguably too accommodating to

conduct by dominant firms that excludes rivals, while European antitrust law fails to identify the conditions under which an obligation to assist rivals is procompetitive. Nonetheless, even if failure to support interoperability is not an antitrust violation, a requirement to support interoperability is a valid remedy for anticompetitive conduct. The purpose of a remedy is to restore competition and deter future anticompetitive conduct. The Final Judgement that solved **US v. MICROSOFT** did not accommodate the plaintiffs' initial request to cleave **MICROSOFT** into separate operating system and application companies. Some believe that the divestiture would have created incentives for the independent applications company to port applications to competing operating systems and for the operating system company to facilitate competition in applications and middleware. As an integrated supplier of operating systems, application software, and middleware, **MICROSOFT** has an incentive to exclude or disadvantage rival products. The divestiture would have eliminated or significantly reduced the incentive for **MICROSOFT** to preference its own applications and middleware.

The computer industry evolved in ways that the DOJ and plaintiff states did not envisage in their complaint. Cloud computing has transformed the industry by providing a remote server-based platform for applications that is agnostic to client's desktop operating system. Cloud computing has achieved some of the objectives of the **MICROSOFT** antitrust litigation by moving applications off the desktop. But cloud computing has not commoditized the operating system, and it owes its success more to industrywide internet protocols than to adoption of a common **JAVA** technology. The prohibitions on restrictive agreements in the Final Judgement likely facilitated competition for internet browsers, **GOOGLE CHROME** is the most popular internet browser by a large margin and delivers some of the promise of **US v. MICROSOFT** by enabling web-centric applications, many of which are powered by servers that run on **UNIX** and **LINUX** operating systems.

Dominant firms are often able to identify nascent competitive threats in these industries and eliminate them before they mature into significant competitors. The Arrow replacement effect teaches that an incumbent firm's profits deter investment in a new product that would replace the firm's existing profits. Weak antitrust enforcement is at least as likely to increase an incumbent's profits from its existing products as it is to increase profits from new products. Therefore, it is likely that the next effect of weaker antitrust enforcement would be to increase the Arrow replacement effect and deter innovation by an established firm. Firms that are new to an industry have stronger innovation incentives than established firms if they can obtain comparable benefits from successful inventions. New entrants do not have profits that are at risk from innovation. They do not suffer from the Arrow replacement effect.

Kenneth Arrow and Joseph Schumpeter are known for their theories associated with competition and innovation. Neither Arrow's nor Schumpeter's describe innovation incentives that apply more generally to dynamic markets. Innovation is quintessentially a dynamic process. Furthermore, it is typically cumulative, with discoveries providing a knowledge base that enables future discoveries. Yet most theories, including the Arrow replacement effect, assume that innovation is a single discrete event with only limited consequences for the future evolution of industry technology and market structure. But industrial structure shapes the incentives for firms to invest in R&D and is shaped by innovations that result from those investments. Industrial structures in which firms compete to improve technologies in discrete steps show that modest increases in competition can increase the probability of innovation, but intense competition can make innovation less likely.

Joseph Schumpeter's name has become shorthand for the proposition that scale and market power enable a more stable and productive platform for R&D. Schumpeter did not speak directly to the effects of market structure on the ability to appropriate the value of innovations. He was more concerned with the failings of models of perfect competition to account for innovation and entrepreneurship and emphasized the power of "creative destruction" to invigorate economic progress, which can come from any source. Schumpeter provided no formal economic model to describe his vision of monopoly power and innovation incentives, and his emphasis on the ability of large firms to attract capital is outdated, given developments in the availability of venture capital. Nonetheless, his criticism of perfect competition as the ideal engine of innovation is valid. Perfect competition is not viable in industries such as semiconductor fabrication, for which new facilities incur multibillion-dollar sunk costs, or industries such as computer software or genomics, for which the marginal cost of technology licensing and distribution is only a small fraction of the R&D costs required to create the licensed products. Pricing these products at or close to their marginal production costs would not generate sufficient profits to justify the R&D expenses that brought them to market. According to this Schumpeterian perspective, a reduction in rivalry can enhance appropriation in several ways. A reduction in rivalry can allow an innovator to profit from a higher profit-maximizing price for the innovation. In that case, antitrust enforcers would have to weigh the adverse effects on prices from a reduction in rivalry against possible benefits for innovation.

Meanwhile, Steve Jobs and Steve Wozniak began assembling **APPLE** machines in 1976 in Job's garage. Although **MICROSOFT** understood that ease of use was important for commercial success. It was Jobs who extended this vision further and conceived a computer that you could use without understanding anything about computers. Jobs drew on another invention from **XEROX PARC**- the graphical interface. **APPLE** integrated software and hardware. **APPLE**'s determination to maintain its proprietary system failed in the face of widespread adoption of more open standard of the **IBM**'s **PC**, **WINDOWS**, a combination of **APPLE**'s graphical user interface with **MICROSOFT**'s ubiquitous **MS-DOS**, won the world. By mid 1990s, **APPLE** was at the edge of bankruptcy. The result was a multi-national complex constellation of thousands of companies that The **ECONOMIST**[1] roughly lumped into three categories. Designing [**AMD, INTEL, BROADCOM, NVIDIA, QUALCOMM, XILINX, ARM, SYNOPSYS, ZUKEN**]; Manufacturing [**INTEL, SAMSUNG, MICRON**, **TSMC**] Packaging/Assembly [**AMCOR**, **JCET**, **ASE**, **KING YUAN**]. Manufacturing, and Packaging/Assembly is supplied by **AIR LIQUIDE**, **APPLIED MATERIALS**, **ASML**, **KMG CHEMICALS**, **LAM REASERCH**, **NAURA**, **SUMCO**, **TOKYO ELECTRON**, **HITACHI HIGH-TECNOLOGIES**.

A typical itinerary of raw silicon to completed microchip is a fair illustration of the elaborate supply chains that emerged. Microchip's initial travel may start in the Appalachian Mountains in north America, where deposits of silicon dioxide are of the highest quality. The sand may arrive in Japan to be turned into pure ingots of silicon. The ingots of silicon are then sliced into standardized wafers, 300mm across, and sent

to a "fab", a chip factory, in Taiwan or South Korea for high-tech and to China for low-tech. It is in this stage that the slices will be imprinted with a particular pattern using photolithography equipment made in Holland by **ASML**. A single company, **TAIWAN SEMICONDUCTOR MANUFACTURING,** dominates the physical production of chips globally. While many US companies develop software and designs for chips, They operate with a fabless business model, meaning they contract out the chips' production. Indeed 80% of production of the final product takes place in Asia, only 12% in the United States, and the rest in Europe. According to **BOSTON CUNSULTING GROUP**, about 75% of semiconductor manufacturing capacity, as well as many suppliers of key materials – such as silicon wafers, photoresist, and other specialty chemicals – are concentrated in China an and East Asia, a region significantly exposed to high seismic activity and geopolitical tensions. Furthermore, all of the world's most advanced semiconductor manufacturing capacity is currently located in South Korea, 8%, and Taiwan, 92%. The vast majority of advanced chips are produced in **TSMC** produces the chips crucial to the production of nearly every electronic device**.** A single company in a single tiny country in one of the most geopolitically contested parts of the world has become the choke point for the global digital economy. The United States largely gave up on chip production over the last few decades as part of the neoliberal global outsourcing model in which the companies off-loaded factory production which is expensive and lower margin and kept the high-value knowledge work at home. The only leading pure-play silicon chip foundry in the United States, the **GLOBAL FOUNDRIES** in Malta, New York, is owned by the Emirate of Abu Dhabi, via a sovereign wealth fund. The cost of a state-of-the-art chip-fabrication operation is around $12billion. The ultraviolet lithography tool necessary for making top-line chips can cost $150 million.

"By the 2000s, it was common to split the semiconductor industry into three categories. 'Logic' refers to the processors that run smartphones, computers, and servers. 'Memory' refers to DRAM, which provides the short-term memory computers need to operate, and flash, also called NAND, which remembers data over time. The third category of chips is more diffuse, including analog chips like sensors that convert visual or audio signals into data, radio frequency chips that communicate with cell networks, and semiconductors that manage how devices use electricity. The third category has not been primarily dependent on Moore's Law to drive performance improvements. Clever design matters more than shrinking transistors. Today around three-quarters of this category of chips are produced on processors at or larger than 180 nanometers, a manufacturing technology that was pioneered in the late 1990s. As a result, the economics of this segment are different from logic and memory chips that must relentlessly shrink transistors to remain on the cutting edge. Fabs for these types of chips generally don't need to race toward the smallest transistors every couple of years, so they're substantially cheaper, on average requiring a quarter the capital investment of an advanced fab for logic or memory chips. Today, the biggest analog chipmakers are American, European, or Japanese. Most of their production occurs in these regions, too, with only a sliver offshored to Taiwan and South Korea. The largest analog chipmaker today is Texas Instruments, which failed to establish an Intel-style monopoly in the PC, data center, or smartphone ecosystems but remains a medium-sized, highly profitable chipmaker with a vast catalog of analog chips and sensors. There are many other U.S.-based analog chipmakers now, like Onsemi, Skyworks, and Analog Devices, alongside comparable companies in Europe and Japan. The memory market, by contrast, has been dominated by a relentless push toward offshoring production to a handful of facilities, mostly in East Asia. Rather than a diffuse set of suppliers centered in advanced economies, the two main types of memory chip – DRAM and NAND – are produced by only a couple of firms. For DRAM memory chips, like the type of semiconductor that defined Silicon Valley's clash with Japan in the 1980s, an advanced fab can cost $20billion. There used to be dozens of DRAM producers, but today there are only three major producers. In the late 1990s, several of Japan's struggling DRAM producers were consolidated into a single company, called Elpida, which sought to compete with Idaho's Micron and with Korea's Samsung and SK Hynix. By the end of the 2000s, those four companies controlled around 85 percent of the market. Yet Elpida struggled to survive and in 2013 was bought by Micron. Unlike Samsung and Hynix, which produce most of their DRAM in South Korea, Micron's long string of acquisitions left it with DRAM fabs in Japan, Taiwan, and Singapore as well as in the United States. Government subsidies in countries like Singapore encouraged Micron to maintain and expand fab capacity there. So even though an American company is one of the world's three biggest DRAM producers, most DRAM manufacturing is in East Asia. The market for NAND, the other main type of memory chip, is also Asia-centric. Samsung, the biggest player, supplies 35 percent of the market, with the rest produced by Korea's Hynix, Japan's Kioxia, and two American firms – Micron and Western Digital. The Korean firms produce chips almost exclusively in Korea or China, but only a portion of Micron and Western Digital's NAND production is in the U.S., with other production in Singapore and Japan. As with DRAM, while U.S. firms play a major role in NAND production, the share of U.S. – based fabrication is substantially lower." informs Chris Miller in **CHIP WAR: THE FIGHT FOR THE WORLD'S MOST CRITICAL TECHNOLOGY** (Miller, 2022) and adds: "Yet demand for chips was 'exploding'. China's leaders realized, driven by 'cloud computing, the Internet of Things, and big data'. These trends were dangerous: chips were becoming even more important, yet the design and production of the most advanced chips was monopolized by a handful of companies, all located outside of China. China's problem isn't only in chip fabrication. In nearly every step of the process of producing semiconductors, China is staggeringly dependent on foreign technology all of which is controlled by China's geopolitical rivals – Taiwan, Japan, South Korea, or the United States. The software tools used to design chips are dominated by U.S. firms, while China has less than 1 percent of the global software tool market, according to data aggregated by scholars at Georgetown University's Center for Security and Emerging Technology. When it comes to core intellectual property, the building blocks of transistor patterns from which many chips are designed, China's market share is 2 percent; most of the rest is American or British. China supplies 4 percent of the world's silicon wafers and other chip making materials; 1 percent of the tools used to fabricate chips; 5 percent of the market for chip design. It has only a 7 percent market share in the business of fabricating chips. None of this fabrication capacity involves high-value, leading-edge technology. Across the entire semiconductor supply chain, aggregating the impact of chip design, intellectual property, tools, fabrication, and other steps, Chinese firms have a 6 percent market share, compared to America's 39 percent, South Korea's 16 percent, or Taiwan's 12 percent, according to the Georgetown researchers. Almost every chip produced in China can be fabricated elsewhere."

"The microprocessor industry is an excellent candidate to explore the effects of competition and antitrust policy on innovation for durable goods." writes Richard J. Gilbert in **INNOVATION MATTERS: COMPETITION POLICY FOR HIGH-TECHNOLOGY ECONOMY**, and adds: "Microprocessors are durable goods; they can function without depreciation for many years. A consumer's incentive to replace a microprocessor is often the desire to upgrade to a more powerful processor. The industry has a duopoly for decades, with **INTEL** and **ADVANCED MICRO DEVICES** (**AMD**) accounting for about 95 percent of desktop PC microprocessor sales. Innovation can be measured by the clock speed of the microprocessor. Both **INTEL** and **AMD** have invested heavily in microprocessor R&D. Clock speeds for the newest microprocessors roughly doubled every seven quarters over the twelve-year period examined by Goettler and Gordon (1993-2004). **INTE**L has been the target of several antitrust actions related to conduct allegedly excluded **AMD** from microprocessor sales. In 2009, **INTEL** paid **AMD** $1.25billion to settle charges that **INTEL** violated antitrust laws offering rebates to Japanese **PC** manufacturers who agreed to eliminate or limit purchases of rival microprocessors. In the same year, the European Commission (**EC**) fined **INTEL** 1.06billion euros and ordered the company to end its rebate program. In 2010, the US Federal Trade Commission (**FTC**) and **INTEL** settled charges that **INTEL** unlawfully maintained a monopoly in microprocessors and attempted to acquire a second monopoly in graphics processors using a variety of unfair methods of competition. ……. Concerns about the effects of rising market concentration in the US economy on innovation are not limited to the effects of concentration on the level of R&D investment. An additional concern is that large firms in concentrated industries have a bias toward incremental improvements in existing products and technologies rather than transformative innovations" (Massachusetts Institute of Technology, 2020).

The **INTERUNIVERSITY MICROELECTRONICS CENTRE** [**IMEC**] in Leuven, Belgium does not design chips, manufacture them or make any of the complicated gear to manufacture them. Instead, it creates knowledge used by everyone in the $550billion chip business. Given chips' centrality to modern economy and increasingly to post-President Trump geopolitics make it one of the most essential industrial research and development [**R&D**] centers on the planet.

IMEC was founded in 1984 by a group of electronics engineers from the **CATHOLIC UNIVERSITY OF LEUVEN** who wanted to focus on microprocessor research. In the early days it was bankrolled by local Flemish government. Today **IMEC** maintains its neutrality to a financial model in which no single firm or state controls a big share of the budget. The largest share comes from the Belgian government, 16%. The top corporate contributors provide no more than 4% each. Keeping revenue sources diverse and finite gives **IMEC** the incentive to focus on ideas that help advance chip-making as a whole rather than any fir in particular.

A case in point is the development of extreme ultraviolet lithography [**EVU**]. **EVU** is a delicate process involving high-powered lasers, molten tin and ultra-smooth mirrors. The bus-sized machines that generate **EVU** are made by **ASML** and used by **TSMC** and **SAMSUNG**. It took 20 years of **R&D** to turn the idea into manufacturing reality. **IMEC** acted as a conduit in the process. That is because **EUV** must work seamlessly with kit made by other firms. Advanced toolmakers want a way to circulate their intellectual property [**IP**] without the big companies gaining sway over it. The large companies, meanwhile, do not want to place all their bets on any one experimental idea that is expensive and could become obsolete soon.

IMEC's neutrality allows both sides to get around this problem. It collects all the necessary gear in one place, allowing producers to develop their technology in tandem with others. And everyone gets rights to the IP the institute generates. Progress in the chip industry has been driven by the free exchange of knowledge, with **IMEC** acting as a 'funnel' for ideas from all over the world. This model has lured ever more contributors. Several hundred are active at **IMEC** according to the institute. They range from startups to global firms.

The deepening rift between the United States, home to some of the industry's biggest firms, and China which imported $378billion worth of chips in 2020, threatens **IMEC**'s spirit of global comity. American and European export controls limit the extent to which **IMEC** can work with Chinese semiconductor companies. Chinese make up 3.5% of people working at **IMEC**, the 5th largest group and ahead of Americans at 1.5%. There is little that **IMEC** can do about the growing distance between the American and Chinese techno-spheres.

ASML is not the only maker of photolithographic machines, which use light to etch integrated circuits into silicon wafers. It competes with **CANON** and **NIKON** of Japan. By 2019, the Dutch firm's market share has nearly doubled, to 62%, since 2006. **ASML** has harnessed "**EXTREME ULTRA-VIOLET**" [**EUV**] light with wavelengths of just 13.5 nanometers. Shorter wavelengths allow the etching of smaller components, vital for chip makers striving to keep pace with **MOORE'S LAW**, which posits that the number of components that can be squeezed into a given area of silicon doubles roughly every two years. The world's three leading chipmakers, **INTEL**, **SAMSUNG**, and **TAIWAN SEMICONDUCTOR MANUFACTURING COMPANY** [**TSMC**] have become as reliant on **ASML** as the rest of the technology industry is on theirs. **ASML**'s revenues reflect this. $13.2billion in 2019 that grew by 8%, with neither **CANNON** nor **NIKON** pursuing **EUV** technology. **ASML**'s market cap grew tenfold since 2010, at $130billion, it is worth more than **SIEMENS** or **VOLKSWAGEN**. The firm started as a joint venture with **PHILIPS** and **ASM INTERNATIONAL**. In 1995, it listed its shares in New York and Amsterdam and shortly afterwards, the firm bet that **EUV** lithography would be the future of chip-making. Big chipmakers planned to use **ASML**'s machines by around 2007.

ASML has around 5000 suppliers. **ASML** is so vital to **INTEL**, **SAMSUNG** and **TSMC** have stakes in the firm. **EUV** lithography is on the **WASSENAAR LIST** of "dual use" technologies that have military as well as civilian applications. China is keen to foster advanced chip-making firms of its own, an ambition that President Trump tried to thwart. In 2018, **ASML** received an order for an **EUV** machine from a Chinese customer widely thought to be the **SEMICONDUCTOR MANUFACTURING INTERNATIONAL CORPORATION**, a Chinese big chip-maker. Under American pressure, the Dutch government has yet to grant **ASML** an export license. **ASML** announced its compliance with US Commerce Department's decision that blacklisted **HUAWEI** and its 70 affiliates in 2019, and notified **HUAWEI** of its decision. The particular pattern will be determined by the overall design of the chip. This design might come from **ARM**, a British company acquired by **NVIDIA** in 2020 from **SOFTBANK**, a Japanese asset manager. The design can be tweaked for specific applications by one of the company's many licensees.

In its next phase, it must be assembled into a package, in which the etched silicon is placed inside the ceramic or plastic containers that are dotted across any circuit board. Then testing follows. Packaging might take place in China, Vietnam or the Philippines. The integration into a circuit board could happen somewhere else again. The final result will be one of the many components that arrive at factories from Mexico to Germany to China, for assembly into a final product: an industrial robot, a smart vacuum cleaner or a tablet. China's domestic microchip industry started at the lower-value end of this process, **SEMICONDUCTOR MANUFACTURING INTERNATIONAL CORP**, China's largest maker of semiconductors. Fueled by a fast growing domestic market, China established **NATIONAL INTEGRATED CIRCUIT INDUSTRY INVESTMENT FUND** help to turn promote design and higher-value manufacturing.

The 2011 earthquake and tsunami in Japan besides revealing how globally integrated the manufacturing had become, starkly revealed that Japanese firms have been producing the bulk of chemicals and other materials to make microchips. Japanese firms had substantial control over copper foils for printed circuit boards, silicon wafers to make chips, and resin to package them. For many components Japan was the home of biggest, sometimes the only, supplier.

Microprocessors are chips that do most of the grunt work in computers. They are built around Instruction-Set Architectures, [**ISAS**], owned either by **INTEL** or **ARM**. **INTEL**'s **ISAS** power desktop computers, servers and laptops. **ARM**'s power phones, watches and other mobile devices. Though there are others, together **ARM** and **INTEL** dominate the market. An Instruction-Set Architectures [**ISAS**] is a standardized description of how a chip works at the most basic level, and instructions for writing software to run on it. Computer scientists at the University of California, Berkeley, wrote **RISC-V** for use for publishable research because commercial producers of **ISAS** were reluctant to make theirs available. The **ISAS** are proprietary, **RISC-V** is available to anyone, anywhere, and is free. **RISC-V** was introduced in 2014 at the **HOT CHIPS MICROPROCESSOR CONFERENCE** in California. It is now governed by a non-profit foundation. It recently moved to Switzerland out of American jurisdiction. The reason for shifting to **RISC-V** is the nature of open-source itself. Since the instruction set is already published online, American export controls do not apply to it. This has made it particularly popular with Chinese IT firms. **ALIBABA** announced its first **RISC-V** chip in July, 2019. **HUAMI** is mass producing smart watches containing processors based on **RISC-V**. Led by **HUAWEI**, many are moving toward the **RISC-V** architecture with its open source code free to all to use.

