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РАЗВИТИЕ ЭФФЕКТИВНОЙ КОРПОРАТИВНОЙ КУЛЬТУРЫ В РИСК-МЕНЕДЖМЕНТЕ БАНКА

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АННОТАЦИЯ

Цель исследования. Цель исследования. Целью исследования является разработка и обоснование эффективной модели корпоративной культуры в блоке риск-менеджмента банка, способной повысить результативность его деятельности и стратегическую устойчивость. Корпоративная культура рассматривается как ключевой инструмент, обеспечивающий согласованность ценностей сотрудников и целей организации, формирование атмосферы доверия, инноваций и командного взаимодействия. В условиях цифровизации, усиления конкуренции и роста регуляторных требований исследование направлено на выявление сильных и слабых сторон существующей корпоративной среды, а также на выработку практических мер по её совершенствованию для повышения вовлечённости персонала, улучшения коммуникаций и укрепления конкурентных позиций банка.

Методология исследования. В статье использованы теоретические и эмпирические подходы к изучению корпоративной культуры в банковской сфере, включая анализ моделей Э. Шейна, Г. Хофстеде, К. Камерона и Р. Куинна. Применены количественные методы (анкетирование сотрудников CRO-блока) и качественные инструменты (фокус-группы с руководителями), а также статистическая обработка собранных данных. Проведена оценка сильных и слабых сторон корпоративной культуры, выявлены проблемные зоны и определены направления её совершенствования для повышения вовлечённости персонала и укрепления внутреннего взаимодействия.

Оригинальность / ценность исследования. Корпоративная культура в банковской сфере выступает важнейшим нематериальным ресурсом, напрямую влияющим на устойчивость и конкурентоспособность финансовых организаций. Она становится фактором, определяющим уровень доверия клиентов, взаимодействие сотрудников и способность банка адаптироваться к изменениям внешней среды. В условиях цифровизации и ужесточения регуляторных требований исследование корпоративной культуры блока риск-менеджмента имеет прикладную значимость: выявленные сильные и слабые стороны, а также предложенные меры по развитию внутренней среды позволяют сформировать устойчивую модель управления персоналом, ориентированную на рост вовлечённости и стратегической адаптивности. Тем самым работа создаёт основу для повышения эффективности управления рисками и укрепления рыночных позиций банка.

Результаты исследования. Рассмотрены ключевые особенности корпоративной культуры блока риск-менеджмента банка, выявлены её сильные стороны и проблемные зоны. Проанализированы недостатки межфункциональных коммуникаций, распределения рабочей нагрузки и адаптации сотрудников к новым инициативам, а также определены потенциальные направления развития внутренней среды. Дана оценка существующим программам мотивации и признания, а также их влиянию на вовлечённость и результативность персонала. Сформулированы практические предложения по совершенствованию корпоративной культуры, включая укрепление командного взаимодействия, развитие лидерских компетенций среднего звена и расширение нематериальных форм стимулирования.

ВВЕДЕНИЕ

Актуальность работы. На сегодняшний день мировая финансовая система функционирует в условиях высокой турбулентности, усиливающейся волатильности и неопределённости экономического и политического развития. Для банковского сектора особое значение приобретает вопрос устойчивости и доверия клиентов, что напрямую связано с внутренней организационной средой и качеством корпоративной культуры. В условиях цифровизации, роста конкуренции и ужесточения регуляторных требований именно корпоративная культура становится стратегическим ресурсом, обеспечивающим согласованность ценностей сотрудников и целей организации.

Действующие модели управления в банках, во многом опирающиеся на формализованные процедуры и контрольные механизмы, не всегда в полной мере отвечают вызовам динамичной рыночной среды и ожиданиям персонала. Возникает необходимость перехода к более «человекоцентричной» и сервисной модели внутреннего управления, где ключевыми ценностями выступают вовлечённость сотрудников, прозрачность коммуникаций, готовность к инновациям и использование цифровых решений.

Особое значение приобретает интеграция современных технологий — автоматизированных аналитических платформ, искусственного интеллекта и больших данных — в процессы риск-менеджмента. Эти инструменты позволяют повысить точность прогнозирования, оперативность принятия решений и прозрачность внутренних коммуникаций. Однако эффективность их применения во многом зависит от готовности корпоративной культуры поддерживать цифровые трансформации и стимулировать сотрудников к освоению новых подходов.

С учётом стратегической роли риск-менеджмента в обеспечении финансовой устойчивости банка, а также его тесной связи с международными стандартами и требованиями регуляторов, возрастает значимость развития эффективной корпоративной культуры именно в этом блоке. Это позволит не только повысить результативность внутренних процессов, но и создать основу для успешного внедрения инновационных технологий, укрепив конкурентные позиции банка в условиях глобальных трансформаций и растущей вовлечённости Казахстана в мировую финансовую систему.

ОСНОВНАЯ ЧАСТЬ ИССЛЕДОВАНИЯ

Научная новизна данной статьи заключается в раскрытии ключевых проблем формирования и развития корпоративной культуры в блоке риск-менеджмента банка и предложении вариантов их решения в рамках внутреннего управления и регуляторных требований. Благодаря этому можно выстроить системный подход к повышению эффективности управления рисками, а также создать условия для формирования адаптивной и устойчивой организационной среды. В результате повышения качества корпоративной культуры в риск-блоке, а также совместных усилий менеджмента и регулятора, удастся более эффективно интегрировать казахстанские банки в глобальную финансовую систему,

что позволит соответствовать современным вызовам и стандартам международного банковского регулирования.

Проблемы.

Несмотря на наличие формализованных процедур и развитую нормативную базу, корпоративная культура в блоке риск-менеджмента остаётся на стадии «управляемого» уровня зрелости. Проведённые опросы и фокус-группы выявили ряд проблем, которые существенно ограничивают эффективность системы управления рисками. Эти проблемы имеют как организационный, так и поведенческий характер и отражают особенности национальной и корпоративной культуры.

1. Потенциал для роста прозрачности коммуникаций и каналов эскалации

Одной из наиболее значимых проблем является низкий уровень прозрачности в процессах эскалации рисков. Согласно результатам анкетирования, 42% сотрудников указали, что не всегда понимают, каким образом и в какие сроки их сообщения о рисках доходят до руководства. На практике это приводит к задержкам в принятии решений и снижает доверие к системе контроля.

Фокус-группы показали, что сотрудники опасаются напрямую сообщать о проблемах, особенно если они касаются ошибок коллег или руководителей. Такая ситуация приводит к эффекту «немой эскалации», когда риск либо вовсе не поднимается, либо поднимается слишком поздно. Это создает угрозу запаздывающего реагирования на критические инциденты.

В международной практике проблема решается через внедрение анонимных каналов обратной связи (speak-up culture), регулярные совещания risk-huddles и обязательную фиксацию всех обращений в системе мониторинга. В исследуемом банке такие инструменты пока используются фрагментарно.

2. Потенциал для роста уровня психологической безопасности

Психологическая безопасность — это готовность сотрудников свободно выражать мнение без страха наказания или негативных последствий. Некоторые респонденты признались, что не готовы открыто обсуждать ошибки из-за давления на выполнение KPI и страха санкций.

В условиях банковского сектора это особенно опасно, поскольку ошибки в управлении рисками могут иметь масштабные последствия. Если сотрудники предпочитают скрыть проблему, а не вынести её на обсуждение, банк теряет возможность вовремя реагировать на угрозы.

Ситуация усугубляется тем, что в корпоративной культуре Казахстана в целом доминирует высокая дистанция власти и избегание неопределенности. Это выражается в стремлении подчинённых согласовывать свои действия с руководством, избегая инициативы. Таким образом, национальные культурные особенности накладываются на корпоративные барьеры и усиливают проблему.

3. Перегруженность менеджеров среднего звена

Руководители подразделений риск-блока отмечают значительную перегруженность отчётностью и контролем за исполнением формальных процедур. По результатам интервью, до 40% рабочего времени руководителей уходит на подготовку отчетов и согласование внутренних документов. В результате у них остаётся мало времени на развитие команд, наставничество и создание здоровой атмосферы взаимодействия.

Перегрузка формальными обязанностями приводит к тому, что управленцы концентрируются на выполнении краткосрочных целей, теряя из виду долгосрочные задачи по формированию культуры риска. Это снижает вовлеченность сотрудников и ограничивает возможности для развития инициатив.

В международной практике решение этой проблемы достигается через внедрение автоматизированных систем отчетности, распределение нагрузки и создание независимых центров компетенций. В исследуемом банке такие меры пока находятся на стадии пилотных проектов.

4. Конфликт KPI и побочные стимулы

Сотрудники риск-блока иногда сталкиваются с конфликтом между финансовыми показателями (рост портфеля, прибыльность) и качеством управления рисками. В системе KPI нередко доминируют показатели, связанные с объемом сделок или скоростью обработки заявок, тогда как качественные метрики риска учитываются в меньшей степени.

В результате сотрудники могут ощущать давление на результат, что снижает внимание к качеству оценки рисков и стимулирует «обходные практики». Это приводит к искажению мотивации и формированию так называемых «побочных стимулов», когда ради выполнения планов сотрудники игнорируют или занижают реальные риски.

Проблема конфликтов KPI актуальна не только для исследуемого банка, но и для всего банковского сектора Казахстана. Решение видится в пересмотре системы вознаграждений с учётом KRI (ключевых индикаторов риска) и интеграции поведенческих показателей в систему бонусов.

5. Потенциал для дальнейшей интеграции цифровых инструментов в повседневную практику

Несмотря на активное внедрение автоматизированных систем и переход к цифровым технологиям, в риск-блоке сохраняется низкий уровень интеграции этих инструментов в ежедневную практику. Многие сотрудники продолжают использовать устаревшие методы анализа и ручную обработку данных, что снижает эффективность и увеличивает вероятность ошибок.

Фокус-группы показали, что молодые сотрудники проявляют готовность к использованию новых технологий, однако сталкиваются с недостаточной поддержкой со стороны руководителей. В результате инновационные решения внедряются медленно и неравномерно, что усиливает разрыв между подразделениями.

6. Разобщенность подразделений и различия в восприятии ценностей

Одним из наиболее ярких результатов исследования стало выявление существенных различий между подразделениями риск-блока. Аналитики и методологи демонстрируют высокий уровень вовлеченности и доверия к руководству, тогда как сотрудники фронт-офиса оценивают культуру значительно ниже.

Такая разобщенность объясняется различием в характере работы: аналитические подразделения более ориентированы на долгосрочные цели и стратегический анализ, в то время как фронт-офис работает в условиях постоянного давления по KPI. В результате внутри банка формируется неоднородная культура, что снижает её эффективность как целостной системы.

Методы решения проблем и ключевые задачи

Анализ корпоративной культуры в CRO-блоке Банка показал наличие отдельных проблемных зон — различие в уровне вовлечённости сотрудников между подразделениями, сложности во внутренней коммуникации, локальные трудности адаптации к новым инициативам, а также перегрузка отдельных специалистов. Решение данных вопросов требует системного подхода, который объединяет управленческие, организационные и культурные инструменты.

Совершенствование внутренних коммуникаций

Одним из приоритетных методов решения является формирование устойчивой системы открытого диалога и регулярного обмена информацией. В частности, рекомендуется проведение ежемесячных кросс-функциональных встреч между

направлениями кредитных, стратегических, модельных рисков и подразделением по залоговому обеспечению. Это позволит согласовывать подходы, устранять барьеры и обеспечивать оперативность управленческих решений. Дополнительно целесообразно активнее использовать корпоративные цифровые платформы (Viva Engage, Teams) для обмена данными и ведения тематических рабочих групп.

Развитие лидерских компетенций среднего звена

Фокус-группы подтвердили запрос на укрепление управленческих навыков руководителей среднего уровня. Для решения задачи необходимо внедрение специализированных программ наставничества и обучения (Executive MBA, целевые тренинги), направленных на развитие навыков командной работы, коммуникаций и мотивации. Усиление лидерства среднего звена обеспечит более равномерное распределение нагрузки, укрепит доверие внутри команд и повысит психологическую безопасность.

Поддержка инициативности и инноваций

Важным направлением становится стимулирование предложений сотрудников. Для этого предлагается создание внутренней платформы сбора идей, проведение ежегодных конкурсов инициатив по оптимизации процессов риск-менеджмента, а также внедрение системы признания заслуг (например, «Лучший сотрудник квартала» и коллективные премии за выполнение командных KPI). Такая практика позволит повысить вовлечённость персонала и сформировать культуру доверия.

Балансировка нагрузки и гибкость работы

Для минимизации риска профессионального выгорания необходимо корректировать распределение задач между подразделениями, а также внедрять элементы гибкого графика, включая возможность дистанционной работы в пиковые периоды. Подобные меры позволят снизить уровень стресса и поддержать стабильную производительность.

Ключевые задачи на перспективу

1. Повышение прозрачности коммуникаций между направлениями и создание единого информационного пространства.
2. Развитие лидерских компетенций руководителей среднего звена через наставничество и обучение.
3. Внедрение программ нематериального и материального признания для укрепления вовлечённости сотрудников.
4. Стимулирование инновационной активности через конкурсы инициатив и цифровые платформы.
5. Устранение перегрузки сотрудников за счёт балансировки задач и применения гибких форм занятости.
6. Регулярный мониторинг индексов вовлечённости, удовлетворённости и лояльности (ESI, EEI, eNPS) как базовых индикаторов состояния корпоративной культуры.
7. Реализация указанных методов и задач обеспечит дальнейшее укрепление корпоративной культуры CRO-блока, повышение эффективности внутренних процессов и создание устойчивой среды, способной поддерживать стратегические цели Банка в условиях возрастающей конкуренции и цифровой трансформации.

ПОЛУЧЕННЫЕ РЕЗУЛЬТАТЫ (ВЫВОДЫ)

Развитие корпоративной культуры в блоке риск-менеджмента является ключевым условием повышения устойчивости и конкурентоспособности банка. В рамках исследования было показано, что традиционно доминирующая иерархическая культура обеспечивает высокий уровень формализации процедур, однако одновременно ограничивает гибкость и снижает готовность сотрудников к открытой эскалации проблем. В условиях цифровизации

и роста регуляторных требований данная модель уже не соответствует новым вызовам и нуждается в трансформации.

Процесс формирования современной культуры риска требует системных изменений. В ходе опросов и фокус-групп выявлено, что сотрудники позитивно оценивают систему профессионального обучения и наличие формализованных регламентов, однако фиксируют низкий уровень прозрачности коммуникаций и недостаточную психологическую безопасность. Это подтверждает необходимость развития клановых и адхократических элементов корпоративной культуры, которые способны стимулировать доверие, инновационность и вовлечённость.

Международный опыт ведущих банков демонстрирует, что интеграция поведенческих индикаторов в KPI, развитие speak-up культуры и использование цифровых инструментов для мониторинга рисков повышают зрелость организационной среды. Для казахстанских банков подобные меры особенно актуальны. Внедрение risk-huddles, анонимных каналов обратной связи и системы data governance, а также интеграция AI-инструментов позволит не только повысить эффективность управления рисками, но и укрепить доверие клиентов и регулятора.

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Regional Disparities in the Development of SMEs in Kazakhstan

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Abstract

This thesis analyzes regional disparities of SMEs in Kazakhstan using official statistical data. It focuses on enterprise structure, distribution, and labor productivity, highlighting significant differences between urban, resource-rich, and agricultural regions, and provides policy recommendations to promote balanced and sustainable SME development nationwide.

Introduction

Small and medium-sized enterprises (SMEs) are an essential part of Kazakhstan's economy, contributing significantly to employment, regional development, and economic diversification. [1]However, their distribution and performance are far from uniform across the country. Large cities such as Almaty and Astana demonstrate high enterprise density and productivity, while many agricultural or peripheral regions lag behind. [2]This regional imbalance is particularly relevant in the context of Kazakhstan's national strategy for inclusive growth and the government's long-term goals to reduce dependence on extractive industries. Understanding regional disparities in SME development is therefore of both academic and practical importance.

The purpose of this thesis is to investigate the regional differences in SME development in Kazakhstan, with a focus on enterprise structure, distribution, and labor productivity. By analyzing quantitative indicators at the regional level, the research seeks to identify the underlying causes of uneven development and to highlight the implications for policy and regional economic planning.

The objectives of the study are:

(1) to map the distribution of SMEs across regions of Kazakhstan;

(2) to examine differences in output and productivity by enterprise type;

(3) to evaluate the structural balance between small enterprises, medium enterprises, individual entrepreneurs, and farm enterprises.

The object of the research is the regional development of SMEs in Kazakhstan.

The subject of the research is the economic relations, mechanisms, and structures that shape regional disparities in enterprise performance.

The theoretical significance of this thesis lies in contributing to the literature on regional economic development and SME studies in resource-dependent transition economies. By applying comparative regional analysis and structural productivity assessment, the study provides evidence of how national-level SME policies manifest unevenly across space. This research thus not only enriches the understanding of Kazakhstan's regional economic landscape but also offers broader insights into the challenges of achieving balanced SME development in countries facing structural and geographic asymmetries.

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Literature review

According to Hirschman's (1958) theory[3] of unbalanced growth, development is inherently uneven due to differences in local resources. Therefore, regional disparities are a normal phenomenon in economic development. Distinct industrial structures across regions naturally lead to specialization and agglomeration, which in turn foster industrial clusters, promote nationwide trade complementarities, and enhance economic efficiency.[4]

The drawback, however, is that unbalanced development may cause certain regions to remain in low value-added industries for a long time, further widening the wealth gap, reducing household income, and ultimately undermining social stability. [5]Young labor forces, in search of greater opportunities, tend to migrate continuously toward economic centers, further weakening the labor supply and efficiency of peripheral regions, leading to hollowing-out, economic stagnation, and accelerated aging. Meanwhile, central cities face intensified job competition and heavier demographic burdens. These trends are often accompanied by governance, legal, and social challenges.[6]

Methodology

This thesis adopts a quantitative research methodology, drawing exclusively on the most recent official data published by the Bureau of National Statistics of Kazakhstan. The analysis is conducted at the regional level, employing comparative and structural methods. Two key indicators are selected: labor productivity, which measures the efficiency of SME operations, and Gross Regional Product (GRP), which reflects the broader economic performance of each region. By comparing SME labor productivity with GRP across different regions, the study identifies structural disparities, regional imbalances, and the extent to which SME performance corresponds to overall regional economic development. Using reliable national statistical data ensures both accuracy and objectivity, providing a solid foundation for policy-relevant conclusions.

Results and discussion

1. Structural Differences of Enterprises

From Figure 1 it can be observed that the number of medium-sized legal entities is extremely low in all regions, while individual entrepreneurs constitute the main structure of SMEs. In Turkistan and Almaty regions, farm enterprises are relatively concentrated and significantly higher than in other regions, reflecting their agricultural dominance. In Almaty city and Astana city, the share of individual entrepreneurs is particularly prominent, with small legal entities also more concentrated, which corresponds to an urban-type economic structure.

In terms of overall numbers, SMEs display a clear regional imbalance. Astana city and Almaty city far outpace other regions, with the number of SMEs being more than twice that of Turkistan, which ranks third, and nearly four times higher than in many peripheral regions.

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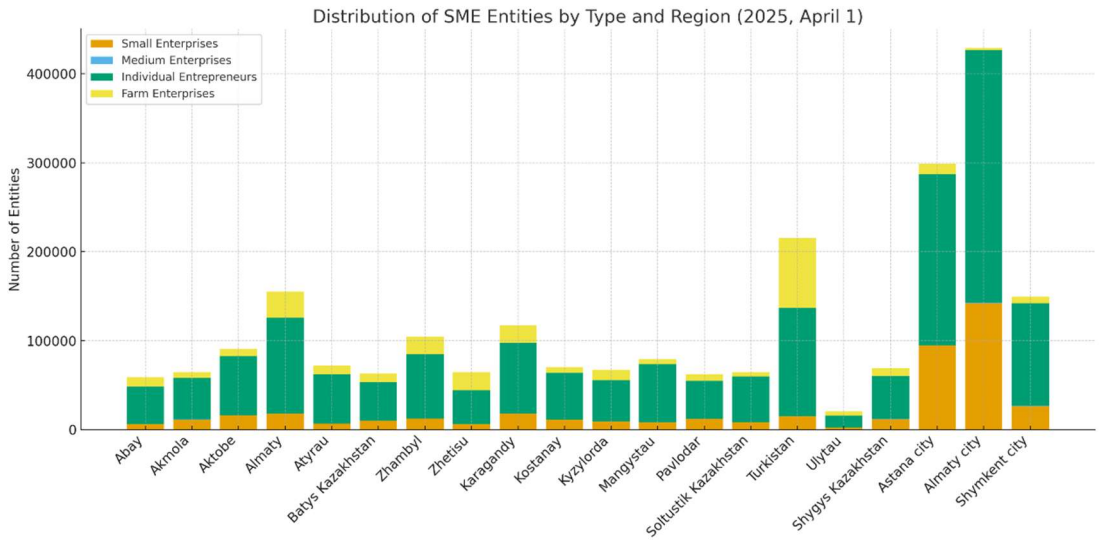

Figure 1. distribution of SME entities by types and region

2. Output Differences

From Figure 2 it can be seen that the output of SMEs demonstrates a highly uneven regional distribution. The outputs of Almaty city and Astana city far exceed those of other regions, being almost four times higher, which corresponds to the distribution patterns observed in SME numbers. In contrast, the outputs of all other regions remain below the threshold of 1.47k million tenge.

From the perspective of different legal entities, although the number of medium-sized enterprises is very small across all regions, their output remains significant, accounting for a noticeable share in most regions (see Figure 3). This indicates that medium-sized enterprises are characterized by low numbers but high output, with a strong tendency toward regional concentration in major cities. Small enterprises, by contrast, represent the largest share of output in nearly all regions, including agricultural areas such as Turkistan and Zhetisu, which confirms their role as the nationwide output backbone, particularly prominent in urban centers. Agricultural enterprises, however, contribute very little to total SME output in all regions, suggesting that agricultural production in Kazakhstan largely relies on the operations of large enterprises rather than SMEs. Individual entrepreneurs account for a considerable share of output in big cities, but nationwide they face the issue of high numbers with relatively limited output contribution.

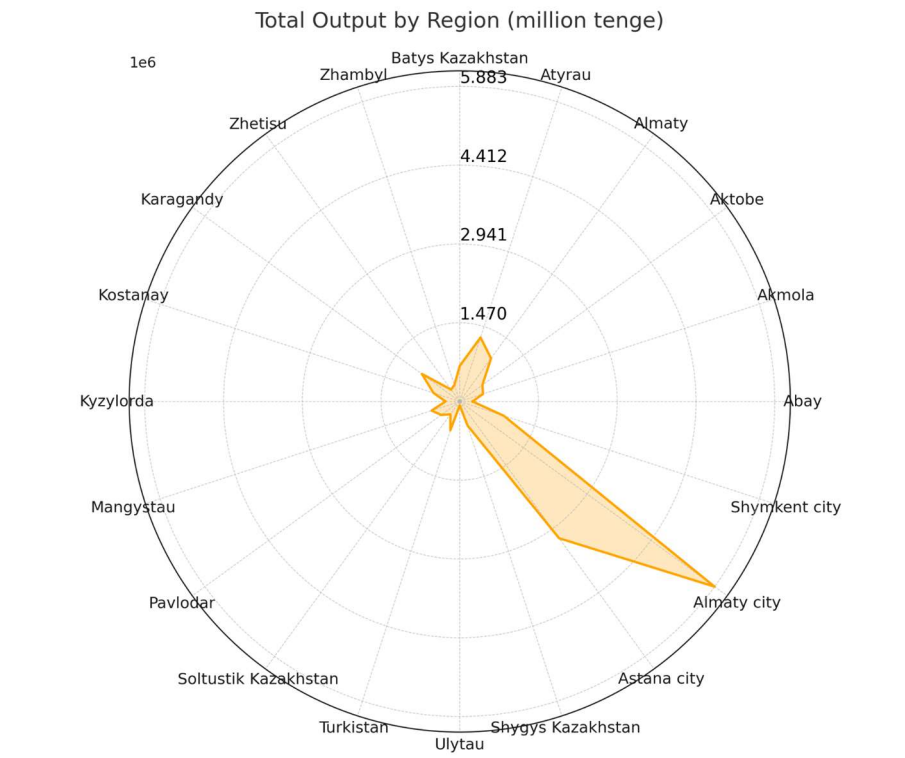

Figure 2. total output by region

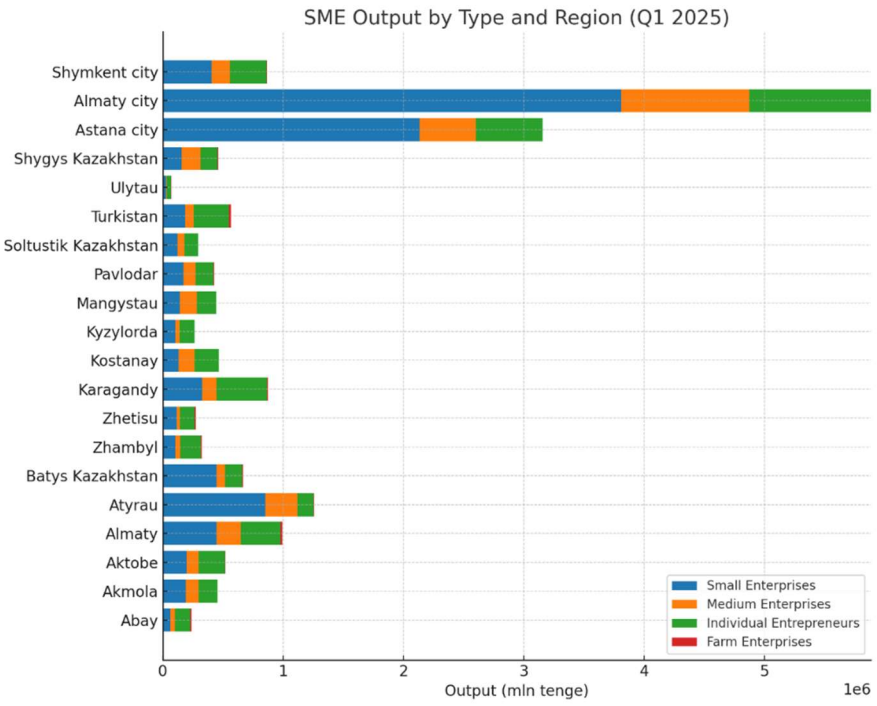

Figure 3. SME output by types and region

3. Analysis of Output Efficiency: Resource-Driven Productivity with Atyrau as a Representative Case

First, let us compare the overall production efficiency of SMEs across regions (Figure 4). Atyrau ranks first nationwide with exceptionally high output efficiency, followed by the two major cities.