The most famous "open" governance system is **LINUX**, an operating system created and maintained through cooperative efforts to which all are, in principle, free to contribute and from which all are welcome to benefit. Others are "closed", as is the convention among many corporate-software makers, such as **ORACLE**. Some are run like absolute monarchies, such as **APPLE** under Steve Jobs, who was the final arbiter over the smallest details in his tech empire. America is a platform like **MICROSOFT**'s **WINDOWS** and **ANDROID**, **GOOGLE**'s mobile operating system. These mix aspects of open and closed systems, allowing others to develop applications for their platforms, but also closely control it. America combines monopolies and a state with competition. China is more like **APPLE** and **ORACLE**, which combine being closed with internal competition. The European Union is best compared to an open-source project like **LINUX**, which needs complex rules to work. India, Japan, Britain, Taiwan, and South Korea all run differently and have technology bases to match.

To advocates, open, public block-chains provide a second chance at building a digital economy. The fact that the application built on top of such block-chains all work with each other, and that the information they store is visible to all, harks back the idealism of the internet's early architects, before most users embraced the walled gardens offered by the tech giants. The idea that a new kind of "decentralized" digital economy might be possible has been bolstered over recently as numerous applications are built on top of various block-chains. Perhaps, the most significant part of that economy has been decentralized- finance [**DeFi**] applications, which enable users to trade assets, get loans, and store deposits. **ETHEREUM**, the leading **DeFi** platform with its near-monopoly, is being challenged by the new startups. The idea behind **DeFi** is that block-chains – databases distributed over many computers and kept secure by cryptography – can help replace centralized intermediaries like banks and tech platforms. Until recently the **ETHEREUM** block-chain was the undisputed host of all this activity. It was created in 2015 as a more general-purpose version of **BITCOIN**. **BITCOIN**'s database stores information about transactions in the associated cryptocurrency, providing proof of who owns what at any time. **ETHEREUM** stores more information, such as lines of computer code. An application that can be programed in code can be guaranteed to operate as written, thereby removing the need for an intermediary.

Current block-chain technology is clunky. Both **BITCOIN** and **ETHEREUM** use a mechanism called proof of work, where computers race to solve mathematical problems to verify transactions, in return for a reward. This slows the networks down and limits its capacity. **BITCOIN** can process only seven transactions per second. **ETHEREUM** can handle only 15. At busy times transactions are either very slow or very costly and at times both. A growing number of networks, such as **AVALANCHE** and **SOLANA**, process thousands of transactions a second. Because of the nature of open, public block-chains, anyone can access the data they produce and view their operating code, making it possible to build bridges or applications that work across many block-chains, or which aggregate information from different block-chains. Some applications, like **1inch**, already scan exchanges on several block-chains in order to find the best execution price for various crypto transactions. Multi-chain block-chains, like **POLKADOT** and **COSMOS**, act like bridges between different networks, making it possible to work across them.

In **COINTELEGRAPH**, "**AVALANCHE** is a high performance, ecofriendly block-chain that scales hard math and science, rather than expensive, energy-intensive hardware. At its core, the innovation of the **AVALANCHE** consensus reduces the amount of communication required between validating nodes, which also decreases the hardware power required to secure the many billions of dollars in value on the network. Taken a step further, **AVALANCHE** is a quiescent protocol, meaning that if network activity slows, nodes will not perpetually expand energy as we see on almost every other platform. Nodes will simply wait until they hear another transaction to broadcast and move swiftly toward the next decision. Sustainability is critical to the block-chain industry's ability to overtake traditional infrastructures, as well as core ethic of this entire ecosystem of using innovation to better the lives of people. Much of the inertia that climate change activists have faced is from incumbents

who wield far too much power. Decentralizing their power and putting more economic control in the hands of individuals, rather than institutions, is an incredible step forward. Momentum toward mass adoption of decentralized services continues to accelerate and users are also witnessing that high performance and eco-friendliness of a block-chain are not enemies. In fact, they are necessary champions to achieve mass adoption doing right for both people and the planet." reports Selva Ozelli.[1]

The 21st century **INTERNET** would evolve to be a **SPLINTERNET** was, perhaps, inevitable. It is not just that nations act in their own interest; they also have different preferences and values, for instance regarding privacy. High digital borders behind which data get stuck, however, are not in the best interests of most countries – though they may be in the interest of some governments. Russia wants to create a "sovereign internet" that can be cut from the rest of the online world at the flip of a switch while retaining the capability to participate around in more open systems. Economies interested in using flows of data to improve their citizens' lot, though, will see few advantages. In a **SPTINTERNET** world choices will be limited, costs higher and innovation slower. And all the while China, with the biggest silo and thus greatest access to data, loses least.

President Trump's **WEAPONIZATION OF INTERDEPENDENCE**, his threats to cut off foreign financial institutions from **SWIFT** banking network and the dollar clearing system for doing business with countries or entities he does not like highlighted China's vulnerabilities. One of the gravest is China's dominant role in electronics assembly. China is home to half of the world's capacity. In May 2019 Commerce Department blacklisted **HUAWEI** and its 70 affiliates, barring American firms from selling certain technologies without government approval to them. On May 15, 2020 Trump administration expended its restrictions from chips to the tools used to make them. Most of them come from **APPLIED MATERIALS**, based in California builds kit used to etch patterns into silicon that has 90% of its assets in US, **LAM RESEARCH**, a maker of equipment used by **TSMC** and others to process silicon wafers has 88% of its assets in US, **TERADYNE** has 69% in US. **ASML** has almost all of its assets in Netherlands, and **TOKYO ELECTRON** and **HITACHI HIGH-TECHNOLOGIES** in Japan.

This shed light on another global network: microchip industry. The industry's geographic scope had already become broader, and less American over time. A crude yardstick for this is to track where the firms' assets are geographically located. Only 20% of the plants of top dozen global semiconductor firms are in America. When Asian firms located their factories at home, American firms have diversified geographically. **INTEL**, for example, in 2019 had 35% of its physical assets, a rough proxy for manufacturing capacity, abroad. Some $8billion was in Israel, $4billion in Ireland, and $5billion in China, its biggest market. $20billion of **INTEL**'s $72billion revenues in 2019 was from China. Another example is **ANALOG DEVICES**, an American firm which makes radio-frequency chips for **HUAWEI** for the assembly of telecoms base stations. Half of **ANALOG DEVICES**'s assets are in the Philippines, Ireland, Singapore and Malaysia.

Around half of the modem chips to manage wireless connections of the world's baseband processors are made by **QUALCOMM**. Virtually all "server-class" chips used in world's data centers are made by **INTEL**. Chips based on designs licensed from **ARM** are ubiquitous in almost every advanced smart-phone. In September 2020, **NVIDIA**, a designer of chips for gaming and **Ai** agreed to buy **ARM** from **SOFTBANK** for $40billion and in October 2020, **ADVANCED MICRO DEVICES** [**AMD**], **NVIDIA**'s main rival in the gaming market and **INTEL**'s **GPUS** which makes blueprints for graphics and general purpose chips agreed to buy **XILINX,** the maker of an accelerator chip called **FIELD PROGRAMMABLE GATE ARRAYS** [**FPGAS**] that **MICROSOFT**'s **AZURE** opted for $35billion. As for the **ARM** acquisition by **NVIDIA**, it became an aborted deal. **SOFT-BANK** paid $32billion for **ARM** in 2016 and as of June 2022 planned to refloat its shares by March 2023 with a secondary listing in London alongside the primary in New York. **ARM**'s customers include all the world's chipmakers as well as **AWS** and **APPLE**, which uses **ARM** chips in **iPhones**. **NVIDIA**'s objective is to use **ARM**'s design process to engineer central processing units [**CPUS**] for data centers and **Ai** users that would complement **NVIDIA**'s existing strength in specialized chips known as graphics-processing units [**GPUS**]. Some have complained that **NVIDIA** could restrict access to the chip designer's blueprints. The **Gravitona**, **AWS**'s tailor-made server chip, is based on an **ARM** design. **NVIDIA** said it had no plans to change **ARM**'s business model. Western regulators had to decide whether to approve the deal. UK's competition authority, which had until July 30th, 2021 to scrutinize it was the first one to issue a ruling. China was unlikely to welcome an American takeover of an important supplier to its tech firms from **SOFTBANK**.

A big reason why **ARM**'s technology triumphed over rival chip architectures was low prices. Unlike firms such as **INTEL**, which sells chips that it both designs and manufactures, **ARM** trades only in intellectual property [**IP**]. For a fee, anyone can license one of its off-the-shelf designs, tweak it if necessary, and sell the resulting chip. Besides licensing revenue, **ARM** takes a small royalty from every sale of a chip built with its technology. In 2021 licensing revenues accounted for a bit over $1billion, while royalties brought in $1.5billion. Removing the need to design a chip – complicated, highly specialized job – has made **ARM**'s off-the-shelf designs popular especially as chips have become more and more complicated. **ARM** is the dominant designer of the smartphone chips. In 2020 **APPLE**, which has long used **ARM** chips in **iPhones**, began replacing **INTEL** silicon in its laptops and desktops with **ARM**-based designs. **ARM** has also increasingly been competing in the high-margin business of servers, the high-spec machines found in data centers. That market has for decades been dominated by **INTEL**, but in recent years **ARM** has scored notable victories. **AMAZON WEB SERVICES** [**AWS**] uses **ARM**-derived **GRAVITON** chips. The emergence of **RISC-V** a novel chip architecture that lacks royalties and license fees is the new challenger in the industry.

For its first 20 years or so **NVIDIA** made **GPUS** that helped video games look lifelike. In the past decade, though, it turned out that **GPUS** also excel in another area of computing. They dramatically speed up how fast machine-learning algorithms can be trained to perform tasks by feeding them oodles of data. Owning **ARM** would give **NVIDIA** the **CPU** chops to complement those in **GPUS**, as well as its new abilities in network-interface cards needed in server farms. For their part, **QUALCOMM**, **ARM** and other chip designers depend on foundries to turn silicon into microprocessors. **INTEL**, **SAMSUNG**, and **TSMC**, in turn, rely on a bevy of specialized equipment suppliers to equip their factories. The emerged technically interdependent complexity of chip-making is multinational as its financial structure. Furthermore, **WEB** giants like **AMAZON** and

GOOGLE are developing their own designs. They are joined on demand for hardware tuned for the needs of **Ai** and networking. The ballooning costs of keeping up with advancing technology mean that the explosion of chip designs is being funneled through a shrinking number of companies capable of actually manufacturing them. Only three firms in the world are able to make advanced processors: **INTEL**, **TSMC** and **SAMSUNG**. **INTEL** announced that it has decided to outsource some of its own production to **TSMC**. Before Trump's declaration of technology cold war, globally, the industry looked poised to polarize further into every greater effervescence in design and ever more concentration in production.

"Perhaps no company represents the quandaries of the post-neoliberal political economy better than, Qualcomm, the U.S. multinational that designs the wireless chips that are the smartest thing in your cellphone." wrote Rana Foroohar in **HOMECOING: THE PATH TO PROSPERITY IN A POST-GLOBAL WORLD**. "It has for decades been one of the most important American firms pushing the development of the internet communications network that is set to culminate in the 5G network that will connect the much-heralded internet of things by which electronic devices, from dishwashers to basketball shoes, will be able to record and transmit valuable user data. ….. But Qualcomm's hands have been tied in recent years by two entities that represent the pinnacle of both private and public sector power: Apple and China. For the last four years, Apple battled Qualcomm on three continents in an effort to reduce the licensing fees it charges for the designs that power the chips Apple needs for all its iPhones. Qualcomm has depended on that income, which amounts to fully half of its global profits, to support its research to win the global 5G competition. Meanwhile, it has in recent years gotten roughly half its revenue from China. But thanks to the tech and trade war between the United States and China, it's become harder to grow there. Indeed, the future of any U.S. tech company doing business in China is precarious, as economic decoupling between the two countries play out. …… 5G is being heralded as a fourth industrial revolution that could boost U.S. GDP by a half trillion a year, just to start, with returns only to boom from there. …… It is not an exaggeration to say that none of this would have happened without Qualcomm, which, over the last several decades, has been spectacularly innovative company, the Bell Labs of the current generation of tech firms. …… CODE DIVISION MULTIPLTE ACCESS [CDMA], a patented coding system (developed by Qualcomm) emerged as one winner of the holly wars to make its way into millions of cellphones in the United States (and around the world for that matter), it was deemed by the U.S. Patent Office an "essential" technology. This was a high honor, but also a tremendous burden. For it meant that Qualcomm was obliged to provide CDMA chips to any U.S. communications company that asked for it. But that very obligation to sell capped the price: set it too high, and the cell manufacturer would complain to the Patent Office that Qualcomm was denying it essential component. In effect, Qualcomm was being penalized for its core product's indispensability. This became glaringly true in 2017, when Qualcomm's legal troubles began. For years leading up to the litigation, Apple had a deal with Qualcomm to sell its iPhones using only Qualcomm chip designs. In addition to paying for the chips, Apple had to pay a licensing fee for the intellectual property that enabled the phones to connect to the internet through the core processor. Qualcomm gave Apple some special discounts in exchange for exclusivity, but it made quite a lot of money from patent licensing – too much, according to Apple, although not enough according to Qualcomm. The cost (to the consumer) of an iPhone XS in 2020 was $999. Apple paid $7.50 per device to Qualcomm, but wanted to pay $1.50. For years, the tech giant didn't have the muscle to wage a legal war with Qualcomm and risk losing access to the technology that allowed its phones any value at all. But as it got bigger and bigger, Apple decided to start working with another chipmaker, Intel (which in the beginning of 2022 announced its first new manufacturing site in forty years, in Ohio, to produce its own chips, in a move away from the fabless model, back toward more vertical integration within the chip sector). Apple also started to cooperate with regulators all over the world to push back on Qualcomm's royalty policies. First, Qualcomm was hit with a Federal Trade Commission suit charging anticompetitive tactics in its supply and licensing terms. Three days later, it was hit again when Apple sued for a billion dollars, claiming unpaid licensing rebates and exclusive fees. Almost immediately, both Apple and Qualcomm began suing each other for billions of dollars on three different continents, over royalty rates and access to crucial technology. …… Once Apple pressed its suit, it simply stopped paying Qualcomm any licensing fees at all, even as it continued to install Qualcomm chips in its iPhones, slashing Qualcomm's worldwide profits nearly in half. Stymied by Apple, Qualcomm relied more and more on its profits in China. But because the Defense Department had deemed China the chief strategic adversary of the United States, this posed new security concerns, particularly as the Trump trade war heated up. …… This left American companies doing business in China in a terrible bind. They were under pressure from U.S. shareholders over quarterly losses, while facing down a one-party state that, playing the long game, thought in terms of decades, if not centuries. Locked into a legal battle with Apple, Qualcomm was suddenly subjected to new restrictions on its operations in China. Its two profit centers were getting walled off by government edicts on both sides. Desperate to find a new revenue stream in China, Qualcomm moved to acquire a Chinese semiconductor firm, NXP. But this required Chinese approval. Now, as the Chinese considered Qualcomm's bid for NXP, they decided the offer price was insufficient, although it was well above market rate. Qualcomm duly raised it. No again. Submitted again. No again. Repeat. The U.S. government, cognizant of importance of Qualcomm, pushed to get the deal through by removing some of its own tech export bans, including one on U.S. tech companies selling components to ZTE, a big Chinese telecom firm. Still no dice. …… Meanwhile, Qualcomm found itself caught not only between Apple and China, but between Trump and Xi. Its share price weakened from years of battling Big Tech and Beijing, Broadcom, a massive Singaporean-owned player in the chip space, saw its chance to acquire the company on the cheap. Broadcom had an unsavory reputation for acting like a private equity firm during its acquisitions, picking targets clean for their IP and leaving them to die. First, it swooped in to make an unsolicited bid to acquire Qualcomm for $103billion, before turning to a hostile takeover for $121billion. But the president decided it was too great a security risk to let Qualcomm fall to another company if it could result in the former's essential technology reaching Chinese hands. Trump vetoed the Broadcom acquisition. At this, coincidentally or not, China rejected Qualcomm's twenty-ninth and, as it proved, final bid for NXP. …….. Government officials fretted that Broadcom, which lined up $106billion in debt financing from private equity groups Silver Lake, KKR, and CVC for the deal, would indeed take a short-term-profit approach and cut Qualcomm's R&D budget. If Qualcomm

were to be starved of investment, the United States would lose a "national champion" in the technology race against China. But their arguments failed to take into account the looming elephant in the room: the neoliberal model of trade itself and how it is fundamentally at odds with the new realities of state capitalism" (Foroohar, 2022).

"Nearly every chip in the world uses software from at least one of the three U.S.-based companies, Cadence, Synopsys, and Mentor (the latter of which is owned by Germany's Siemens but based in Oregon). Excluding the chips Intel builds in-house, all the most advanced logic chips are fabricated by just two companies, Samsung and TSMC, both located in countries that rely on the U.S. military for their security. Moreover, making advanced processors require EUV lithography machines produced by just one company, the Netherland's ASML, which in turn relies on its San Diego subsidiary Cymer (which it purchased in 2013), to supply irreplaceable light sources in its EUV lithography tools. It is far easier to control choke points in the chip-making process when so many essential steps require tools, materials, or software produced by just a handful of firms. Many of these choke points remained in American hands. Those that didn't were mostly controlled by close U.S. allies" (Miller, 2022). Another example of the neoliberal trade model's promises' stark contrast to the emerged realities of the global economy.

In 2020, **APPLE** announced that it would replace **INTEL**'s products with tailor-made ones. In 2018, **AWS** began replacing some **INTEL** chips in its data centers with its own **GRAVITON** designs, claiming that its chips are 40% more cost-efficient than **INTEL**'s. Around the same time **GOOGLE** began offering its custom **TENSOR PROCESSING UNIT** chip to boost **Ai** calculations to its cloud clients. **BAIDU** claims that its **KUNLUN** outpace offerings from **NVIDIA**.

Taiwan had no comparative advantage in semiconductor manufacturing in the 1980s. Yet the Taiwanese government made a political decision to create state-sponsored **TAIWAN SEMICONDUCTOR MANUFACTURING COMPANY**. The Taiwanese government nurtured **TSMC** with tariffs and subsidies in its early days when it was most vulnerable to foreign competition. **TSMC**, now, is a publicly traded company, a status the company could not have achieved without Taiwanese government's help. Those who shamelessly teach Ricardo's comparative advantage as science in their international economics classes should note that the Taiwanese created their comparative advantage, as **SAMSUNG** did in South Korea.

The mainframe did not cause the invention of the personal computer, but the wide market the mainframe created enabled the rather easy penetration of the personal computer into an expanding market. In addition, the spreadsheet is often described in histories of technologies as the killer app that caused an explosion of the personal computer market. The spreadsheet is the complement of the personal computer. Each helped the other gain market share. The personal computer did not cause but enabled the invention of word processing, and software companies like **MICROSOFT** emerged, which was originally founded to make the operating system for **IBM** personal computers.

The invention of word processing and abundant files invited the possibility of file sharing, and the modem was invented. The existence of file sharing did not cause, but invited, the invention of the **WORLD WIDE WEB**. The existence of the **WEB** did not cause, but enabled, selling on the **WEB**, and **eBay** and **AMAZON** emerged. And **eBay** and **AMAZON** put content on the **WEB** as did myriad other users, enabling the invention of **WEB** browsers; and also companies like **GOOGLE** emerged. Thence has followed social media and **FACEBOOK**.

When Tim Berners-Lee released his first **WORLD WIDE WEB** browser in March 1991, it was not at all obvious that a near-monopoly in searching would arise. **MOSAIC**, the first popular **INTERNET** browser became available in 1993 and during the next five years, before **GOOGLE**'s launch, there was a mini-universe of search engines, from **ALTA VISTA** and **ASK JEEVES** to **WEBCRAWLER** and **YAHOO SEARCH**. But then **GOOGLE** either eliminated the competition or relegated other options to marginal shares, and now anybody with a computer or a mobile phone is able to access most of the reproduced, copied, or encoded historical, technical, medical, and scientific information – as well as to download any recipe, famous painting, photograph, how-to advice, or out-of-copyright text.