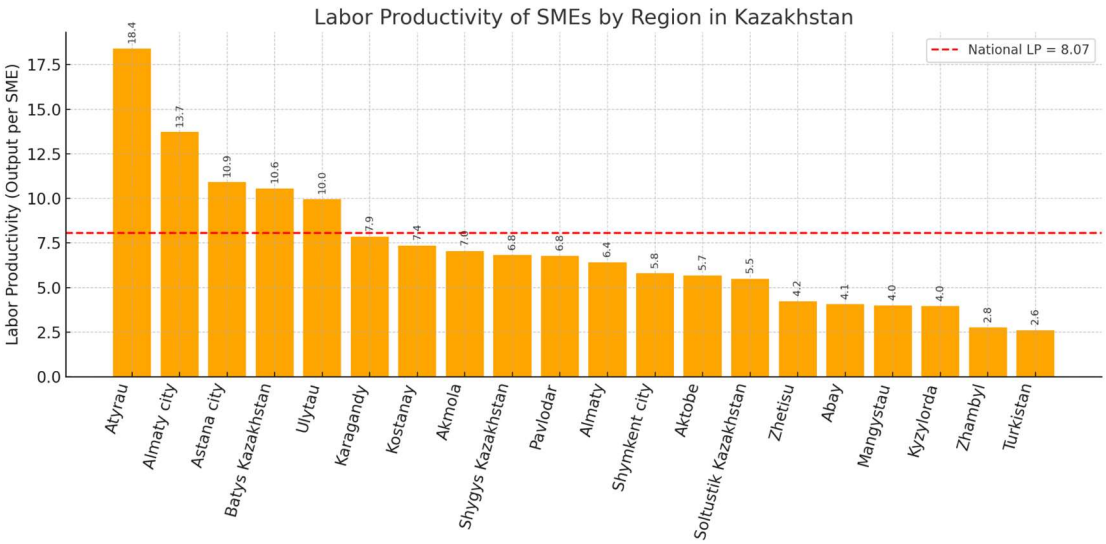

Figure 4. labor productivity of SMEs by region in Kazakhstan

A further analysis(see figure 5 and 6) shows that in both medium-sized and small legal entities, Atyrau ranks first nationwide in production efficiency, far exceeding any other region. However, based on previous data, the overall performance of SMEs in Atyrau is not particularly outstanding; rather, their extremely high efficiency is closely tied to the fact that Atyrau is Kazakhstan's most typical oil and gas base. [7]These enterprises are therefore not entirely comparable to traditional SMEs, but instead resemble resource-dependent, high-output entities. This indicates that the exceptional efficiency of medium-sized enterprises in Atyrau is largely associated with the capital-intensive nature of the energy sector, reflecting structurally inflated productivity.

In contrast, except for the two major cities, SMEs in other regions demonstrate efficiency levels that are more consistent with the conventional patterns of SME operations and structures.

Thus, it can be concluded that the distribution of SME efficiency in Kazakhstan is highly dependent on the industrial structures of resource-based regions. This not only highlights the strong spillover effects of the energy sector but also reveals a broader regional imbalance: SMEs in resource regions are "artificially elevated," while those in non-resource regions remain in a state of low efficiency.

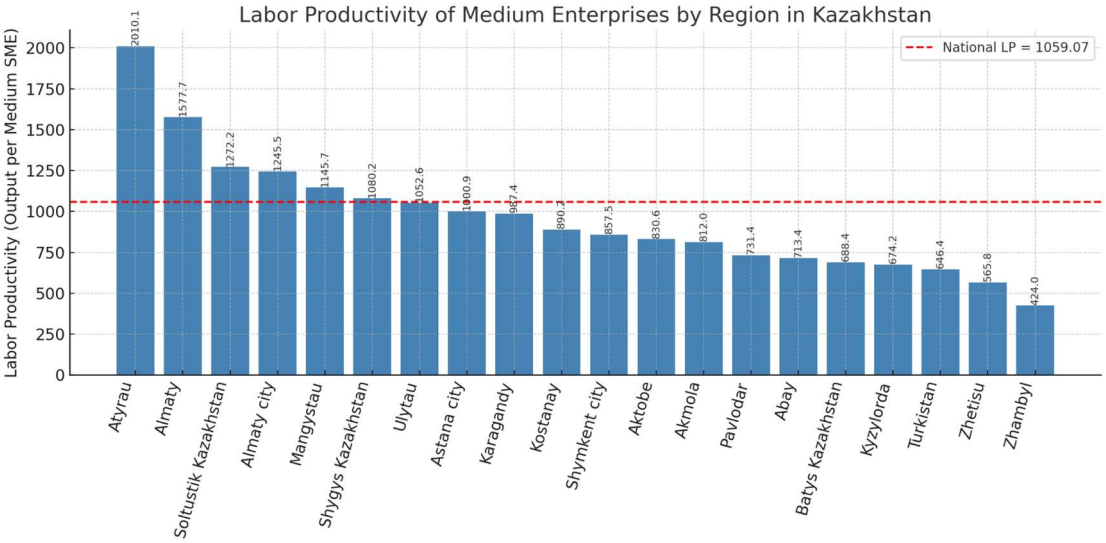

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Figure 5. labor productivity of medium enterprises by region in Kazakhstan

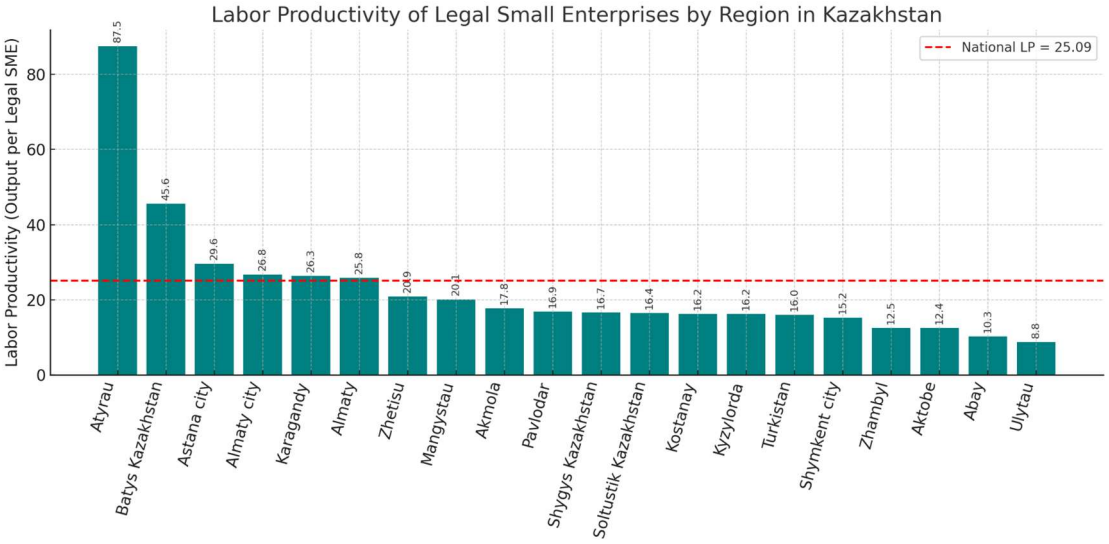

Figure 6. labor productivity of medium enterprises by region in Kazakhstan

4. The Unique Role of Almaty

Almaty is the largest city in Kazakhstan, where SMEs are less dependent on resources and are predominantly concentrated in the service sector. [8]As discussed earlier, Almaty serves as the center of many extremes and represents the highest overall level of SME development in the country. According to Figures 7 and 8, Almaty ranks first nationwide in the productivity of both farm enterprises and individual entrepreneurs. In contrast, agricultural regions such as Turkistan and Zhambyl host large numbers of farm enterprises but with relatively low efficiency. As shown in Figure 9, Almaty demonstrates a unique dual structure: while its urban areas are dominated by high value-added industries such as services, its rural areas exhibit the highest level of agricultural organization and market integration in the country. This indicates that Almaty benefits strongly from positive spillover effects.

Astana, by comparison, performs only moderately in terms of SME productivity across categories, with slightly above-average levels in individual entrepreneurs and small enterprises. This is likely linked to its role as the political center of Kazakhstan, where SMEs are concentrated in administrative and service-oriented sectors.[9]

In conclusion, Almaty occupies a unique position in Kazakhstan: it is not only the primary economic engine but also demonstrates a dual-core model of urban and rural economic development. Unlike resource regions or the political capital, Almaty's SMEs follow a more diversified path, making it a model for promoting balanced SME development nationwide.

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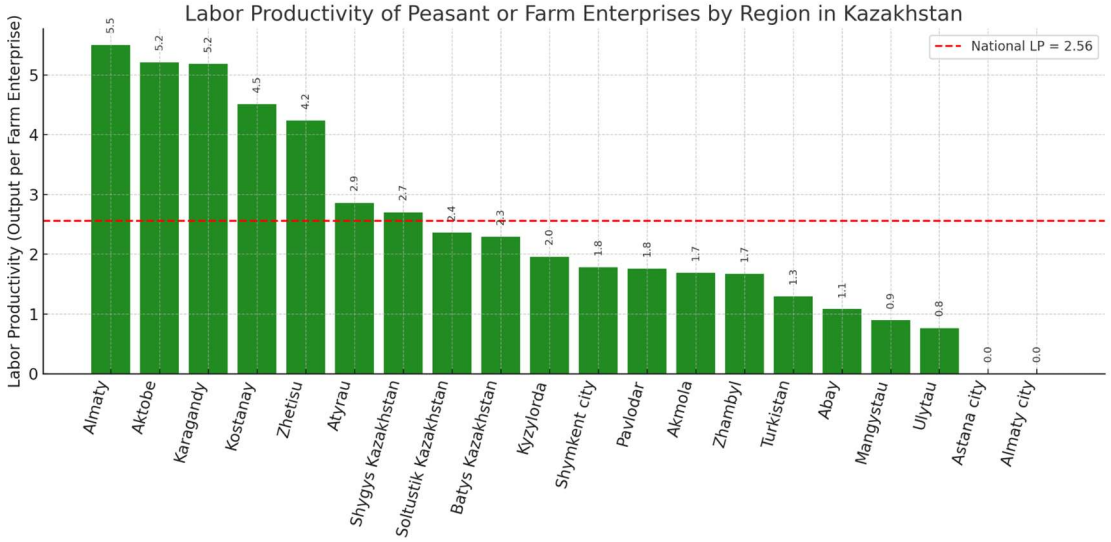

Figure 7. labor productivity of peasant or farm enterprises by region in Kazakhstan

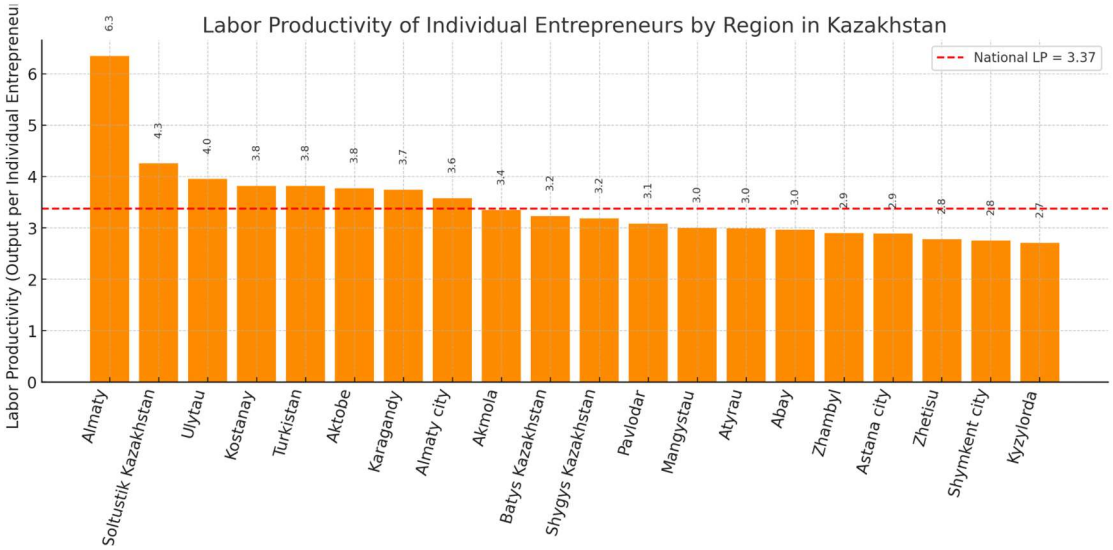

Figure 8. labor productivity of individual entrepreneurs by region in Kazakhstan

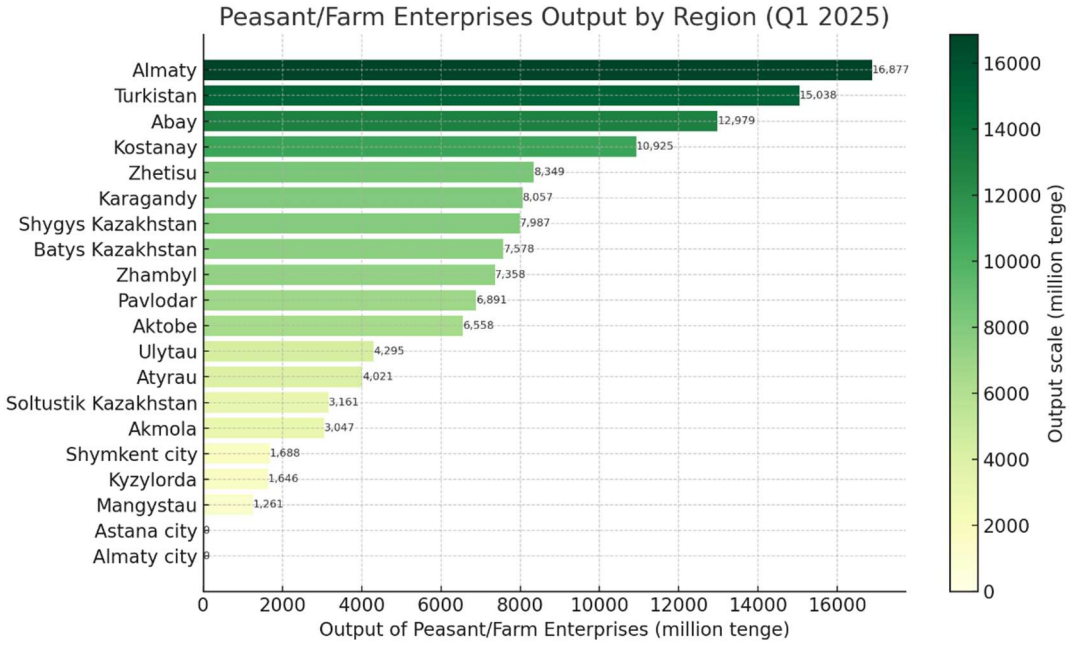

Figure 9 peasant/farm enterprises output by region

5. SMEs' Contribution to Regional Economic Development

From Figure 10 it can be observed that the share of SMEs in gross regional product (GRP) varies significantly across regions. In Almaty city and Astana city, the SME contribution approaches or even exceeds 60%, indicating that in major urban centers SMEs are the primary drivers of economic growth. The economic dynamism of these cities largely depends on the vitality of the SME sector. By contrast, in most other regions—except for the top five—the share of SMEs in GRP does not exceed the national average, suggesting that these areas remain more dependent on large enterprises, such as state-owned companies or resource-based industries, with SMEs playing a relatively limited role.

In many developed economies, SMEs typically contribute around 50–60% or more to GDP or GRP. The fact that Almaty and Astana approach this level shows that their economic development has shifted from reliance on large enterprises and resource sectors toward a more diversified model centered on services, trade, and the digital economy. For Kazakhstan as a whole, the SME contribution to GRP stands at 38.6%, suggesting that while SMEs have become an important component of the economy, their potential has not yet been fully realized. The overall economy remains dominated by large and state-owned enterprises. Moreover, this national average is skewed upward by the performance of major cities, thereby making significant regional disparities. Overall, Kazakhstan continues to rely heavily on its traditional resource-based economy, particularly oil and mining.

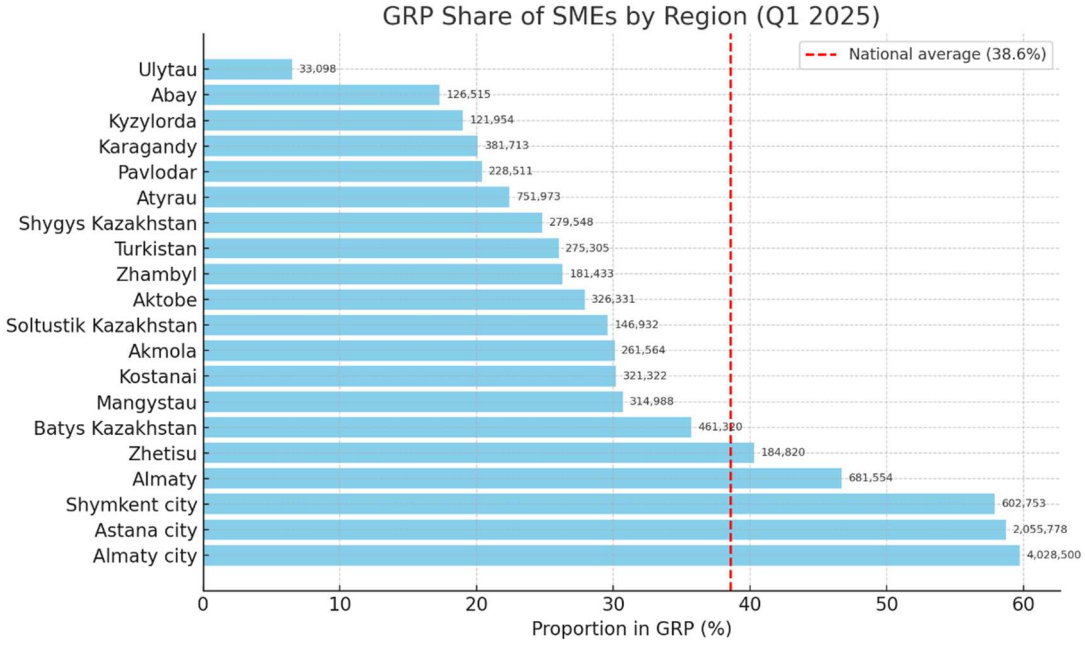

Figure 10 GRP share of SMEs by region in Kazakhstan

Source: Calculations are carried out by the author, with data sourced from the Bureau of National Statistics of Kazakhstan (2025) (figure 1-10).[10]

Conclusion

From the above analysis, the following conclusions can be drawn: at present, the economic role of SMEs in Kazakhstan has not yet been fully realized, and their distribution, output, and efficiency still exhibit significant regional disparities. Major cities have already reached a level of development comparable to that of advanced economies, but nationwide SME development remains dependent on resource-based activities. Almaty, as the country's main economic engine,

[10] Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan. (2025, August 15). *The main indicators of the number of subjects (as of August 1, 2025)*. Retrieved from https://stat.gov.kz/en/industries/business-statistics/stat-org/publications/411597/

plays a particularly distinctive role, and its development model offers valuable lessons.

Based on this analysis, several recommendations can be made. First, in agricultural regions such as Turkistan, Zhambyl, and Zhetisu, policies should prioritize modernization, technology adoption, and integration into value chains to enhance the efficiency of farm enterprises and narrow the productivity gap with urban SMEs. Second, in urban centers such as Almaty and Astana, where SME numbers are large but efficiency varies, policies should focus on fostering innovation, digitalization, and support services to sustain competitiveness. Third, in resource-rich regions such as Atyrau and Mangystau, despite their exceptionally high productivity, SMEs should be encouraged to diversify beyond oil-related activities in order to strengthen economic resilience. Finally, at the national level, institutional support should be reinforced, financing channels improved, and entrepreneurial training enhanced to reduce structural imbalances. Aligning SME policies with regional characteristics will enable Kazakhstan to achieve more balanced and sustainable SME development.

THE GROWTH AND CHALLENGES OF NEW ENERGY PROJECTS

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Introduction

In recent years, the global energy system has undergone a profound transformation, with the development of new energy projects emerging as a crucial measure to address climate change and achieve sustainable development. As traditional fossil fuels are depleted and environmental issues become increasingly severe, new energy has been widely recognized as a vital component of future energy supply across nations. New energy projects have been shown to contribute to the reduction of greenhouse gas emissions, while also driving economic growth and technological innovation. Nevertheless, despite substantial progress in technology, policy, and market aspects, the development of new energy projects continues to confront a multitude of challenges.Presently, new energy projects have garnered widespread attention and active promotion on a global scale. Numerous countries have instituted policies to promote the development of new energy sources, including subsidies, tax incentives, and renewable energy targets. Technological advancements have led to enhanced efficiency and reliability in new energy projects, accompanied by a steady decline in costs. However, extant research suggests that the development of new energy projects still faces multiple challenges, including an imperfect legal system, high financing costs, fierce market competition, and high technological barriers. Furthermore, the evaluation system for investment benefits in new energy projects remains underdeveloped, exhibiting a dearth of comprehensive and scientific assessment methodologies.

Despite the exploration of the present state and challenges of new energy project development in previous studies, there are several unresolved issues. First, extant research has focused predominantly on new energy projects in individual countries or regions, with a paucity of systematic studies on transnational new energy project investment cooperation. Secondly, with respect to the evaluation of investment benefits for new energy projects, extant research has predominantly focused on economic benefits. In contrast, comprehensive evaluations that incorporate environmental and social benefits are comparatively scarce. Furthermore, the evaluation methods employed in extant studies are frequently unidimensional, devoid of comprehensiveness and scientific rigor. Consequently, the development of a comprehensive and scientific investment benefit evaluation system for new energy projects to more effectively guide investment decisions has emerged as a significant research gap.

The objective of this study is to address the aforementioned research gaps. The research will adopt a combination of a literature review and a case analysis. The present study will undertake a systematic review of extant literature to provide a comprehensive summary of the current status and deficiencies in the evaluation of benefits from investment in new energy projects. Subsequently, a series of case studies will be examined in meticulous detail. The specific steps are as follows:

Literature Review: A systematic review of domestic and international research on new energy project investment benefits will be conducted to identify the strengths and weaknesses of existing evaluation systems.

Case Selection: A select group of novel energy initiatives will be chosen for case analysis to assess their economic, environmental, and social benefits.

Comprehensive Evaluation: A comprehensive evaluation of the selected cases will be

performed to analyze their investment benefits and propose improvement suggestions.

This study possesses significant theoretical and practical implications. Theoretically, the construction of a comprehensive investment benefit evaluation system is expected to enhance the content of new energy project investment benefit studies and to provide new perspectives and methods for academic research in related fields. In practice, the study provides scientific evidence for investment decisions in new energy projects, which can enhance their investment benefits and promote sustainable development. Furthermore, it offers references for policymakers to formulate more scientific and rational new energy policies, thereby promoting the healthy development of the new energy industry.

1. Research status of new energy projects and their investment benefits

1） Status of foreign research

Research on new energy projects and their investment returns abroad commenced relatively early and has been conducted in greater depth, encompassing multiple aspects such as evaluation methods, influencing factors, and improvement recommendations. Yang and Blyth (2007) simulated the impact of climate change policies on electricity investments, comparing the effects of policy uncertainty versus market uncertainty on energy investments. This study offers a critical perspective on the influence of the policy environment on investment decisions. Kastner's (2016) study revealed that investors with stronger eco-social values were more inclined to participate in renewable energy investments. The sustainability of such investments was influenced by economic consequences and the reliability of funding sources. Moreover, Rioja and Valev's (2013) examination of the impact of financial structure on physical capital accumulation revealed that debt financing exhibited advantages over equity financing in the context of energy investments[a]. Xie (2021) analyzed how corporate equity structures influence investment behavior during economic policy transitions, noting that state-owned enterprises can secure policy benefits during such shifts to enhance investment returns[b]. Mykhayliv and Zauner's (2013) examination of the relationship between corporate investment behavior and ownership structure revealed that government ownership exerts a negative impact on investment and introduces budgetary constraints[c]. Peng et al. (2021) conducted a simulation-based evaluation of investment proposals for photovoltaic power generation projects, focusing on economic efficiency indicators such as net present value, levelized cost of electricity, and return on assets[d]. This study provides a methodology for comprehensive project assessment. Farhani et al. (2021) and Nmk et al. (2020) conducted in-depth studies on input costs and benefit evaluation indicators for PV projects based on the life cycle theory[e]. These studies provide theoretical support for project cost-benefit analysis.Mykhayliv and Zauner's (2013) examination of the relationship between corporate investment behavior and ownership structure revealed that government ownership exerts a negative impact on investment and introduces budgetary constraints[f]. Peng et al. (2021) conducted a simulation-based evaluation of investment proposals for photovoltaic power generation projects, focusing on economic efficiency indicators such as net present value, levelized cost of electricity, and return on assets. This study provides a methodology for comprehensive project assessment. Farhani et al. (2021) and Nmk et al. (2020) conducted in-depth studies on input costs and benefit evaluation indicators for PV projects based on the life cycle theory, providing theoretical support for project cost-benefit analysis[g]. In their 2019 study, Liu et al. developed a framework that incorporates a variety of factors, including innovation, operations, and debt repayment, from a value chain perspective. They employed principal component analysis to identify significant influencing factors for PV enterprises. In her 2018 study, Ozorhon sought to incorporate environmental and social factors into an investment benefit impact analysis model[h]. To this end, she employed the grid-based analytic hierarchy process to determine the importance weights of key indicators such as regulatory intensity, capital adequacy, and returns. Lu et al. (2021)

developed a levelized cost of electricity model that incorporated fiscal and tax factors to assess the costs and sensitivity factors of photovoltaic power generation projects. These studies offer substantial theoretical and methodological support for the evaluation of investment benefits for new energy projects[i].

2） Status of Chinese Research

Despite the belated initiation of research on new energy projects in China, significant progress has been achieved through the implementation of robust national policy support and the active consideration of international research findings. A substantial body of research has been conducted by numerous scholars who have explored the investment returns of new energy projects from various perspectives. This research has provided a rich theoretical foundation and practical guidance for research in this field.

Xin Qingquan et al. (2004) conducted a study that analyzed the return on capital investment of domestic listed companies. The researchers emphasized the importance of a sound investment environment and a reasonable equity structure in enhancing the return on capital investment. Bai, Chong'en, et al. (2004) discovered that the investment environment exerts a significant and positive influence on the returns of foreign direct investment. However, this effect undergoes a gradual diminution as the duration of the investment operation period increases. Hu, Zongyi, et al. (2011) employed a partial least squares regression model to reveal that the proportion of foreign investment and the share of coal consumption are key factors influencing regional disparities in energy efficiency. In their seminal study, Wang Yizhong and Song Min (2014) examined the patterns of external demand, liquidity requirements, and expectation factors that influence corporate investment behavior from the perspective of macroeconomic uncertainty. Zhang Qiong and Fan Kexin (2022) developed an oil and gas investment risk evaluation system using a multi-criteria decision-making approach based on singular value decomposition and Theil indices. They identified oil and gas resources, the political environment, and the economic environment as primary influencing factors. He Hongqu et al. (2018) discovered a significant positive correlation between financial elasticity value and investment scale. Yu Shanshan (2021) has demonstrated that accounting conservatism exerts dual effects on both overinvestment and underinvestment. Lu Xin et al. (2013) found that financing constraints limit R&D investment in high-tech enterprises, while adequate funding can effectively alleviate such constraints. Peng Min and Tian Yuan (2012) employed the Analytic Hierarchy Process to analyze constraints on energy enterprise investment under a low-carbon economy, emphasizing the importance of low-carbon technology, talent, and policy. The following text is intended to provide a comprehensive overview of the subject matter.According to Zhang Ruijie (2022), the financial leasing model has been demonstrated to be an effective solution to the bottlenecks that are often encountered in the development of photovoltaic projects. He Jianxiong (2012) posited that the costs associated with energy installation, operation and maintenance, loan conditions, and annual peak sunshine hours exert a significant influence on the returns of photovoltaic power projects[j]. Zhang Yue (2016) employed curve estimation to demonstrate that the optimization of environmental investment allocation and operating revenue maximization is a strategy that can be employed to achieve the maximization of corporate value. Song Xiaomin et al. (2002) established a project investment economic benefit selection criteria system based on economic efficiency theory. Li Xingyuan et al. (2009) developed evaluation indicator systems for smart grids and traditional grids from an asset management perspective. Wang Bin et al. (2011) integrated macro and micro perspectives to establish a multi-level demand system architecture. Xu Jinyue and Wang Menglin (2015) developed a value chain-based investment decision model using large-scale enterprise equipment as a case study[k]. Li Fengyun et al. (2016) examined the impact of financing constraints and government subsidies on investment efficiency in new energy enterprises using heterogeneous bilateral theory and

stochastic frontier models. In their 2023 study, Zeng Ming and Wang Yuqing proposed investment operation and profit models for independent energy storage, integrating the concept of the sharing economy. Fu Xu et al. (2020) assessed the economic viability of various energy storage technologies using the life-cycle cost approach. Li Rui (2017) examined the economic benefits of distributed generation projects based on life-cycle theory. Ding Hong and Liu Qinhua (2019) conducted an analysis of policy factors affecting the economic viability of wind power projects, employing wind power engineering as a case study. Zhu Zhifang et al. (2022) conducted an examination of the economic benefits of energy storage in grid applications from the perspective of the grid base-load revenue model. In the year 2022, Zhao Huiru and Huang Yuhui conducted a study.

In their 2022 study, Zhao Huiru and Huang Yuhui examined the compliance management effectiveness of grid companies and proposed an evaluation model based on portfolio weighting. Wei Ping (2022) developed a financial benefit evaluation process using photovoltaic power generation projects as a case study[l]. Yang Zhan (2016) underscored the significance of incorporating social benefits, including energy conservation and emission reduction, into the evaluation of investment benefits for energy projects. In their study, Zhao Huiru and Zhao Hang (2022) examined the comprehensive benefits of ultra-high voltage transmission projects. They proposed an evaluation method based on Bayesian and improved material-element extended analysis. Shu Mengdi (2020) developed a hierarchical fuzzy investment-benefit evaluation model to examine the investment benefits of distributed energy under multi-energy complementary conditions. Guan Huiyao et al. (2021) conducted an examination of the social benefit patterns of distributed photovoltaic power generation projects. In 2013, Cai Wen and Yang Chunyan introduced extension theory and proposed a novel performance evaluation model. Shen Genxi et al. (2022) conducted a comprehensive benefit assessment of engineering renovations. This assessment was based on an AHP-object extension model. Luo Yi and Li Yulong (2013) employed entropy weighting and grey relational analysis to evaluate the feasibility and economic viability of transmission grid planning and design schemes.

These studies provide theoretical support and practical guidance for evaluating the investment benefits of new energy projects across multiple dimensions, including the investment environment, technological efficiency, policy impact, and economic benefits. These findings lay a solid foundation for further refinement of the evaluation system for the benefits of new energy project investment.

2. Case study-Take the development of new energy projects in China as an example

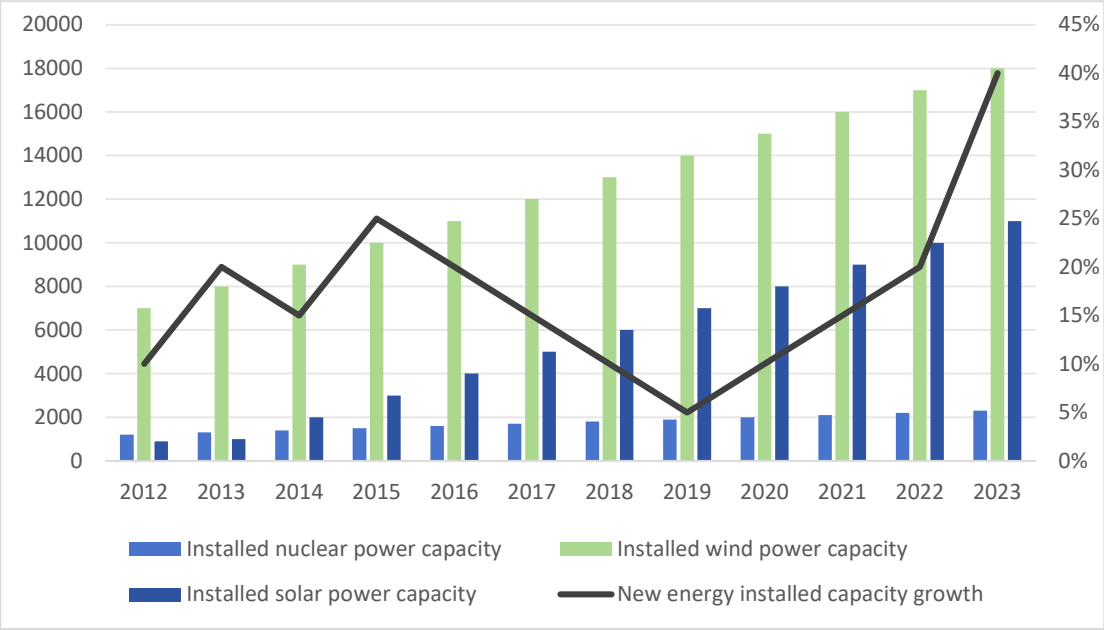
In recent years, China has made significant strides in the domain of new energy, particularly with the advent of the Belt and Road Initiative, as evidenced by the substantial investment and collaborative endeavors of Chinese enterprises in new energy projects across participating nations. In October 2023, the Third Belt and Road Forum for International Cooperation was successfully held in Beijing, yielding 458 outcomes, including a series of achievements aimed at jointly building a Green Silk Road and promoting green development. The Beijing Initiative on Green Development for the Belt and Road, adopted at this summit, emphasizes several key points. Firstly, it calls for the strengthening of cooperation in the realm of green energy. Secondly, it advocates for the support of developing countries in their pursuit of green and low-carbon energy development. Thirdly, it encourages nations to establish renewable energy targets in accordance with their nationally determined contributions. Finally, it supports developing countries in accessing affordable and sustainable clean energy.

China's initiatives in the field of new energy have exhibited a marked increase in the rate of growth. In 2023, China augmented its renewable energy generation capacity by 294 gigawatts, thereby elevating the cumulative installed capacity to 1,108 gigawatts. From 2012 to 2023,

cumulative new energy capacity increased by 1,030 gigawatts, representing an average annual growth rate of 27.4%. Among these, nuclear power reached a cumulative capacity of 57 GW, an increase of 44 GW from 2012, with an average annual growth rate of 14.7%. As indicated by the data, wind power has achieved a cumulative capacity of 441 GW, which represents an increase of 380 GW from 2012. The average annual growth rate of wind power is 19.6%. Similarly, cumulative photovoltaic capacity has reached 60.9 million kilowatts, which is an increase of 60.6 million kilowatts from 2012. The average annual growth rate of photovoltaic capacity is 60.2%. With respect to the structure of power generation capacity, new energy power generation accounted for 37.9% of China's total installed power generation capacity in 2023. This proportion has increased from less than one-tenth in 2012 to over one-third at present. Specifically, nuclear power, wind power, and solar power accounted for 1.9%, 15.1%, and 20.9% of the national total installed power generation capacity, respectively. This represents an increase of 0.8, 9.7, and 20.6 percentage points compared to 2012.

Table1-New energy installed capacity from 2012 to 2023

Note-Compiled by the author based on the source[m].



The People's Republic of China has achieved significant advancements in the domains of new energy technology innovation and industrial chain development. Presently, China has established the world's largest, most comprehensive, and competitive new energy industrial and supply chains, fostering a cohort of world-class energy equipment manufacturers. In the nuclear power sector, China made significant breakthroughs in 2023 across fourth-generation nuclear power plant construction, nuclear fusion, and nuclear heating projects. In the field of wind power technology, China has emerged as a global leader in the research and development of large-capacity turbines, elongated blades, and tall tower applications. In the domain of photovoltaic power generation, technological advancements are characterized by rapid progress, marked by ongoing enhancements in cell conversion efficiency. In the domain of hydrogen energy, the year 2023 was marked by significant advancements in the field of demonstration applications. A substantial number of integrated wind/solar hydrogen production and synthetic ammonia projects were initiated, signifying a notable development in the sector.Recent developments in China's energy sector have witnessed the emergence of international cooperation and exports of new energy projects as notable highlights. In 2023, China's "new trio" of export commodities—electric passenger vehicles, lithium batteries, and solar cells—combined to reach 1.06 trillion yuan in exports, surpassing the trillion-yuan threshold for the first time and marking a 29.9% year-on-year

increase. China's wind power and photovoltaic products have been exported to over 200 countries and regions worldwide, with cumulative export values exceeding US$33.4 billion and US$245.3 billion, respectively. Moreover, China has achieved notable success in the realm of overseas investment cooperation for new energy projects, with notable examples including wind power, photovoltaic, and nuclear power projects in South Asia, Central Asia, Central and Eastern Europe, South America, and Africa.

China's new energy projects have achieved significant progress under the Belt and Road Initiative; however, these endeavors are confronted with numerous challenges in the context of rapid development. In order to ensure sustained economic growth and global competitiveness, the Chinese government must prioritize the following measures: first, the further strengthening of technological innovation and industrial chain development; second, the optimization of international cooperation and export strategies; third, the addressing of uncertainties in both domestic and international markets; and fourth, the promotion of high-quality development of new energy projects.

Conclusion

The present study focuses on investment cooperation in China's new energy projects under the Belt and Road Initiative. It employs a systematic analysis to reveal the current development status of these projects in participating countries, as well as the challenges they face. The findings indicate that while China's new energy projects have achieved significant accomplishments in technological innovation, industrial chain development, and international cooperation, persistent issues such as intensified market competition, project implementation difficulties, and policy uncertainties continue to pose challenges to sustainable project development. The present study proposes a comprehensive analytical framework that evaluates not only economic benefits but also incorporates environmental and social benefits, thereby providing a scientific basis for investment decisions that is holistic in nature. Moreover, the proposed recommendations furnish guidance for Chinese companies developing overseas new energy projects, thereby promoting high-quality development.

However, it must be acknowledged that the present study is not without its limitations. The study's primary reliance on extant literature and partial case analyses, as opposed to exhaustive research on contemporary projects, may compromise the study's comprehensiveness and representativeness. The evaluation indicator system still requires enhancement to adequately reflect project sustainability and social impact. Additionally, the study did not fully consider the differences in policies, markets, and technologies across various countries and regions, resulting in an incomplete analysis of investment cooperation.

Overall, under the impetus of the Belt and Road Initiative, China's new energy projects have achieved significant progress while facing numerous challenges. In order to address these challenges, China must prioritize the following measures: first, the strengthening of technological innovation and industrial chain development; second, the optimization of international cooperation and export strategies; third, the addressing of market uncertainty risks; and fourth, the promotion of high-quality development of new energy projects. Through continuous research and practice, China is poised to achieve greater accomplishments in the new energy sector and make more substantial contributions to global sustainable development.

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CHALLENGES AND OPPORTUNITIES FACING SME CREDIT

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Introduction

In recent years, the role of small and medium-sized enterprises (SMEs) in economic development has become increasingly prominent. These enterprises play an irreplaceable part in promoting employment, driving innovation, and fueling economic growth. However, SMEs encounter significant obstacles when attempting to access credit resources, which has emerged as a primary factor hindering their growth and development. The limited availability of credit has been demonstrated to have a deleterious effect on the survival and expansion of SMEs, as well as on the overall healthy development of the economy. The rapid advancements in digital financial technologies and the deepening implementation of inclusive finance policies have led to a growing focus on optimizing the credit environment for SMEs by both academia and the business community. The objective of this study is to examine the challenges and opportunities SMEs encounter in accessing credit, with a particular focus on their specific manifestations against the backdrop of digital transformation and policy support.Research on credit accessibility for small and medium-sized enterprises (SMEs) has made considerable progress. Research has identified information asymmetry as a primary contributing factor to the challenges faced by SMEs in accessing credit. Small- and medium-sized enterprises (SMEs) frequently lack standardized financial information and sufficient collateral, which makes it challenging for financial institutions to accurately assess their credit risk. Consequently, this dynamic has the effect of increasing lending costs and risk premiums. Additionally, the reduced operational scale and diminished risk-bearing capacity of SMEs serve to further exacerbate the financial institutions' credit caution. Nonetheless, the advent of digital financial technologies—including big data, artificial intelligence, and blockchain—has engendered innovative solutions to address information asymmetry. The integration of multi-source data facilitates the development of precise credit assessment models, thereby enhancing SMEs' access to credit. Despite the innovations introduced by digital financial technologies, small- and medium-sized enterprises (SMEs) continue to encounter significant challenges within the credit market. These challenges include limitations in technology application, data security concerns, and inadequate policy support.

Despite the extensive exploration of factors influencing SME credit availability and pathways for improvement in extant research, several research gaps persist. First, the majority of studies concentrate on analyzing credit constraints within traditional financial models, lacking systematic evaluations of the effectiveness of digital financial technologies in SME lending. Secondly, there is a paucity of research examining the potential for digital financial technologies to be integrated with policy support to enhance SME credit accessibility. Moreover, extant studies have inadequately addressed the long-term ramifications and sustainability of enhancements in SME credit accessibility, exhibiting an absence of in-depth analysis of the dynamic shifts in the SME credit environment. These discrepancies underscore the necessity for further investigation into the synergistic impacts of digital financial technologies and policy interventions, as well as the potential of innovative mechanisms to augment SME credit accessibility.The objective of this study is to conduct an in-depth analysis of the challenges and opportunities facing SME credit, particularly in the context of rapid advancements in digital financial technologies. The study explores the potential of technological innovation and policy support to enhance credit

accessibility for SMEs. The study will employ a combined methodology of literature review, case analysis, and empirical research to systematically examine the factors influencing SME credit accessibility. The study will examine the present implementation of digital financial technologies and their impact mechanisms on SME lending, formulating targeted policy recommendations. The objective of this research is to provide theoretical support and practical guidance for optimizing the credit environment for small and medium-sized enterprises.

The academic significance of this study lies in its contribution to theoretical research on SME credit accessibility, particularly in exploring the synergistic effects of digital financial technologies and policy support. A comprehensive analysis of the application outcomes of digital financial technologies in SME lending will be conducted to provide new perspectives and theoretical foundations for academic studies in related fields. Concurrently, the practical significance of this study lies in its provision of concrete guidance and recommendations for policymakers, financial institutions, and SMEs. This will assist them in more effectively navigating challenges in the credit market, enhancing SME credit accessibility, and thereby promoting sustainable economic development.

1. Overview of the Theory of small, medium and micro enterprises

The theory of information asymmetry, proposed by Akerlof and Spencer, elucidates how uneven information distribution in financial markets engenders inefficient resource allocation. Small and medium-sized enterprises (SMEs) encounter challenges in securing financing due to their limited scale and the absence of standardized operations. Financial institutions encounter challenges in acquiring precise information regarding these entities, thereby amplifying credit risk and intensifying financing constraints[a]. The credit rationing theory, proposed by Stiglitz and Weiss, posits that information asymmetry prompts banks to raise lending rates or reduce supply. Enterprises in the low-risk category are deterred, while those in the high-risk category become more receptive, further intensifying the financing difficulties faced by SMEs. Signaling theory, proposed by Spencer, analyzes how firms mitigate information asymmetry by sending signals (e.g., financial reports, patent counts) to secure credit support[b]. However, signals may be incomplete or misleading, necessitating financial institutions to filter genuine signals to mitigate risk.Digital inclusive finance employs big data, artificial intelligence, and other technologies to integrate SME data, construct precise credit assessment models, mitigate information asymmetry, enhance financial institutions' decision-making efficiency, reduce financing costs, and broaden financing channels. However, its advancement faces challenges such as an imperfect credit reporting system, data security concerns, and lagging regulatory policies[c]. A global analysis of SME financing models reveals significant variations. The United States adopts a market-driven approach, Germany strikes a balance between government and market roles, and India follows a government-led model. The People's Republic of China places significant reliance on government support, yet the nation confronts challenges such as the absence of comprehensive credit reporting systems and regulatory policies that are not sufficiently robust[d]. The success experienced by foreign banks, such as Wells Fargo and Kasikornbank, offers valuable insights for commercial banks in China as they seek to innovate their service models.

In summary, addressing SME credit issues necessitates the integration of multiple theoretical perspectives. Theories of information asymmetry and credit rationing reveal the underlying mechanisms of financing difficulties, while signaling game theory emphasizes the importance of information transmission and screening. Digital inclusive finance provides technological solutions. Government support and innovations in commercial bank service models are pivotal to enhancing SME credit accessibility. Subsequent research endeavors should integrate these theories to investigate institutional, technological, and policy innovations, thereby constructing a comprehensive credit system that fosters the sustainable development of SMEs.

2. Credit status of small, medium and micro enterprises

Creditworthiness is defined as a company's capacity to secure credit facilities from financial institutions, such as bank loans or letters of credit, through credit assessments. Financing capacity serves as the primary indicator of creditworthiness. It is imperative to acknowledge the pivotal role that small and medium-sized enterprises (SMEs) play in the national economy. These enterprises are the cornerstones of employment opportunities, innovation, and economic growth. Their contributions are indispensable and cannot be substituted. However, small- and medium-sized enterprises (SMEs) encounter considerable challenges in allocating resources effectively within the credit market. A pronounced disparity exists between their economic contributions and their access to financing, with their market potential long constrained by financing barriers. Despite the implementation of certain measures intended to enhance the allocation of credit resources, ongoing national initiatives aimed at optimizing SME financing policies have not yet yielded the desired results[e]. Structural imbalances continue to persist at a pronounced level. In comparison to the extensive credit support systems utilized by large enterprises, small- and medium-sized enterprises (SMEs) continue to grapple with a pronounced financing gap.In recent years, the People's Republic of China has implemented a series of policies with the objective of optimizing the financing environment for small and medium-sized enterprises (SMEs). By the conclusion of 2021, the aggregate outstanding balance of inclusive loans extended to micro and small enterprises amounted to 19 trillion yuan, signifying a year-over-year growth rate of 24%, which surpasses the average annual growth rate of all loans by 13 percentage points. The data suggest that policy implementation has mitigated, albeit to a limited extent, the financing challenges faced by SMEs[f]. However, persistent imbalances in the allocation of credit resources underscore the need for continued policy intervention to address these structural deficiencies. Empirical research reveals that 63% of micro and small enterprises receive approved loan amounts that are less than 70% of the sums requested. Among these, 71% are only able to meet 40% of their funding needs, while a staggering 98% encounter difficulties fully covering their financing requirements through bank credit channels. This credit constraint, as argued in this paper, primarily stems from two obstacles: high levels of information asymmetry surrounding SMEs and insufficient innovation capabilities. The interplay of these dual constraints has resulted in SMEs facing persistent disadvantages within the credit market.

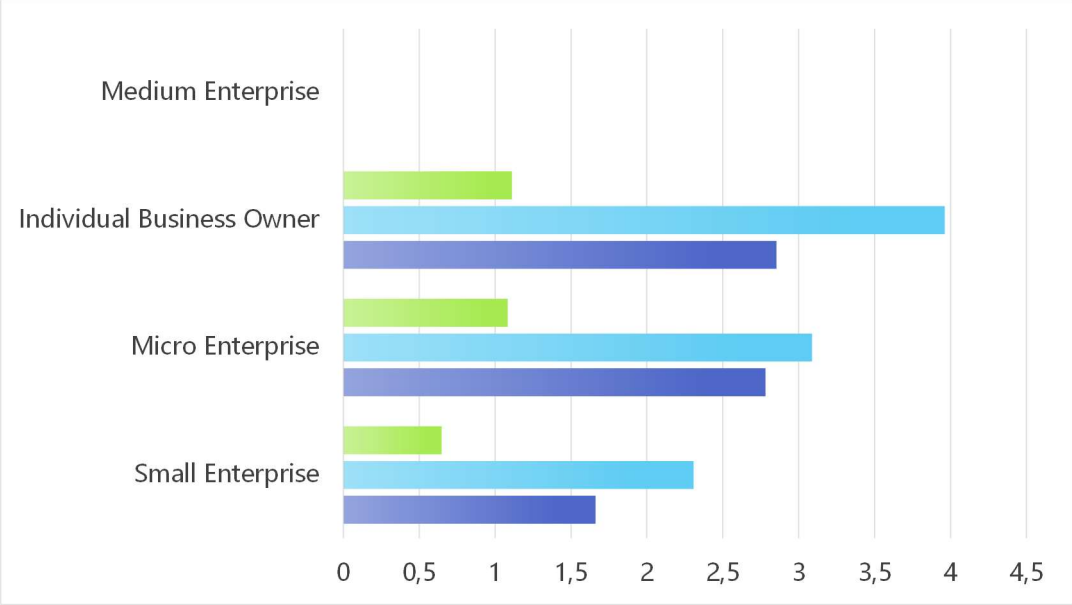
High financing barriers represent a significant challenge for small and micro enterprises. Given the relatively limited availability of financing channels, these businesses primarily rely on internal funding from owners and bank loans, leaving them under significant pressure when facing capital shortages[g]. Among enterprises utilizing credit services, 60%-70% initially rely on their legal representatives or major shareholders to raise funds when facing liquidity crises, only turning to banks for loans when the situation becomes critical. However, financial institutions impose elevated credit thresholds on SMEs, frequently requiring collateral or guarantees from guarantee companies, which hinders the capacity of most enterprises to meet these requirements. The 2025 China SME Financing Development Report indicates that micro and small enterprises account for a mere 8% of total bank loans. Beyond bank loans, equity financing, and bond financing, these financing options impose stringent requirements on registered capital and profitability, making these channels virtually inaccessible to SMEs[h]. Trust financing and lease financing involve relatively complex operations with narrow applicability, leaving SMEs with markedly limited financing options. High financing costs also pose a considerable challenge for small and micro enterprises in securing capital. The businesses' vulnerability is attributable to several factors, including their limited scale, absence of standardized internal management, opaque financial information, constrained resources, unstable operations, and weak risk-bearing capacity[i]. Consequently, they demonstrate heightened susceptibility to market fluctuations, raw material price volatility, and policy changes. This high-risk profile prompts financial institutions to exercise

greater caution when approving loans to small and micro enterprises, with some requiring collateral guarantees. These factors compel SMEs grappling with cash flow crises to seek private capital when bank loans are declined due to inadequate credit scores, leading to financing costs that surpass 10% (annualized). A cash flow crisis may result in a bank loan rejection, which may lead to the enterprise seeking financing from private lenders. However, private lenders often impose high interest rates, exacerbating the financial burden of the enterprise. This, in turn, may lead to a credit rating downgrade, further complicating future financing. Consequently, the enterprise may find itself trapped in a vicious cycle of financial distress, commonly referred to as a "capital black hole."