Almost all of these successive innovations are the complements of the preceding ones. The existing goods and services at each state are the context in which the next good and/or service emerges. Word processing is a complement of the personal computer, the modem a complement of word processing, the **WEB** is a vast interconnected modem and is a complement and much more to file file-sharing. The opportunity to share files invited the invention of the modem. Accordingly, Schumpeter's depiction of capitalism's cycles of creation and destruction need to be modified to reflect goods and services as contexts that do not cause, but enable, the invention and introduction of the next good or service. Enablement is neither a Schumpeterian nor a neoclassical equilibrium theory concept.

The industrial revolution was the greatest transformation in economic history. For centuries scholars have sought to understand why this process occurred in Britain around 18750. But without the ability to run counter-factual experiments, it is hard to prove any single explanation. Researchers have and are testing theories why similar parts of Britain industrialized at different rates. So far, they have provided evidence for a few key factors: slave-owners' capital; entrepreneurs who stood to benefit from investing; and shortages of lower-skilled workers. Industrialization requires investment, which requires capital. The riches Britons extracted from slaves in America flowed mainly to a few cities, such as Liverpool. By the 1930s these regions had large numbers of cotton mills and shares of workers employed in manufacturing. In 1536-1540, Henry VIII dissolved the monasteries and sold their land. The buyers could farm or rent it on market terms. Researchers' evidence shows that areas once held by monasteries were at the vanguard of industrialization. By 1830s these areas had unusually large numbers of workers in trades and crafts, agricultural-machine patents, textile mills and grain separators. Researches claim that market-based firms, common on ex-monastic land, created an entrepreneurial class and incentives for technological advances. Low-skilled labor shortages were largely caused by Britain's wars with France during 1793-1815 when conscription shrank the workforce abruptly. Researchers found that adoption of devices replacing manual labor was greatest in areas that provided the most servicemen, so long as those regions also had mechanics. The effect was weaker without such skilled workers, and on non-labor saving machines. The strength of evidence for each of these causes implies that industrialization probably required a complex mix of conditions. Many important variables are hard to test statistically. But measuring even a

few is promising advance.

"The Industrial Revolution started in eighteenth-century Britain, where most of the population had little political or social power. Predictably, the direction of progress and productivity growth in such a two-tiered society initially worsened the living conditions of millions. This began changing only when the distribution of social power shifted, altering technology's course so that it raised the marginal productivity of workers. Also critical were institutions and norms for robust rent sharing in workplaces, ensuring that higher productivity translated into wage growth. This struggle over technology and worker power started to transform the highly hierarchical nature of British society in the second half of the nineteenth century. ….. Twentieth-century US technology moved even more decisively in the direction of raising worker marginal productivity. In this way it laid the foundations of shared prosperity, not just domestically but also in much of the world, as American techniques and innovations spread globally and enabled mass production and rise of a middle class in scores of countries. …. The United States has remained at the forefront of technology over the last fifty years, and its production methods and practices, especially its digital innovations, are still spreading throughout the world, but now with very different consequences. The US model of shared prosperity broke down as power became concentrated in the hands of big corporations, the institutions and norms of rent sharing unwound, and technology went in a predominantly automating direction starting around 1980. … All of this was underway, and the vision that animates the use of technology for automating work, monitoring, and squeezing out workers was firmly in place, before the latest wave of Ai. We were already on our way back to a two-tiered society long before the 2010s. With a heightened Ai illusion, we are seeing this process accelerate. Modern Ai amplifies the tools in the hands of tech elites, enabling them to create more ways of automating work, sidelining humans, and supposedly doing all sorts of good deeds such as increasing productivity and solving major problems facing humanity (they claim). Empowered by Ai, these leaders fell even less need to consult the rest of the population. In fact, many of them think that most humans are not wise and may not even understand what is good for them" (Acemoglu and Johnson, 2023) wrote Daron Acemoglu and Simon Johnson in **POWER AND PROGRESS: OUR 1000-YEAR STRUGGLE OVER TECHNOLOGY & PROSPERITY** and offer a thousand years of history and contemporary evidence in organizing new ways of production and communication to either serve narrow interests of an elite or become the foundation for widespread prosperity depending on the collective choices made in implementing technological improvements. "In the 1960s, only about 6 percent of American men between the ages of 25 and 54 were out of labor market, meaning they were long-term unemployed or not seeking a job. Today that number is around 12 percent, primarily because men without a college degree are finding it increasingly difficult to get a well-paid jobs. …… New digital technologies are everywhere and have made vast fortunes for entrepreneurs, executives, and some investors, yet real wages for most workers have scarcely increased" (Acemoglu and Johnson, 2023).

Three business models embraced by firms born after the dot.com crash and subsequently by investors were: the movers which shuttle people or things around urban centers; the streamers which offer music and TV on line; and the creepers which make money by watching their users and selling well-targeted advertisements. Since 2021, the firms that epitomize these business models: **UBER** and **DoorDash**; **NETFLIX** and **Spotify**; **Snap** and **META** have shed two-thirds of their market capitalization on average by the third quarter of 2022. **UBER** in its 13-year life has burned $25billion, equivalent to roughly half its current market value. **DoorDash**, the leader in food delivery, remained a loss maker in 2022. So did **Spotify** despite rising revenue and **Snap** on top of sharply slowing sales in 2022. **META**'s revenues shrunk in two consecutive quarters the same year, but was profitable. **NETFLIX** that has been a streamer since 2007 was profitable in 2022, but with only 6% growth on year on year revenue in the third quarter of 2022 compared to a historical average of more than 20%. On the surface, the movers, streamers and creepers and their problems look distinct. On closer look, however, their business all turn out to face the same main weaknesses: misplaced faith in network effects; low barriers to entry; and a dependence on someone else's platform.

Network effects, called "flywheels" in Silicon Valley, is the idea that a product's value to a user rises with the number of users. Once the user base passes a certain threshold, the argument goes, the flywheel powers a self-perpetuating cycle of growth. This explains why so many startups seek growth at all cost, spending millions acquiring ever more customers to get the flywheel spinning. Though network effects are real, they also have their limits. **UBER** believed that its head-start in ride-hailing gave it a ticket to riches, as more riders and drivers would mean less idle time for both, drawing ever more users into an unstoppable vortex. Instead, it encountered high unit costs and diminishing returns to scale: reducing average wait times from two minutes to one would require as many drivers, even though most riders would barely notice the difference. **DoorDash**'s customers likewise only require so many alternative Italian restaurants to choose from, and what network effects the movers enjoy are local. **Spotify** and **NETFLIX** also try to capitalize on network effects, as data on the listening and viewing habits of similar users promised to deliver an unbeatable product. Belief that **NETFLIX**'s user data would give it a winning edge in creating content has been shattered by a series of flops. For the creepers, whose social networks are a network-effects business par excellence, the risk is what happens if the flywheels start spinning in reverse. **META** had a warning shot in the 4th quarter of 2021, when it lost one million users. It has added users since. The second problem, low barriers to entry, is another boon turned bane. Advances in technology, from smart phones to cloud computing, allowed all manner of startups, including movers, streamers and creepers, to build consumer software cheaply and quickly. But it also enabled copycats to emerge, Fed's gift of cheap and easy credit allowed the copycats to offer generous discounts to quickly build the minimum necessary scale. Although in the United States **UBER** faces only one rival, **LYFT**, its global expansion soon was met by local competitors as **DIDI** in China, or **GRAB** and **GOJEK** in South-East Asia. The barriers to entry for the streamers are higher. **NETFLIX** and **Spotify** spend a lot of money making or licensing content, but they are not insurmountable for cash rich rivals like **DISNEY**.

The third problem common to the three business models is their reliance on distribution platforms that are not their own. **UBER** and **DoorDash** pay substantially to advertise on **APPLE**'s iPhone and **ALPHABET**'s Android app stores. **Spotify** pays over 15% commission on subscriptions purchased on iPhones. **NETFLIX** avoids the commission by forcing users to subscribe through their web browser, possibly missing

out on some subscriptions. Worst affected by the lack of their own platforms are the creepers. Their dependence on the iPhone-Android duopoly is an existential threat. **APPLE**'s requirement that users give iPhone apps permission to track their activity across other apps and websites, a move replicated by **ALPHABET** can cost **META** substantial foregone revenue.

Seventeen years after the launch of the iPhone, most people understand the bargain with smartphones. You get navigation anywhere in the world, the web and email on the go and as much music as you can stream, but first you must sacrifice some privacy. Your location, preferences and habits will be transmitted to some corporation to be parsed for insights and sold on to advertisers keen to sell what they want to sell. Some companies profit from tools that allow people to be snooped on without their consent. **NSO Group**, an Israeli firm, is probably the best known. It sells **Pegasus**, a piece of spyware that allows the program's operators, typically spies and secret police, to see everything a mobile phone's owner does. By reading messages directly off the phone's screen, it can bypass the encryption built into apps such as **WhatsApp** or **Signal**. **Pegasus** can even surreptitiously activate a phone's camera and microphone, uploading whatever it hears or sees to its controllers.

As the 21st century developments in digital technologies enabled firms to generate and amass data, data have become increasingly central to firms to recast their relations with their employees, their customers, and competitors. A new business model has emerged, the platform, capable of extracting and controlling unimagined amounts of data, and with this development, there emerged gigantic monopolistic data owning centers. Primarily, platforms are digital infrastructures that enable two or more groups to interact. Instead of having to build a marketplace from the ground up, a platform provides the basic infrastructure to mediate between different groups. This is platforms' key advantage over traditional business models when it comes to data. A platform positions itself between users, as the medium upon which their activities take place, hence giving the platform the privileged access to record the users' activities and store and own them.

Moreover, digital platforms produce and depend on 'network effects', more users begetting more users which develop their innate inertia to monopolize. The ability to rapidly scale many platform businesses by relying on pre-existing infrastructure and low marginal costs with few limits to growth further enables monopolization. Platform owners set the rules of service and development, as they set marketplace interactions. In their intermediary positions, platforms gain not only access to more data but also control and governance over the rules of the game. Far from simply being the owners of data, these data giants are emerging to become the owners of the emerging infrastructures of societies in the future.

The monopolistic **DNA** of these platforms must be taken into account in any analysis of their effect on the broader economy. "Capitalism without competition is not capitalism." warn Jonathan Tepper with Denise Hearn (Tepper and Hearn, 2019). But not according to vocal defender of the monopoly form, Peter Thiel, a Silicon Valley entrepreneur and the author of **ZERO TO ONE: NOTES ON STARTUPS, OR HOW TO BUILD THE FUTURE** (Theil, 2014). Peter Theil's view is that commercial success is built in 4 strategies: building a proprietary technology; exploiting network effects; benefiting from economies of scale; and branding. The management literature calls these "strategic resources", and says they have three characteristics. They are valuable; rare; and hard to imitate. But, one strategy of successful business that Theil seems to omit is building a good organization. Labelling the competitive-economy a "relic of history" and a "trap", as robber barons did at the turn of 20th century, he proclaims that "only one thing can allow a business to transcend that daily brute struggle for survival: monopoly profits." **FACEBOOK** to "bringing the world together" requires a global monopoly. Meanwhile, **GOOGLE** wants to organize the world's information and **AMAZON** wants nothing more than all the information to serve the world's consumers. Neoclassicals' economic model to explain and predict the platform world in the making is not helpful, but actually distorting. Since platforms are grounded on the extraction of data and generation of network effects, the following broad strategies seem to have emerged from the competitive dynamics of these large platforms. Expansion of **DATA EXTRACTION STRATEGIES** by driving cross-subsidization of services to draw users into their network. **GATEKEEPER STRATEGIES** by positioning as a gatekeeper to occupy key positions within the ecosystem around a core business neither by horizontal nor vertical nor conglomerate mergers. They are more like rhizoidal connections driven by permanent effort to place themselves in key platform positions. **CONVERGENCE OF MARKETS STRATEGIES**. The convergence thesis is the tendency for different platform companies to become increasingly similar as they encroach upon the same market and data areas. **SILOED PLATFORM STRATEGIES** by enclosing ecosystems and funneling of data extraction into siloed platforms. Their strategic choices are being installed in the 21st century ecosystems.

Ariel Ezrachi and Maurice E. Stucke in **VIRTUAL COMPETITION: THE PROMISE AND PERILS OF THE ALGORITHM-DRIVEN ECONOMY** (The President and the Fellows of Harvard College, 2016) warns: "Competition as we know it - the invisible hand that distributes the necessities of life - is being displaced in many industries with a digitalized hand. The latter, rather than being a natural force, is man-made, and as such is subject to manipulation. The digitalized hand gives rise to newly possible anticompetitive behaviors, for which the competition authorities are ill-equipped." (Ezrachi and Stucke, 2016) "The upsurge of algorithms, **BIG DATA** and super-platforms will hasten the end of competition as we know it - a decline of the market system to which we have become accustomed. …. The innovations from machine learning and **BIG DATA** can be transformative …..... lowering entry barriers, creating new channels for expansion and entry, and ultimately stimulating competition …….if companies' incentives are aligned with consumers' interests, and on their actions' collective impact on markets." (Ezrachi and Stucke, 2016) But, data-driven online markets do not have the built-in incentives to correct the market realities that emerged as declining upward mobility, diminishing rates of small-company creation, increasing market concentration and power, and widening wealth inequality. According to Ezrachi and Stuckle big companies use three main strategies supported by software technology. The first is collusion. While traditional illegal agreements for competitors to fix prices were made in back rooms, today computer algorithms fix prices automatically. Prices of airfares vary at different times before departure. Flight carriers and reservation platforms use algorithms that compare consumer demand for their own supply and the supply of their competitors. The second strategy is price discrimination, which is also made by algorithms processing large amounts of personal and user data to give different prices to their best or not so best customers. Lastly, the platforms simultaneously compete

in their own market. The markets of platforms partly overlap and are partly different. In equal or overlapping markets, competition is alive.**APPLE** and **MICROSOFT** compete in software and hardware, **ALIBABA** and **AMAZON** in retail, **FACEBOOK** and **GOOGLE** in targeted personal advertisements. However, in their primary markets - **GOOGLE i**n searching for information and **FACEBOOK** in social networking – the oligarchies are close to becoming a monopoly. "Despite having one of the older antitrust laws, the United States is no longer viewed as the intellectual leader of antitrust." (Ezrachi and Stucke, 2016) The US antitrust laws barely work on the dynamic market of platform and data companies acting in networks where all actors are linked, moving and merging all of the time, and where actors work with data continually recorded, coped, exchanged, sold or given away for free. Continually they extract, capture and exchange personal data.

Continuous production may still be going strong, in fact stronger than ever thanks to industrial robots, but it has lost its excitement of the early and middle twentieth century particularly in the United States, with the emergence of **ASSET MANAGER CAPITALISM**. The platform company, which uses software to bring together buyers and sellers of goods and services, represents a new kind of efficiency, based less on the organization of machines and human labor than on gathering, analysis, and exchange of data. This is disruptive business process innovation. It reduces transaction costs by matching buyers and sellers with automated software.

The platform era that began in the late 1990s with **AMAZON.com** entered a new phase in the 21st century with the rise of search engines, smartphones, social media, networked web-based software, and a revival of artificial intelligence. In the 1990s Greenspan's monetary policies fueled Wall Street's romance with platform-based efficiency and diverted capital and talent from riskier but ultimately more broadly beneficial market creating innovation to dot.com IPOs. The dramatic run-up in dot.com stocks transferred trillions of dollars from those that bought to those that sold dot.com stocks. Retirement funds of the rich countries that fell under Greenspan's spell were major buyers, therefore major losers. The money managers of the retirement funds, however, kept their bonuses. Rasputin would have envied.

The continuous process innovations did not just reduce friction. In eliminating some jobs, they created many others, often more skilled and higher paid. Some believe that this phase of technology was a one-time event that will not be repeated by 21st century platform companies. Such a view is not tweeted by President Trump who has promised to bring the off-shored jobs back to his nostalgic supporters. Now, we are in the midst of the third saltation that McAfee and Brynjolfsson call it the second machine age in **THE SECOND MACHINE AGE: WORK, PROGRESS, AND PROSPERITY IN A TIME OF BRILLIANT TECHNOLOGIES** (Brynjolfsson and McAfee, 2014), and in **MACHINE, PLATFORM, CROWD: HARNESSING OUR DIGITAL FUTURE** (McAfee and Brynjolfsson, 2017), they offer explanations of these technologies, and argue that exponential progress in computing is on the verge of delivering explosive advances in machine capabilities that has marked the start of another fierce debate between optimists and pessimists about technological change.

Erik Brynjolfsson and Andrew McAfee in **THE SECOND MACHINE AGE** offer a bleak view of the impact of digitalization on the future of employment in the United States. Digitization, they suspect, will make workers with ordinary skills increasingly redundant. As tasks from car painting to spreadsheet manipulation are done by computers or robots, highly educated workers who are adaptable and can program and install the robots will become more and more valuable, but other workers who can be replaced will find themselves without jobs unless they accept extremely low salaries. Accordingly, artificial intelligence will be the final nail in the coffin of these ordinary workers.

Survey of recent American business cycles offers yet another perspective. Recent American recoveries have tended to be 'jobless', meaning that labor markets have taken far longer to regain lost ground than has overall production. During the seven recessions from 1948 to 1980, it took an average of about five quarters for GDP to surpass its previous peak. Employment took only a little longer to recover: six quarters on average. From the 1980s onwards, however, the recovery in employment began to lag behind that in in output. Across the four downturns preceding COVID-19 crisis, GDP regained its peak in just six quarters, on average. But employment did not pass its previous high for full fifteen quarters. America was producing more output than it managed before the recessions with fewer workers. Jobs-rich recoveries were productivity-poor ones, and visa versa.

Nick Bostrom calls the third saltation superintelligence in **SUPERINTELLIGENCE: PATHS, DANGERS, STRATEGIES** (Bostrom 2014), Max Tegmark's moniker is life:3.0 in **LIFE 3.0: BEING HUMAN IN THE AGE OF ARTIFICIAL INTELLIGENCE** (Tegmark, 2017). **GOOGLE**'s in house technology guru Ray Kurzweil declares **THE SINGULARITY IS NEAR: WHEN HUMANS TRANSCEND BIOLOGY** (Kurzweil, 2005), and also in **HOW TO CREATE A MIND: THE SECRETS OF HUMAN THOUGHT REVEALED** (Kurzweil, 2013). Ray Kurzweil's notion of singularity, i.e. to the mathematical meaning of the term as a point in time at which a function assumes an infinite value. Kurzweil predicts that, come 2045, machine intelligence will have surpassed human intelligence, what he calls biological and non-biological intelligence will merge, and machine intelligence will fill the universe at infinite speed. Kurzweil explains the many layered process: A hierarchical machine learner will recognize letters at one level, words at another, phrases at another, and on up the scale paragraphs and deeper meanings. **GOOGLE** calls its Go-mastering machine learning division **DEEP LEARNING**. These writings either imply or explicitly posit the arrival of singularity when the contributions of artificial superintelligence will rise to such a level that they will be transformed into an unprecedented runaway process. This implies not only artificial intelligence surpassing any human capabilities imaginable but also coming ever closer to an instantaneous rate of physical change. Kurzweil predicted that as computer power and artificial intelligence expands to the point that it has the capacity to improve itself, computers effectively designing and creating more computers that is, the nature of humanity will irrevocably transcend our biological limitations. Kurzweil's prediction for artificial intelligence taking over is for 2045. In **THE DEEP LEARNING REVOLUTION** (Sejnowski, 2018), Terrence J. Sejnowski gives us a concise history of learning algorithms that extract information from raw data; how information can be used to create knowledge; how knowledge underlies understanding; and how understanding leads to wisdom.

In 1999, Ray Kurzweil launched a hedge fund based on complex mathematical strategies called **FatKat**, short for **FINANCIAL ACCELERATING TRANSACTIONS** from Kurzweil's **ADAPTIVE TECHNOLOGIES**. **FatKat** deployed algorithms to ceaselessly comb through the

market for new opportunities. The algorithms competed against one another in a Darwinian death match. The algorithms that made money survived. The weak died off. Many financial operations mandate making choices based on pre-defined rules. In performing these predefined rules as fast as possible machines were deployed. This is where the bulk of automation has taken place so far, transforming financial markets into ultra-fast hyper-connected networks for exchanging information. High-frequency trading is a prime example. Algorithms developed to model fluctuations in financial markets gained control of those markets, leaving human traders behind.

"The essential tool of econometrics is multivariate linear regression, an 18th century technology that was already mastered by Gauss before 1794. Standard econometric models do not learn. It is hard to believe that something as complex as 21st century finance could be grasped by something as simple as inverting a covariance matrix. …. If the statistical toolbox used to model these observations is linear regression, the researcher will fail to recognize the complexity of the data, and the theories will be awfully simplistic, useless. I have no doubt in my mind, econometrics is a primary reason economics and finance have not experienced meaningful progress over the past decades." writes Marcos Lopez De Prado in **ADVANCES IN FINANCIAL MACHINE LEARNING** (Wiley, 2018). Discretionary portfolio managers, [**PM**s], make investment decisions by consuming raw news and analyses, but mostly rely on their judgement or intuition rationalizing their decisions by some story. There is some story for every decision. Discretionary **PM**s are at a disadvantage when betting against a machine learning, [**ML**], algorithm, but better results are possible by combining **PM**s with **ML**s in "quantamental" way.

"What the Americans termed "artificial intelligence" the British termed "mechanical intelligence", a designation that Alan Turing considered more precise. We began by observing intelligent behavior (such as language, vision, goal seeking, and pattern-recognition) in organisms, and struggled to reproduce this behavior by encoding it into logically deterministic machines. We knew from the beginning that this logical, intelligent behavior evident in organisms was the result of fundamentally statistical, probabilistic processes, but we ignored that (or left the details to the biologists), while building "models" of intelligence – with mixed success. Through large-scale, probabilistic information processing, real progress has been made on some of the problems, such as speech recognition, language translation, protein folding, and stock market prediction – even if for the next millisecond, now enough time to complete a trade. …. The behavior of a search engine, when not actively conducting a search, resembles the activity of a dreaming brain. Associations made while "awake" are retracted and reinforced, while memories gathered while "awake" are replicated and moved around William C. Dement, who helped make the original discovery of what became known as **REM** (rapid eye movement) sleep, did so while investigating newborn infants, who spend much of their time in dreaming sleep. Dement hypothesized that dreaming was an essential step in the initialization of the brain. Eventually, if all goes well, awareness of reality evolves from the internal dream – a state we periodically return to during sleep. "The prime role of 'dreaming sleep' in early life may be in the development of the central nervous system", Dement announced in **SCIENCE** in 1996" (Dyson, 2012).

"Only one-third of a search engine is devoted to fulfilling search requests. The other two-thirds are divided between crawling (sending a host of single-minded digital organisms out to gather information) and indexing (building data structures from the results). The load shifts freely between the archipelagoes of server farms. Twenty-four hours a day, 365 days a year, algorithms with names such as **BigTable**, **MapReduce**, and **Percolator** are systemically converting the numerical address matrix into a content-addressable memory, effecting a transformation that constitutes the largest computation ever undertaken on planet Earth. We see only the surface of a search engine – by entering a search-string and retrieving a list of addresses, with contents, that contain a match. The aggregate of all our random searches for meaningful strings of bits is a continuously upgraded mapping content, meaning, and address space: a Monte Carlo process for indexing the matrix that underlies the World Wide Web. …. The Monte Carlo method was invoked as a means of using statistical probabilistic tools to identify approximate solution to physical problems resistant to analytical approach. Since the underlying physical phenomena actually are probabilistic and statistical, the Monte Carlo approximation is often closer to reality than the analytical solutions that Monte Carlo was originally called upon to approximate" (Dyson, 2012).

The information theory of Kurt Godel, John Von Neumann, Alan Turing, and Claude Shannon tells us that human creations and communications are transmissions across a channel, whether that channel is a wire or the **www** measure the outcome as its "news" or surprise, defined as entropy and consummated as knowledge. Entropy is higher or lower depending on the freedom of choice of the sender. The larger the available alphabet of symbols – that is, the larger the set of possible messages – the greater the composer's choice and the higher the entropy and information of the message. Information is not order but disorder, not the predictable regularity that contains no news, but the unexpected modulation, the surprising bits.

"Claude Shannon used "entropy" to designate information content in a communication channel. More entropy in Shannon's theory signifies more information. In Shannon's terms, entropy is a measure of unexpected bits, the only part of a message that actually bears information. Otherwise the signal is telling you what you already know. To send unexpected bits – a high entropy message – you need a low entropy carries: a predictable vessel for your meaning. You need a blank sheet of paper that does not alter or obscure the message inscribed on it. … In order for the message to be high entropy (full of information), the carrier must be low entropy (empty of information). In the ideal system, the complexity is the message rather than in the medium. … Another word for a low entropy carrier is a dumb network. The dumber the network the more intelligence it can carry." stated George Gilder in **TELECOSM: HOW INFINITE BRANDWIDTH WILL REVOLUTIONIZE OUR WORLD** (Gilder, 2000). Low entropy corresponds to low uncertainty and little information being revealed. When an outcome occurs in a low-entropy system, such as sun rising in the east, we experience little surprise. In high-entropy systems, such as the drawing of numbers in a lottery, the outcomes are uncertain and when realized, they reveal information. We are surprised. Entropy measures the uncertainty associated with a probability distribution over outcomes. It therefore also measures surprise. Entropy differs from variance, which measures the dispersion, but the two differ. Distributions with high uncertainty have nontrivial probabilities over many outcomes. Those outcomes need not have numerical values.

Distributions with high dispersion take on extreme numerical values. Using entropy, we can compare disparate phenomena, and distinguish between 4 classes of outcomes: equilibrium, periodicity, complexity, and randomness.

Equilibrium outcomes have no uncertainty and therefore, have an entropy equal to zero. Cyclic, or periodic processes have low entropy that does not change with time, and perfectly random processes have maximal entropy. Complexity has intermediate entropy. It lies between ordered and random. While entropy provides us a definitive answer in the two extreme cases, equilibrium and random, it does not for cyclic and complex outcomes.

"Information theory provides a measure of the amount of information conveyed by a message. …. This measure is based on the extent of surprise, or unexpectedness of the message to the receiver." (Lev and Gu, 2016) write Baruch Lev and Feng Gu in **THE END OF ACCOUNTING AND THE PATH FORWARD FOR INVESTORS AND MANAGERS** (Lev and Gu, 2016), and add "over the past 60 years, the role of corporate earnings, book values, and other key financial indicators in setting share prices diminished rapidly, and in terms of information timeliness or relevance to investors' decisions, financial report information (not just earnings and book values) is increasingly preempted by more prompt and relevant information sources" (Lev and Gu, 2016). "It is not only fraudulent information (**ENRON**'s; **WORLDCOM**'s) that impedes investment and growth; it's mainly the poor quality of "honest" financial reports, legitimately disclosed under the current, universally used accounting system, that seriously harms the capital allocation system and economic growth" (Lev and Gu, 2016).

But, human creativity and surprise depend upon a matrix of regularities, from the laws of physics to the stability of money and Isaac Newton was the godfather of both. Since these creations and communications can be business plans or experiments, information theory provides the foundation for an economics driven not by equilibrium or order but by falsifiable entrepreneurial surprises. Information theory has impelled the global ascendancy of information technology. From worldwide webs of glass and light to a boom in biotech based on treating life itself as chiefly an information system, a new system of the world is transforming our lives. And, the static neoclassical economic theory is not at all helpful in understanding this transformation, actually a hindrance.

Claude Shannon's breakthrough was mapping electrical circuits to **BOOLE**'s symbolic logic and then explaining how **BOOLEAN** logic could be used to create a working circuit for adding 1s and 0s. Shannon had figured out that computers had two layers: physical [container] and logical [the code]. While Shannon was working to fuse **BOOLEAN** logic onto physical circuits, Turing was testing Leibniz's language translator that could represent all mathematical and scientific knowledge. Alan Turing combined mathematical insight with mathematical theory to give us a principled way of finding computationally complete sets of instructions – sets of instructions that, subject to constraints of memory size, can be sequenced to define any conceivable algorithm. In a similar way, the vast and bewildering array of chemical reactions observed by alchemists became organized and, in principle, predictable once we had Mendeleev's periodic table of the elements and their "valences". The system got synthesized by combining a simple, fixed set of building blocks: rules, axioms, instructions, or elements. Much the same can be said for the five axioms of Euclidean geometry. After two millennia of study, geometers are still discovering new theorems. More prevalent to our current concerns, the "machine code" of a contemporary computer chip usually involves 32 or 64 basic instructions, and a program is simply a sequence of these instructions. Turing aimed to prove what was called the **ENTSCHEIDUNGSPROBLEM**, or "decision problem", that is: no algorithm can exist that determines whether an arbitrary mathematical statement is true or false. The answer would be negative.

Alan Turing was able to prove that no algorithm exists, but as a byproduct, he formulated a mathematical model for an all-purpose computing machine. Alan Turing figured out that a program and data it used could be stored inside a computer. Turing's universal machine intertwined the machine, the program and the data. From a mechanical standpoint, the logic that operated circuits and switches also encoded into the program and data. The container, the program, and data were part of a singular entity. Not unlike humans. We too are containers [our bodies], programs [autonomous cellular functions], and data [our DNA combined with indirect and direct sensory information]. The mind, accordingly, consists of a collection of content-specific information-processing modules adapted to past environments. This was the high point of what is called the **COGNITIVE REVOLUTION**. "Theories of cognition have evolved through multiple stages." writes Gyorgy Buzsaki in **THE BRAIN FROM INSIDE OUT**. "The first was the outside-in, empiricist view, postulating that the brain is an associational representational device that analyzes the world around us and makes judgements. Then came the Pavlovian reflex theory, which did not make much space for cognition; everything was hierarchy of associative reflexes. Similarly, the behaviorist paradigm argued that there is no need to think about cognition as actions can always be explained as a response to immediate external cues. In response to these views, a hard-thinking minority argued that behavior cannot be understood simply as input-output function and activity in the hidden layers of the brain is critical. ….. Humans and likely other animals can imagine into the future and recall the past. ….. The core idea is that cognition depends on prior action-based experiences of the world, which allow internally generated sequences to test 'what if' scenarios and anticipate the possible consequences of alternative actions without actually taking them. This process then helps to select future actions. …… For the brain network, there is no difference between sensory inputs or activity conveyed by the same upstream neuronal group in the absence of external inputs. Without external constraints, disengaged processing in the brain can create an internalized 'virtual world' and new knowledge through vicarious or imagined experience, tested against preexisting and stored knowledge. This process – which most scientists and philosophers would call cognition – provides dramatic advantages in predicting the consequence of actual behavior in complex environments and at long time scales. ….. At times, they are connected to sensory input or motor output, directly or indirectly, and vary their cell assembly contents at the pace of changing sensory inputs. At other times, they rely largely on their internal dynamics, often maintained by brain rhythms" (Oxford University Press, 2019).

Gyorgy Buzsaki has been applying Hebb's ideas about cell assemblies to modern data sets, in particular in terms of fluctuating interactions between networks of cells during brain activity. This has led him to argue for what he called an "inside-out" view of brains, which he sees as systems for taking action, rather than for simply receiving and processing information. The activity of cell assemblies needs to be seen in terms

of their output and its implications for the organism, rather than simply representing the outside world. According to Buzsaki, the brain is not simply passively absorbing stimuli and representing them through neural code, it is actively searching through alternative possibilities to test various options. His conclusion, building on the insights of Helmholtz and Marr, is that the brain does not represent information: it constructs it. However, while this view is welcome recognition that brains are not passive structures, it has yet to be widely accepted.

Though it now owes much to the tragic genius of Alan Turing, with his extraordinary mathematical proof that reasoning could take mechanical form, that it was a form of computation, the **COGNITIVE REVOLUTION** actually began in 1950s with Noam Chomsky. Contrary to Alan Turing's empirical view of the brain as a notebook with lots of blank sheets that sensory experience progressively fills out, Chomsky argued that the universal features of human language, invariant throughout the world, plus the impossibility of a child deducing the rules of language as quickly as it does merely from the scanty examples available to it, must imply that there was something innate about language. Much later Steven Pinker in **THE LANGUAGE INSTINCT: HOW THE MIND CREATES LANGUAGE** (Pinker, 1995) and in **HOW THE MIND WORKS** (Pinker, 1997) dissected "language instinct", the notion that what the mind was equipped with was not innate data but innate ways of processing data.

Bret Stetka in **A HISTORY OF HUMAN BRAIN: FROM THE SEA SPONGE TO CRISPR: HOW OUR BRAIN EVOLVED** elaborates: "Chomsky argues we are born with innate language ability, which arose once in one species. Steven Pinker agrees we have a universal capacity for language, but believes its evolution followed a more gradual Darwinian course, driven by certain key mutations along the way, like those allowing for syntax. There are four laws of behavioral genetics that together describe how genes influence our behavior. The first three are: All human behavioral traits are heritable (affected by genes). The effect of being raised in the same family is smaller than the effect of genes. A substantial portion of the variation in complex human behavioral traits isn't accounted for by the effects of genes or families. In short, they say human behaviors are heritable, but that depending on our upbringing, the environment also shapes the differences between us. …… The fourth law states that most heritable behavioral traits are a result of many genes working together, each with only a very small effect on its own. 'Though a single gene can disrupt a psychological trait, no single gene can install one,' says Pinker. 'This is consistent with the mechanism of natural selection, in which a beneficial ability, because it is statistically rare, is astronomically unlikely to have arisen by a single lucky mutation.' He believes the same explanation goes for language acquisition. …… In 2002, researchers reported on a gene called **FOXP2** that appeared to be Chomsky's language gene" (Stetka, 2021). In **BECOMING HUMAN: A THEORY OF ONTOGENY**, Michael Tomassello disagrees: "All this language learning rests on biologically evolved cognitive and social capacities and is carried out with biologically evolved social learning skills. However, there is much controversy over the nature of humans' biological predispositions for linguistic communication. At the extreme, Chomsky and his followers have maintained that children are born with a kind of innate template that guides language acquisition, a so-called universal grammar, modelled as a quasi-mathematical system. The evolution of its particular structure was a kind of accident, as it has nothing to do with human cognition or communication. The problem is that this proposal is contradicted by cross-linguistic investigations, which do not find any of the kinds of universal structures that universal grammar supposedly makes available to all the world's languages. It is also contradicted by empirical investigations of language acquisition, which have not found the kinds of abstract linguistic representations that universal grammar is supposed to make available to children. Moreover, there are fundamental logical problems of how a child is born with a universal grammar, abstract enough to fit any of the world's 6,000 languages, could actually link its structures to the particular conventions she experiences. At the other extreme, at least since the demise of behaviorism, there have been no serious proposals that children acquire language by the same kind of simple and straightforward learning processes as other animals. Human beings are clearly biologically prepared for special forms of communication, including linguistic communication based on social conventions. The key is that this preparation is not about specific linguistic structures, as the universal grammar hypothesis claims, rather, it is about more general and basic psychological processes that we recruited for this specific task. ….. For this account to work we need a theory of word learning of rich variety that is not based on association learning as employed by animals, but rather is based again in joint attention, communicative intentions, and conventional symbols. And finally, for this account to work we need a theory of acquisition of grammar that is not based in contentless abstract rules, but rather is based in a schema-based notion of linguistic constructions acquired with the same basic cognitive and social processes as all other aspects of conventional linguistic communication" (The President and Fellows of Harvard College, 2019).

Michael Tomasello in **A NATURAL HISTORY OF HUMAN THINKING** adds further, "In general, humans are able to coordinate with others in a way that other primates seemingly are not, to form a 'we' that acts as a kind of plural agent to create everything from a collaborative hunting party to a cultural institution. …. Important aspects of human thinking emanate not from culture and language per se but rather from some deeper and more primitive forms of uniquely human social engagement" (The President and Fellows of Harvard College, 2019) and, Michael Tomasello with Carol Dweck, Joan Silk, Brian Skyrms, and Elizabeth Spelke in **WHY WE COOPERATE** add "There is evidence for at least five cognitive systems in young infants: what I call systems of core knowledge. There are systems for representing and reasoning about (1) inanimate, material objects and their motions, (2) intentional agents, and their goal-directed actions, (3) places in the navigable environment and their geometric relations to one another, (4) sets of objects or events and their relationships of ordering and arithmetic, and (5) social partners who engage with the infant in reciprocal interactions. Each of these cognitive systems emerges early in infancy (in some cases, at birth) and remains present, and essentially unchanged, as children grow. Thus, the systems are universal across our species, despite the many differences in the practices and belief systems of people in different cultural groups. Most important, these core knowledge systems are relatively separate from one another and limited in their domains of application" (MIT, 2009).

Stanislas Dehaene in **HOW WE LEARN: WHY BRAINS LEARN BETTER THAN ANY MACHINE…FOR NOW** (Dehaene, 2020) argues that the basic circuitry is the same in all of us, as is the organization of our learning algorithm, the four pillars of learning - focused attention, active engagement, error feedback and the cycle of daily rehearsal and nightly consolidation – that lie at the foundation of the universal human learning

algorithm present in all our brains, children and adults alike. He adds "by constantly attending to probabilities and uncertainties, it optimizes its ability to learn. During its evolution, our brain seems, to have acquired sophisticated algorithms that constantly keep track of the uncertainty associated with what it has learned – and such a systematic attention to probabilities is, in a precise mathematical sense, the optimal way to make the most of each piece of information" (Dehaene, 2020).

"Our quick review of neuroanatomy and neural dynamics indicates that the brain has special features of organization and functioning that do not seem consistent with the idea that it follows a set of precise instructions or performs computations. We know that the brain is interconnected in a fashion no man-made device yet equals. First, the billions and billions of connections that make up a brain's connections are more exact: If we ask whether the connections are identical in any two brains of the same size, as they would be in computers of the same make, the answer is no. At the finest scale, no two brains are identical, not even those of identical twins. Although the overall pattern of communications of a given brain area is describable in general terms, the microscopic variability of the brain at the finest ramifications of its neurons is enormous, and this variability makes each brain significantly unique. ….. Another organizing principle that emerges from the picture we are building is that in each brain, the consequences of both a developmental history and experiential history are uniquely marked. For example, from one day to the next, some synaptic connections in the same brain are likely not to remain exactly the same, certain cells will have retracted their processes, others will have extended new ones, and certain others will have died, all depending on the particular history of the brain. The individual variability that ensures is not just noise, or error, but can affect the way we remember things and events. ….. If we compare the signals a brain receives with those of computers, we uncover a number of other features that are special to brains. First, the world certainly is not presented to the brain like a piece of computer tape containing an unambiguous series of signals. Nonetheless, the brain enables an animal to sense the environment categorize patterns of a multiplicity of variable signals, and initiate movement. It mediates learning and memory and simultaneously regulates a host of body functions. The ability of the nervous system to carry out perceptual categorization of different signals for sight, sound, and so forth, dividing them into coherent classes without a prearranged code, is certainly special and is still unmatched by computers. ……. The brain contains a special set of nuclei with diffuse projections – the value system – which signal to the entire nervous system the occurrence of a salient event and influence changes in the strength of synapses. Systems with these crucial properties are typically not found in man-made devices yet their importance for learning and adaptive behavior is well documented. ….. Finally, if we consider neural dynamics (the way patterns in the brain change with time), the most striking special feature of the brain of higher vertebrates is the occurrence of a process we have called reentry. Reentry, which depends on the possibility of cycles of signaling in the thalamocortical meshwork and other networks. It is the ongoing, recursive interchange of parallel signals between reciprocally connected areas of the brain, an interchange that continually coordinates the activities of these areas' maps to each other in space and time. …… This synchronous firing of widely dispersed neurons that are connected by reentry is the basis for the integration of perceptual and motor processes." inform Gerald M. Edelman and Giulio Tononi in **CONSCIOUSNESS: HOW MATTER BECOMES IMAGINATION** (Edelman and Tononi, 2000).

Gyorgy Buzsaki further suggests "that brains come with a preexisting dynamic even without prior experience, providing a scaffold that allows it to make guesses about the consequences of that actions of the body it controls and to filter which aspects of the world are worth attending. The brain is not a blank tablet to be filled gradually by the truths of the world but an active explorer with a performed dynamics ready to incorporate events from its points of view. The brain's only job is to assist the survival and prosperity of the body it interacts with, independent of whether, in the process, it learns 'objective reality' of the outside world or not. For the tabula rasa brain, knowledge is synthesized from scratch. For the inside-out model, it is experience that adds meaning to preformed neuronal trajectories and their combinations. …… The nervous system may have evolved to mimic the statistical probabilities of the physical world and thus become an efficient predictor of events. As a result, neurophysiological and perceptual brain dynamics, both spanning several orders of magnitude, share a common mathematical foundation: the log rule" (Oxford University Press, 2019).