A significant yet frequently disregarded concern for small and medium-sized enterprises (SMEs) is the high financing mismatch. A review of the literature on the financing process for SMEs through credit service companies reveals a common phenomenon: many business operators lack long-term strategic thinking regarding financing due to information asymmetry. The majority of credit facilities proffered by prominent state-owned banking institutions feature a one-year term with interest-only payments subsequently followed by principal repayment, while certain commercial banking products employ a one-year equal principal and interest repayment schedule[k]. In circumstances where businesses encounter cash shortages, there is often an absence of thorough consideration given to repayment methodologies and factors such as loan renewal upon maturity. This oversight can result in financing mismatches, which can introduce latent risks with regard to future funding. For instance, a trading company recently sought financing from a credit service firm. The company had obtained a credit line of 3 million yuan from a major state-owned bank that was approaching its maturity date and did not have an option to renew. In addition to this, there were three loans from local commercial banks, which were structured so that the principal and interest were repaid equally. The credit service firm's analysis revealed that the company had a high historical rate of financing mismatches. This, in turn, resulted in subsequent financing difficulties, which prolonged the funding cycle and led to increased costs.

To illustrate this point, consider a Chinese bank. As of September 2020, the bank's outstanding loans to small, micro, and medium-sized enterprises totaled 2.025 billion yuan, serving a total of 12,000 clients. Of these, the most significant were loans to small enterprises and micro enterprises, which amounted to 461 million yuan and 772 million yuan, respectively. The total of these two categories was 1.233 billion yuan, accounting for 19.32% of the bank's total loans. The total value of loans extended to individual business owners amounted to 792 million yuan, with 92 million yuan of these loans being directed to operators lacking the requisite licenses. The average loan amount for SMEs was 168,750 yuan, with the most substantial credit line amounting to 5 million yuan and the least amounting to 50,000 yuan. The credit terms were subject to a maximum duration of one year, with the majority of borrowers undertaking monthly payments of both interest and principal upon reaching maturity. The balance of non-performing loans was 82 million yuan, with a non-performing rate of 4%. The average annual comprehensive loan pricing was 8.8%, with mortgage loans exhibiting a comparable pricing structure to the other two loan categories. These figures suggest that, despite the bank's advances in SME lending, inherent imbalances in the allocation of credit resources persist. The limited availability of financing channels and the high cost of financing remain significant challenges for SMEs.

Table1-Distribution table of loans to Small, Medium and micro Enterprises of Chinese Bank (unit: 100 million yuan)



In summary, small- and medium-sized enterprises (SMEs) encounter a multitude of challenges in the credit market, including information asymmetry, insufficient innovation capacity, limited financing channels, high financing costs, and mismatched financing. The aforementioned issues, which are intricately intertwined, perpetuate the long-term disadvantaged position of SMEs in the credit market. Consequently, the establishment of a more robust SME credit system through institutional innovation, technological advancement, and policy support is imperative and requires immediate attention.

Conclusion

This study explores the challenges and opportunities SMEs encounter in accessing credit. The findings indicate that information asymmetry and inadequate innovation capacity are the predominant barriers to SME credit constraints. These issues are intricately linked to elevated financing costs, constrained financing channels, and high financing thresholds, perpetuating the long-term disadvantaged position of SMEs in credit markets. Despite the implementation of inclusive finance policies, which have been shown to improve the allocation of credit resources, structural imbalances persist. A considerable number of SMEs encounter difficulties in fulfilling their financing requirements through conventional banking channels, compelling them to depend on alternative, costly financing options.SMEs encounter numerous challenges when attempting to access credit. Information asymmetry complicates financial institutions' assessment of SME credit risk, raising lending thresholds. The limited collateral assets and relatively high operating costs further exacerbate credit constraints. The limited availability of financing options is primarily attributable to the reliance on internal funding and bank loans. However, financial institutions impose stringent credit requirements, necessitating collateral or guarantees, which renders these conditions unattainable for the majority of SMEs. High financing costs compel some SMEs with inadequate credit ratings to seek private loans, where annualized financing costs frequently surpass 10%, engendering a pernicious cycle. Moreover, the issue of financing mismatch cannot be overlooked. A significant number of SME operators demonstrate an absence of long-term strategic thinking with regard to financing, resulting in funding methods that fail to align with actual business needs. This discrepancy has the effect of increasing financing costs and complicating subsequent financing efforts.

Notwithstanding the numerous challenges confronting the sector, opportunities do exist to enhance credit access for small and medium-sized enterprises (SMEs). Advancements in digital financial technologies have presented novel methodologies for credit assessment. The integration of multi-source data by financial institutions has been demonstrated to facilitate the development of more precise credit evaluation models, thereby increasing the likelihood that SMEs will obtain loans. The implementation of inclusive finance policies has been demonstrated to have a positive effect on the supply of credit and the financing environment. Concurrently, the advent of novel financing models, including supply chain finance, crowdfunding, and peer-to-peer lending, has furnished SMEs with a plethora of alternative financing options, thereby diversifying their funding avenues.The findings of this study hold significant implications for the formulation of policy. To address this imbalance, policymakers must prioritize the enhancement of credit reporting systems and the promotion of financial transparency. Additionally, financial institutions should be encouraged to adopt digital financial technologies, thereby enhancing the efficiency and accuracy of credit assessments. Policies should prioritize the reduction of operational costs associated with SME lending and the provision of targeted fiscal support to alleviate financing difficulties. Subsequent research endeavors should delve deeper into the long-term ramifications of digital financial technologies on SME credit accessibility and the efficacy of disparate policy measures across a range of economic environments. This will enhance comprehension of the evolving SME credit landscape and enable the formulation of sustainable financing solutions.

In summary, small and medium-sized enterprises (SMEs) face multiple challenges in accessing credit, including information asymmetry, limited financing channels, and high financing costs. However, the development of digital financial technologies and policy support present new opportunities to enhance credit availability. By leveraging technological advancements and implementing targeted policy measures, a more inclusive and efficient credit environment can be created for SMEs, fostering their development and driving economic growth. Further research and policy efforts are needed to address remaining challenges and ensure SMEs can fully capitalize on existing opportunities.

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RISK MANAGEMENT IN CHINESE COMMERCIAL BANKS

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Introduction

In recent years, with the acceleration of global economic integration and the continuous adjustment of China's domestic economic structure, commercial banks have assumed an increasingly vital role within the financial system. Commercial banks, as pivotal participants in economic activities, play a crucial role in facilitating capital flows and supporting the development of the real economy. However, they are confronted with an increasingly intricate and erratic risk environment. The international financial crisis has demonstrated that the risk management capabilities of financial institutions have a direct impact on the stability and security of the financial system. In the context of China, the progression toward interest rate liberalization, the emergence of financial innovations, and the escalating intensity of market competition pose novel challenges and opportunities for the risk management of commercial banks. Conducting in-depth research on risk management issues in Chinese commercial banks is of significant practical importance. A substantial body of research has emerged on the subject of risk management in Chinese commercial banks, with both academic and practical contributions yielding notable results. On the one hand, scholars have extensively explored the identification, measurement, and control of various risks faced by commercial banks. These risks include market risk, credit risk, and operational risk. In response, scholars have proposed multiple risk management models and methodologies. Examples include the application of the Value at Risk (VaR) model in market risk measurement and the use of credit rating models in credit risk assessment. Conversely, extant research has underscored the significance of organizational structures, internal controls, and corporate governance in the prevention and control of risk for commercial banks. Moreover, with the advent of fintech, the application of technologies such as big data and artificial intelligence in risk management has emerged as a prominent research subject. Nevertheless, despite the advancements witnessed in both theoretical and practical domains, residual deficiencies persist.

A survey of extant literature reveals an overwhelming emphasis on the analysis of individual risk types, with a paucity of systematic studies on the comprehensive risk management of commercial banks. In the context of actual operations, the risks confronted by commercial banks are interconnected and mutually influential, necessitating a holistic, integrated management approach. Secondly, while extant research on SME credit risk management has recognized the unique characteristics of such risks, targeted and actionable solutions for constructing a scientific and rational risk assessment system and management mechanism remain lacking. Thirdly, in the midst of rapid financial market shifts and advancing financial innovation, the dynamic and adaptive nature of commercial bank risk management remains inadequately addressed. The pressing concern is the prompt adjustment of risk management strategies in evolving environments to counter emerging risks. Finally, research on the synergistic mechanisms between commercial bank risk management and other factors—such as corporate governance and internal controls—remains superficial, lacking systematic empirical analysis and theoretical underpinnings.In light of the identified research lacunae, the objective of this study is to undertake a thorough and methodical examination of risk management within the context of Chinese commercial banks. The primary objectives of this study are twofold: firstly, to investigate the synergistic mechanisms between commercial bank risk management and factors such as corporate governance and

internal controls, revealing their impact on risk management effectiveness; and secondly, to propose targeted and actionable risk management optimization recommendations tailored to the actual conditions of Chinese commercial banks, thereby enhancing their risk management capabilities and competitiveness. In order to accomplish the aforementioned research objectives, this study will utilize a variety of methodologies, including a review of the extant literature, a case analysis, and empirical research. A comprehensive review of pertinent domestic and international literature, along with a meticulous examination of extant research findings, will be conducted to identify existing knowledge gaps. A select group of prominent commercial banking cases will be subjected to rigorous scrutiny, with an emphasis on the examination of their risk management practices. The application of statistical analysis methods will serve to empirically test relevant data, thereby verifying the scientific validity and effectiveness of research hypotheses and conclusions.

1. Theoretical analysis

Commercial banks are considered the core pillar of the modern financial system, and their sound operation is crucial to economic stability. However, the intricacies of banking operations and the inherent uncertainties in the external environment render them susceptible to a multitude of risks, including, but not limited to, credit risk, market risk, operational risk, liquidity risk, reputational risk, and strategic risk. Enterprise Risk Management (ERM) employs a systematic approach to identify[a], assess, monitor, and mitigate these risks, ensuring that banking institutions maintain capital adequacy and business sustainability while pursuing profits[b]. This paper reviews the historical evolution, theoretical foundations, and current challenges of commercial bank risk management through a literature review, providing theoretical support and research directions for subsequent studies.

In the early 20th century and beyond, the primary approach to risk management employed by commercial banks entailed a significant degree of experiential judgment on the part of bankers, coupled with rudimentary diversification strategies[c]. To illustrate, financial institutions typically mitigate credit risk by diversifying their lending activities across various industries, regions, and customer segments. This approach is designed to prevent the potential pitfall of concentrating all assets in a single, high-risk category. While rudimentary, this approach has proven effective during periods of relatively simple financial products and low market volatility[d]. However, its dearth of systematic, quantitative analysis and forward-looking perspective rendered it ill-equipped to handle complex market environments and large-scale financial crises. The oil crisis of the 1970s led to global stagflation and significant interest rate fluctuations, thereby highlighting the limitations of banks in managing interest rate risk. The debt crisis experienced by Latin America in the 1980s exposed the banking sector's substantial deficiencies in the management of international lending and sovereign credit risks[e]. This was evidenced by the substantial losses incurred by several prominent banks due to considerable non-performing loans. These crises prompted the industry and regulators to rethink their approaches and explore more structured, scientific risk management methodologies[f]. The Basel Accords, a set of regulations developed by the Basel Committee on Banking Supervision (BCBS), serve as the fundamental framework for contemporary banking risk management. The establishment of uniform capital standards for banks by Basel I in 1988 was a significant development in the field, contributing to enhanced industry stability[g]. However, the model's simplified risk weight classifications proved inadequate in accurately reflecting the true risk of assets. Moreover, it failed to encompass the growing complexity of financial products and the emergence of novel risk types. The 2004 Basel II accords further refined risk management methodologies by encouraging financial institutions to employ internal models for the quantification of risk[h]. However, the system's intricacy resulted in increased implementation costs, and the global financial crisis of 2008 revealed its inadequacy in

addressing systemic risks and evaluating complex financial instruments. The 2008 financial crisis prompted the establishment of Basel III[i], a regulatory framework aimed at enhancing bank resilience by optimizing capital quality and liquidity levels. However, this shift has concomitantly led to an escalation in compliance costs, a phenomenon that has been particularly acute for small and medium-sized banking institutions. In response, China's Banking and Insurance Regulatory Commission (presently the National Financial Supervision and Administration Bureau) undertook a revision of the "Commercial Bank Capital Management Measures," mandating that domestic banks progressively adhere to the stipulated standards and effectuate transitional arrangements. However, the implementation phase revealed that the utilization of internal models resulted in significant variations in risk-weighted assets (RWA), thereby compromising the comparability of capital adequacy ratios and even giving rise to a phenomenon known as "model arbitrage." The Basel IV framework[j], released in 2017, aims to further standardize risk measurement, enhance the comparability and transparency of capital adequacy ratios, and significantly impact large banks heavily reliant on internal models. This may result in an increase in risk-weighted assets for such institutions, necessitating higher capital holdings[k]. It is imperative for China's banking sector to methodically recalibrate its risk assessment procedures and capital management frameworks in alignment with the directives outlined by the SFSA, ensuring compliance with the revised regulatory mandates.China's banking sector must gradually adjust its risk measurement methodologies and capital management strategies in accordance with the guidelines issued by the China Banking and Insurance Regulatory Commission.

Table-Industry Risk Rating System Evaluation Indicators

Evaluation or Analysis Indicator	Specific Description
Assessment of Industrial Ecological Characteristics	This primarily encompasses the overall state of the industry and its operational performance. Among these factors, economic cycles, fiscal policy, and monetary policy are key determinants influencing macroeconomic conditions. At the micro level, deeper analysis is required regarding domestic industrial policies, government regulations, and economic transformation; while the impact of World Trade Organization (WTO) elements and significant activities must also be examined. Through a comprehensive analysis of these factors, an evaluation of the industry's overall development status can be made.
Operational Status Evaluation	The assessment is conducted from three dimensions: market demand, asset maturity, and technological risk. Industry operations are evaluated based on factors such as monopoly intensity, product substitutability, and asset dependency, enabling a comprehensive assessment of companies within the sector and forecasting its developmental trajectory. Leveraging industrial financial data, a quantitative analytical model is established to systematically analyze and evaluate metrics including average industry default probability, expected loss rate, and external shadow ratings.
Industry Financial Data Analysis	Based on industrial financial data, establish a quantitative analytical model to conduct a unified and systematic analysis and assessment of indicators such as the average default probability of the industry, expected loss rate, and external impact level。
Credit Quality Evaluation	From the structure of credit, the quality of credit assets, and the reasons for the occurrence of credit risk, a comprehensive understanding of the credit assets of various industries is carried out.

2. Case analysis

Following the implementation of the comprehensive risk management model in 2004, the China Banking Regulatory Commission (CBRC) has proactively integrated international best practices, established uniform capital constraint standards, and promulgated the "Commercial Bank Capital Management Measures" in 2012. This regulatory provision elucidated the stipulations concerning capital adequacy ratios, risk assessment, and information management systems, thereby establishing a comprehensive risk management framework. Guided by these policies, Chinese commercial banks have achieved notable progress in risk management, particularly in the domain of operational risk management. By adopting advanced risk management concepts and technologies, they have enhanced their capabilities in risk identification and control. However, the prevailing focus of financial institutions on capital management overshadows other risk management areas. This finding suggests that, despite advancements in institutional frameworks and technological capabilities, the implementation of comprehensive risk management remains encumbered by challenges.

In recent years, China's banking sector has undergone a significant digital transformation, incorporating advanced technologies such as big data and artificial intelligence into its risk management processes. This strategic shift has yielded notable outcomes, underscoring the efficacy of these technological solutions. The subsequent case study illuminates the intelligent credit risk assessment implemented by a prominent state-owned bank in China. In 2020, a major Chinese state-owned bank extensively refined its credit risk assessment model for small and micro enterprise loans by incorporating big data and AI technologies. The bank employed big data analytics to integrate non-traditional data sources, including business registration information, tax data, utility payment records, supply chain transaction data, and even social media behavior. This multidimensional data integration enabled the bank to gain a more comprehensive understanding of enterprises' operational and credit conditions, thereby enhancing the accuracy of credit risk assessments. Concurrently, the bank implemented machine learning algorithms, including deep learning and random forests, to construct a more precise probability of default (PD) prediction model. This model has the capacity to identify risk signals that are not easily captured by traditional models. For instance, it can predict a company's operational health and debt-repayment capacity by analyzing fluctuations in utility bills and employee social security contributions. The implementation of a big data and AI-driven risk assessment model has been demonstrated to enhance the accuracy of risk evaluation and improve its efficiency. The outcomes are noteworthy. The new model has enhanced the accuracy of predicting default probabilities for small and micro enterprise loans by over 15%, leading to a substantial reduction in the non-performing loan ratio. The implementation of automated approval processes and real-time risk assessments has led to a significant reduction in loan approval times, thereby enhancing the customer experience. The bank's real-time monitoring system facilitates the expeditious identification of potential risk events, enabling the implementation of timely intervention measures, thereby mitigating risk.

The outcomes are noteworthy. The new model has enhanced the accuracy of predicting default probabilities for small and micro enterprise loans by over 15%, leading to a substantial reduction in the non-performing loan ratio. The implementation of automated approval processes and real-time risk assessments has led to a significant reduction in loan approval times, thereby enhancing the customer experience. The bank's implementation of a real-time monitoring system facilitates the prompt identification of potential risk events, enabling the implementation of intervention measures and, consequently, a reduction in the incidence of operational risk incidents.This case exemplifies that contemporary risk management transcends mere compliance requirements; rather, it is a technology-driven innovation process that delivers tangible business value and competitive advantages to banking institutions. In the context of comprehensive risk management, financial institutions are obliged to perpetually explore and implement novel

technologies to augment the scientific rigor and efficacy of risk management. Concurrently, financial institutions should underscore the symbiotic relationship between risk management and business development. The optimization of risk management processes has been demonstrated to improve operational efficiency and customer satisfaction, thereby fostering a virtuous cycle between risk management and business growth.

Conclusion

In summary, this paper conducts a systematic study of the historical evolution, theoretical frameworks, practical cases, and future outlook of risk management in commercial banks. This study thoroughly examines the significance of risk management within modern commercial banking and its developmental trajectory. A review of the extant literature indicates that the evolution of commercial bank risk management has been a continuous process of adapting to shifts in economic and financial environments alongside heightened regulatory demands. Its evolution—from early reliance on experiential judgment to modern quantitative models and comprehensive risk management frameworks—profoundly reflects both the progress and challenges within the financial sector. The global financial crisis of 2008 serves as a paradigmatic example of risk management failure, poignantly demonstrating the potentially disastrous ramifications of inadequate risk management practices. For instance, the collapse of Lehman Brothers resulted not from a single factor but from the simultaneous eruption of multiple risk management failures. The company's excessive reliance on subprime mortgages and high leverage, its inadequate assessment of systemic risk, its neglect of liquidity risk, its overly optimistic internal models, and its deficiencies in corporate governance and risk culture collectively precipitated its downfall during the crisis. This case exemplifies the necessity for financial institutions to adopt a comprehensive operational perspective to systematically manage market risk, credit risk, liquidity risk, and other pertinent factors. This comprehensive approach necessitates the establishment of effective risk governance structures and a prudent risk culture within the institution. Concurrently, risk management practices within China's banking sector indicate that integrating theory with practice is crucial for enhancing risk management capabilities. A major Chinese state-owned bank has developed a comprehensive credit risk assessment model for small and micro enterprise loans. This model integrates big data and AI technologies, resulting in significant improvements in the accuracy and efficiency of risk evaluations. This case exemplifies that contemporary risk management transcends mere compliance and manifests as a technologically driven innovation process, thereby yielding substantial business value and competitive advantages to banking institutions.

Therefore, the future development of commercial bank risk management requires sustained efforts in reinforcing the concept of comprehensive risk management, enhancing risk management techniques, strengthening supervision and compliance, and fostering a prudent risk culture. Banks should adopt a holistic operational perspective to establish a management system covering all risk types, ensuring alignment between risk management and strategic objectives, while building flexible risk management mechanisms to adapt to evolving market conditions. Simultaneously, banks should actively adopt advanced technologies such as big data and artificial intelligence to enhance the scientific rigor and effectiveness of risk management. By optimizing risk management processes, they can improve operational efficiency and customer satisfaction, fostering a virtuous cycle between risk management and business growth. Furthermore, banks must strictly adhere to regulatory requirements, strengthen capital adequacy, liquidity management, and leverage ratio oversight, and establish robust risk governance structures to ensure clear delineation and effective execution of risk management responsibilities. Finally, banks must cultivate a prudent risk culture, encouraging employees to actively participate in risk management and promptly identify and report risk issues. A robust risk culture forms the

foundation of comprehensive risk management, effectively reducing the incidence of risk events. Through these efforts, commercial banks can significantly enhance their risk management capabilities, strengthen resilience against risks, and achieve stable operations and sustainable development. Looking ahead, as fintech continues to evolve and external environments grow increasingly complex, commercial banks must persistently explore and innovate to address emerging risk challenges.

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INTERNATIONAL ENERGY PROJECT MANAGEMENT AND STRATEGIC MARKETING

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Introduction

In recent years, the global energy transition has accelerated, resulting in significant changes to the international energy landscape. From 2021 to 2025, the international energy governance landscape is poised to encounter a series of challenges, including the instability of energy security and the inconsistency of climate change responses. The energy transition within the international oil and gas industry exhibits characteristics of unevenness and fragmentation. During this period, the interplay of factors such as the international political and economic situation, geopolitical dynamics, energy security, and technological advancements has led to complex, multidirectional changes in the global energy system. For instance, while the rapid advancement of renewable energy technologies has significantly increased the share of solar and wind power in the global energy mix, traditional oil and gas sectors remain dominant[1]. As leaders in the global oil and gas industry, the energy transition pathways and strategies of international oil companies have become key subjects of research. In light of these developments, it is imperative for China's leading oil and gas enterprises to formulate transformation strategies that are both scientifically sound and rational[2]. This is necessary to ensure they can effectively navigate the complex and volatile international energy market environment.

A substantial body of research has been conducted on the international energy transition, with notable advancements being made in this field. A subset of scholars has chosen to prioritize macro trends associated with this transition, emphasizing the proliferation of renewable energy sources and their concomitant rise in the energy mix. For instance, a report by the International Renewable Energy Agency (IRENA) indicates that global renewable energy capacity grew by 10% year-on-year in 2021, with solar and wind power installations showing particularly significant growth. Concurrently, other studies have focused on the strategic transformation of international oil companies, meticulously analyzing the heterogeneity of their approaches and the evolution of their objectives across diverse stages. However, extant research has focused predominantly on macro-level policy analysis or specific national energy transition practices, with relatively limited investigation into corporate-level digital transformation and its implications for the broader energy transition[3]. Despite the fact that extant research has thoroughly examined the macro trends and policy implications of the international energy transition, there remains a paucity of systematic analysis regarding the role and pathways of corporate digital transformation within this energy shift. This is particularly salient during the critical period from 2021 to 2025, when the global energy market is experiencing heightened complexity and uncertainty[4]. In this context, the ability of enterprises to leverage digital transformation to enhance competitiveness, optimize energy structures, and navigate market volatility has become an urgent issue requiring resolution. For instance, international oil companies such as ExxonMobil and Shell have adopted divergent strategies in the realm of digital transformation. However, the specific impacts of these approaches on corporate energy transitions remain understudied.

This study aims to fill this gap by analyzing the context and trends of the global energy transition to explore the role and pathways of corporate digital transformation within the energy transition. The study employs case analysis, drawing on actual transformation cases from major global oil and gas companies to deeply dissect the impact mechanisms of digital transformation on corporate energy transition[5]. For instance, it examines investment trends in the international energy transition market. Simultaneously, through comparative analysis of transformation strategies adopted by international oil companies, it proposes optimization recommendations for the digital transformation of oil and gas enterprises, aiming to provide theoretical support and practical reference for relevant companies.

1. Energy trends of international oil companies from 2021 to 2025

From 2021 to 2025, the energy transition of international oil companies unfolded in three distinct phases[6]. The period from early 2021 to early 2023 was characterized by the "Divergence in Energy Transition Pathways," a phase during which international oil companies exhibited a shared understanding and strategic alignment with regard to the energy transition. However, this commonality gave way to a divergence in their respective implementation approaches. European companies, such as BP and Shell, have adopted aggressive strategies, integrating clean energy and carbon reduction into their strategic frameworks. For instance, BP established carbon neutrality targets, while Shell initiated its "Empowering Progress" initiative[7]. In addition, organizational structures were optimized, as evidenced by TotalEnergies' establishment of a "Strategy and Corporate Responsibility Committee." The company also diversified into wind power and photovoltaic generation. North American companies, including prominent names such as ExxonMobil and Chevron, adopt a more cautious strategy, concentrating on sectors closely related to their primary business interests. These sectors include carbon capture and storage (CCS) and biofuels, while wind and solar power projects are primarily implemented on a pilot basis. This divergence can be attributed to the strategic focus of European firms, which are pursuing a "big energy" vision, while North American companies are following a "big oil and gas" trajectory[8].