Gyorgy Buzsaki sweepingly declares, "We have two brains in our skull or at least two virtual divisions. First, there is the 'good enough' brain. This is largely prewired and acts quickly via a minority of highly active and bursting neurons connected by fast-conducting axons and strong synapses into a network. The good-enough brain judges the events in the world in a fast and efficient way but is not particularly precise. The privileged minority of this virtual division is responsible for perhaps half of the spikers in the brain at any given time and share information among themselves and have faster access to the rest of the brain than remaining majority of neurons. The strongly interactive circuits that form the good-enough brain can generalize across situations but with less than perfect fidelity. In short, 10% or so of the synapses and fast firing neurons in the brain do the heavy lifting at all times. …… To perform better, we also need to deploy the second virtual brain: a large fraction of slow-firing neurons with plastic properties that occupy a large brain volume connected by weaker synapses into a more loosely formed giant network. Their work is absolutely critical for increasing the accuracy of brain performance. Of course, I am not thinking about two discrete brains in one skull, but instead a continuum of a broad distribution of mixed networks that performs apparently different qualitative computations at the left and right tails. This distribution allows the brain to implement anything from preexisting rigid patterns to highly flexible solutions. Thus there is no definable boundary between the 'fast decision, low precision' and 'slow decision, high precision' networks. Brain performance is a tradeoff between speed and accuracy" (Oxford University Press, 2019) Thus provides a neurological explanation of Amos Tversky and Daniel Kahneman's **THINKING, FAST AND SLOW**.

The progress of digital technology is generally associated with Gordon Moore of **MOORE'S LAW** which state that computer processing speeds grow exponentially, doubling every 18 months or so. The one about the growth in data transmission, associated with George Gilder, is called **GILDER'S LAW** which state that the data transmission rates would grow 3 times faster than computer power. Data transmission speeds did grow much faster than processing speeds for few years, but then slowed to about the same pace as Moore's law. The one about the growth

of usefulness of digital networks, associated with Robert Metcalf, is called **METCALF'S LAW** which states that the value of a network grows faster than the number of people connected to it. It grows twice as fast. The outcome is sometimes called **TIPPING-POINT ECONOMICS**. When the size of a thing gets past its tipping-point, it can snowball into something very big, very fast. Thus, it also explains the winner-take-all outcomes seen with on line competition among networks. The one that explains the mind bogging pace of innovation, associated with Hal Varian, is called **VARIAN'S LAW** which state that digital components are free while digital products are highly valuable. Innovation explodes as people try to get rich by working through the nearly infinite combinations of components in search of valuable digital products.

These Laws help to explain why the economy in cyberspace seems to act differently than the economy in real space. **METCALF'S LAW** helps to explain the tendency of virtual economy to act as a winner-take-all contest. The power of networks and the eruptive pace of raw computing and transmission power are not the only thing driving the inhumanly fast pace of digitech. There is something very different about innovation in the digital world compared to the industrial world. The nature of digital innovation is quite different. It is radically faster because the nature of the underlying components is different. It is **DIGITAL COMBINATORIC INNOVATION** that is what Hal Varian calls it. The components are open-source software, protocols, and **APPLICATION PROGRAMMING INTERFACES** [**API**s], all free to copy.

3. Discussıon: how did open, anarchic, decentralized free internet become centralızed profit seeking data monopolıes monetizing data extracted from surveillance? Technofeudalism? Surveillance capitalism?

"The largest industry in the world now is quite literally the attention-seeking industry. Just as in the nineteenth and twentieth centuries the global economy was dominated by natural-resource extraction, today the world's largest companies have grown as large as they have entirely on the promise of providing to their clients the attention, however fleeting, of their billions of users. And these users are, at the same time, being used. One vivid and disconcerting term that has begun circulation in social media to describe anyone who spends time on line is 'data-cow'. The role that users of 'free' on line platforms occupy might sometimes feel creative, or as if it has something in common with traditional work or leisure. But this role sometimes appears closer to that of a domesticated animal that is valuable only to the extent that it has its very self to give. We do not usually provide our bodily fluids, and are not usually asked to do so, though sites such as Ancestry. com do ask for saliva as part of their data-collecting efforts, and health bracelets and other such devices owned by Apple and Amazon are increasingly discovering ways to monitor a number of our vital fluid levels. But even if we are not giving our fluids, we are giving something that has proven more valuable to the new economy than milk ever was in the system of industrial agriculture: information about who we are, what we do, what we think, what we fear. Some of us continue to have old-fashioned careers in the twenty-first century – we are doctors, professors, lawyers, and truck drivers. Yet the main economy is now driven not by what we do, but by the information extracted from us, not by our labor in any established sense, but by our data. This is a revolution at least as massive as the agricultural and industrial revolutions that preceded it. Whatever else happens, it is safe to say that for the rest of all of our lifetimes, we will only be living out the initial turbulence of this entry into a new historical epoch. This then is the first thing that is truly new about the present era: a new sort of exploitation, in which human beings are not only exploited in the use of their labor for extraction of natural resources; rather, their lives are themselves the resource, and they are exploited in its extraction." observes Justin E. H. Smith in **THE INTERNET IS NOT WHAT YOU THINK IT IS: A HISTORY, A PHILOSOPHY, A WARNING** (Smith, 2022 pp. 14-15).

A brief history of the institutionalization of deception is pertinent in understanding the prevalence of propaganda by the state to manage political choices of the voters and advertising by the profit seeking private companies to manage consumers' choices. "'Guided democracy' was first formulated in the 1920s by the American journalist Walter Lippmann, the leading media theorist and one of the most influential intellectuals of his time. …… Lippmann was of the opinion that in a modern democracy there are two kinds of people. On the one hand, there is the 'bewildered herd', whose unqualified opinions are based on short-sighted self-interests. The complexity of modern societies is too much for them to cope with, so their participation in political life must be limited to choosing every four years between two competing factions of the 'specialized class'. The 'specialized class' on the other hand, are the only ones who know to control the complexities of the Megamachine in the interests of the general public. For this reason, it is necessary for the experts to steer the herd by specifically influencing public opinion, which Lippmann called the 'manufacture of consent". …… Lippmann's views are in line with those of Madison and most other American founding fathers. His thoughts were further developed by Edward Bernays, who is considered the founder of public relations along with Ivy Lee. Bernays, a nephew of Sigmund Freud, used his uncle's theories about the unconscious in order to influence the wishes, feelings and thoughts of crowds. He wrote in the introduction to his 1928 book **PROPAGANDA**: 'The conscious and intelligent manipulation of the organized habits and opinions of the masses is an important element in democratic society. Those who manipulate this unseen mechanism of society constitute an invisible government which is the true power of our country. We are governed, our minds are molded, our tastes formed, our ideas suggested, largely by men we have never heard of.' What Bernays wrote sounds like a full-fledged conspiracy theory with dark figures pulling the strings that society dances to." is Fabian Scheidler's concise reminisces in **THE END OF THE MEGAMACHINE: A BRIEF HISTORY OF A FAILING CIVILIZATION** (Zero Books, 2020).

"Cambridge Analytica is the American brand of the English-based Strategic Communication Laboratories (SCL) group also the most widely-publicized analytics firm for their utilization of Big Data. Although just a small and typical Big Data operation, they are the most infamous firm of their kind as a consequence of their role in the U.S. 2016 presidential election. Politics is irrelevant to the analysis of this event: Instead, it is significant as proof that human behavior is reducible to bits. ……. CA is an analytics company that worked to maximize the effectiveness of online advertisements. Its data collection consisted of demographic data (race, gender, age, income, geographic features, etc.) and psychographic data

(advertising resonance, life style data, consumer confidence, etc.), amounting to as many as 5,000 data points on 220million Americans. With a sample size somewhere in the millions, data was collected with online quizzes measuring levels of what behavioral psychologists call the big five personality traits: Openness, Conscientiousness, Extroversion, Agreeableness, and Neuroticism (OCEAN). Cross-referencing the resulting behavioral data with that of social networking sites (SNS) provided the algorithmic precondition for personality blueprints from SNS data alone.

In other words, someone who took the personality test that was high in agreeableness will have measurably different clicking patterns than someone who was scored as disagreeable. This was done with individual traits, but with the unique combinations formed from all five. After analyzing thousands of the test-takers and their on line activity, every clicking behavior could be accurately linked to personality traits. You no longer need to take a personality test for companies to understand you: Just browsing the web is sufficient. Personality profiling results were then used to connect offline data with the cookies of different sites to deliver individualized ads." informs Evan McFarland in **BLOCKCHAIN WARS: THE FUTURE OF BIG TECH MONOPOLIES AND THE BLOCKCHAIN INTERNET** (McFarland, 2021).

Vaclav Smil in **INVENTION AND INNOVATIN: A BRIEF HISTORY OF HYPE AND FAILURE** provides another genesis of deception, "On August 12, 2013, Elon Musk, at the time the chairman of TESLA, released his Hyperloop Alpha Paper. At its very beginning, when outlining the background of the idea, he asked whether there was "a truly new mode of transport- fifth mode after planes, trains, cars and boats"- that would be safer, faster, costs less, and be more convenient while being immune to weather, sustainability, self-powering, resistant to earthquakes, and not disruptive to people living along its route. …… Unfortunately, none of these have panned out." ……. The historical record shows that there is nothing new about any of these ideas, that the basic concept for the fifth mode of transportation has been around for more than two hundred years, and that during the intervening time various patents were filed, several detailed proposals were made, and some models and muck-ups of specific components were built. And yet not a single (near) vacuum- or low-pressure-tube, superfast transportation project (be it for people or goods, or both) has been completed and put into operation, not even a trial short-distance link encompassing all of the design's basic components." (The MIT Press, 2023) and, adds: "In 2008, 49 percent of America's electricity was generated by coal combustion, 20 percent by natural gas, about 20 percent by nuclear fission, and 6 percent by hydroelectricity; the rest was produced from fuel oil, wind, and geothermal energy. …….. This means that an all-electric national fleet would offer no overall primary energy savings and no carbon emissions advantage compared to the alternatives of a highly efficient gasoline-car fleet or the large-scale adoption of hybrid vehicles – unless, of course, all electricity consumed by all electric vehicles were generated by renewable conversions rather than by the current mix of generation relying on coal, natural gas, nuclear fission, and water power." in **ENERGY MYTHS AND REALITIES: BRINGING SCIENCE TO THE ENERGY POLICY DEBATE** (The American Enterprise Institute for Public Policy Research, 2010).

"The **WWW** is a network whose nodes are documents and whose links are the URLs that allow us to "stuff" with a click from one web document to another. With an estimated size of over one trillion documents (N=10 to 12^{th} power), the Web is the largest network humanity has ever built. It exceeds in size even the human brain (N=10 to 11^{th} power neurons). It is difficult to overstate the importance of the **WWW** in our daily life. Similarly, we cannot exaggerate the role the **WWW** played in the development of network theory: it facilitated the discovery of a number of fundamental network characteristics and became a standard testbed for most network measures.", informs Albert-Laslo Barabasi in **NETWORK SCIENCE** (Cambridge University Press, 2016 p.113) In **INFORMATION RULES: A STRATEGIC GUIDE TO NETWORK ECONOMY** (Shapiro and Varian, 1999), Carl Shapiro and Hal Varian popularized the term **NETWORK EFFECT** which came to mean that in digital world size easily begets size. Hal Varian has been described as the Adam Smith of the discipline of **GOOGLENOMICS** and the godfather of **GOOGLE**'s advertising model.

"To understand what networks really are and how they 'behave', we have to realize that they have particular structural properties. These can be summarized in a number of 'laws' of the Web. They are not some kind of natural laws. These are defining and enabling conditions that exert pressure on human behavior in networks, but that can also be changed, as usually happens to structures according to structuration theory. Understanding these 'laws' helps to explain things we can observe on the Web and it assists in finding mechanisms to intervene in the network structures concerned. Seven laws that summarize a large part of the general theoretical argument are: the law of network articulation [In the network society, the social relations are gaining influence as compared to social units they are linking.]; the law of network externality [Networks have effects on things/people external to the network. The more people participate in a network the more others are likely to join. There is a pressure to connect.]; the law of network extension [When networks such as the Web grow, they tend to become too big. Network units lose oversight and do not reach each other anymore. To solve this problem intermediaries, such as search engines, portals, and social networking sites are necessary.]; the law of small worlds [In large-scale networks, most units are not neighbours, but still can reach almost every other unit in a few steps (six degrees of separation) creating a small world. Explanation: units are grouped in clusters with strong ties, and they reach people in other clusters by long-distance and often weak ties. Taking these steps, the influence of people by contagion reaches three degrees.]; the law of the limits to attention [As everybody in a network is able, in principle, to connect and communicate to everyone else in the network, there is a limit to attention because the time to read, listen, or view for receivers runs out. The more people write/produce content on the Web, the smaller on average their audiences become.]; the power law in networks [In large, scale-free networks those units already having many links acquire even more, while most units keep only a few links. The mechanisms are a continuous growth of links, preferential attachment and social contagion.]; the law of trend amplification [Networks are relational structures that tend to amplify existing social and structural trends. When technologies such as ICT networks and computers are used, they serve as reinforcing tools.]", informs Jan van Dijk in **THE NETWORK SOCIETY** (Jan van Dijk, 2012 pp.37-42).

Jack Goldsmith and Tim Wu in **WHO CONTROLS THE INTERNET: ILLUSIONS OF A BORDERLESS WORLD** (Oxford University Press, 2008) tells the story of the death of the dream of self-governing cyber-communities that would escape geography forever, and also tells the story of

the birth and early years of a new kind of **INTERNET**, a bordered network where territorial law, government power, and international relations matter as much as technological invention. As China and America wall off their respective digital markets from one another, each are looking for growth in the rest of the world. A divided world wide web or **SPLINTERNET** is already a reality, as China's internet grows behind a great firewall of censorship. **AMAZON** is promoting payment services in India. China's **ALIPAY** service is active in Brazil.

The **INTERNET** has become a new kind of battleground for the world's great powers. No longer a single entity, the **INTERNET** is becoming a **SPLINTERNET** as the Unites States and China fight to control the way in which it will be run and regulated, as part of a larger rivalry to control high-growth high-tech industries. Both rivals are increasingly nationalistic, supporting their own home grown companies in an effort to win the tech cold war by ring-fencing some of their supply chains to prepare themselves for a long-term tech and trade war. Emphasizing the organization and the relation of elements entails less attention to the elements and units themselves. The characteristics of units and elements among them human individuals, and the way they are made up, are not the focus of attention. Instead every network approach in the natural and social sciences stresses the relations of elements. It is opposed to atomistic views of reality and methodological individualism of orthodox economic theory which measures social reality by adding individual attributes. Hence, orthodox economic theory is not useful, actually distorting understanding of networks.

ARPANET, funded by Pentagon, was the brainchild of Paul Baran of the **RAND CORPORATION** who relied on the idea called packet switching. Baran's main goal was to develop something that would survive a Soviet first strike and still transmit messages to missile bases to retaliate. Hence the decentralized nature of the network. The **INTERNET** is more than packet switching. It requires computers, communications, all sorts of software and other protocols, many of which the government-funded research projects bought from the private sector. The **ARPANET** was effectively privatized in the 1990s.

Paul Baran for packet switching, Vint Cerf for writing **TCP/IP** protocols that proved crucial in allowing different programs to run on the **INTERNET**, and Sir Tim Berners Lee for developing the worldwide web were instrumental in the emergence of an open means of connecting computers to each other so that people could see what was on other nodes than their own hard drive.

To understand the internet's recent history, it helps to keep in mind that like most digital systems, it is designed in layers. At the bottom are all the protocols that allow different sorts of networks and devices to exchange information, or **INTERNETWORK**; hence **INTERNET**. At that level, it is still largely decentralized. No single company controls these protocols, although the number of firms providing internet access has dropped sharply. The **INTERNET**'s base was designed to move data around and publish information, so its protocols did not record what had been transmitted previously by whom.

The **INTERNET** was built without memory. The **INTERNET**'s arrival seemed to herald a new way of ordering human affairs that would free us from the tyranny of territorial rule. Self-governing cyber-communities would escape geography forever. It was to rely in open source, peer-to-peer networking. The **INTERNET** was created by, and continues to be shaped by, decentralized groups of scientists and programmers and hobbyists freely sharing the fruits of their intellectual labor with the world. **OPEN-SOURCE** collaborative network created a very large portion of the lines of code on which the **INTERNET** depends, and not just the **INTERNET**, but smartphones, stock markets, and airplanes. But the last decade has shown that national governments have an array of techniques for controlling offshore **INTERNET** communications, thus enforcing their laws, by exercising coercion within their borders.

"Now a forgotten company, subsumed into Verizon's vast telecom empire, UUNET is worth recalling because, in addition to illustrating the power law, it illuminates two features of venture investing. First, it showcases the distinct roles of government-backed science and Venture-capital-backed entrepreneurs in driving technological progress. Second, it demonstrates a paradox at the heart of venture capital's impact on society. Venture Capital [**VC**] as individuals can stumble sideways into lucky fortunes: chance and serendipity and the mere fact of being in the venture game can matter more than diligence or foresight. At the same time, venture capital as a system is a formidable engine of progress - more so than is frequently acknowledged. UUNET began life in 1987 as an obscure Northern Virginia nonprofit. It mission was to address the central limitation of the INTERNET as it existed then: only around 100,000 computers were connected to it. Having started out as a military communications system funded by the pentagon, the internet had become an email, bulletin board, and a file-sharing platform for scientists at government labs, including government-backed ones at universities. Private companies and individuals were barred from the network, and commercial activity prohibited. But by the late 1980s, a growing community of nongovernment scientists wanted a similar utility. Armed with $250,000 loan guarantee from a loose association of programmers, UUNET set out to be their internet service provider. UUNET's founder was Rick Adams an engineer who worked for the government's CENTER FOR SEISMIC STUDIES. Still holding down his government job, Adams worked part time on the rudiments of a parallel internet for private-sector scientists who were excluded from the main one. Typically, major private corporations had linked up their employees via local area networks, but sending messages from one corporation to another was horribly expensive. Adams combined CISCO routers and networking software to build cheaper connections. He charged for the service but only enough to recover costs. At first, almost nobody noticed. The INTERNET had always been a government project. Most people assumed that if anyone was going to bring online connections to the masses, it would be the government, again, in July 1990 a young Tennessee senator named Al Gore laid out a public sector vision for an 'information superhighway'. Rather than operating on the existing telephone lines, as the INTERNET did, Gore's superhighway envisioned brad-new fiber-optic pipes would turn household TVs into interactive terminals. The jump to fiber optics would allow information and entertainment to reach American household in dazzling Technicolor, replacing the INTERNET's drab bulletin boards. Initially, the flashy superhighway plan generated broad excitement. In 1991, Gore championed a $1.74billion government spending. ….. Scientists at corporate labs began flocking to UUNET, which finding itself awash with revenue, gave up its non-profit status. Then, acknowledging the progress of UUNET and one or two smaller rivals, the NATIONAL SCIENCE FOUNDATION [NSF]announced a policy reversal.

Rather than trying to keep private users off the government network, it would invite internet service providers into the tent; in fact, it would let them take over its management. The government had invented the INTERNET, to be sure. But as far as the NATIONAL SCIENCE FOUNDATION was concerned, the job of turning the INTERNET into a mass medium that democratized information and changed lives was best entrusted to the private sector. Gore's government-led fiber-optic superhighway was still dominating headlines, But the way Mitch Kapor saw things, it would be prohibitively disruptive and expensive. Rather than ripping up the ground to lay fiber-optic cable, it would be cheaper by far to build out the copper-wire-based internet. Responding to insatiable customer demand, not political edict, UUNET was already grafting routers and servers into the existing phone networks, turning voice lines into data lines, and now the NSF's privatization announcement opened the way to even faster progress. As a way of getting millions of users online, this market-led movement would eclipse Gore's grandiose project. Kapor, the first investor to back UUNET, had passed the baton to Arthur Patterson at ACCEL. In turn, Patterson had passed it to Peter Barris, who, because of his East Coast base, would be the most hands-on of the three venture backers." explains Sebastian Mallaby in **THE POWER LAW: VENTURE CAPITAL AND THE MAKING OF THE NEW FUTURE** how the **UUNET** version of information future trumped that of the US vice-president. [Mallaby, 2022 pp. 132-134]

"Tim Berners-Lee, a creator of the web, thinks the **INTERNET** itself is dying. In 2014 the web took a very dark turn. Beforehand, traffic to websites came from many places and the web was a lively ecosystem. But starting in 2014, over half of all traffic started coming from **FACEBOOK** and **GOOGLE**. Five years later, over 70% of traffic was dominated by these two sources" (Tepper and Hearn, 2019). "The **INTERNET** was meant to be open, anarchic, decentralized, and above all free. In the 1990s, **AMERICA ON LINE** helped people get online and discover content. It was a walled garden. **AOL** determined and curated the user experience, which was contrary to the spirit of the web. Once users started going online with their local cable company, **GOOGLE** helped them find anything on the web, most consumers did not go back to **AOL**. **FACEBOOK** has become **AOL 2.0**, a centrally designed internet for its users. You discover only what the company wants. It is as restraining as **AOL** with a lock on user's life history, photos, friends, and family connections. Countless articles and videos appear only behind **FACEBOOK**'s guarded gate. **FACEBOOK** has become a digital passport, and many apps and sites will not let a user join without a **FACEBOOK** account." (Teeper and Hearn 2019). "There is now a vast imbalance of power between individuals and private companies. The web is no longer free when two companies control most of the traffic. …. Faced with a closed web controlled by two private companies, users are demanding that **FACEBOOK** and **GOOGLE** fix themselves. As Matt Taibbi has succinctly put it, 'For **GOOGLE** and **FACEBOOK** to be the cause of and the solution to problems tells you how irrelevant governments and regulators have become" (Tepper and Hearn, 2019). **INTERNET** has split apart and is becoming bordered. Far from flattening the world, the **INTERNET**, its language, its content, its norms, is conforming to local conditions. The result is an **INTERNET** that differs among nations and regions that are increasingly separated by walls of bandwidth, language, and filters. This bordered **INTERNET** reflects top-down pressures from governments that are imposing national laws on the **INTERNET** within their borders. It also reflects bottom-up pressures from individuals in different places who demand an **INTERNET** that corresponds to local preferences, and from the web page operators and other content providers who shape the **INTERNET** experience to satisfy these demands.