The period spanning from early 2023 to late 2024 was characterized as the "initial phase of energy transition goal recalibrations." In the aftermath of the Ukraine crisis, energy security emerged as the paramount concern, compelling international oil companies to undertake a comprehensive reevaluation and recalibration of their transition objectives. European firms, having reduced oil and gas operations excessively, encountered suboptimal performance during periods of elevated oil prices and mounting pressure from shareholders and markets, compelling strategic revisions[9]. For instance, BP increased its 2025 and 2030 oil and gas production targets, while Shell reduced its carbon reduction goals. North American companies have pursued a strategy of integrating stable oil and gas markets and cash flows with the objective of enhancing economies of scale through mergers and acquisitions. This strategy has been complemented by a commitment to low-carbon technology. During this period, oil and gas operations were re-established as the industry's foundation, with their cash flows providing capital support for the transition to low-carbon energy sources. The interval spanning from the beginning of 2025 to the present is designated as the "Energy Transition Methodology Transformation Period." In the context of declining oil and gas prices and slowing economic growth, international oil companies are exploring alternative avenues for transformation. Firstly, there is a pursuit of integrated development of oil and gas with renewable energy. For instance, prominent actors in the energy sector, such as BP and Shell, are incorporating renewable energy technologies into their oil and gas projects. Secondly, there has been an expansion into new sectors, as evidenced by TotalEnergies' entry into base metals and charging infrastructure businesses. Thirdly, the pursuit of asset-light operations and ecosystem alliances, exemplified by BP's divestiture of its solar

division and TotalEnergies' sale of renewable energy asset stakes, has been shown to reduce risk through joint ventures while maintaining control.

The three phases of international oil companies' energy transition and the formation of their characteristics encompass both proactive corporate strategies and reactive responses to demands from governments, investors, environmental organizations, and the public. This evolution is closely tied to factors including the international political and economic landscape, policy regulations, the global energy structure, assessments of oil and gas operations and markets, regional resource endowments, and their own operational performance. Following 2022, the global political and economic environment underwent a period of stabilization. However, geopolitical events, such as the Ukraine crisis, led to an escalation in the prioritization of energy security[10]. The elevated prices of oil and gas prompted corporations to reorient their business strategies, focusing on their fundamental operational activities. As conditions stabilized and prices decreased, companies reassessed the economic viability and stability of renewable energy, seeking new development pathways. Since 2020, the tightening of regulatory frameworks and legal requirements has compelled multinational oil and gas companies to integrate climate issues into their core decision-making processes. For instance, a Dutch court ruling that required Shell to significantly reduce carbon emissions compelled the company to refine its energy transition strategy objectives. Europe, on the other hand, has demonstrated a consistent commitment to its green and low-carbon policies[11]. In contrast, the United States has exhibited greater policy volatility across administrations, which has in turn affected corporate transition pathways. The prevalence of extreme weather events underscores the intermittent nature of renewable energy, thereby accentuating the significance of energy security as a pivotal concern within the broader context of global energy governance[12]. The ongoing crisis in Ukraine has led to heightened energy market volatility, with energy security emerging as a priority over transition. This has prompted companies to recalibrate their transformation strategies. International oil companies have come to acknowledge the persistent role of oil and gas as the cornerstone of the global energy system. These enterprises have recognized that cash flows derived from their oil and gas operations can serve as crucial financial resources, facilitating the transition to low-carbon energy sources.

Projections indicate that oil and gas will still account for over 50% of the energy mix by 2050, necessitating coordinated development of both fossil fuels and renewables. Europe, facing a dearth of domestic oil and gas resources and a consequent heavy reliance on imports, has embarked on a proactive campaign to promote the transition to renewable energy sources.In contrast, North America, endowed with substantial hydrocarbon reserves, has witnessed companies adopt a circumspect approach toward renewable energy investments, exhibiting a more gradual pace in their actions[13]. European international oil companies, having undergone a rapid transition, encountered market pressures due to substandard performance during periods of elevated oil prices, compelling strategic recalibrations. North American companies, leveraging robust hydrocarbon operations and cash flows, are steadfastly advancing low-carbon transitions, achieving a balance between short-term profits and long-term sustainable development[14].

2. Investment trends in the international energy transition market

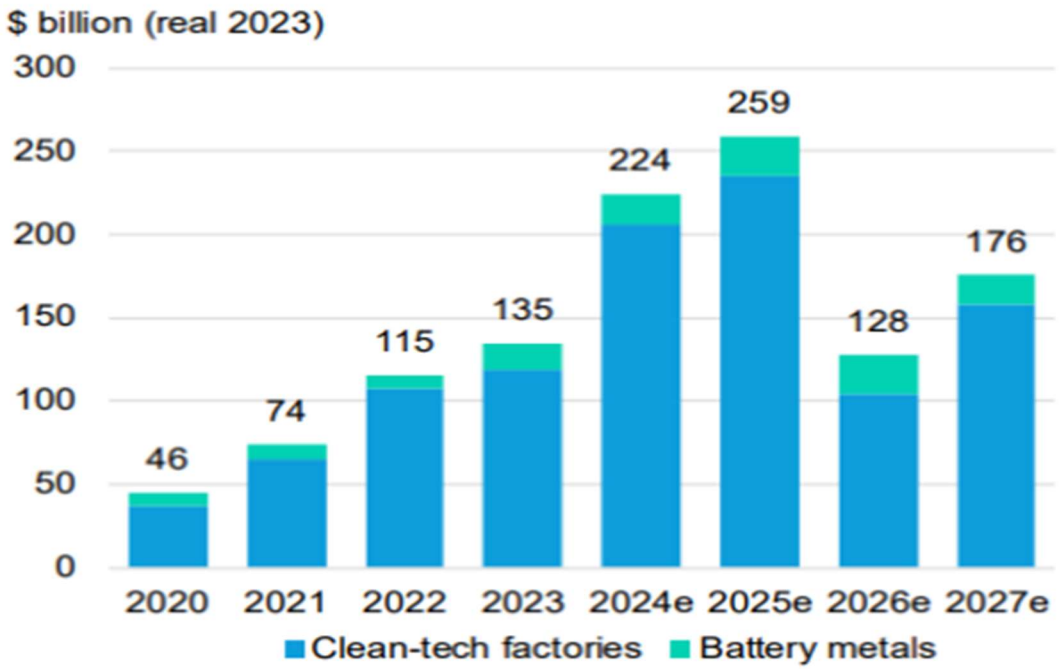
In 2023, global energy transition investments reached a record high of $1.77 trillion, marking a 17% increase from the previous year. This growth underscores the remarkable resilience of the clean energy transition, despite challenges such as geopolitical turbulence, elevated interest rates, and substantial costs. According to data from BloombergNEF, global -investments in the energy transition in 2023 surpassed investments in fossil fuel supply by $671 billion, marking a 32% increase from the $508 billion gap in 2022. This discrepancy has been progressively widening since 2020. In 2023, global investments in the energy transition sector surged by $258 billion,

significantly outpacing the $95 billion growth in global expenditures on fossil fuel supply. The augmentation in fossil fuel supply spending was predominantly propelled by oil projects in the Middle East and Asia-Pacific regions.

Table1-Comparison of global clean energy and fossil energy investment

Note-Data source: IEA

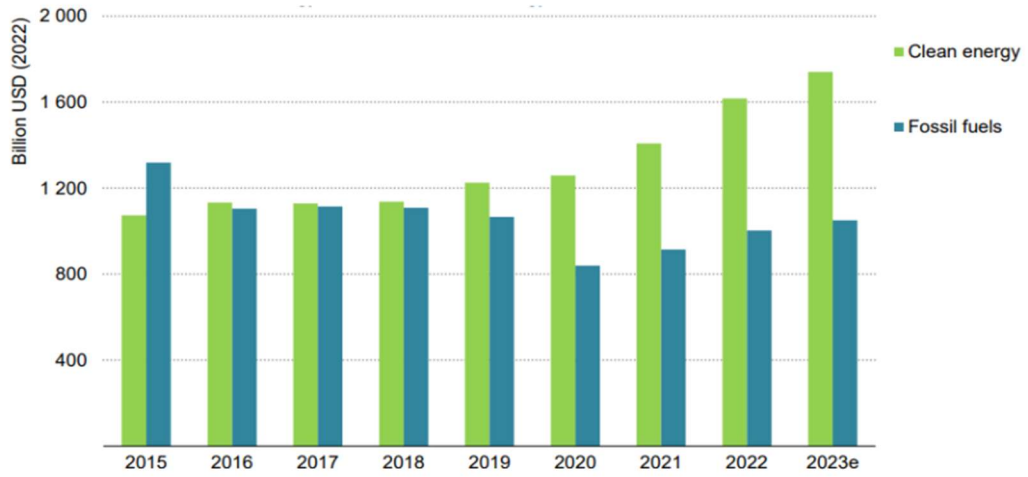
Across all sectors of the energy transition, investments in electrified transportation emerged as the largest driver, reaching $634 billion in 2023—a 36% year-over-year increase. This



growth reflects the rapid global expansion of electric vehicles. Following closely was the renewable energy sector, encompassing wind, solar, biomass, and geothermal power, which saw investments rise 8% to $623 billion in 2023. Investment in the power grid sector ranked third at $310 billion, with significant room for future growth. Furthermore, emerging sectors demonstrated robust investment growth: hydrogen energy investment tripled year-over-year to $10.4 billion; carbon capture and storage investment nearly doubled to $11.1 billion; and energy storage investment increased by 76% to $36 billion.

Table 2-Clean energy technology factory and battery metal investment trends

Note-Data source: BloombergNEF



In 2023, global clean energy supply chain investment reached an unprecedented high of $135 billion, encompassing investments in manufacturing equipment for clean energy technology plants, battery metals mining, and smelters. According to BloombergNEF, the investment in the clean energy supply chain is expected to demonstrate sustained growth over the subsequent two years. According to the most recent national investment plans that have been made public, this sector is projected to reach $259 billion by the year 2025. It is noteworthy that the current supply of solar panels has surpassed the demand, with no imminent necessity for the establishment of new factories until the year 2030. Furthermore, the cost of solar panels is expected to remain under pressure in the coming years. In recent years, governments worldwide have begun to prioritize the acquisition of critical metals such as lithium, cobalt, nickel, copper, and manganese. Notwithstanding the persistent decline in the prices of certain pivotal minerals in 2023, governments persist in their commitment to allocating resources to these minerals to underpin the energy transition. In 2023, investments in battery metal technologies constituted 11% of total spending within the clean energy supply chain. Projections indicate that this share will rise to 18% by 2026. The advent of renewable energy and clean transportation has led to a surge in early-stage equity financing for energy startups. According to statistics provided by the International Energy Agency (IEA), the year 2022 represented the highest annual total for equity financing in energy startups, with the majority of clean energy technology sectors demonstrating positive growth. It is noteworthy that the funding levels for startups in the domains of renewable energy, carbon capture, energy efficiency, and nuclear energy have increased substantially compared to 2021 figures, surpassing the average of the preceding decade. From 2020 to 2022, the majority of global venture capital investments directed towards the energy transition were allocated to startups based in the United States. In contrast, Europe emerged as a dominant player in hydrogen-related investment. The People's Republic of China demonstrated ongoing engagement in the domains of electric vehicles, energy storage, and battery technology. The macroeconomic conditions that prevailed in 2023 had a deleterious effect on the enthusiasm of potential investors for new business enterprises, a development that resulted in a diminution of the available funding and a precipitous decline in the venture capital sector for clean energy initiatives. However, funding levels in this sector remained higher than in other sectors. Electric vehicles and power batteries have garnered significant venture capital investment, ranking second and third globally among all industries. These investments amounted to $16.5 billion and $9.2 billion, respectively, placing them behind only generative artificial intelligence.

In summary, achieving carbon peaking and carbon neutrality represents a broad and profound systemic transformation of the economy and society. Each country's energy transition should prioritize ensuring energy security, continuously expand the competitive edge of its new energy industries, deepen international cooperation in the energy sector to address climate change, and contribute to the global transition toward green, low-carbon energy and the fight against climate change.

Conclusion

From an international perspective, the global energy transition is undergoing a period of accelerated progress at a critical juncture, characterized by substantial increases in investment, continuous technological breakthroughs, and deepening international cooperation. In 2023, global investments in the energy transition sector amounted to $1.77 trillion, representing a 17% year-on-year increase and establishing a new historical record. This growth underscores the remarkable resilience of the clean energy sector, which has persisted despite considerable challenges, including geopolitical turbulence, elevated interest rates, and escalating costs. Investment in electrified transportation reached $634 billion, representing a 36% increase year-on-year; renewable energy investment totaled $623 billion, up 8%; and energy storage investment

surged 76% to $36 billion. China maintained its global leadership position, with investments amounting to $676 billion, constituting 38% of the global total. The United States and the European Union also made substantial contributions. In the context of the global energy transition, nations encounter a range of challenges and opportunities. Developed nations have been shown to possess a distinct advantage in technological innovation and policy support. However, these nations also face considerable challenges, including high costs and market volatility during the transition process. Developing countries possess potential in terms of resource endowments and market demand; however, they lack sufficient technology, funding, and infrastructure. Consequently, international cooperation has become a critical factor in advancing the global energy transition. In order to address the global climate change issue and achieve sustainable development goals, it is essential that countries coordinate their policies, exchange technologies, and provide financial support in a collective manner.

Technological innovation is identified as the primary catalyst for the global energy transition. Advancements in domains such as electrified transportation, renewable energy, energy storage, and hydrogen provide substantial technical support for this transformation. To this end, it is imperative for countries to allocate increased resources to research and development in the field of clean energy technologies, thereby fostering innovation and facilitating the translation of research findings into practical applications. Concurrently, international collaboration provides avenues for technological exchange and innovation. The acceleration of the energy transition process can be achieved through transnational collaborative projects and global technical exchanges, which facilitate the sharing of technological achievements among nations. International cooperation is imperative for the successful implementation of the global energy transition. In order to address the challenges posed by climate change, it is imperative that countries enhance their collaborative efforts in policy, technology, and financing. It is incumbent upon developed nations to assist their counterparts in developing countries in enhancing their energy transition capabilities through technology transfer and financial support. Conversely, developing countries have the potential to expedite their own energy transitions by engaging in international cooperation projects that facilitate the introduction of advanced technologies and management expertise. Furthermore, international organizations and multilateral mechanisms play a crucial role in coordinating national policies, facilitating technology exchange, and advancing project collaboration.

In summary, the global energy transition is currently at a critical stage of accelerated advancement, driven by substantial investment and technological progress. To this end, countries must progressively advance green and low-carbon development while ensuring energy security, refining policy frameworks, strengthening technological innovation, and actively pursuing international cooperation. Through concerted global efforts, the energy transition holds promise for achieving sustainable development goals and making significant contributions to addressing climate change.

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Beyond the Barrel: Azerbaijan's Strategic Pivot Towards Non-Oil Sector Development and Economic Diversification

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Introduction: The Imperative of Diversification

For the better part of the last three decades, the economy of the Republic of Azerbaijan has been synonymous with hydrocarbons. The "Contract of the Century," signed in 1994, unlocked vast oil and gas reserves in the Caspian Sea, propelling the nation into a period of unprecedented economic growth and transforming its infrastructure and geopolitical standing. However, this very reliance on a finite, volatile resource also created a classic "resource curse" scenario—a rentier economy vulnerable to global price shocks, stifled non-oil sector development, and long-term unsustainable growth models.

Recognizing these inherent vulnerabilities, the Azerbaijani government, under the leadership of President Ilham Aliyev, has long proclaimed economic diversification as a paramount national strategic objective. The goal is to construct a resilient, modern, and competitive economy that is not solely dependent on oil and gas revenues. This article delves into Azerbaijan's multifaceted policy framework aimed at developing its non-oil sector, analyzing its key pillars, the sectors targeted for growth, the challenges encountered, and the future prospects for building a post-oil economy.

The Foundations of the Diversification Strategy

Azerbaijan's diversification policy is not a recent reaction to oil price crashes but a deliberate, long-term strategy initiated in the mid-2000s. Its foundations are built on several key understandings:

1.Volatility of Oil Revenues: The 2008-2009 global financial crisis and, more acutely, the 2014-2015 oil price collapse were stark reminders of this vulnerability. The subsequent devaluation of the Manat and pressure on foreign exchange reserves underscored the urgent need for a more balanced economic structure.
2. Finite Nature of Resources: While the recent discovery of new gas fields like Absheron and the expansion of the Southern Gas Corridor extend the hydrocarbon horizon, these resources are ultimately finite. Planning for a post-hydrocarbon era is an exercise in national prudence.
3. Job Creation and Balanced Development: The oil sector is capital-intensive but not labor-intensive. To absorb a growing and young workforce, create sustainable employment opportunities across the country, and reduce regional disparities, a vibrant non-oil sector is essential.
4. Sustainable and Inclusive Growth: A diversified economy is inherently more stable, fosters innovation, and supports the development of small and medium enterprises (SMEs), which are the backbone of any advanced economy.

The primary vehicle for financing this ambitious transition has been the State Oil Fund of the Republic of Azerbaijan (SOFAZ). Established in 1999 to manage oil revenues transparently and for

the benefit of future generations, SOFAZ has been instrumental in channeling wealth into strategic infrastructure projects, social programs, and, crucially, investments in non-oil sectors.

Key Pillars of the Diversification Policy Framework

Azerbaijan's approach to non-oil sector development is multi-pronged, involving significant state investment, legislative and business climate reforms, and targeted support for priority areas.

1. Strategic Roadmaps and Vision Documents:
The government has laid out its vision through several key documents. The most comprehensive among them is the "Strategic Road Maps for the National Economy and Main Sectors of the Economy," approved in 2016. This document outlines specific goals, actions, and targets for 11 key sectors of the economy, including:

* Production and processing of agricultural products
* Development of heavy industry and machinery
* Development of the chemical industry
* Development of tourism
* Development of logistics and trade services
* Development of financial services
* Development of communications and information technologies
* Development of housing provision at the national level
* Development of vocational education and training

These roadmaps provide a clear, actionable plan for both the public and private sectors, aligning efforts towards common national objectives.

2. Institutional Support and Investment Promotion:
Several state institutions have been established or empowered to drive diversification:

* Azerbaijan Investment Holding (AIH): Created to manage state-owned enterprises (SOEs), enhance their efficiency, attract foreign investment into them, and promote public-private partnerships (PPPs).
* Agency for the Development of Economic Zones (ADEZ): Manages industrial parks and quarters offering preferential terms for investors, including tax holidays, simplified customs procedures, and ready-to-use infrastructure. Key examples include:
    * Sumgayit Chemical Industrial Park: Focused on petrochemicals and pharmaceutical production.
    * Balakhani Industrial Park: Focused on light industry and manufacturing.
    * Pirallahi Industrial Park: Focused on high-tech and pharmaceutical industries.
    * Neftchala Industrial Zone: Focused on agro-processing.
* Small and Medium Business Development Agency (KOBİA): Provides support services, access to finance, and training for SMEs, which are critical for diversification and employment.

3. Macroeconomic Stability and Business Climate Reforms:
The government has undertaken efforts to improve the ease of doing business, streamline regulations, and fight corruption. The establishment of the ASAN Service (a one-stop shop for government services) is a landmark reform that has significantly reduced bureaucracy and increased transparency. Furthermore, monetary policy led by the Central Bank of Azerbaijan (CBA) has focused on maintaining price stability and ensuring a stable banking sector after a cleansing period post-2015.

4. Massive Infrastructure Investment:
SOFAZ funds have been used to finance a nationwide infrastructure upgrade, which is a prerequisite for non-oil sector growth. This includes:
* The construction of the Baku-Tbilisi-Kars (BTK) railway, enhancing regional trade connectivity.
* The modernization of the Baku International Sea Trade Port, positioning Azerbaijan as a key logistics hub on the Caspian.
* The development of the Alat Free Economic Zone (AFEZ) adjacent to the port, offering attractive conditions for manufacturing and logistics companies.
* Investment in renewable energy projects (solar and wind) to free up natural gas for export and ensure long-term energy security.

Sectoral Focus: Engines of Non-Oil Growth

The diversification strategy identifies several non-oil sectors with high growth potential.

1. Agriculture and Agro-Processing:
Azerbaijan boasts a favorable climate and diverse agricultural zones. The strategy focuses on moving from raw material exports to high-value-added processed goods. Investments are directed towards modern irrigation systems, greenhouses, seed banks, and food processing plants. The goal is to increase self-sufficiency, boost exports of branded Azerbaijani products (like wine, pomegranate juice, and hazelnuts), and develop the entire value chain within the country.

2. Tourism:
Azerbaijan's tourism potential is vast but underexploited. The "Land of Fire" offers a unique blend of cultural heritage (the UNESCO-listed Walled City of Baku, Gobustan rock art), diverse landscapes (from the Caspian coastline to the Caucasus Mountains), and modern amenities. The government is aggressively promoting Azerbaijan as a destination through international campaigns, simplifying the visa regime, and encouraging investment in hotel infrastructure, particularly in regions outside Baku. The development of winter tourism in Gabala and Gusar and thermal spas in Nakhchivan are key projects.

3. Logistics and Transportation:
Azerbaijan's geographic location is its strategic asset. Situated at the crossroads of Europe and Asia, it is a natural hub on the East-West and North-South transport corridors. The development of the BTK railway, the modernized Baku port, and the AFEZ aims to capitalize on this advantage. The vision is to transform Azerbaijan from a transit country into a logistics center where value-added services like packaging, assembly, and distribution occur.

4. Information and Communication Technology (ICT):
The ICT sector is identified as a critical driver of the future knowledge-based economy. The government has launched initiatives to foster a tech startup ecosystem, improve digital literacy, and expand high-speed internet access. The establishment of high-tech parks offering tax benefits is designed to attract IT companies and talent. This sector holds promise for creating high-value jobs and fostering innovation that can permeate other traditional sectors.

5. Manufacturing and Industry:
Beyond agro-processing, the strategy aims to develop light industry (textiles, garments), chemical industries (fertilizers, polymers), and metallurgy, leveraging the existing industrial base in cities like

Sumgayit and Ganja. The industrial parks are central to this effort, providing a conducive environment for manufacturing enterprises.

Challenges and Obstacles on the Path to Diversification

Despite the comprehensive strategy, the path to a truly diversified economy is fraught with challenges:

The "Oil Mentality": Decades of hydrocarbon wealth have created a rentier mentality among some segments of the population and businesses, where seeking state patronage can be more attractive than engaging in competitive, productive entrepreneurship.

* Access to Finance: While state banks offer concessional lending, many SMEs still struggle to secure affordable financing for expansion and innovation. The private banking sector remains cautious in lending to new, non-oil ventures perceived as risky.
* Bureaucratic Hurdles: Despite significant improvements, bureaucratic inertia and red tape can still persist at various levels of implementation, hindering business activity.
* Skills Mismatch: The education system, particularly vocational training, has not always kept pace with the demands of a modernizing non-oil economy, leading to a mismatch between the skills of the workforce and the needs of employers in sectors like ICT, advanced manufacturing, and tourism services.
* Regional Disparities: Economic activity is heavily concentrated in Baku. Spreading development and investment to the regions remains a significant challenge, crucial for balanced and inclusive growth.
* Global Competition: Azerbaijan's non-oil exports must compete in highly competitive global markets, requiring high standards, competitive pricing, and strong branding.

The Post-Conflict Paradigm: Karabakh as a New Frontier

The liberation of Azerbaijani territories following the 44-Day Patriotic War in 2020 has added a new and profound dimension to the diversification strategy. The government has embarked on a massive reconstruction and rehabilitation effort in Karabakh and East Zangazur, envisioning it as a green energy zone and a hub for high-tech agriculture.

The plan involves building modern "smart" cities (like Aghali village), deploying extensive renewable energy sources (solar and hydro), and establishing advanced agricultural complexes. This ambitious project is not only about restoring territorial integrity but also about creating a model of sustainable, innovative, and diversified economic development from the ground up, potentially serving as a blueprint for the entire nation.

Conclusion: A Long-Term Journey of Transformation

Azerbaijan's policy for non-oil sector development and diversification is a well-acknowledged necessity backed by a sophisticated strategic framework, significant financial resources, and clear political will. The progress made in developing infrastructure, establishing industrial zones, and promoting sectors like tourism and agriculture is tangible.

However, true economic diversification is a decades-long journey, not a short-term project. It requires not just capital investment but also a fundamental shift in mindset, continuous institutional reform, and a relentless focus on education and human capital development. The

ultimate success will be measured by the ability to create a vibrant private sector-led economy where innovation and competitiveness, rather than resource rents, are the primary engines of growth.

The transformation of the liberated territories presents a unique opportunity to accelerate this transition. By persevering on this path, Azerbaijan can hope to secure a prosperous and sustainable future, ensuring stability and well-being for its people long after the last barrel of oil is extracted from the Caspian Sea. The journey beyond the barrel is well underway, but its most challenging and crucial stages still lie ahead

Conclusion: A Long-Term Journey of Transformation

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However, the analysis reveals that true economic diversification is a decades-long journey of profound transformation, not a short-term project. It requires not just massive capital investment but also a fundamental shift in mindset—from a rentier mentality towards a culture of competitive entrepreneurship. Continuous institutional reform, further simplification of bureaucratic procedures, and a relentless focus on modernizing the education system to bridge the skills gap are imperative for sustainable success.

The ultimate measure of success will be the creation of a vibrant, resilient, and private sector-led economy where innovation, human capital, and competitiveness are the primary engines of growth, rather than volatile resource rents. The reconstruction of the liberated territories of Karabakh and East Zangazur as a green energy and high-tech agro-hub presents a unique and symbolic opportunity to accelerate this transition. It serves as a test case for building a modern, diversified, and sustainable economic model from the ground up.

In conclusion, while the challenges are significant, the strategic direction is clear. By persevering on this path, fostering public-private partnerships, and integrating further into global value chains, Azerbaijan can hope to secure a prosperous and sustainable future. This will ensure long-term economic stability, job creation, and enhanced well-being for its people, ultimately guaranteeing the nation's resilience long after the last barrel of oil is extracted from the Caspian Sea. The journey beyond the barrel is well underway, but its most challenging and crucial stages still lie ahead.

ENTERPRISE DIGITIZATION

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Introduction

In recent years, with the rapid advancement of information technology, enterprise digital transformation has emerged as a key driver for promoting high-quality economic development. Digital transformation is not merely an optional course for businesses to adapt to the digital economy era; it is also an indispensable route to enhancing competitiveness and achieving sustainable development. The report of the 20th National Congress of the Communist Party of China, held in China, explicitly called for "accelerating the development of the digital economy and promoting the deep integration of the digital economy with the real economy," providing policy guidance and strategic direction for corporate digital transformation. However, enterprises encounter a multitude of challenges in their pursuit of digital transformation, including yet not limited to: inadequate technological capabilities, insufficient capital investment, and a paucity of digital talent. These factors impose significant constraints on the pace of digitalization. Consequently, conducting in-depth research on the driving factors, operational mechanisms, and economic consequences of enterprise digital transformation is of significant theoretical and practical importance for advancing this process.The extant research is chiefly concentrated on the following areas: First, with regard to the drivers of corporate digital transformation, studies have examined both external environmental factors and internal factors. With regard to the external environment, factors such as market access systems, economic growth targets, and the establishment of free trade zones have been shown to exert a significant influence on corporate digital transformation[a]. The internal dynamics of corporate shareholder governance and the characteristics of executive teams have been shown to exert a significant influence on the process of digital transformation. Secondly, with respect to the ramifications of digital transformation, extant research suggests that it can substantially augment firms' total factor productivity, innovation capabilities, and market value. However, extant studies seldom provide systematic analyses from perspectives such as talent support and policy environments. Additionally, research on signal management related to digital transformation and its effects on market value remains insufficient.

While extant research has yielded certain results regarding the driving factors and impact mechanisms of corporate digital transformation, several research gaps remain. First, with regard to the influence of talent support on corporate digital transformation, extant studies predominantly focus on conceptual definitions, developmental trajectories, and implementation effectiveness evaluations of talent policies, lacking empirical testing grounded in signaling theory. Secondly, with respect to signal management in the context of digital transformation and its impact on market value, extant studies primarily adopt perspectives of corporate strategic change or textual manipulation, overlooking micro-level cognitive research on the "mismatch" phenomenon between digital information disclosure and actual actions. Furthermore, with regard to the policy environment for digital transformation, extant research predominantly engages with macro-level factors, eschewing micro-level verification of specific policy implementation outcomes. The objective of this study is to address these gaps by systematically analyzing the impact of factors such as talent support and policy environments on corporate digital transformation. The study explores the signaling management of digital transformation and its underlying mechanisms affecting market value. Specifically, drawing from the tenets of signaling theory, this research endeavors to empirically examine the influence of talent support on digital transformation and its

operational mechanisms.The objective of this research is to provide theoretical support and practical guidance for corporate digital transformation, while also offering reference points for the formulation of relevant policies.

This study possesses significant theoretical and practical implications. From a theoretical perspective, it enriches research on the drivers and influence mechanisms of corporate digital transformation, providing new empirical evidence for the application of signaling theory in this field. From a pragmatic standpoint, this study proffers concrete guidance on how enterprises can effectively leverage talent, support, and policy environments to advance digital transformation. Moreover, it provides theoretical foundations for government policy formulation. By systematically analyzing signal management in corporate digital transformation and its impact on market value, this research assists enterprises in more effectively managing information transmission during digital transformation and enhancing their market value.

1. Analysis of the current situation of Digital transformation of Chinese Enterprises

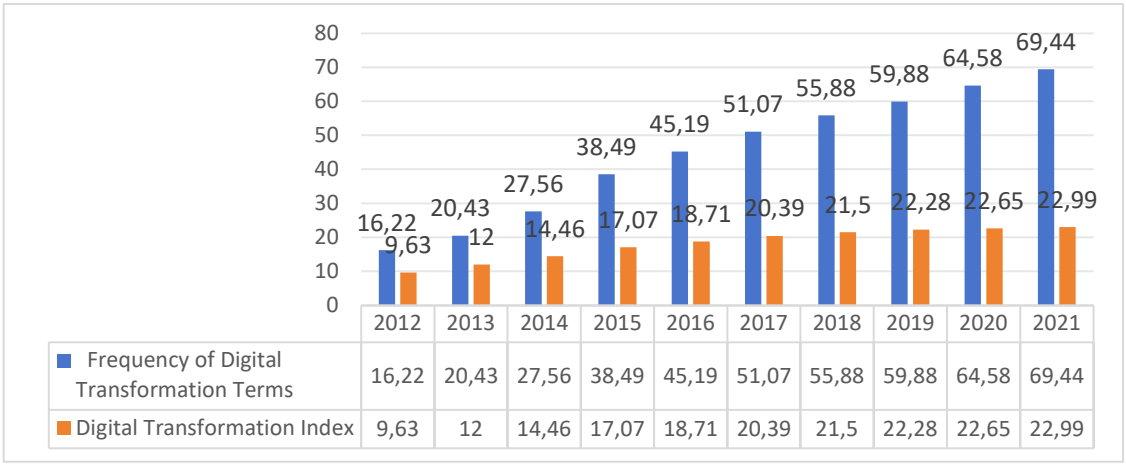
In recent years, corporate digital transformation has emerged as a focal point of attention in both academic and practical circles. Digital transformation is not merely a strategic imperative for enterprises to adapt to the digital economy era; it is also a pivotal pathway to enhancing competitiveness and achieving sustainable development. A substantial body of research has been dedicated to exploring the multifaceted nature of digital transformation, with a focus on its drivers, the mechanisms through which it exerts influence, and its impact on corporate performance. With respect to technological drivers, emerging technologies such as big data, artificial intelligence, blockchain, and cloud computing are regarded as fundamental components that are driving corporate digital transformation. The implementation of these technologies has the potential to markedly improve operational efficiency and innovation capabilities (Pappas et al., 2018; Wu et al., 2020)[k]. In consideration of the factors that propel corporate digital transformation, government support emerges as a pivotal element, exerting a substantial influence on these processes. For instance, the establishment of free trade zones has been demonstrated to facilitate factor mobility and optimize resource allocation, thereby providing a foundational resource base for corporate digital transformation (Jing Li and Sun Zheyuan, 2022). As market demand drivers, such as evolving consumer behavior and diversifying market needs, continue to evolve, enterprises find themselves compelled to undergo digital transformation to better meet customer demands (Vial, 2019)[b].

With respect to the impact mechanism of digital transformation, extant research indicates that the integration of digital technologies promotes technological innovation and product upgrades within enterprises, thereby enhancing their innovation capabilities (Yu, R. J., et al., 2023; Li et al., 2022). Concurrently, digital transformation enhances resource allocation efficiency through data analytics and intelligent decision-making, optimizes cost structures, and significantly enhances operational efficiency (Bloom et al., 2014; Zhang Jichang and Long Jing, 2022). Moreover, it has been demonstrated to enhance market competitiveness by increasing transparency and improving customer relationship management (Lendle et al., 2016; Ma Shuzhong et al., 2019). Collectively, these mechanisms enable digital transformation to positively impact corporate performance, significantly improving financial and organizational outcomes (Johnson, 2017; Zhang et al., 2016)[c], optimizing cost structures, and reducing operational expenses (Sheng et al., 2020; Shen et al., 2020).

Regarding the current state of digital transformation among Chinese enterprises, the overall trend highlights the urgency of this transition. With the rapid development of the digital economy, Chinese companies are increasingly compelled to pursue digital transformation. Data indicates that between 2012 and 2021, the digital transformation index of Chinese listed companies rose from 9.63 to 22.99, with an average annual growth rate of approximately 9.62% (Wu Fei et al., 2021)[d]. This demonstrates that both awareness and implementation of digital

transformation are steadily increasing among Chinese enterprises. However, significant disparities exist in digital transformation levels across different industries. Service-oriented industries such as telecommunications demonstrate outstanding performance in digital transformation, with their transformation index exceeding the national average by over 15%. Conversely, traditional labor-intensive sectors like construction, mining, agriculture, forestry, animal husbandry, and fisheries lag behind in digital transformation[e]. These disparities primarily stem from differing technological application environments and varying degrees of digital development across industries. Furthermore, enterprise scale correlates positively with digital transformation levels[f]. Large enterprises possess advantages in resources, capital, and talent, achieving higher maturity in digital transformation. In contrast, small and medium-sized enterprises face challenges of insufficient funding and technology, resulting in slower transformation speeds. At the enterprise level, the utilization of big data, cloud computing, and artificial intelligence has become prevalent among companies, with the objective of enhancing production and management processes. For instance, data analytics tools are employed to enhance supply chain management and inventory control, thereby improving operational efficiency[g]. According to the data, a significant proportion of large enterprises have incorporated big data analytics into their fundamental operations. In contrast, this adoption rate is substantially lower, at approximately 30%, among small and medium-sized enterprises. Concurrently, enterprises are progressively allocating greater resources to technological R&D and innovation during their digital transformation processes. A close examination of the available data suggests a positive correlation between the degree of digital transformation exhibited by companies and their propensity to allocate substantial financial resources toward the acquisition of foundational technologies such as big data and cloud computing[i]. For instance, enterprises in the top 20% of the digital transformation index allocate an average of 8.5% of their revenue to R&D, compared to just 3.2% for those in the bottom 20%. Furthermore, the implementation of digital transformation has been demonstrated to have a substantial impact on enhancing corporate market competitiveness. Enterprises can leverage technologies such as cloud computing and artificial intelligence to more accurately identify market demands and localize products and services[j], thereby enhancing market acceptance and customer satisfaction. A review of the extant data indicates that enterprises that have undergone significant digital transformation achieve an average customer satisfaction rate of 85%, whereas those with less advanced transformation levels achieve an average rate of 65%.

Table 1-Overall Trend of Digital Transformation of Chinese Enterprises (2012-2021)
Note-Compiled by the author based on the source[m].



	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Frequency of Digital Transformation Terms	16,22	20,43	27,56	38,49	45,19	51,07	55,88	59,88	64,58	69,44
Digital Transformation Index	9,63	12	14,46	17,07	18,71	20,39	21,5	22,28	22,65	22,99

Nevertheless, Chinese enterprises confront a multitude of challenges in their digital transformation. The initial concern pertains to the issue of funding constraints. It has been

demonstrated that small and medium-sized enterprises (SMEs) encounter insufficient capital during digital transformation, which has the effect of limiting their technological applications and innovation investments. According to the available data, small- and medium-sized enterprises (SMEs) allocate a mere 2.5% of their operating revenue to digital transformation funding. This figure is significantly lower than the 6.8% invested by large enterprises. Secondly, the technical capability is inadequate. In the context of contemporary business operations, certain enterprises encounter challenges in effectively implementing and integrating digital technologies due to a deficiency in both technical expertise and specialized talent. A review of relevant data reveals that a mere 15% of SMEs employ digital specialists, a figure that stands in stark contrast to the 45% representation observed among large enterprises. Finally, the study identified the persistence of outdated management philosophies, with some executives demonstrating a lack of comprehension regarding digital transformation. This is further compounded by their adherence to obsolete management concepts, which hinders comprehensive enterprise-wide digital transformation[l]. Surveys indicate that over 40% of SME management perceives digital transformation as the exclusive responsibility of the technology department, rather than as a strategic transformation for the enterprise as a whole.

Table 2-Digital Transformation Maturity Index of Chinese Enterprises of Different Sizes
Note-Compiled by the author based on the source[m].

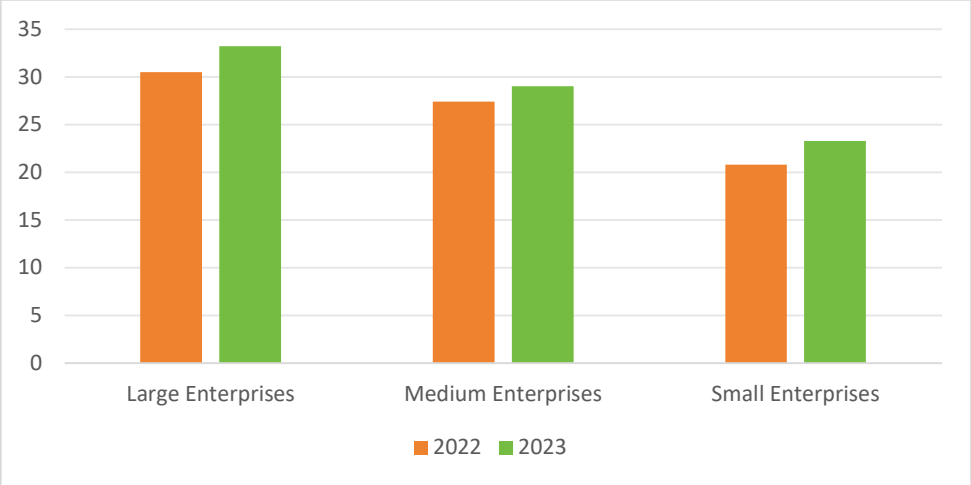
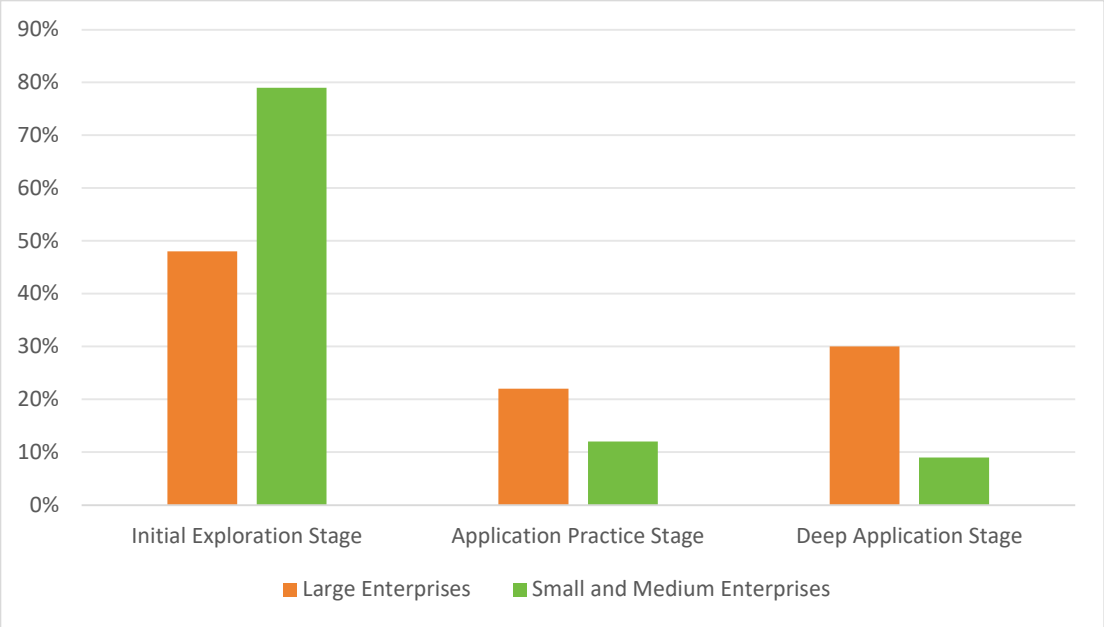


Table 3-Level of Digital Transformation of Enterprises of Different Sizes
Note-Compiled by the author based on the source[m].



In summary, Chinese enterprises are demonstrating a positive trajectory in digital transformation, though significant disparities exist across industries and company sizes. While substantial progress has been made by large enterprises in the realm of digital transformation, small and medium-sized enterprises (SMEs) continue to grapple with a myriad of challenges. In the future, enterprises should consider increasing investments in technological R&D and innovation, enhancing management philosophies, and leveraging government policy support to facilitate comprehensive implementation of digital transformation. Concurrently, the government should strengthen its support for SMEs by allocating more resources and implementing policy safeguards to promote balanced development in corporate digital transformation.

Conclusion

This paper systematically examines the driving factors, impact mechanisms, and challenges of enterprise digital transformation. It conducts an in-depth analysis of the current state of digital transformation among Chinese enterprises. The research indicates that technological advancement, policy support, and market demand are pivotal factors in the digital transformation of enterprises. These factors have been shown to have a significant impact on corporate performance and market value. This impact is achieved through mechanisms such as the enhancement of innovation capabilities, the optimization of resource allocation, and the strengthening of market competitiveness. However, significant industry and scale disparities exist among Chinese enterprises during digital transformation. Small- and medium-sized enterprises (SMEs) encounter constraints in the domains of funding, technology, and management concepts, which impede the velocity and efficacy of their transformation processes. In summary, enterprise digital transformation is a critical strategy for enhancing competitiveness and achieving sustainable development. In the future, enterprises must strengthen investments in R&D and innovation, upgrade management concepts, and fully leverage policy support to drive comprehensive digital transformation implementation. Furthermore, the government should consider augmenting its support for SMEs to promote balanced development in enterprise digital transformation.

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APPLICATION AND EFFECTIVENESS OF CROSS-CULTURAL MANAGEMENT STRATEGIES

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Introduction

Globalization has significantly transformed the international business landscape, making multinational operations a crucial strategy for enterprises to achieve their objectives. In recent years, many companies have sought new growth opportunities in international markets. However, international expansion is fraught with challenges, particularly cultural differences, which can impede success. Chinese enterprises, for instance, have experienced both success and failure in foreign markets due to their ability or inability to adapt to foreign environments. This highlights the critical importance of cross-cultural management in international business. Multinational corporations face numerous challenges when managing personnel from diverse cultural backgrounds, including communication styles, work ethics, decision-making processes, and organizational hierarchies. Failure to address these differences can lead to low employee morale, high turnover rates, and even corporate failure. Empirical research indicates that many international business failures stem from cultural misunderstandings and mismanagement, as exemplified by the Daimler-Benz and Chrysler merger, which suffered financial losses and organizational turmoil due to cultural differences.

Despite extensive research on cross-cultural management, significant gaps remain, especially in emerging markets like Kazakhstan. Existing studies, primarily focused on developed nations, may not be fully applicable to such markets. Kazakhstan's unique cultural, social, and economic contexts, characterized by collectivist traits, the importance of interpersonal relationships, and traditional values, necessitate tailored cross-cultural management strategies. However, empirical research on the application and effectiveness of these strategies in Kazakhstan is limited. This study aims to examine cross-cultural management theories and evaluate their application and effectiveness through global case studies. The objectives are to identify key cultural dimensions influencing corporate management practices, analyze cross-cultural management strategies used by multinational corporations, assess the effectiveness of these strategies in terms of employee satisfaction, organizational performance, and business success, and formulate recommendations for enhancing cross-cultural management practices. A mixed-methods research design combining qualitative analysis of intercultural management theories and case analysis of multinational corporations will be employed. Data will be collected through a meticulous examination of theories and case studies, with effectiveness measured using metrics such as employee satisfaction and work performance.

Theoretically, this study enriches cross-cultural management theory by providing new perspectives and empirical evidence on the application and effectiveness of strategies in emerging markets. Practically, it offers valuable guidance for enterprises to develop targeted management approaches, enhancing employee satisfaction, organizational performance, and international competitiveness. Insights from this research can also inform policymakers on the impact of cultural differences on international business. In summary, this study contributes to both theoretical research and practical guidance in cross-cultural management, highlighting its significance in the context of globalization and corporate internationalization.

1. Current State of Cross-Cultural Management Research

In the domain of cross-cultural management research, the concept of culture occupies a central position[a]. According to Kluckhohn (1954)[b], culture may be defined as "a set of beliefs, values, behaviors, customs, and attitudes" that collectively constitute the characteristics of a society and serve to distinguish it from other societies. Triandis (1994) further elaborated that culture represents a group's patterned ways of thinking and unstated norms of behavior, emphasizing its shared nature, adaptability, and transgenerational transmission[c]. Despite the presence of subtle variations in scholarly definitions, a broad consensus exists regarding the profound influence of culture on the attitudes and behaviors of group members. In the context of multinational corporations, employees who have been influenced by specific cultural backgrounds exhibit a range of attitudes toward uncertainty and ambiguity. These disparities may result in cultural conflicts or facilitate integration within the organizational structure. The influence of cultural values on individual behavior and the transformation of organizational culture is a subject of significant interest[d]. The phenomenon of corporate culture may involve a process of replication, rejection, or disregard of national cultural values, thereby giving rise to a distinct microenvironment within the organizational structure. As Adler (1986) observed, cultural influences play a substantial role in shaping managerial values[e], resulting in notable disparities in decision-making across managers from diverse international backgrounds. This underscores the necessity for cross-cultural management strategies to effectively navigate these variations.

The field of comparative cultural studies is chiefly concerned with the examination of cultural differences and their subsequent influence on management practices. According to Adler et al. (2008)[f], cross-cultural management is defined as "the discipline that studies people's behavior in organizations worldwide and trains individuals to work in organizations with employees and customer groups from diverse cultural backgrounds." The objective of research in this field is to achieve optimal allocation of corporate human resources. This is accomplished by designing rational organizational structures and management mechanisms, thereby maximizing overall corporate benefits. Research methodologies generally draw upon psychological and sociological perspectives, employing cultural theories and frameworks for analysis. Kluckhohn et al. (1961) established the foundational principles of comparative cultural studies with their theory of six universal value orientations, identifying six core human values that manifest differently across cultures[g]. Hofstede's (1997) The Cultural Consequences is widely regarded as a foundational text in this field. Through the implementation of psychological testing on employees of multinational corporations, he identified six cultural dimensions: individualism versus collectivism, power distance, uncertainty avoidance, masculinity versus femininity, long-term versus short-term orientation, and indulgence versus restraint[h]. These dimensions have provided management scholars with practical tools for studying cultural differences. In the GLOBE research project, House et al. (2002) expanded Hofstede's cultural dimensions to nine, thereby further distinguishing between cultural practices (i.e., current practices) and cultural values[i]. The GLOBE project was not only systematic in its examination of cultural dimensions; it was also exploratory in nature, investigating the influence of these dimensions on leadership behavior and effectiveness. Other scholars, including Triandis (1995), Trompenaars (1998), and Schwartz (1992), have proposed their own dimensional models, thereby enriching the theoretical foundation for cross-cultural management research. However, the majority of these models prioritize[j-k]. However, most of these models focus on convergent trends across cultures while paying insufficient attention to intra-cultural variations. Consequently, they serve only as starting points for cross-cultural research.

In the field of cross-cultural research, scholars integrate cultural frameworks from comparative cultural studies with theories from social psychology, cross-cultural communication, and cross-cultural psychology to enhance their understanding of communication dynamics in

intercultural contexts. A review of the extant research reveals that, while interpersonal communication across cultures does adhere to certain universal principles, the specific implementation of these principles varies significantly. For instance, individualistic societies tend to link compensation to individual performance, whereas collectivist societies emphasize egalitarianism, believing remuneration should be distributed based on group effort. In instances of conflict between disparate cultural groups in corporate interactions, effective resolution strategies entail the mitigation of tensions through understanding, communication, coordination, and integration, thereby facilitating efficient management. Moreover, cross-cultural research encompasses studies on business expatriates. As Yvonne et al. (2017) observe, expatriates generally undertake temporary relocations to other countries in pursuit of career opportunities, a process that entails navigating challenges associated with transcending national and cultural boundaries. Ward et al. (1998) proposed a model delineating four stages of expatriate adaptation to foreign cultures: the honeymoon phase, disillusionment phase, initial adaptation phase, and full adaptation phase. These studies establish the foundation for comprehending global assignments and the role of global leaders. As the process of globalization continues to unfold, corporate executives find themselves assuming increasingly strategic roles. Concurrently, global leaders must cultivate the capacity to lead effectively in multicultural environments. Mendenhall et al. (2002) proposed a categorization of global leadership competencies into six dimensions: vision, global business expertise, global organizational competence, traits and values, cognitive orientation, and cross-cultural relationship skills. Caligiuri et al. (2009) identified a set of key job activities for global leadership through a thorough job analysis, including collaboration with multinational colleagues, development of global strategic plans, and cross-border negotiations. The following text is intended to provide a comprehensive overview of the subject matter.In their seminal work, Caligiuri and Tarique (2012) delved deeper into the nexus between personality traits and global competence, culminating in the formulation of models for global leadership development, including the Global Leadership Pyramid Model. Research by Robert et al. (2004) and Dorfman et al. (2012) indicates that charismatic leadership and team-oriented leadership are recognized across cultures. This suggests the necessity of task-specific training for managers tailored to organizational needs.