The **INTERNET**'s design was not the result of some grand theory or vision that emerged fully formed. Rather, open design of the **INTERNET** was necessitated by the particularities of the specific engineering challenges. The **INTERNET**'s creators, mainly academics operating within and outside the government, lacked the power or ambition to create an information empire. They faced a world in which the wires were owned by **AT&T** and computing power was a patchwork of fiefdoms centered on the mainframe computers, each with idiosyncratic protocols and systems. The construction and maintenance of networks were and are tasks largely performed or contracted out by network operators and carriers. The network operators and carriers serve as gatekeepers for networks. Telephone operators, Internet platforms, Internet service providers and broadcasting operators largely decide who and what has access to networks and how expensive particular applications on networks are. "In the last three decades, the world market for telecommunications and computer network equipment has been controlled by 10 companies. Important names in this content are **HUAWEI**, **CISCO SYSTEMS**, **ALCATEL-LUCENT** (**NOKIA**), **FUJITSU**, and **ERICSSON** in 2020. These companies involved have to make extraordinarily capital-intensive investments and they have extremely high research and development costs. Therefore, high turnovers and profits are required. This is a problem because profit margins on hardware are much lower than those on software and services in the information and network economy. Usually they are less than 2% or 3% of total revenue. Considering the production of terminal equipment (telephones, computers, modems, decoders, radios, and televisions), big companies are also on the rise, and for the same reasons: low profit margins. The giants of computer equipment manufacturing in 2020 are **LENEVO**, **HP**, **APPLE**, **DELL**, **SAMSUNG**, **ACER**, and **ASUS**. Four of the are East Asian and three are American." (van Dijk, 2020).

Successful implementation of **WASHINGTON CONCENSUS** in 1980s and 1990s privatized big national public monopolies in telephony and broadcasting and split them into parts with different functions, such as a carrier or a content provider. "However, after 2000, a second trend of monopolization in the form of oligopolization recurred in the private sector. The trend in operating and carrying telephony and broadcasting has gone from public monopolies to private oligopolies. Public monopolies acted on a national scale. Contemporary private oligopolies increasingly operate on an international level. In fixed telephony, they are companies such as **AT&T**, **CHINA TELECOM**, **NTT**, **VERIZON**, **DEUTSCHE TELECOM**, and **TELEPHONICA**. In mobile telephony, they are among others **CHINA MOBILE**, **AIRTEL** (India), **VODAFONE** (UK), **TELEFONICA** (Spain), and **AXIETA** (Malasia). In broadcasting companies such as **TIME WARNER**, **NEWS CORPORATION** (Murdoch), **BERTELSMANN**, **CANAL+**, **UPC** (Liberty Global) and **MICROSOFT NBC** dominate the international market. There are no complete monopolies in telephony and broadcasting – basically, there is competition – but companies can split the world market among themselves, fix prices and benefit from international regulations on standardization and interconnectivity. Increasingly, large international telephone and broadcasting companies cooperate and merge. A handful of conglomerates are preparing to divide the world market. The final result will be a replacement

of a national government-controlled public monopoly without competition by a small number of international private oligopolies with limited competition and scarcely any public responsibility. Operators and providers on the Internet are either concentrated and big or fragmented and small. The internet platforms, increasingly the core of all network producers have become oligopolies right from the beginning. They are the Big Five American platforms – **APPLE**, **AMAZON**, **ALPHABET** (**GOOGLE**), **MICROSOFT**, **FACEBOOK** and the giant Chinese platforms – **ALIBABA** and **JINGDONG** for e-commerce, **TENCENT** for communication and **BAIDU** as search engine. Platforms from other countries are much smaller. The data companies and cloud computing services are also concentrated. There is a close relation with the Internet platforms. The biggest in 2020 are **AMAZON WEB SERVICES**, **MICROSOFT, GOOGLE** and **ORACLE**. Instead, at the start, the Internet providers were relatively small and fragmented on a local scale. There were countless **INTERNET SERVICE PROVIDERS** [**ISP**s] in the world. After some time, they also merged with privatized national telephone carriers and big private carriers" (van Dijk, 2020).

Internet works over an infrastructure that does not belong to those using it. The owner is always someone else, and in the 1970s, it was generally **AT&T** in the United States. It was designed to link human brains, but it had no control over their activities than that. Egalitarianism born of necessity would persist as the network grew over decades to include everyone.

The concept of **ENCAPSULATION** was how a network interconnected with other networks. It means wrapping information from local networks in an envelope that **INTERNETWORK** could recognize and direct. In what would come to be known as **TRANSMISSION CONTROL PROTOCOL** [**TCP**] created a standard for the size and flow rate of data packets, thereby furnishing computer users with a **LINGUA FRANCO** [**ESPERANTO**] that could work among all networks. As a practical matter, this innovation would allow the **INTERNET** to run on any infrastructure, and carry any application, it packets traveling any type of wire or radio broadcast, even those owned by an entity as given to strict controls as **AT&T**.

It was an electronic information network independent of the physical infrastructure over which it ran. The invention of **ENCAPSULATION** permitted the layered structure of the **INTERNET**, whereby communications functions are segregated allowing the network to negotiate the differing technical standards of various devices, media, and applications. This was also born of necessity to link different types of networks by inventing a protocol that took account of the existence of many networks over which the creators had limited power.

TRANSMISSION CONTROL PROTOCOL/INTERNET PROTOCOL [**TCP/IP**] and other aspects of the **INTERNET**'s architecture rested on the founders' beliefs about networks. In technical jargon, they created a network with **OPEN ARCHITECTURE**, or **END-TO-END DESIGN**. In non-technical terms, the founders embraced a design that distrusted centralized control. In effect, they built strains of American liberalism, and even 1960s idealism, into the universal language of **INTERNET**. The **INTERNET**'s design was open, minimalist and neutral. It was open, because it was willing to accept almost any kind of computer network to join in one universal network-of-networks. It was minimalist, because it required very little of the computers that wanted to join in. Finally, it was neutral between applications.

The concept of network neutrality grew out of the **END-TO-END DESIGN** structure of the **INTERNET**, which favored the users rather than the network providers. While users pay for **INTERNET** connection, and the price they pay can depend on the speed or quality provided by their **INTERNET** service provider, once connected, their transmitted packets are treated the same way everyone else's by the network providers. Network providers are trying to secure control of information exchanged over the **INTERNET** for commercial gain. Proponents of network neutrality argue that the network should remain "stupid", thereby allowing end users to collaborate and innovate by developing their own applications. This **DISTRIBUTED INTELLIGENCE** that makes the **INTERNET** such a unique communications medium. The governments and the network providers feel differently. In 2011, Russia, Uzbekistan, Tajikistan and China submitted a proposal to the United Nations General Assembly calling for an international code of conduct for the information society. The preamble to the proposal states that "policy authority for **INTERNET** related public issues is the sovereign right of states." As of 2019, nations pushing for new forms of government control increased to include India, Brazil, South Africa and Saudi Arabia.

The **INTERNET** plays a central role in the American economy as it does in the Chinese. But there is a profound flaw in its architecture. Its software stack lacks a trust and transactions capability. Its **OPEN SYSTEM INTERCONNECTIONS** [**OSI**] model defines seven layers. While some of the layers have merged, none of the existing layers provide trust or validation or factuality or veracity of real monetary values. Perhaps, that abides well with the theoretical mainframe of the MBA programs: the money neutral neoliberal economic theory.

The original distributed **INTERNET** architecture sufficed when everything was "free", as the **INTERNET** was not a vehicle for transactions. When all it was doing was displaying **WEB** pages, transmitting emails, running discussions forums and news groups, and hyperlinking academic sites. The **NET** did not absolutely need a foundation of security. But when the **INTERNET** became a forum for monetary transactions, new security regimes became indispensable. The groups which developed the original protocols, the **INTERNET ENGINEERING TASK FORCE** and the **WORLD WIDE WEB** could have added security regimes to the rule book. But they did so, only belatedly. Perhaps, one reason was that many internet pioneers believed that the protocols would have been enough to prevent centralization. They were proven wrong.

To understand the contemporary **INTERNET**, one needs to start with **STACK**s which imitate hardware and transcend it in virtual threads and cores and chains. The seven-layer **NETPLEX** scheme of the **OPEN SYSTEMS INTERCONNECTION** model of the **INTERNATIONAL STANDARDS ORGANIZATION** consists of a hierarchical stack in which lower functions are controlled by higher functions. At the bottom is the physical layer, the fiber-optic lines, microwave oscillators, mixers, 1550 and 900-nanometer lasers, photodetectors, silicon routers, erbium-doped amplifiers, and twisted-pair telephone wires, antennas, coaxial cables – the list is endless – that carry the data packets across the network at the behest of the layers above it.

In **OSI** stack, above the physical layer is the **DATALINK**. This is the medium where hardware becomes "firmware" and software that define the electrical specifications, timing rules, and electron-photon conversions that enable the transmission of information across a link from one

node or computational address to the next. **SWITCHES** operate at level two, passing packets only to the next node. Local area networks such as **ETHERNET** or **WiFi** function at this level. The third layer is the **NETWORK** layer, the domain of routers, which combines with the transport layer [layer four] to establish the end-to-end links that constitute the **TPC/IP INTERNET PROTOCOLS**. This is the entire system of **IP** addresses and **TRANSPORT CONTROL PROTOCOL** traffic shuffles that comprises the connections from end to end across the **NET**.

Layer three does the headers on the packets, the identities and addresses. Layer four does the actual transmission and reception of data packets and traffic management, load balancing and **ACKS** [**I got it!**] and **NACKS** [**I'm still waiting**] that assure connections. Layers three and four tend to be the bastion of central powers, where governments and their intelligence arms chase down domain names and addresses. Layer five governs a particular two-way communication from beginning to end, whether a video stream, a **SKYPE** call, a **SESSION INITIATION PROTOCOL** conference, a messaging exchange, an email post, or a transaction. Layers six and seven are the schemes for presentations and applications – user interfaces, windows, formats, operating systems. These are summed up in schemes of hyperlinks. The 70% of all links came to be handled through **GOOGLE** and **FACEBOOK**, major walled gardens. The **INTERNET** needs a new payment method that conforms to the shape and reach of global networking and commerce. It is to obviate the constant exchange of floating currencies, more volatile than the global economy that they supposedly measure. The new system should be distributed as far as **INTERNET** devices are distributed: a dispersed heterarchy based on peer-to-peer links between users rather than a centralized hierarchy based on national financial institutions. It is invented and called **BITCOIN BLOCKCHAIN**. " Blockchain is just a fancy database, even though it is now often used to refer to much more than that. …… The governing technology behind Bitcoin is cryptography, the mathematical framework that allows blockchain's network consensus to be achieved in a decentralized and pseudonymous manner, and is nothing new. Cryptography long predates the Internet, and its application to currency is nothing extraordinary: About 100 notable cryptographic payment systems were attempted in the 20 years before Bitcoin came out in 2008. Bitcoin's decentralized network concept is nothing new either: Platforms such as Napster, BitTorrent, and Grokster enabled anonymous P2P data transfer with far more usability than blockchain-based equivalents. Using encryption techniques for online anonymity is also not unique to blockchain and has already been made surprisingly easy with standards such as Tor. …… The internet now has a centralized and capitalistic business model based on advertisements and subscriptions. ……. Being the first bclockchain, Bitcoin is a terrible poster child for the technology. Bitcoin is not user friendly. It's slow, inefficient, and expensive, which only gets worse as the network grows." writes Evan McFarland in **BLOCKCHAIN WARS: THE FUTURE OF BIG TECH MONOPOLIES AND THE BLOSKCHAIN INTERNET** (McFarland, 2021).

Don Tapscott and Alex Tapscott offer a nuanced view: "Bitcoin or other digital currency isn't saved in a file somewhere, it's represented by transactions recorded in a blockchain – kind of like a global spreadsheet or ledger, which leverages the resources of a large peer-to-peer bitcoin network to verify and approve each nitcoin transaction. Each blockchain, like the one that uses bitcoin, is distributed: it runs on computers provided by volunteers around the world, there is no central database to hack. The blockchain is public: anyone can view it at any time because it resides on the network, not within a single institution charged with auditing transactions and keeping records. And the blockchain is encrypted: it uses heavy-duty encryption involving public and private keys (rather like the two-key system to access a safety deposit box) to maintain virtual security. ….. Every ten minutes, like the heartbeat of the bitcoin network, all transactions conducted are verified, cleared, and stored in a block which is linked to the preceding block, thereby creating a chain. Each block must refer to the preceding block to be valid. This structure permanently time-stamps and stores exchanges of value, preventing anyone from altering the ledger. ….. Like the World Wide Web of information, it's the World Wide Ledger of value – a distributed ledger that everyone can download and run on their personal computer. ……. The financial services industry has already rebranded and privatized blockchain technology, referring to it as distributed ledger technology, in an attempt to reconcile the best of bitcoin – security, speed, and cost – with an entirely closed system that requires a bank or financial institution's permission to use. To them, blockchains are more reliable databases than they already have, databases that enable key stakeholders – buyers, sellers, custodians, and regulators – to keep shared, indelible records, thereby reducing cost, mitigating settlement risk, and eliminating central points of failure." (Tapscott and Tapscott, 2016).

On top of the existing seven layers of **INTERNET** infrastructure, the **BITCOIN** ledger builds a new layer of functionality – layer 8 – just as hypertext transfer protocol [http] builds network layer on the **TRANSMISSION CONTROL PROTOCOL /INTERNET PROTOCOL** [**TCP/IP**] network layer. This new transactions layer allows for the separation of the security and identification functions from the network. Based on new breakthroughs in information theory, security can be heterarchical rather than hierarchical – distributed on millions of provably safe devices beyond the network and unreachable from it. It is a security paradigm diametrically opposed to existing morass of passwords, usernames, **PINS**, personal tokens, and post-hack fixes on the network. In a **BITCOIN** transaction, there is no more need for the disclosure of personal information than in cash transactions. "From 1988 to 2016, the American top 1% of people went from controlling just under 30% of the wealth to 39% while the bottom 90% went from holding 33% to less than 23% of the wealth. It is no coincidence that the five largest companies in the S&P 500 by market capitalization are Facebook, Apple, Amazon, Microsoft, and Google (FAAMG). They remain immune to crisis: As the COVID-19 pandemic destroys entire industries, Big Tech continues to see rapid growth in wealth and power. FAAMG is the top 1% of the global wealth Pareto distribution, the steepest corporate Pareto distribution in history. ……. Before the year 2000, people could create and run software but had no easy way to succeed on the Internet.

The Cloud solved this problem by providing computational power, storage, and a place to host software. This opened a new doorway for data sharing and is the bedrock of the Internet today. It also stripped users and developers of ay power they might have had. This kick-started a positive feedback loop, funneling all the Internet's leverage into today's cloud giants. …. Beyond size and control. FAAMG wins by optimizing technology and minimizing overhead better than anyone. Their software can be copied virtually for free, and it scales to infinity. Customers do the work to improve existing systems by providing their data. Digital labor theory validates the idea that users can inadvertently act as workers,

especially in social media. FAAMG users are the product, not the customer. The economic proof is apparent when comparing annual economic value per worker in traditional companies to tech titans, such as GM and Facebook: Economic value is $231,000 per GM employee and is $20.5million per Facebook employee" (McFarland, 2021).

With the ascendancy of **AMAZON**, **APPLE** and other on line emporia early in the 21st century, much of the **INTERNET** was occupied with transactions, and the industry retreated to the **CLOUD**. Abandoning the distributed **INTERNET** architecture, the leading Silicon Valley entrepreneurs replaced it with centralized and segmented subscription systems, such as **PAYPAL**, **AMAZON**, **APPLE**'s **iTUNES**, **FACEBOOK**, and **GOOGLE**'s **CLOUD. UBER**, **Airbnb**, and other **UNICORNS** followed. These centralized fortresses violate the **COASE THEOREM OF CORPORATE REACH**. "Business should internalize transactions only to the point that the costs of finding and contracting with outside parties exceed the inefficiencies incurred by the absence of real prices, internal markets, and economies of scale.", states the theorem. The industry sought safety in centralization, but centralization is not safe. It turned out to be.

Distributed organizations are as old as the **INTERNET**. Its first users some 50 years ago realized how much can be done by swapping emails and digital files. These exchanges led to the development of **OPEN SOURCE**. Software, jointly written by groups of strangers geographically distant. Today, most distributed startups have **OPEN SOURCE** roots, **GATSBY** is one. Nearly all 1200 employees of **AUTOMATTIC**, best known for **WordPress**, software to build websites, work from home. **GitHub**, which hosts millions of **OPEN SOURCE** products that was acquired by **MICROSOFT** in 2018 may be the world's biggest distributed enterprise. Two thirds of 2000 staff work remotely. Most firms that build blockchains, a type of distributed database, are by their nature dispersed.

Joel Gascoigne, the director of **BUFFER**, which helps customers manage social-media accounts, works remotely from Boulder, Colorado. **STRIPE**, an online-payment firm, has its headquarters in San Francisco and its engineering hub is a collection of remote workers. **d:code:it**, a Fin-Tech, has its head office in London and its design studio in Vienna. Distributed startups exist because of a panoply of digital tools, most obviously corporate-messaging services such as **SLACK** [chat] and **ZOOM** [videoconferencing] as lesser known firms like **MIRO** [virtual whiteboards for brainstorming] or **DONUT**, which pair employees to forge personal bonds. Others like **PROCESS STREET**, **CONFLUENCE** or **TRELLO**, help manage work flow and keep track of what goes on in virtual corridors, crucial when people do not share the same physical space. Firms offering organizational scaffolding for distributed firms include **RIPPLING**, which manages payroll and employee benefits, grants workers access to corporate services and sets up their devices.

GOOGLE developed the integrated model of reality combining a theory of knowledge, named **BIG DATA**, a technological vision, **CENTRALIZED CLOUD COMPUTING**, a cult of commons rooted in **OPEN SOURCE** software. The **GOOGLE** theory of knowledge, **BIG DATA**, is as radical as Newton's as intimidating as Newton's was liberating. Newton proposed a few relatively simple laws by which any new datum could be interpreted and the store of knowledge augmented and adjusted. Hundreds of thousands of engineers have added and are adding to the store of human knowledge by interpreting one datum at a time. John Gribbin, in **DEEP SIMPLICITY: BRINGING ORDER TO CHAOS AND COMPLEXITY** (Gribbin, 2004), shows how chaos and complexity permeate the universe on every scale, governing the evolution of life and galaxies alike. Far from overturning all that has gone before, chaos and complexity are triumphant extensions of simple scientific laws.

BIG DATA's approach is different. The idea of **BIG DATA** is that the previous slow, clumsy, step-by-step search for knowledge by human brains can be replaced if two conditions are met. All the data in the world can be compiled in a single "place", and algorithms sufficiently comprehensive to analyze them can be written. Upholding this theory of knowledge is a theory of mind derived from the pursuit of artificial intelligence. In this view, the brain is also fundamentally algorithmic, iteratively processing data to reach conclusions. Belying this notion of the brain are the studies of actual brains which show human brains to be much more like sensory processors than logic machines.