Notwithstanding the substantial advancements witnessed in the realm of cross-cultural management research, extant studies continue to manifest certain limitations. Initially, the preponderance of research concentrates on the cultural dimension of individualism versus collectivism, with comparatively limited exploration of alternative cultural dimensions[l]. This single-dimensional research approach may fail to comprehensively address the cultural conflicts faced by enterprises, leading to limitations in research findings. Secondly, extant studies have predominantly emphasized the tendency toward cultural convergence, while paying insufficient attention to intraregional variations. This limitation in turn affects the precision of cross-cultural management strategies. Moreover, research on cross-cultural management has seen relatively scarce application in emerging markets, particularly lacking systematic empirical studies in markets like Kazakhstan. These research gaps provide new directions for future studies and offer theoretical support for multinational corporations' practices in emerging markets.

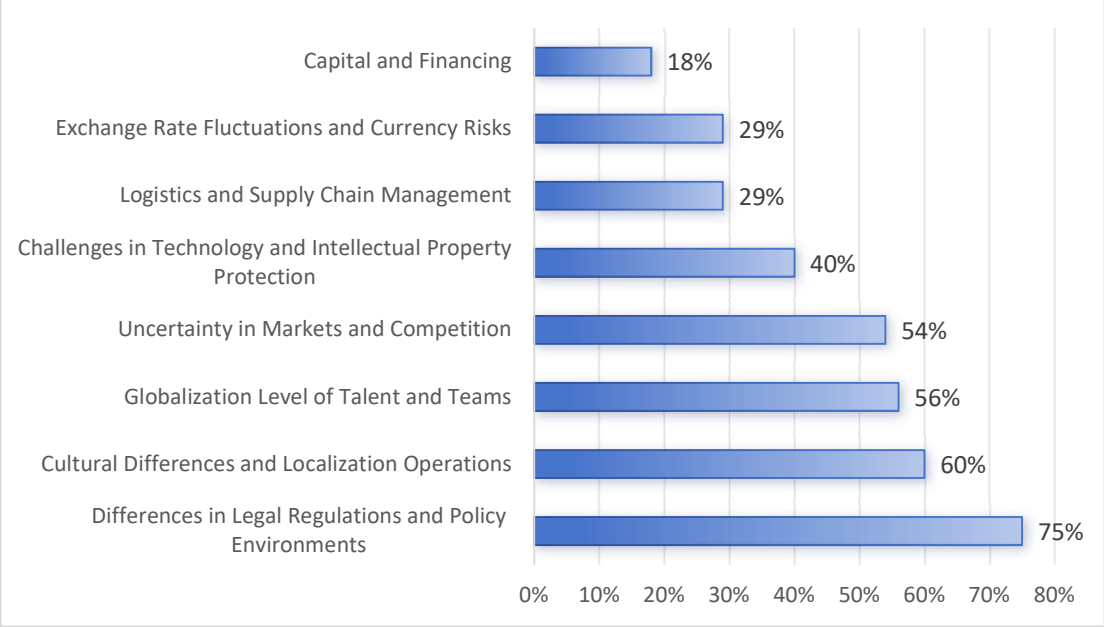
2. Analysis of Real-World Cases

In the context of globalization, the decision to pursue global expansion has emerged as a strategic imperative for numerous Chinese enterprises, driven by the objective of accessing new markets and achieving growth. Nevertheless, the process of achieving global expansion is not without its challenges. In the contemporary business landscape, companies are compelled to navigate a complex terrain, characterized by the confluence of overseas policies, regulations, and

competitive markets. Concurrently, they must surmount significant challenges, including cultural dissonance and intricate talent management issues.The most recent findings from DDI's "2025 Global Leadership Outlook" survey (henceforth referred to as "the survey data") offer insights into the talent management challenges enterprises encounter during international expansion. This analysis explores systematic strategies for developing cross-cultural leaders, providing robust support and success assurance for companies navigating overseas markets with stability and confidence.

At present, the motivations for enterprises to expand overseas are diverse and complex. These factors encompass both internal drivers, such as the pursuit of a second growth curve abroad, the impetus of internal transformation and upgrading, and the fulfillment of innovation needs, as well as external environmental factors. These external environmental factors include the reduction of export costs through overseas manufacturing and the improvement of customer service for an increasingly globalized customer base. Regardless of the underlying motivations, the pursuit of global expansion has emerged as a prominent trend. However, an examination of extant research data suggests that enterprises encounter a multitude of challenges in their international endeavors. The primary challenges that must be addressed are as follows: the presence of divergent legal regulations and policy environments, cultural differences and localization challenges, the absence of global capabilities among talent teams, and uncertainties in market and competitive environments.In addition, an in-depth analysis of global M&A cases by Deloitte reveals that 53% of failed acquisitions stem from inadequate integration. Among these integration failures, 44% are attributable to cultural incompatibility. It is evident that cultural differences have evolved into a pivotal critical issue in the context of corporate globalization. For instance, despite relatively lower economic development in certain regions, people's work attitudes do not necessarily reflect strong enthusiasm simply because of economic backwardness. A similar dynamic can be observed among employees in Europe and the United States, who may exhibit a lack of enthusiasm or even perceive team-building initiatives and incentive conferences as immature. The underlying causes of these surface phenomena are often attributed to stark differences in values, diverse work patterns, and varying incentive mechanisms across different cultural systems.

Table1-Challenges Faced by Companies in Global Expansion
Note-Compiled by the author based on the source[m].



The challenges of cross-cultural management in multinational operations are exemplified by the experience of a new energy vehicle parts company that established a factory in Poland. The

company encountered significant cultural differences in the interpretation of "work intensity." The Chinese management team, accustomed to working overtime to meet deadlines, clashed with Polish workers who strictly adhered to scheduled working hours. This discrepancy led to discontent among Polish workers, who felt their lifestyle was disrespected, while the Chinese production manager complained about the local employees' perceived lack of "drive." This conflict affected production efficiency and workforce morale. Similarly, in multinational teams, distinct communication styles among members from different cultural backgrounds can impede information flow and project progress. For instance, American colleagues tend to be direct, Japanese counterparts prefer tactful approaches, and Chinese teams often discuss matters privately after meetings. Digital collaboration has further exacerbated these issues, as cultural differences become more pronounced in remote settings. The European General Manager of a photovoltaic company observed that German customers not only scrutinize product carbon footprint data but also prioritize whether environmental protection is a core corporate value. This highlights that cultural differences extend to deeper layers of values and corporate culture, necessitating the integration of company values with local culture for market acceptance.

To address these challenges, companies can implement "cultural immersion" programs, allowing key managers to live and work in target markets for extended periods. This approach has been shown to enhance managers' understanding of local cultural perspectives and behaviors, improving their cultural sensitivity. For example, a construction machinery company conducted a thorough analysis of the local commercial legal environment and the impact of tribal cultures on business collaborations before entering the African market. This knowledge accumulation and application earned the company significant recognition from local communities, facilitating smooth project execution. Additionally, companies must adopt diversified management strategies across different cultural contexts. For instance, the U.S. market values individual achievement and competitive incentives, while Japan prioritizes team harmony and long-term development, and Germany emphasizes process standardization and quality benchmarks. Haier, following its acquisition of GE Appliances, identified a shared value pursuit of creating user value while preserving each entity's cultural distinctiveness. Some companies also establish cross-cultural coordinator roles, filled by individuals with multicultural backgrounds or extensive international experience, to reduce cultural friction and enhance team efficiency. Geely Auto, for example, implements diversified cultural strategies across markets while ensuring effective communication through cross-cultural coordinators.

In conclusion, cross-cultural management is a pivotal challenge in the context of globalization. By fostering cultural sensitivity, adopting locally tailored management strategies, and appointing cross-cultural coordinators, companies can navigate cultural differences effectively. Recognizing the benefits of cultural diversity, companies can leverage it to drive innovation and competitive advantage. In the future, systematically cultivating cross-cultural competence as a strategic asset through ecosystem collaboration and capacity building will enhance the effectiveness of cross-cultural management. In the globalized world, cross-cultural management is not just a tool for overcoming challenges but an integral part of a company's core competitiveness.

Conclusion

This study systematically reviews the development of cross-cultural management theory and thoroughly analyzes the application and effectiveness of cross-cultural management strategies in real-world cases. The findings of this study indicate that since the mid-20th century, cross-cultural management theory has evolved from single-dimensional cultural analysis to multidimensional frameworks. Theories such as Hofstede's cultural dimensions, the GLOBE research project, and Trompenaars' cultural framework provide a robust theoretical foundation for understanding cultural differences and their impact on management practices. These theories not

only reveal the specific manifestations of cultural differences in organizational behavior but also emphasize the critical role of cultural intelligence in cross-cultural management. This study further corroborates the efficacy of cross-cultural management strategies in resolving cultural conflicts, fostering innovation, and enhancing corporate competitiveness by analyzing successful cases from multinational corporations such as Haier, Geely, and ByteDance. These enterprises effectively transformed cultural differences into competitive advantages through measures such as cultivating cultural sensitivity, implementing locally adapted management strategies, and establishing cross-cultural coordinators. The findings indicate that cultural differences do not merely impede the process of internationalization; rather, they can also function as a catalyst for corporate innovation and development.

From a pragmatic standpoint, this study proffers substantial cross-cultural management insights for multinational corporations. In the context of operating in overseas markets, it is imperative for companies to acknowledge and address the impact of cultural differences on management practices. By cultivating employees' cultural intelligence, implementing flexible management strategies, and establishing cross-cultural coordination mechanisms, organizations can effectively address cultural conflicts and enhance performance. Concurrently, businesses must capitalize on the innovation opportunities that emerge from cultural diversity, thereby achieving synergistic effects by integrating advantageous resources from diverse cultural backgrounds. Future research could further explore the long-term effects of cross-cultural management strategies and the application of emerging technologies (such as artificial intelligence and virtual reality) in cross-cultural training and communication. Furthermore, the development of enhanced scientific cultural intelligence assessment instruments to quantify the efficacy of cross-cultural management strategies constitutes a significant future research direction. In summary, cross-cultural management capability has become one of the core competencies for enterprises in the era of globalization. It is incumbent upon companies to regard it as a strategic resource, cultivating and managing it systematically to navigate the increasingly complex global business environment.

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Political Studies

ҚАЗАҚСТАН САЯСАТЫНДАҒЫ ЖАСАНДЫ ИНТЕЛЛЕКТ: ДАМУ БОЛАШАҒЫ ЖӘНЕ ХАЛЫҚАРАЛЫҚ КЕЙС-ТАЛДАУ

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Аннотация. Мақалада жасанды интеллектіні (ЖИ) саясат саласында қолданудың негізгі бағыттары қарастырылады. Зерттеудің мақсаты – ЖИ-дің саяси үдерістерге енгізілуінің маңызды кейстерін айқындау және әртүрлі елдердегі оны реттеудің құқықтық-нормативтік ерекшеліктерін талдау. Автор кейс-талдау әдісін пайдалана отырып, ЖИ қолданылған нақты мысалдарды зерделейді және саяси тәжірибеге енгізудің ықтимал түрлерін жіктейді. Зерттеу нәтижелері көрсеткендей, ЖИ-дің қазіргі қолданысы көбіне басқарушылық сипаттағы міндеттерді шешуге бағытталған, ал саяси технологиялардың күрделі ауқымына бейімделуі сирек кездеседі. Сонымен қатар, әрбір мемлекеттің ЖИ-ді құқықтық тұрғыдан реттеу тәсілдері айтарлықтай ерекшеленетіні анықталды: кейбірі икемді әрі бейімделгіш құқықтық негіздер құруға ұмтылса, басқалары этика мен ашықтық мәселелерінде қиындықтарға кезігуде. Зерттеудің ғылыми жаңалығы – әртүрлі елдердегі ЖИ енгізу тәжірибесін кешенді талдау және оны саяси үдерістер контексінде қарастыруында.

Түйін сөздер: *жасанды интеллект, нейрожелі, сайлау үдерісі, саясат, заңнамалық реттеу.*

... Бізге жасанды интеллектіні
саясат пен қоғам үшін пайдалану қажет,
бірақ бұл технология әрқашан
адамға қызмет етуге тиіс

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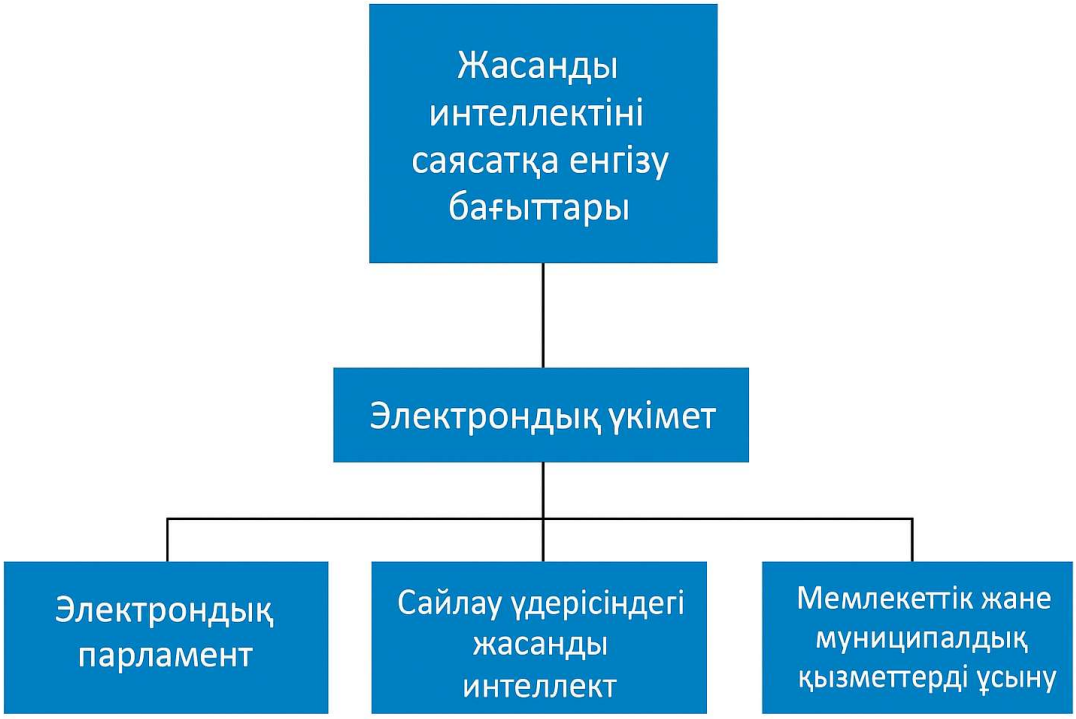
Қазіргі саяси үдерістер контексіндегі жасанды интеллектінің дамуы

Соңғы бірнеше жылда, әсіресе 2022 жылдың соңынан бастап, желіде ашық нейрожелілік құралдардың (ChatGPT, OpenAI және т.б.) қолжетімді болуы жасанды интеллект (ЖИ) феноменін көпшілік санасында жаңа деңгейге көтерді. Бұқаралық ақпарат құралдарында нейрожелілерді пайдаланып жазылған біліктілік жұмыстары, сондай-ақ

нейрожелілердің түрлі салаларда (копирайтинг, дизайн, қаржы және т.б.) қолданылу мүмкіндіктері туралы жаңалықтар жиі жариялана бастады. Бұл үрдіс саясат саласын да айналып өткен жоқ.

ЖИ-ді саясатқа енгізу туралы сөз қозғалғанда, ең алдымен оның мақсатына назар аудару қажет. Бұл мақсаттардың басты бағыты – мемлекеттік басқаруды оңтайландыру. Мысалы, ЖИ енгізу арқылы сыбайлас жемқорлық деңгейін төмендету немесе басқару үдерістерін компьютерлік жүйелерге беру арқылы адамдық (соның ішінде сыбайлас жемқорлықтық) факторды азайтуға қол жеткізу көзделеді. Саясаттағы жасанды интеллект көбіне мемлекеттік басқару, сайлау, саяси науқандар және өзге де саяси қызмет салаларында мәліметтерді талдау мен шешім қабылдауға арналған компьютерлік технологиялар мен алгоритмдердің қолданылуы ретінде айқындалады.

Жасанды интеллект әлі де жас технология болғанына қарамастан, қазіргі таңда тек әлсіз ЖИ жүйелері жасалғанымен, ол революциялық сипатқа ие және оның құралдары бүгінде көптеген салаларда кеңінен қолданыс табуда [1].



Сурет 1. Жасанды интеллектіні саяси үдерістерге енгізудің ықтимал салалары

Енді осы бағыттарды толығырақ қарастырайық.

Электрондық үкімет – бұл мемлекеттегі атқарушы биліктің жасанды интеллектіні пайдалану арқылы жүзеге асырылатын қызметі ретінде түсіндіріледі. Электрондық үкімет шеңберінде ЖИ ведомстволар арасындағы деректер алмасу және оңтайлы шешімдерді қалыптастыру үшін енгізілуі мүмкін.

Мемлекеттік қызмет көрсетулерді электрондық үкімет саласына да жатқызуға болады, алайда атқарушы билік органдарының жұмысына енгізіліп жатқан жасанды интеллекті (ЖИ) технологиялары, ең алдымен, олардың қызметін және ведомствоаралық өзара әрекеттестігін оңтайландыруға, сондай-ақ мемлекеттік қызметшілерді іріктеу мен басқа да функцияларды жетілдіруге бағытталуы мүмкін болғандықтан, бұл мәселені жеке қарастыру орынды деп санаймыз. Әрбір салалық атқарушы органның (ФОИВ) қызмет ерекшеліктеріне байланысты ЖИ-ді енгізудің өзіндік тәртібі әзірленуі ықтимал. Мәселен, Ресей Федерациясының Құрылыс министрлігі шеңберінде ЖИ құрылыс сараптамасына арналған

құжаттар базасын құру және тұрғын үйлердегі инженерлік коммуникациялардың тозуын мониторингтеу үшін қолданылуы жоспарлануда [2].

Финляндияда 2022 жылы «Солтүстік шұғыла» атты жоба іске қосылды. Оның мақсаты – мемлекеттік қызметшілерді кейбір қайталанатын және рутинді шешім қабылдау үдерістерінде ішінара алмастыру. Жоба азаматтар, бизнес және мемлекет мүдделерін ескере отырып, олардың үйлесімділігін қамтамасыз ету арқылы шешім қабылдау үдерісін оңтайландыруды көздейді [3]. Бұл ретте ЖИ негізінде білім қоры қалыптастырылып, шешім нұсқалары ұсынылады, алайда түпкілікті шешімді мемлекеттік қызметші қабылдайды. Финляндия Үкіметінің мәлімдеуінше, азаматтардың өздері қандай деректерді мемлекетке беруге дайын екенін, ал қандайын құпия сақтағысы келетінін таңдауға құқы бар. Мысалы, егер азамат өмірлік дағдарыс жағдайына тап болып, жақын арада жұмыссыз қалуы айқын болса, «Солтүстік шұғыла» жүйесі оған алдын ала қолайлы бос жұмыс орындарын іріктеп, уақытылы ұсынатын болады. Осылайша, ел басшылығы алдында тұрған жұмыссыздықпен күрес, еңбек жағдайларының нашарлауы сияқты мәселелерді шешуге ықпал етеді.

Қазіргі таңда кейбір мемлекеттерде ЖИ әлеуметтік көмек тағайындау мәселелерінде де қолданылып отыр. Мұндай тәжірибенің негізгі мақсаты – әлеуметтік көмекті тиімді етіп, ол шынымен азаматтарға жәрдемдесуіне қол жеткізу. Мысалы, мұндай бағдарламалар Армения Республикасында енгізілген. Бұл елде халықтың 25%-ы кедейшілік шегінен төмен өмір сүріп отырғандықтан, әлеуметтік қолдау шаралары мемлекеттің аса өзекті бағытына айналған [4]. Сонымен қатар, Арменияның стратегиялық мақсаттарының бірі – әлеуметтік көмекті қысқарту, яғни оның азаматтарды экономикалық тұрғыдан тәуелсіз әрі өзін-өзі қамтамасыз ететін деңгейге жеткізу функциясын атқаруы. 2022 жылы Армения Республикасының Еңбек және әлеуметтік мәселелер министрлігі халықты әлеуметтік қолдауды цифрландыру үшін ЖИ қолдануды көздейтін жобаны әзірледі. Министрдің пікірінше, әлеуметтік бағдарламаларды жүзеге асыру барысында жиі кездесетін мәселе – олардың талаптарына ешбір бағдарламаға сәйкес келмейтін азаматтар кірмей қалуы. Бұл топ – ең осал санат.

Жаңа жүйе келесі бес міндетті шешуге бағытталған [5]:

1. әлеуметтік қамсыздандыру бағдарламасында үш жылдан астам уақыт қалатын бенефициарларды анықтау;
2. табысының өсуіне байланысты қолдау бағдарламасынан шығатын бенефициарларды айқындау;
3. бағдарламалық алгоритм арқылы әлеуметтік қамсыздандыру саласының бенефициарларын топтастыру және жасырын үрдістерді айқындау.

Қазіргі заманғы әлемде азаматтардың саяси қатысуының көріністері ретінде митингілер мен ереуілдер жиі байқалады. Бельгияның CitizenLab атты технологиялық компаниясы жасанды интеллекті қолданатын краудсорсингтік платформаны әзірледі [6]. Ол Бельгия билігіне қоғамның талап-тілектерін түсінуге және сол негізде мемлекеттің дамуына арналған бағдарламалық құжаттарды қалыптастыруға көмектеседі. Осылайша, саясат саласында жасанды интеллект әлеуметтік үрдістерді жедел тануға және саяси шешімдерді жедел қабылдауға пайдаланылуда.

Мемлекеттік және муниципалдық қызмет көрсету де жасанды интеллектіні енгізудің әлеуетті салаларының бірі болып табылады. Бүгінде «Мемлекеттік қызметтер» платформасында азаматтың жеке профилін талдап, оған қажетті қызметтерді ұсынатын чат-бот көмекшісі жұмыс істейді. Бұл жүйенің жұмысы жасанды интеллект, сөйлеуді тану және пайдаланушы сұраныстарын өңдеу технологияларына негізделген. Азаматтардың дауыстық сұраныстары бойынша мемлекеттік қызметтердің іске қосылуы «сөйлеуді тану және синтездеу» сияқты сквозной технологиялармен тығыз байланысты. Мұндай технологиялар

сөйлеу түріндегі сұранысты мәтіндік форматқа ауыстырып, оның мазмұнын талдауға мүмкіндік береді.

Практикалық мысалдардың ішінде Нидерланд Өкілдер палатасының тәжірибесі назар аударарлық. Ол Speech2Write жүйесін енгізіп, Парламенттік есептілік басқармасына отырыстардың стенограммаларын автоматты түрде дыбыстан мәтінге көшіруге және редакциялауға жағдай жасады [7].

АҚШ-та парламенттік тәжірибеде жасанды интеллект заң жобалары, түзетулер мен қолданыстағы заңдардың арасындағы айырмашылықтарды автоматты түрде анықтау үдерісін оңтайландыру үшін қолданылады [8].

Австрияда 2017 жылдан бері ЖИ жүйесі парламент мүшелерін сенімді ақпаратпен қамтамасыз етуге жәрдемдесуде [9]. EULE медиамониторы әлеуметтік желілерден, жаңалықтардан және сараптамалық есептерден қажетті тақырып бойынша мәліметтерді іздеп, сүзгіден өткізіп, талдау жүргізеді.

Электронды парламент – жасанды интеллектіні енгізудің тағы бір әлеуетті саласы. Бұл тәсіл заңнамалық үдерістерді ашықтық және қолжетімділік қағидаттарына негізделе отырып тиімді пайдалануға мүмкіндік береді.

Сонымен қатар, жасанды интеллектіні электронды парламентке енгізу мен оны сайлау үдерістерінде қолдануды ажырата білу қажет. Біріншісі парламент жұмысының ұйымдастырылуына бағытталса, екіншісі сайлау үдерістерінде және парламентке өту мақсатында қолданылады.

Сайлау үдерісінде жасанды интеллектіні қолданудың ерекше мысалдарының бірі – басқару жүйесі жасанды интеллект арқылы жүзеге асырылатын саяси партияның құрылуы болып табылады. Мұндай партия Данияда 2021 жылы құрылған. Заманауи дизайнерлер мен суретшілерден құралған Computer Lars шығармашылық тобы Синтетикалық партияны (Det Syntetiske Parti) негіздеді. Партияны Leader Lars атты жасанды интеллект моделі басқарады. Партияның басты мақсаты – парламентте орындарға ие болу. Оның бастамашылары ешқашан парламентте өкілдігі болмаған шағын партиялардың қоғамдық пікірін және соңғы сайлауда дауыс беруге қатыспаған ел халқының 15%-ының мүдделерін білдіруді көздейді [10].

Жасанды интеллект моделі – «Лидер Ларс» (Даниядағы ең танымал есімдердің бірі) 1970 жылдан бері шағын партиялардың жариялаған мәтіндеріне негізделіп оқытылған [11]. Нәтижесінде ол партия бағдарламасына енгізілетін саяси ұсыныстарды қалыптастыруы тиіс. Мәселен, партия қазірдің өзінде әмбебап базалық табыс енгізу, Дания Үкіметінің жанынан қоғамдық меншікке негізделген IT-компания құру және басқа да популистік сипаттағы бастамаларды жариялады [12]. Бұл идеялар ЖИ-дің дәл осындай мәтіндік деректер корпусында үйретілуімен тікелей байланысты. Дегенмен, қазіргі заңнама жасанды интеллектінің парламентте мемлекеттік қызмет атқаруына рұқсат бермейді. Сондықтан партиядан ресми түрде адам – нақты тірі кандидат ұсынылуы тиіс.