Iain McGilchrist argues in **THE MASTER AND HIS EMISSARY: THE DIVIDED BRAIN AND THE MAKING OF THE WESTERN WORLD** (McGilchrist, 2010) that one's feelings are not reaction to, or a superposition on, one's cognitive assessment, but the reverse: the affect comes first, the thinking later. We make an intuitive assessment of the whole before any cognitive process come into play, though they will, no doubt, later be used to 'explain' and justify, our choice. We make an assessment of the whole at once, and pieces of information about specific aspects are judged in the light of the whole, rather than the other way around. The implication is that our affective judgement and our sense of the whole, depend on the right hemisphere, occur before cognitive assessment of the parts, the contribution of the left hemisphere of the brain. Marvin Minsky in **THE EMOTION MACHINE: COMMONSENSE THINKING, ARTIFICIAL INTELLIGENCE, THE FUTURE OF THE HUMAN MIND** (Minsky, 2006) offers a nuanced version.

The cloud is the great new heavy industry of gargantuan data centers composed of immense systems of data storage and processors, linked together by millions of miles of fiber optic lines and consuming electric power and radiating heat to an extent that exceeds most industrial enterprises in history. In 2006, **GOOGLE** purchased **ANDROID**, an **OPEN-SOURCE OPERATING SYSTEM** that is endowing companies around the world with ability to compete with **iPHONE**. As **ANDROID** thrives, two things become apparent. The **INTERNET** may have ushered in a new age of sustainable open systems, but as **APPLE** have shown an integrated closed system monopoly remains as irresistible as ever.

The next layer up has become more concentrated, including many consumer services, from on line search to social networking. Centralization is rampant in what could be called the "third layer" of the **INTERNET**. All of its the extensions has spawned. **APPLE**'s **iOS** or **GOOGLE**'s **ANDROID** are what most people use as their smartphones' operating system. **AMAZON**, **GOOGLE** and **MICROSOFT** are the major competitors in cloud services outside of China. **ALIBABA** has a strong global lead in cloud services. In 2017 **ALIBABA** captured 45% of China's fledging cloud services market worth 69billion yuan [$10billion] compared to 10% for **TENCENT** according to **BLOOMBERG**. **TENCET**'s **WeChat**, however, is on 4 in every 5 Chinese smartphones, and thus offers multiple products and a massive market for firms.

FACEBOOK may have been the world's largest social network, but **TENCENT**'s broad product based business model and technology is, by

many measures, far superior. Less than 20% of **TENCENT**'s revenue comes from online advertising, 98% of **FACEBOO**K's revenue, the other hand, is from online advertising. **TENCENT** has a digital assistant, **XIAOWEI**, a mobile payment system, **TENPAY**, and a cloud service, **WEIYUN** and also launched a movie studio, **TENCENT PICTURES**. In 2007, it introduced a cloud-based platform that allows companies to offer services to users in **WeChat** via 'mini programs' [i.e. tiny apps.]. More than 1million such 'mini programs' are used by over 200million people every day, and most of them are **WeChat** users. **TENCENT**'s revenue from such mini programs, for now, is marginal, and furthermore, competitors like **ByteDance**, are crowding what is on the offer with their 'mini programs'.

ANT FINANCIAL's **MYbank TENCENT**'s **WeBank** have grown fast. Both have used automation, machine-learning and troves of data to define identification and security standards crucial as banks and payments move on line. **WeBank**'s facial-recognition tool has an error rate of less than one in a million, the human eye averages 1%. **MYbank** in 2018 served 20million of the country's **SMES**. **MYbank** also rents its kit to 200 other banks and hopes to use Hong Kong and Singapore as testing grounds for those skills abroad. Investors think internationalization has promise: **ANT FINANCIAL**, which is private, was valued at $150billion in its latest funding round. **WeBank** is taking a different track. It is making the infrastructure it created available on an open-source basis, so foreign banks can build upon it.

PING AN, the Chinese insurer has decided to become a cloud company with 32 stand-alone businesses to help export the tech it hones at home. **OneConnect**, an offspring, that listed in2019 in New York, supplies the artificial brain and nervous system of financial firms that go digital. It serves China's top lenders and 99% of the next tier down. The firm offers cloud-based services that cover everything, from back office to client-facing tasks. It belongs to a new breed of Chinese firms that are re-welding the pipes channeling money in the developing world.

Quick success develops its own downside is a folk-wisdom. In February 2019 in America, **ByteDance**, the parent of **TikTok** paid $5.7million fine for illegally collecting data on users under the age of 13, and in April an Indian court banned the app on the grounds that it abets sexual predators. **ByteDance**'s largest market outside China is in India where 2 of 5 **TikTok** users live. **TikTok**, short-video app no Western teenager can do without these days, stresses its independence from authorities in Beijing. Its parent company less so. **ByteDance** whose valuation in 2019 makes its world's biggest unlisted startup, has teamed up with **SHANGHAI DONGFANG NEWPAPER COMPANY**, a state-run publisher. The joint venture, in which **ByteDance** holds a 49% stake, will among other things, develop **Ai** technologies. Natural though it may appear in China, the joint venture comes weeks after President Trump's government opened a national security review of **TikTok** on worries that it gives Beijing access to data on millions of Americans and censors content the regime does not like. **ByteDance** insists that data on non-Chinese users sit on non-Chinese servers and what Americans are or aren't shown is decided in America.

Donald Trump tried and failed to force **ByteDance** to sell **TikTok**'s American business to a domestic owner towards the end of his presidency. The most frequently cited risk was national security, the same argument American authorities used to ban **HUAWE**I's superior 5G technologies. China's government has the right to demand whatever data it likes from firms based in China, including data held abroad. For that reason, the Committee on Foreign Investment in the United States [**CFIUS**], a Treasury-led panel which vets deals for national security risks, ordered the reversal in 2020 of a Chinese company's purchase of **Grindr**, a dating app which records users' sexuality and **HIV** status, among other things. Like most social apps, **TikTok** hoovers up information about customers' phones, usage patterns and locations, and uses third-party tracking services. Most of the data collected from **TikTok** users could be scraped from **TikTok**'s front end or bought on line – especially regarding Americans, who are poorly protected by data-privacy laws. The advantage of inside access would be marginal. The bigger, underappreciated problem with **TikTok** is the chance it offers Chinese government to manipulate what the app's vast foreign audience sees. **TikTok** has become a major news platform. A quarter of American users say they consider **TikTok** to be a news source. In countries with weaker mainstream media the share is as high as 50%. **TikTok**'s content moderators are outside China. But the app's algorithm is nurtured in Beijing.

ByteDance is not the only big Chinese tech firm that works closely with state-owned enterprises, especially in **Ai** that the Communist Party regards as strategic. In 2016, **BAIDU** agreed to develop technologies with state-owned telecoms firms. In June 2019, Jack Ma of **ALIBABA** started discussions with **SASAC**, a government body that oversees state-owned enterprises to develop tie-ups to promote digital innovations with state-owned telecom firms. **TENCENT** has been urged to do the same according **SOUTH CHINA MORNING POST**.

According to **SOUTH CHINA MORNING POST**'s **ABACUS**, **BAIDU**, **ALIBABA**, **TENCENT** [**BAT**] hold stakes in 150 companies abroad. **ALIBABA** has 56 data centers overseas, according to **ABACUS**, and **TENCENT**'s equity in **SNAP** is 17.5% and 7.5% in **SPOTIFY**. But in 2018, The Committee on Foreign Investment in the United States, [**CFIUS**], blocked several Chinese firms' investments, largest being $1.2billion purchase of **MoneyGram** by **ALIBABA**'s **ANT FINANCIAL**. In 2019, Chinese firms' investments in America fell below $5billion. It was $46billion in 2016. So far, President Trump's **MAGA** policies seem to be set to defer global spaghetti-like financial entanglements, not untangle them.

CHINA INTERNET INVESTMENT FUND (**CIIF**) owns part of a subsidiary of **ByteDance**, parent of **TikTok** and **WEIBO**, a **TWITTER**-like platform. It has a stake in **SenseTime**, an Ai company and **KUAISHOU**, a short video service. **CIIF** is mostly owned by the **CYBERSPACE ADMINISTRATION OF CHINA** (**CAC**), an internet watchdog, akin to America's Federal Communications Commission taking stakes in tech groups such as **Facebook** and **TWITTER**, appointing board members, then steering them in the direction it sees fit. In 2020, Chinese corporate landscape might best be described as a sprawling complex of state-private commerce. More than 130,000 private companies had formed joint ventures with state-owned companies by 2019, up from 45,000 at the turn of the century.

In 2012 Zhang Yiming founded a software firm called **ByteDance**. Among its first creations were **Neihan Duanzi**, a platform for sharing jokes, and **Toutiao**, a news aggregator that became China's biggest aggregator in ten years. In 2016 Zhang Yiming released **Douyin**, an app for recording and sharing lip-sync videos. **Douyin** was modelled after **Musical.ly**, another Chinese-made lip-synching app that was popular with Americans, but enhanced by **ByteDance**'s Ai discovery engine. It was a hit. The following year **ByteDance** released a twin app outside China,

with an identical interface and algorithm but separate content. It used **Douyin**'s logo of juddering musical quaver but had a snappier name **TikTok**. A little after four years, **TikTok** reached 1billion users, a milestone that **Facebook**, **YouTube** and **Instagram** took eight years to pass, albeit at a time when fewer people were online. It has been the world's most downloaded mobile app since 2020. Beneath **TikTok**'s simpleinterface lies fearsomely advanced artificial intelligence. Its knack for learning what people like. **TikTok** makes creating films easy. It has done for video-editing what **Instagram** did for photo-editing, allowing amateurs to turn wobbly recordings into slick-looking films. Better yet, the Ai discovery algorithm dangles the prospect of viral success before unknown creators, who struggle on apps like **Facebook**, which reward those with lots of followers. **TikTok** is also easy to watch. Whereas most social-media apps recommend content from the user's network of friends, **TikTok** requires no network, no searching, nor even any login: its algorithm plucks videos from vast archives and learns what the viewer likes. The format is addictive. In America, **TikTok**'s users spend an average of 46 minutes a day on the app. **TikTok** is monetizing this attention. Its revenues were $4billion in 2021 and is to reach $12billion in 2022. Its effect on competition has been dramatic. In 2020 American trustbusters sued **Facebook**, now known as **Meta**, for alleged dominance of social media. Two years later such worries looked eccentric. **Facebook** is re-engineering its products to mimic **TikTok**. America often accuses China of copying capitalism. Now the boot is on the other foot as was the case with **HUAWEI**'s **5G**. **ByteDance**, **TikTok**'s owner, is incorporated in Cayman Islands and has investors from all over, including America's **General Atlantic** and Japan's **SoftBank**.

The data giants, **AMAZON**, **Facebook** and **GOOGLE**, as they dominate their respective core markets, they also have accumulated more digital information than any other Western company. They use the information they store to sell targeted advertising and to fuel the development of their artificial intelligence [**Ai**] services. At its core, **GOOGLE** is a list of websites and a database of people's search histories. **Facebook** keeps track of their users' identity and interactions among them. **AMAZON** collects credit-card numbers and purchasing behavior.

These data giants' capacities to process, transmit and store data are growing by explosive increments. Scientists define an explosion as the injection of energy into a system at a pace that overwhelms the system's ability to adjust. This produces a local increase in pressure, and if the system is unconfined or the confinement can be broken, shock waves develop and spread outward. These explosive increments are injecting pressure into the prevailing socio-economic systems via job displacement faster than the prevailing socio-economic systems can absorb it via job replacement. The explosive potential emerges from the mismatch between the speed at which disruptive energy is injected into the system by job displacement and the socio-economic system' ability to absorb it with job creation. The displacement is driven by the eruptive pace of digital technology's application to information and communication technology. Artificial intelligence's and tele-migration's [remote intelligence's] elimination of jobs. The replacement is driven by human ingenuity which moves at the leisurely pace it always has. The radical mismatch between the speed of job displacement and the speed of job replacement has been a perennial downside of technological transformations. In the age of hyper-intelligence, the disruptions are faster. Technology produces and economic transformation, the economic transformation produces and economic and social upheaval, the upheaval produces a backlash and backlash produces a resolution according to Richard Baldwin in **THE GLOBOTICS UPHEAVAL: GLOBALIZATION, ROBOTICS, AND THE FUTURE OF WORK** (Baldwin, 2019).

4. Conclusion

So far, the American data giants seem to have adopted the business model of attention merchants. They capture out attention by providing us with free information, services, and entertainment, and they then sell our attention to advertisers. The data giants seem to have far higher goals than any previous **ATTENTION MERCHANTS**. In 1920s, Sigmund Freud's nephew, Edward Bernays, realized that his uncle's psychotherapy opened up a new lucrative world of retail therapy by inventing the public relations industry. Despite being far richer than kings of old, we are too easily trapped on a treadmill of consumerism, continually searching for identity, connection and self-transformation through the things we buy. Edward Bernays's method of persuasion – tastefully named 'public relations' – transformed marketing worldwide and, over the course of the 20th century embedded consumer culture as a way of life. Drawing on his uncle's insights into the workings of the human mind his advertising firm convinced some women on behalf of the **AMERICAN TOBACCO CORP** that cigarettes were their "Torches of Freedom" and reduced **MARLBORO MAN**'s existentialist choice to "Good Taste or Good Tobacco".

These data giants' strategic goal is not to sell adverting, their tactical goal for now is. By capturing our attention, they manage to accumulate immense amounts of data about us, [how, when, where, why we behave] which is worth more than any advertising revenue. It is not accurate to think of **GOOGLE**'s users as its customers. There is no economic exchange, no price, and no profit. Nor do users function in the role of workers. Users are not paid for their labor, nor do they operate the means of production. The user is not the product, but rather they are the sources of raw-material supply. **GOOGLE**'s products are derived from data about users' behavior. Its products are about predicting users without caring what the users do or what is done to the users.

In the medium term, this data hoard opens path to a radically different business model whose victim will be the advertising industry itself. The strategic business model is based on transferring decision making from humans to algorithms, including the authority to choose and buy things. Once algorithms choose and buy things for us, the traditional advertising industry will be redundant. **GOOGLE** is aiming to reach a point where we can ask **GOOGLE** anything and get the "best answer" in the world.

In **THE GREAT TRANSFORMATIOIN: THE POLITICAL AND ECONOMIC ORIGINS OF OUR LIVES** (Polanyi, 1944), Karl Polanyi identified three transformations. First was branding human life as labor. Second was branding nature as real estate. Third was branding free exchanges of goods and services as money. The fourth, Shoshana Zuboff explains in **THE AGE OF SURVEILLANCE CAPITALISM: THE FIGHT FOR A HUMAN FUTURE AT THE NEW FRONTIER OF POWER** (Zuboff, 2019) is "as the emerging economic order that expropriates human experience

as free raw material for hidden commercial practices of extraction, prediction, and sales that subordinate production of goods and services to a new architecture of behavioral modification" (Zuboff, 2019) **GOOGLE** was the first in Silicon Valley to understand the concept of "behavioral surplus" in which human experience is subjugated to attention merchants' surveillance capitalism's market mechanisms and reborn as behavior. Everything one does and think on line has the potential to be monetized by platform tech firms. All human activity is potentially raw material to be commodified by the tech firms. "**GOOGLE** is to surveillance capitalism what the **FORD MOTOR COMPANY** and **GENERAL MOTORS** were to mass-production based **MANAGERIAL CAPITALISM**," Shoshana Zuboff wrote. (Zuboff, 2019) Nearly everything we do can be mined by platform companies. But only if they can keep information free. That means keeping value of personal data opaque, ignoring copyrights on content by making it difficult to protect.

"Now, with the rise of the surveillance capitalism practiced by Big Tech, we ourselves are maximized for profit. Our personal data is, for Big Tech companies and others that harvest it, the main business input. …. You are the raw material used to make the product that sells you to advertisers." writes Rana Foroohar in **HOW BIG TECH BETRAYED ITS FOUNDING PRINCIPLES AND ALL OF US: DON'T BE EVIL**. (Foroohar, 2019). "As in any transaction, the party that knows the most can make the smartest deal. The bottom line is that both big-platform tech players and large financial institutions sit at the center of an hourglass of information and commerce, taking a cut of whatever passes through. They are the house, and the house always wins" (Foroohar, 2019). Companies that both create marketplaces or platforms, and then also do commerce within them have an unfair advantage.

TWITTER and **FACEBOOK** may look similar at first glance. Each is a social network connecting users online and presenting them with content in a "feed", a never-ending list of posts, pictures and videos of pets. Each employs every trick to glean data from users' behavior that enable advertisers to hit targets precisely for which advertisers pay to influence the decisions users are to make. Dipayan Ghosh in **TERMS OF DISSERVICE: HOW SILICON VALLEY IS DESTRUCTIVE BY DESIGN** (Brookings Institute, 2020) illuminates the differences between the two social networks. **TWITTER** is essentially an internet "Speakers' Corner", where anyone can hold forth and others can talk back. It is "one-to-many" broadcast network. **FACEBOOK** is "one-to-one" or "one-to-few" network, replicating social relationships of the sort between friends, family or colleagues. The difference may seem subtle, but it has several implications for both firms' business.

FACEBOOK is able to gather more data about its users because they are more engaged with others. This makes it easier to target ads. **FACEBOOK** also benefits from stronger "network effects". Each additional subscriber makes the service more useful for others, which attracts more subscribers. **TWITTER** cannot rely on such a turbocharged engine of growth. Having friends is a social need, maintaining a soapbox is non-essential for most, even for some serious extroverts. In 2019 **FACEBOOK** reported 9 times the users, 21 times the revenue and 12 times the profit of **TWITTER**. Moreover, the strong network effects are a prime asset that **FACEBOOK** has defended vigorously. It has spent $1billion in acquiring **INSTAGRAM** in 2012, and $19billion for **WHATS-APP** in 2014. **FACEBOOOK**'s size has made it the dominant outlet for political discourse outside of China.

One particular area of concern is how big tech firms use machines rather than human relationships to judge customers, as Cathy O'Neil exposes in **WEAPONS OF MATH DESTRUCTION: HOW BIG DATA INCREASES INEQUALITY AND THREATENS DEMOCRACY** (O'Neil, 2016, 2017) to hoover up online data by using opaque algorithms and use the data to create customer profiles and sell them. ".... many of these models encoded human prejudice, misunderstanding and bias into the software systems that increasingly managed our lives. Like gods, these mathematical models were opaque, their workings invisible to all but the highest priests in their domain: mathematicians and computer scientists. Their verdicts, even when wrong or harmful, were beyond dispute or appeal. And they tended to punish the poor and the oppressed in our society, while making the rich richer" (O'neil, 2016). What you do online thus may end up affecting opportunities in your offline life.

In the longer term, by bringing together enough data and enough computing power, the data giants could hack the deepest secrets of life, and then use this knowledge not just to make choices for us or manipulate us but also to reengineer organic life and create inorganic life forms. Selling advertisements may be necessary to sustain the giants in the short term, but tech companies often evaluate apps, products, and other companies according to the data they harvest rather than according to the money they generate. The business model of a popular app may be a money loser, but as long as it sucks data, it could be worth billions. Cash rich tech firms have become the financial engineers of the 21st century. The rate of return analysis of corporate finance does not help much.

Tim Wu in **THE MASTER SWITCH: THE RISE AND FALL OF INFORMATION EMPIRES** (Wu 2011) suggest that to understand the forces threatening the **INTERNET** as we know it, we must understand how information technologies give rise to industries and industries to monolithic structures. As with any economic theory, there are no laboratories but past experience. Illuminating the past to anticipate the future is the raison d'etre of economic history, which is conspicuously absent in MBA programs mass-marketed by American universities. Understandably so, because history, many times, negates their neoclassical mantra.

Schumpeter had no patience for what he deemed Adam Smith's fantasy of price warfare, growth through undercutting your competitor and improving the market's overall efficiency thereby. "In capitalist reality as distinguished from its textbook picture, it is not that kind of competition which counts," argued Schumpeter, but rather "the competition from the new commodity, the new technology, the new source of supply; the new type of organization." Schumpeter's theory did not account for the power of law to stave off industrial death and arrest the creative destruction or help to speed up the destructive process by not regulating mergers and acquisitions.

Digital Millennium Copyright Act Congress passed in 1998 gave companies that provided online services "safe harbor" immunity from copyright-infringement liability for their user's actions to protect e-commerce sites from being responsible what third-party actors are selling on their sites. "E-commerce represents about 10% of all US retail and **AMAZON** is by far the largest player, with an estimated share of 43%. In 1998 **AMAZON** accounted for 53% of all the incremental growth of online shopping, which means they are only growing their dominance.

AMAZON's anticompetitive effect stems from its inherent conflict as both a direct seller and the operator of a platform that it invites other sellers to use. … According to **UPSTREAM COMMERCE**, **AMAZON** tracks third-party sales on its site and uses that data to sell the most popular items in direct competition with marketplace members. …. **AMAZON** has a clear conflict of interest when it comes to policing counterfeits and competing with its own partners. As a platform, it wants the maximum number of people selling on its site, much like **FACEBOOK** and **GOOGLE** want the maximum number of eyeballs to sell ads against. Whether that comes from pirated content or not, the tech giants simply don't care. … A recent study by **ProPublica** found that the company is using its market power and proprietary algorithm to advantage itself at the expense of sellers and many customers. When they searched for hundreds of items on the site, about three-quarters of the time, **AMAZON** put its own products above third-party products using its platform, when competing products were cheaper. As a platform, it pays to be the regulator of your own marketplace" (Tepper and Hearn, 2019).

ALPHABET, **GOOGLE**'s holding company, in 2018 was the second largest company in the world. Measured by market capitalization, **APPLE** was first. Joined by **AMAZON**, **MICROSOFT** and **FACEBOOK**, the five form an increasingly feared global oligopoly. "Between **GOOGLE**, **AMAZON**, **APPLE**, **FACEBOOK**, and **MICROSOFT**, they have collectively bought over 436 companies and startups in the past 10 years, and regulators have not challenged any of them. In 2017 alone, they spent over $31.6billion on acquisitions. Most small companies now do not expect to succeed on their own and their only goal is the 'exit' to one of the big tech companies before they are crushed" (Tepper and Hearn, 2019).

In the 1970s, the microprocessor radically reduced the cost of computers. In the 1990s, **OPEN SOURCE** software started to dethrone **WINDOWS**, **MICROSOFT**'s then dominant operating system. Richard M. Stallman of **MIT**'s **ARTIFICIAL INTELLIGENCE LABORATORY** argued that software code was quickly becoming the language of communication between people, and people and things, and that it was immoral and unethical to enclose and privatize the new communications media, allowing few corporate players to determine the conditions of access while imposing rent. To keep software distributed, collaborative and free, Stallman assembled a consortium of programmers and erected an operating system called **GNU** made up of free software that could be accessed, used, and modified by anyone. In 1985 founded the **FREE SOFTWARE FOUNDATION**. **GNU GENERAL PUBLIC LICENSE** [**GLP**], unlike conventional copyrights that give the holder the right to prohibit others from reproducing, adopting, or distributing copies of an author's work, allow an author to give every person who receives a copy of a work permission to reproduce, adapt, or distribute it and require that any resulting copies or adaptations are also bound by the same licensing agreement. **GPL** became the vehicle for the establishment of free sharing of software.

Six years after Stallman's **GNU** operating system and the **GPL**, Linus Torvalds designed a free software kernel for a Unix-like operating system for personal computers that was compatible with Stallman's **GNU** project and distributed it under the **FREE SOFTWARE FOUNDATION**'s **GPL**. The **LINUX** kernel made it possible for thousands around the world to collaborate via **INTERNET** on improving free software code. In 1998, Eric S. Raymond and Bruce Perens created **OPEN SOURCE INITIATIVE**, **OSI**, to dampen **FREE SOFTWARE MOVEMENT**'s fear of commercial interests.

MICROSOFT might never have come to rule **PC** software had **IBM**, accused of monopolizing mainframes, not decided in 1969 to market computers and their programs separately, a move that created the software industry. **GOOGLE** might not have taken off in the way it did had **MICROSOFT** not agreed, at the end of its antitrust trials in America and Europe in the 2000s, not to discriminate against rival browsers and to license technical information which allows other operating systems to work easily with **WINDOWS**.

MICROSOFT's first operating system [**MS-DOS**] that **MICROSOFT** acquired from another firm, **SEATTLE COMPUTER PRODUCTS**, was actually a clone of **CP/M**, another operating system. **MICROSOFT WINDOWS** was a rip-off of the **APPLE MACINTOSH** operating system; **MICROSOFT WORD** and **EXCEL** were copies of **WORDPERFECT** and **LOTUS 1-2-3** respectively. By late 1990s, **MICROSOFT** unleashed its predatory strategy against **NETSCAPE**. **EXPLORER** was **MICROSOFT**'s copy of **NAVIGATOR**, and soon **NAVIGATOR** was nowhere **EXPLORER** was everywhere. In few short years **NETSCAPE** was bankrupt. As Brian McCullough detailed in **HOW INTERNET HAPPENED: FROM NETSCAPE TO THE IPHONE** (McCullough 2018). With minimal antitrust enforcement, **MICROSOFT** would have been in a perfect position to control the future of internet, had Department of Justice not decided to prosecute the last big antitrust case of the 20th century.

MICROSOFT was built as technological walled garden. On April 21, 2020, however, it announced its plans to launch 20 data-sharing groups by 2022 and give away some of its digital information, including data it has gathered on COVID-19. The OECD recons that if data were more widely exchanged, many countries could enjoy gains worth 1-2.5% of GDP. The estimate is based on heroic assumption on opportunities for start-ups. But most agree that readier access to data is broadly beneficial, because data are non-rivalling. Unlike oil, they can be used and re-used without being depleted to power various artificial-intelligence algorithms at once. **MICROSOFT**, besides encouraging non-commercial sharing, is developing software, licenses and rules frameworks to let firms trade data or provide access without losing control. Optimists believe that **MICROSOFT**'s move could be to data what **IBM**'s embrace of **LINUX** operating system was to open-source software in 1990s. **LINUX** went on to become a rival to **MICROSOFT's WINDOWS** and today underpins **GOOGLE's ANDROID** mobile software and much of cloud-computing.

Fewer than 100 firms collect more than half of all data generated on line. More sharing would counteract concentration. Data are more complex than code. Most programmers speak the same language and open-source collectives mainly solve technical problems. People in charge of data often come from different industries without a common vocabulary. Unlike **ALPHABET** and **FACEBOOK** that extract value from hoarded data through targeted advertising, **MICROSOFT** makes most of its money by selling services and software to help others process digital information. The more data shared the better for **MICROSOFT**.

FIREFOX, a web browser made by the non-profit **MOZILLA FOUNDATION**, was born as 'phoenix'. It rose from the ashes of **NETSCAPE NAVIGATOR**, slain by **MICROSOFT**'s **INTERNET EXPLORER**. In 2012, **MOZILLA** created **FIREFOX OS**, to rival **APPLE**'s **IOS** and **GOOGLE**'s **ANDROID** mobile operating systems. **MOZILLA** began life in 1998 after the "browser war" between **MICROSOFT**'s **INTERNET EXPLORER** and

NETSCAPE's **NAVIGATOR**. Even though the fight got **MICROSOFT** into deep trouble with completion regulators, which nearly broke it up, **NETSCAPE** had to capitulate. But released the **NAVIGATOR**'s source code so that an alliance of volunteer developers could keep the browser alive. Even compared with other **OPEN-SOURCE** projects, **MOZILLA** is an unusual hybrid. It boasts a volunteer workforce of nearly 23,000 that contributes about half of the company's code in exchange for little more than recognition from their peers and the satisfaction of chipping in to a project they believe in. It is two organizations in one; the **MOZILLA FOUNDATION** and the **MOZILLA CORPORATION** that has 1,100 employees on payroll. The first is a charity which owns the second and makes sure that it does not stray away from its mission. The corporate arm is in charge of products and gets the cash that search engines pay for appearing on **FIREFOX**'s start page. Together **GOOGLE**, **BAIDU** and **YANDEX** and a host of others paid $542million for the traffic they got from **FIREFOX** in 2017.

MOZILLA has shown that open-source approach can work in consumer software. **FIREFOX** was the first browser to block-up ads and allow users to surf anonymously, promoting commercial browsers to offer similar features.

Unable to compete, **MOZILLA** killed the ill-fated mobile operating system project. Another 'phoenix' has arisen from it. **KAIOS**, an operating system conjured from the defunct software, powered 30million devices in 2017 and another 50millioin in 2018. Most were simple flip-phones sold in the West for about $80 a piece, or even simpler ones which Indians and Indonesians can have for as little as $20 or $7, respectively. **KAIOS**, based in Hong Kong, designed the software for smart-ish phones with old-fashioned number pad and long battery life, plus 4G connectivity, popular apps like **FACEBOOK** and features like contactless payments without snazzy touchscreens. **GOOGLE** invested $22million in **KAIOS** in 2018. Even if **KAIOS** powers another 70million devices in 2019, as the company expects in 2019, that would barely be one tenth of the 1.5billion **APPLE** and **ANDROID** phones sold annually.

A decade ago American firms took an early lead in 4G setting standards for new handsets and applications that spread word-wide. That dominance helped **APPLE**, **GOOGLE**, and other American businesses generating billions of dollars in revenues. China learned its lessons, investing $180billion to deploy 5G networks over the next 5 years and assigning swathes of wireless spectrum to three state providers. In America the same part of the spectrum is largely off-limits commercially because it is used by the federal government. American firms are experimenting with different parts of the spectrum that has some advantages under laboratory conditions but easily blocked by buildings and trees. **AT&T** and **VERIZON** had to delay switching on their of 5G networks in 2021 after Federal Aviation Administration aired concerns that their 5G radio spectrum interferes with avionics on some aging aircraft. Until 2022, actual 5G coverage in America had been limited. Only one of the country's three biggest carrier, **T-MOBILE** offered broad 5G connectivity. The potential consequences of the market power held by the new technology giants are greater and more pernicious than anything seen at the turn of the 20th century. Then the market power of companies like **SWIFT**, **STANDARD OIL**, **AMERICAN TOBACCO**, The **AMERICAN SUGAR REFINING COMPANY**, or **US STEEL** allowed them to raise the price they charged for food, steel, tobacco, sugar and oil. Now, it is about more than just the price.

The equivalent course of action now is to force today's giants to open up their data vaults, thus lowering the barriers to entry and giving newcomers a better chance to compete. Now it is the turn of data. Today online applications bundle user interface, code and data. **FACEBOOK**, for example, is known for its website and app, but both are just the tip of a virtual iceberg. Most of the software and all the information that keep social network going live in the firm's **CLOUD**. Controlling those data gives these companies power. Users are free to move to another service, but they would lose all that information, including the links to their friends.

In the early 1980s, US antitrust regulators allowed **AT&T**, the world's largest network operator then, and **IBM**, the biggest computer firm of the era, to enter each other's markets. **AT&T** started selling personal computers and **IBM** bought **ROLM**, which sold telecoms equipment. Pundits predicted an epic battle between the two giants and a rapid convergence of the telecoms and computer industries into one. Neither the battle nor the convergence materialized. Forty years ago the two markets proved too distinct and the technology was not up to the challenge. In 2022 things look different. Clouds, **AWS** and **AZURE** are becoming able to deal with the task of powering network.

5G was conceived from the start not as collection of switches and other hardware, but as a set of services that can be turned into software, or "virtualized". The telecoms industry is becoming less proprietary, embracing "open radio access network" (**O-RAN**) standards that make it possible to virtualize ever more functions previously performed by hardware. As a result, networks can turn into platforms software add-ons, just as mobiles turned into smartphones which could run on apps. **DISH NETWORKS**, a satellite-service company is launching the fourth **5G** connectivity in America. Except for antennas and cables, it is mostly a cluster of code that runs on **AMAZON WEB SERVICES**. Instead of bulky base stations used in conventional mobile networks, it technology is housed in slender boxes attached to antenna posts. These are connected directly to the **AWS** cloud, which hosts the virtual part of the network. As a result, DISH's network will be cheaper to set up and to run. **DISH** also plans to use Ai to optimize the use of radio spectrum, including by training algorithms which are able to adapt parts of network to specific conditions such as a storm or a mass concert. In 2021, **MICROSOFT** bought **AFFIRMED NETWORKS** and **METASWITCH**, the main software suppliers for the core of **AT&T**' 5G network. In June 2021, **AT&T** sold the technology that powers the core of its 5G network to **MICROSOFT**. **AZURE FOR OPERATORS**, a new business unit, will run it for **AT&T**'s 5G network. **GOOGLE** has a similar unit with forged partnership with **TELENOR**, the Norwegian telecoms company. In November 2021, **AWS** announced a new offering that lets customers set up private 5G networks on their premises. **RAKUTEN**, the Japanese on-line company has already built a DISH-like network in Japan. Rather than outsourcing its cloud operation, **RAKUTEN** has built its own, and launched a subsidiary, called **RAKUTEN SYMPHONY**, to offer the system to other operators. Existing mobile networks will not be replaced overnight. Serious technical barriers remained to be solved in 2022.

EUROPEAN COMMISSION fined **GOOGLE** 4.3billion Euros on 7/18/2018 and ordered to **GOOGLE** to stop emulating the 1990s **MICROSOFT**'s product strategy. To assure its market lead, instead of giving the buyers the option to choose, **MICROSOFT** bundled several software in tie-in contracts and offered the bundle to the buyers. **GOOGLE**'s case involved its mobile operating system, **ANDROID**, and bundled

related software and services, such as **GOOGLE PLAY**, its app store, internet search and several other apps. **GOOGLE**, in practice, gives smart phone makers and telecoms operators an all or, nothing choice as **MICROSOFT** did in the 1990s. If, the makers want to install any of these programs on their devices, they have to install them all and show their icons in prominent positions. Since firms need at least the app store to make their products commercially viable, they have no choice but to comply. Furthermore, **GOOGLE** does not allow the phone manufacturers to install competing versions of **ANDROID** on any of their models.

By contrast, in **WEB 3.0** interface, code and data are meant to be kept separate. This would allow power to flow back to users, who would decide which application can access their information. If they were not happy with one social network, they could easily switch to another. With such decentralized applications, [**DAPP**s], users could also interact directly with other users without an information-hoarding intermediary in the middle. Similar ideas have been tossed around. Decentralized services, then called "peer-to-peer" briefly flourished in the late 1990s and 2000s. They fizzed out mainly because a robust decentralized database did not exist.

Combining database and network technologies, **BLOCKCHAIN** is a digital peer-to-peer decentralized platform for tracking all kinds of value exchanged between people. Its name derives from the blocks of data, each one a snapshot of all transactions that have just been made in the network, which are linked together to create a chain of data blocks, adding up to a minute-by-minute record of the network's activity. Since, that record is stored on every computer in the network, it acts as a public ledger that cannot be altered, corrupted or deleted, making it a highly secure digital backbone for the future of e-commerce and transparent governance.

With the invention of **BLOCKCHAIN**, a ledger without a centralized administrator maintained collectively by some of its users, called "miners", who also protect the **BLOCKCHAIN** and keep others in check a robust decentralized system is feasible. The **BLOCKCHAIN** is a specialized database in the form of an immutable record of the transaction history, a digital **BABYLONIAN TABLETS**. Most **WEB 3.0** projects comes with **SMART CONTRACTS**, snippets of code that encapsulate business rules which are automatically executed if certain events occur. The advanced projects focus on building the software infrastructure needed for **DAPP**s. **BLOCKSTACK**, arguably very ambitious, is seen as an operating system for such applications.

One digital currency that uses **BLOCKCHAIN** technology is **ETHEREUM,** which among its possible applications, is enabling electricity micro-grids to set up peer-to-peer trading in renewable energy. These micro-grids allow every nearby home, office or institution with a smart meter, **INTERNET CONNECTION**, and solar panel on its roof to hook in and sell or buy surplus electrons as they are generated, all automatically recorded in units of the digital currency. Such decentralized networks, ranging from a neighborhood block to a whole city, build community resilience against blackouts and cut long-distance energy transmission losses at the same time.

The landscape of Chinese **FinTech** is dominated by two players: **ANT FIANCIAL** of **ALIBABA**, and **TENCENT**, best known for **WeChat**, its social media network. **ANT** was estimated to be worth $150billion in 2017, a little less than **HSBS**. Both firms got their start in payments. **ANT FINANCIAL** stems from **ALIPAY** created in 2004, **TENPAY** was launched in 2005 for **QQ**, **TENCENT**'s online-messaging platform, and was later grafted into **WeChat**. Both have boomed by linking mobile apps with offline payments. Almost all merchants in China provide **QR** codes to be scanned by phone in order to pay. In 2017, **ALIPAY** had 54% of the mobile-payment market. It worked with more than 250 financial firms outside of China so that Chinese tourists can use it.

ANT and **TENCENT** are more interested in hooking users on other financial services than in payments alone. Once a user is on their platforms, mutual funds, insurance products, and virtual credit cards are accessible with a tap of a finger on smart phone. The duo's move into retail banking with **TENCENT**'s **WeBank** and **ANT**'s **MYbank** increased regulator's concerns for money-laundering, but also protecting the banks from **FinTech**'s competition.

The control structures built to ensure the ironclad hold of the founders of corporations are referred as "Key man risk", and is a big point of contention in China and abroad. China does not allow foreign entities to own sensitive assets, such as government licenses needed. These licenses are owned by Chinese individuals, often including the founders, are bundled into **VARIABLE INTEREST ENTITIES**. In addition, the Chinese companies listed in America have "dual class" stock structure which allows founders to own a special class of stocks with superior voting rights. **JD.com**, for example, **ALIBABA**'s rival in e-commerce, has the ratio set at one share to 20 votes, enabling Richard Liu, the founder of **JD.com**, to control 80% of **JD.com** voting rights by owning less than 20% of the stock. **JD.com** has not convened an annual stockholders' meeting since its floatation in 2014 which is allowed under corporate governance laws of Cayman Islands where it is incorporated as most global Chinese tech champions are. Cayman Islands, one of Britain's Caribbean territories, seem to be the most favored location to incorporate for Chinese companies set to list in New York. **BAIDU**, for example, listed in America in 2005, and to list it incorporated in Cayman Islands, but has not held a stockholder's meeting since 2008. **TENCENT** of **BAT** is different. It has **VARIABLE INTEREST ENTITIES**, but one-stock-one-vote, and listed in Hong Kong in 2004.

Another first of **GOOGLE** in Silicon Valley was to introduce a dual-class share structure with its 2004 public offering. The two founders, Page and Brin, would control the super-class B voting stock, shares that each carried 10 votes, as compared to the A class of shares, which each carried only 1 vote. The arrangement inoculated Page and Brin from market and investor pressures. Subsequently, the founders imposed a tri-share structure adding a C class of zero voting rights stock. By 2017, Brin and Page controlled 83% of the super-voting-class of B shares, which translated into 51% of the voting power.

When **GOOGLE**'s leads, many Silicon Valley founders follow. By 2015, 15% of **IPO**s were introduced with dual-class structure, compared to 1% in 2005. In 2012 **FACEBOOK**'s **IPO** with a two-tiered stock structure left Mark Zuckerberg in control of voting rights. The company then issued nonvoting class C shares in 2016, solidifying Zuckerberg's personal control over decisions. While the consequences of these share structures are being debated, absolute corporate control enabled the founders of **GOOGLE** and **FACEBOOK** to aggressively pursue acquisitions

of start-ups in facial recognition, deep learning, augmented reality and more. Brin and Page at **GOOGLE** who do not enjoy the legitimacy of the vote, democratic oversight, or the demands of shareholder governance exercise control over their organization and presentation of the world's information, but neither do **BAIDU**'s and **ALIBABA**'s CEOs. Zuckerberg at **FACEBOOK** who does not enjoy the legitimacy of the vote, democratic oversight, or the demands of shareholder governance exercise control over an increasingly universal means of social connection along with the information concealed in its networks. So does Jack Ma.

Jack Ma, a founder of **ALIBABA** is a member of the Chinese Communist Party, and indirectly owns four of its five **VARIABLE INTEREST ENTITIES** with one of his co-founders. In 2019, when Jack Ma steps down as chairman, as he said he would, all **VARIABLE INTEREST ENTITIES** will be transferred to two layers of holding companies, in turn owned by a broad set of **ALIBABA**'s senior Chinese staff. Jack Ma will remain a lifetime member of the **ALIBABA PARTNERSHIP**, which concentrates control of the company in a club of 36 senior staff. **ALIBABA PARTNERSHIP** is empowered to appoint majority of board seats. Thus, Jack Ma will keep to have an influential role in the company's culture and ecosystem. This succession plan will unite **ALIBABA**'s, Chairman and CEO, under Daniel Zhang. He has been an adroit CEO for **ALIBABA** since 2015. The succession plans of the founders of the Chinese tech firms who are now in their 40s and 50s, is expected to develop new challenges for global corporate governance in the next decade.

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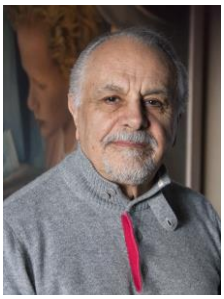

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