Осыған байланысты, жасанды интеллектіні электрондық дауыс беру жүйесін ұйымдастыруға қолдануды сайлау үдерісінің бір бөлігі ретінде қарастырсақ болады. Себебі мұндай технологиялар парламент сайлауларымен қатар, аймақ немесе мемлекет басшысын сайлау барысында да пайдаланылуы мүмкін.

Жалпы алғанда, жасанды интеллект технологиялары сайлау үдерісінде саяси партиялар мен қозғалыстар тарапынан әртүрлі деңгейде енгізілуі ықтимал. Оларды саяси үдерістің дерлік барлық кезеңінде қолдануға болады. Негізгі бағыттарын төмендегідей бөлуге болады:

Агитациялық контентті жасау (мәтіндер, бейнелер, бейнероликтер). ЖИ ақпараттық кеңістікті талдап, жағдайға сәйкес ұрандар мен материалдар қалыптастыра алады. Бұл сөз сөйлеу мәтіні, баспасөз релизі, фотосурет немесе бейне болуы мүмкін. Сондай-ақ ЖИ

коммуникациялық дағдарыс кезінде жаңалықтарды жедел қадағалап, заңдылықтар мен қауіптерді анықтауға және зиянды барынша азайтуға мүмкіндік береді. Жауап беру уақыты минуттарға дейін қысқаруы мүмкін. Алайда әзірге мұндай контент әлеуметтік-мәдени контексті толық ескермеуімен және студенттік не тағылымдамалық жұмыстарға ұқсас болып, редакциялауды қажет етуімен ерекшеленеді.

Мақсатты хабарламаларды тарату. Болашақта пайдаланушылардың іздеу тарихы мен қалауларына негізделген жекелендірілген мәтіндер анағұрлым нақтыланатын болады. Мысалы, АҚШ-тағы сайлау кампанияларында таргеттелген хабарламалар шешуші рөл атқаратын ауытқымалы сайлаушылар тобына әсер ету үшін пайдаланылады. Бұл тәсіл кандидаттарға өз таңдауларын жасаған азаматтарға қаражат жұмсамай, шешімін әлі қабылдамаған сайлаушыларға назар аударуға мүмкіндік береді [13]. Айқын мысал ретінде Д. Трамптың сайлауалды кампаниясын келтіруге болады. Онда Cambridge Analytica компаниясы әлеуметтік желілерден жиналған деректер негізінде микротаргетингті сәтті жүзеге асырды.

Сайлаушылар сұрақтарына жауап беретін чат-боттарды пайдалану. Арнайы оқытылған чат-бот операторлардың уақытын үнемдеп, сайлаушылардың жиі қойылатын сұрақтарына жауап бере алады. Әртүрлі топтағы сайлаушыларды тиімді сендіру үшін жауаптардың күрделілігі эмоциялық үндеулерден статистикалық деректер мен халықаралық тәжірибеге дейін өзгеруі мүмкін. Сонымен бірге партия өкілдері арнайы цифрлық платформаларда өз электоратын біріктіріп, олармен тікелей қарым-қатынас жасай алады. Бұл платформаларда сайлаушылардың мінез-құлқын талдау (олардың келісімімен) жүргізіледі.

Болжамдық модельдерді жетілдіру. ЖИ сайлау және басқа да саяси кампаниялардың нәтижелерін болжауда көмекші құрал бола алады. Ол дәстүрлі болжамдық әдістерді толықтыра отырып, адамға көрінбейтін тәуелділіктерді айқындауға мүмкіндік береді.

Жасанды интеллектіні саяси салаға енгізудің мәселелері мен келешегі

Жасанды интеллектінің (ЖИ) саяси процестерге ықпалы ғылыми қауымдастықта кең талқылаулар тудырып отыр.

В. А. Бажанов ЖИ-ді саясатқа енгізу саяси шешімдердің тиімді әрі оңтайлы нұсқасын табуға мүмкіндік береді деп есептейді [14]. Алайда ғалым ЖИ негізінде қабылданған шешімдердің легитимділігіне күмән келтіреді: мұндай шешімдер саяси процестерге көбірек рационалдылық енгізіп, оларды кең халық бұқарасы үшін қабылдауға қолайлы ете ала ма, әлде белгілі бір әлеуметтік топтардың ғана мүддесіне қызмет ете ме деген сұрақ қояды. Сонымен бірге зерттеуші «цифрлық авторитаризм» құбылысын атап өтеді. Ол үлкен деректер мен ЖИ технологияларының кеңінен таралуымен байланысты. Мұндай жағдайларда ЖИ адамдарды белгілі бір белгісі бойынша кемсіту құралына да айналуы мүмкін. Мәселен, мемлекеттік қызметке іріктеуде ЖИ алгоритмдерінің қолданылуы ұлтқа, сенімге немесе саяси көзқарастарға байланысты дискриминация туғызуы ықтимал.

ЖИ технологияларын сайлау процесінде қолдану қосымша тәуекелдерге алып келеді. Соның ішінде жалған ақпараттар, «фейктер» мен шынайы көрінетін жасанды бейнелер (deepfake) арқылы белгілі саясаткерлердің атынан жалған сөз сөйлеулердің жасалуы ерекше алаң тудырады [15].

Сонымен қатар, «цифрлық демократия» ұғымы да бар. Бажановтың пікірінше, бұл құбылыстың ерекшелігі – электоралдық процедуралардың алгоритмдерге тәуелділігі, ал қоғамдық бақылаушылар ол алгоритмдердің жұмысын тексере алмайды. Мұндай жағдайда биліктің нақты тетіктері мемлекеттік құрылымдарға қызмет ететін бағдарламашылардың қолына шоғырлануы ықтимал.

Р. А. Алексеев блокчейн технологияларын сайлау жүйесінде қолданудың да шектеулері бар деп санайды [16]. Оның ішінде: техникалық ақаулар мен интернет-дауыс беру жүйелерін бұзу қауіптері, азаматтардың еркін білдіру нәтижелерінің бұрмалануы, жеке деректердің ұрлану ықтималдығы, қателескен жағдайда қайта дауыс берудің мүмкін еместігі сияқты мәселелер бар. Сонымен бірге анонимділікті сақтау да күмән тудырады, себебі дауыс берген азаматтардың бірегей кілттері дерекқорда сақталмай қалуы мүмкін емес. Электрондық дауыс беру белгілі бір ақпараттық құрылымдар арқылы қамтамасыз етілетіндіктен, олардың саяси нәтижелерге ықпал ету қаупі де жоқ емес.

Дипфейк (deepfake) технологиялары – ЖИ көмегімен адамның бейнесін және дауысын синтездеп, жалған бейнематериалдар жасау әдісі – қазіргі таңда ерекше өзекті қауіптің бірі. Мұндай өнімдерді бақылау мен шектеу қиынға соғады. Кейбір мемлекеттер ЖИ көмегімен жасалған материалдарды арнайы таңбалау талабын енгізіп, жалған контентті таратқандарға жауапкершілік қарастырғанымен, олардың авторын нақты анықтау әлі де күрделі [17].

Сонымен қатар, ЖИ жүйелерінің дамуы қоғамдық басқаруда жаңа мүмкіндіктер ашады. ЖИ ақпаратты өңдеу жылдамдығын арттырады, жоспарлауды тиімді етеді, басқару процесіндегі тәуекелдерді төмендетеді және уақыт шығынын қысқартады.

Әлеуметтік желілер мен платформалар (Instagram, Facebook – Meta компаниясына тиесілі, Twitter – И. Маск меншігінде) дипфейктердің таралуына басты арна болып отыр. Бұл платформалардың контентті іріктеу мен таратуы көбіне алгоритмдерге негізделген, ал олар өз кезегінде белгілі бір саяси немесе идеологиялық бағыттарды қолдауы мүмкін. Мысалы, Meta платформалары либералдық идеяларды жиі алға шығарады. 2023 жылы Human Rights Watch ұйымы Instagram-ның «пропалестиндік» контентті бұғаттағанын, мыңнан астам аккаунтты уақытша немесе түбегейлі шектегенін тіркеген [18].

Мемлекеттер де платформалардың жұмысын шектеуге тырысуда. Мәселен, АҚШ-та Әділет министрлігі 2020 жылы Facebook, Google және Twitter секілді компанияларды контент үшін көбірек жауапкершілікке тарту жөнінде ұсыныс жасаған [19]. Ресей билігі Meta-ны экстремистік ұйым деп танып, оның платформаларына ел аумағында қолжетімділікті шектеді.

Платформалардың жауапкершілігі шектеулі: олар тек өздері тікелей жариялаған материалдарға жауап береді, ал пайдаланушылардың барлық жарияланымын тексеру мүмкін емес. Сондықтан дипфейктердің таралуы толықтай бақылаудан тыс қалып отыр.

ЖИ саяси салада қолданылған мемлекеттердің тәжірибесіне сүйенсек, оның маңызы артып келе жатқаны анық. Дегенмен ЖИ – тек құрал, саяси шешімдерді дербес қабылдай алмайды. Қазіргі кезеңде шешім қабылдаушы – адам. Бұған себеп – заңнамалық базаның әлсіздігі мен ЖИ-дің саяси дербестікке дайын еместігі. Мәселен, Даниядағы ЖИ көмегімен құрылған партияны Парламентте тек адам ғана өкілдік ете алады.

Әлемдік тәжірибеде ЖИ-ді құқықтық реттеу тәсілдері әртүрлі. ЕО 2022 жылы ЖИ туралы заң жобасын ұсынып, кейбір ЖИ жүйелеріне қатаң шектеулер енгізуді жоспарлады. АҚШ-та 2022 жылы «ЖИ құқықтары туралы билль» жарияланып, ЖИ жүйелерін әзірлеуде бес негізгі принцип айқындалды, бірақ қатаң шектеулерден бас тартылды. Қытай 14-бесжылдық жоспар аясында ЖИ технологияларын кеңейтуге басымдық беріп, барлық ЖИ жасалған контентті арнайы белгілеуді талап етеді [20].

Қазақстандағы жасанды интеллектіні дамыту: стратегиялық басымдықтар және Президент Қ.Тоқаевтың көзқарасы

Қазақстан Республикасының Президенті Қасым-Жомарт Кемелұлы Тоқаев қазіргі таңда әлемде жасанды интеллектінің қарқынды дамуы жаңа сипаттағы технологиялық өзгерістерге алып келіп отырғанын атап өтті [21]. Оның пікірінше, бұл технология барлық

елдің даму траекториясына тікелей ықпал етіп, жаһандық бәсекеге қабілеттіліктің негізгі факторы болып отыр. Президенттің айтуынша, «жасанды интеллект ұлттың дербестігі мен экономикалық өсімінің қозғаушы күшіне айналып, стратегиялық тұрғыдан мемлекет үшін маңызды басымдықтардың бірі болуы тиіс».

БҰҰ-ның Сауда және даму жөніндегі конференциясы (UNCTAD) ұсынған болжамдарға сәйкес, 2033 жылға қарай ЖИ нарығының көлемі 4,8 триллион АҚШ долларына жетіп, әлемдік технологиялық индустриядағы үлесі 7%-дан 29%-ға дейін артады. Бұл көрсеткіштер жасанды интеллектінің экономикалық әлеуетін айқын дәлелдейді [22].

АҚШ «America's AI Action Plan» стратегиясын қабылдап, жасанды интеллектіні экономикалық, технологиялық және қорғаныс салаларында ұлттық мүдденің басты құралы ретінде анықталды [23]. Ал Қытай ЖИ саласындағы жаһандық ынтымақтастықты дамыту ұйымын құру бастамасын көтеріп отыр. Қазақстан мұндай ұйымға қатысуы ел мүддесі үшін стратегиялық маңызды екені анық. Сонымен қатар ол Қазақстанның негізгі мақсаты Еуразиядағы жетекші цифрлық хабқа айналу басты мақсатымыз.

11.08.2025 ж. Қ.Ж. Тоқаевтың төрағалығымен өткен жасанды интеллектіні (ЖИ) дамыту мәселелеріне арналған кеңесте жасанды интеллектіні дамытудың тоғыз басым бағытын айқындады [24]:

1. Экономиканың нақты секторына ЖИ енгізу – өндірістік тиімділікті арттырып, еңбек өнімділігін көтеру. Бұл бағытта «Самұрық-Қазына» қорымен бірлесіп, нақты жобалар әзірлеу міндеті қойылды.

2.Мемлекеттік басқаруды цифрландыру – бюрократиялық рәсімдерді қысқартып, азаматтарға көрсетілетін қызмет сапасын арттыру.

3.Денсаулық сақтау саласында ЖИ қолдану – диагностика сапасын жақсартып, емдеу тиімділігін арттыру, сонымен қатар медициналық деректерді біріздендіру.

4.Заңнамалық базаны жетілдіру – жасанды интеллектіні қолданудың құқықтық моделін құру, инновация, қауіпсіздік және азаматтық құқықтар тепе-теңдігін сақтау.

5.Цифрлық инфрақұрылымды дамыту – ABCDE моделі (AI, Big Data, Cloud, Data Centers, Education) негізінде ұлттық цифрлық ландшафт қалыптастыру.

6.Киберқауіпсіздікті күшейту – биометриялық деректерді қорғау, деректердің заңсыз қолды болуын болдырмау және бірыңғай басқару вертикалін қалыптастыру.

7.Қорғалған ұлттық коммуникация жүйесін құру – шетелдік мессенджерлерге тәуелділікті азайтып, деректерді ұлттық юрисдикция аясында сақтау.

8.Жастардың цифрлық сауаттылығын арттыру – «AI-Sana» сияқты оқыту бағдарламаларын кеңейту арқылы жаңа буынды ЖИ саласында даярлау.

9.Инновациялық стартаптарды қолдау және инвестициялық тартымдылықты күшейту – венчурлық қаржы тарту және отандық жобаларды әлемдік нарыққа шығару.

Президент Тоқаевтың айтуынша, Қазақстан алдағы бес жыл ішінде толыққанды цифрлық мемлекетке айналуға тиіс. Бұл мақсатқа жету үшін Үкімет пен Стратегиялық жоспарлау агенттігі жасанды интеллектіні дамытуға арналған кешенді ұлттық бағдарлама әзірлеуі қажет. Аталған құжатта ЖИ-дің экономика, мемлекеттік сектор және қоғам өміріндегі қолданылу тетіктері жан-жақты қамтылуы тиіс.

Сонымен қатар Мемлекет басшысы кадр даярлау, ғылыми-зерттеу экожүйесін құру, деректерді басқару, киберқауіпсіздікті қамтамасыз ету және инвестициялық климатты жақсарту мәселелерін ерекше атап өтті.

Қазақстан Республикасының Президенті Қасым-Жомарт Тоқаев **«Жасанды интеллект дәуіріндегі Қазақстан: өзекті мәселелер және оны түбегейлі цифрлық өзгерістер арқылы шешу» атты Қазақстан халқына Жолдауында** [25] жасанды интеллектіні дамытуға және оны институционалдық тұрғыда ілгерілетуге басымдық берді. Мемлекет басшысы атап өткендей,

еліміздің экономикалық жаңғыруы жаппай цифрландыру мен жасанды интеллект технологияларын енгізуге тікелей байланысты.

Президент бұл мақсатқа жетудің негізгі алғышарты ретінде Цифрлық кодексті қабылдауды ұсынды. Аталған заңда цифрландыру үдерісінің негізгі бағыттары – жасанды интеллект, платформалық экономика, үлкен деректерді пайдалану, сондай-ақ басқа да стратегиялық мәселелер нақты айқындалуы тиіс. Кодекс Қазақстанның жаңа технологиялық қалыптың ажырамас бөлігіне айналуына құқықтық негіз болмақ.

Жолдауда мемлекеттік басқару жүйесін толық қайта құру қажеттілігі де атап өтілді. Мемлекет басшысының пікірінше, басқару тетіктері азаматтардың мүддесіне қызмет етуі тиіс, ал оның ашықтығы мен тиімділігі бірнеше есе артуы қажет. Осы орайда Президент Жасанды интеллект және цифрлық даму министрлігін құруды тапсырды [26]. Жаңа ведомствоны Премьер-министрдің орынбасары деңгейіндегі білікті маман басқаруы тиіс. Мұндай құрылым елдегі цифрлық саясатты үйлестіріп, барлық салада жасанды интеллектіні жүйелі енгізуге жауапты болады.

Президент Тоқаевтың айтуынша, Үкімет экономиканың барлық саласын жаңғырту үшін жаппай жасанды интеллектіні енгізуі қажет. «Қазақстанды бәсекеге қабілетті ел ретінде дамыту үшін жұмысымызды жаңа тәсілмен жүргізуіміз керек. Салаға селқос қараудың салдары ауыр болады» [27], – деп атап өтті Мемлекет басшысы.

Соңғы жылдары Қазақстанда жасанды интеллект саласында бірқатар маңызды бастамалар жүзеге асты. Атап айтқанда, Орталық Азиядағы ең ірі суперкомпьютерлік кластер іске қосылды. Сонымен қатар Alem.AI ұлттық орталығы ашылып, қазақ тіліндегі алғашқы ірі тілдік модель – KazLLM жасалды. Үкімет бұл бағытта 5 жылдық тұжырымдаманы қабылдап, саланы дамытуға институционалдық негіз қалады. Енді жаңа министрлік осы бастамаларды үйлестіріп, жүйелі түрде іске асыруға тиіс.

Сонымен бірге, Президент атап өткендей, ЖИ саласын реттейтін заң жобасында инновация, жауапкершілік және қауіпсіздік мәселелері тең дәрежеде ескерілуі тиіс. Ең бастысы – заң нормалары жасанды интеллектіні дамытуға кедергі емес, керісінше, қолайлы құқықтық орта қалыптастыруға бағытталуы қажет.

Сарапшылардың бағалауынша, 2033 жылға қарай жасанды интеллект нарығының көлемі 5 триллион АҚШ долларына жетіп, әлемдік технология индустриясындағы үлесі 30%-ға дейін ұлғаяды. Бұл көрсеткіш Қазақстан үшін де жаңа мүмкіндіктердің бастамасы болмақ.

Қазақстан саясатындағы жасанды интеллектінің дамуы және оны енгізу бойынша ұсыныстар

Мақаламызды қорытындылай келе, Қазақстанда жасанды интеллектіні (ЖИ) дамыту мәселесі мемлекеттік деңгейде стратегиялық маңызға ие екеніне көзіміз жетіп отыр. Президент Қасым-Жомарт Тоқаев бірнеше Жолдауында және кеңестерінде ЖИ технологияларының ұлттық экономика мен мемлекеттік басқаруды жаңғыртудағы шешуші рөлін ерекше атап өтті. Әлемдік тәжірибе көрсеткендей, жасанды интеллект елдің инновациялық даму қарқынын айқындайтын негізгі факторлардың біріне айналып отыр.

ЖИ-дің саясаттағы орны мен маңызы

Мемлекеттік басқару тиімділігін арттыру. ЖИ мемлекеттік органдардың шешім қабылдау сапасын арттырады, бюрократиялық рәсімдерді азайтады және мемлекеттік қызмет көрсетуді автоматтандырады.

Сайлау процесін жетілдіру. ЖИ негізінде электоралдық процестерді ұйымдастыру, нәтижелерді талдау және бұзушылықтардың алдын алу мүмкіндігі бар. Сонымен қатар дипфейк пен фейк ақпараттарға қарсы құқықтық тетіктер қажет.

Қоғамдық пікірді талдау. Үлкен деректерді ЖИ арқылы талдау халықтың нақты сұраныстарын ескеріп, саяси шешімдерді негіздеуге мүмкіндік береді.

Ұлттық қауіпсіздікті қорғау. Кибершабуылдар, биометриялық жалған көшірмелер мен дипфейктердің таралуы жаңа қауіптер туғызуда. ЖИ бұл қатерлерге қарсы тұрудың да құралы бола алады.

Қ.Тоқаевтың пікірінше, қазіргі құзырлы министрліктің негізінде Жасанды интеллект және цифрлық даму министрлігін құру қажет. Жаңа ведомствоны Премьер-министрдің орынбасары деңгейіндегі маман басқаруы тиіс. Бұл қадамның бірнеше артықшылығы бар:

Институционалдық үйлестіру. ЖИ-ге қатысты бастамаларды бір орталықтан басқару арқылы әртүрлі мемлекеттік органдар арасындағы шашыраңқылық азаяды.

Жүйелілік. Ұлттық стратегияны іске асыру, заңнамалық базаны жетілдіру және инфрақұрылымды дамыту нақты жоспарға негізделеді.

Халықаралық бәсекеге қабілеттілік. Министрліктің құрылуы Қазақстанды Еуразиядағы цифрлық хабқа айналдыруға жол ашады.

Инновация мен кадрлық саясат. ЖИ саласында кадр даярлау, стартаптарды қолдау және ғылыми-зерттеу орталықтарын дамыту жүйелі жүргізіледі.

Сонымен қатар, жаңа министрліктің құрылуы белгілі бір тәуекелдермен де байланысты: басқару аппаратын ұлғайту, жаңа құрылымның функцияларын нақтылау қажеттігі және жеке сектордың белсенділігін төмендету қаупі. Сондықтан министрлік қызметінің басты принципі – мемлекет пен жеке сектордың тең серіктестігі болуы тиіс.

Қазақстанға арналған негізгі ұсыныстар

Мемлекеттік басқару және электрондық үкімет.ЖИ мемлекеттік қызмет көрсетулерді жеделдету, азаматтардың өтініштерін талдау, бюрократиялық процестерді оңтайландыру үшін қолданыла алады. Мысалы, Gov.kz порталындағы чат-боттарды интеллектуалды негізде жетілдіру.

Қоғамдық пікірді талдау. Әлеуметтік желілердегі үлкен деректерді өңдеу арқылы азаматтардың саяси белсенділігі, көңіл-күйі мен негізгі талаптарын талдау мүмкіндігі бар. Бұл Үкіметке стратегиялық шешімдерді халықтың нақты сұраныстарына бейімдеуге көмектеседі.

Сайлау процесі. Электронды дауыс беру жүйесін құруда ЖИ-ді қолдану — дауыс берушілерді тіркеу, дауыс санауды автоматтандыру және бұрмалауларды анықтау үшін маңызды. Сонымен қатар, саяси партиялар ЖИ арқылы электораттың мінез-құлқын болжау мен таргеттелген ақпарат тарату құралдарын пайдалана алады.

Қоғамдық қауіпсіздік және ашықтық. ЖИ жалған ақпарат пен дипфейктерді анықтауға, фейк жаңалықтардан қорғауға мүмкіндік береді. Бұл Қазақстандағы саяси тұрақтылықты сақтауда ерекше маңызды.

Қорытынды

Қазақстанда жасанды интеллектіні саясатқа енгізу – елдің цифрлық даму траекториясын айқындайтын стратегиялық міндет. ЖИ мемлекеттік басқаруды жетілдіріп, шешім қабылдау сапасын арттыруға, электоралдық процестердің ашықтығын қамтамасыз етуге және қоғамның нақты сұраныстарына негізделген саясат жүргізуге мүмкіндік береді.

Президент Қасым-Жомарт Тоқаев ұсынған Жасанды интеллект және цифрлық даму министрлігін құру идеясы – бұл бағыттағы институционалдық негізді нығайтатын және саладағы жұмыстарды жүйелендіретін шешім. Жаңа ведомствоның құрылуы Қазақстанды

Еуразиядағы цифрлық хаб ретінде дамытуға, сонымен бірге инновация мен қауіпсіздікті тең ұстауға ықпал етпек.

Алайда, ЖИ-дің дамуы этикалық, құқықтық және қауіпсіздік тұрғысынан жаңа сын-қатерлерді де туындатады. Сондықтан Қазақстан үшін басты басымдық – жауапты, қауіпсіз әрі қоғам мүддесіне сай жасанды интеллектіні дамыту болып қала бермек.

Жалпы алғанда, жасанды интеллектіні саясатқа жүйелі енгізу Қазақстанды тек цифрлық мемлекет қана емес, сонымен бірге технологиялық көшбасшы елге айналдырудың басты құралына айналады.

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Philological Sciences

THE ROLE OF PSYCHOLINGUISTICS IN UNDERSTANDING LANGUAGE PROCESSING

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Abstract
Psycholinguistics is an interdisciplinary field that explores the complex relationship between language and the human mind. By combining insights from psychology, linguistics, and cognitive science, psycholinguistics seeks to understand how individuals acquire, produce, and comprehend language. This field addresses a variety of questions, such as how people understand sentences in real-time, how they produce speech, and how language is processed in the brain.
Keywords: Psycholinguistics, language acquisition, speech comprehension, speech production, neurolinguistics, cognitive science, brain processing

Xülasə
Psixolinqvistika, dil ilə insan zehninin mürəkkəb əlaqəsini araşdıran çoxsahəli bir sahədir. Psixologiya, dilçilik və koqnitiv elmlərin baxış bucaqlarını birləşdirərək, insanların dili necə mənimsədiyini, istehsal etdiyini və başa düşdüyünü anlamağa çalışır. Əsas tədqiqat sahələrinə insanların cümlələri real vaxtda necə emal etməsi, nitqi necə yaratması və dil funksiyalarının beyində necə təmsil olunması və işlənməsi daxildir.
Açar sözlər: Psixolinqvistika, dilin mənimsənilməsi, nitqi başa düşmə, nitq istehsalı, neyrolinqvistika, koqnitiv elm, beyin işlənməsi

Аннотация
Психолингвистика — это междисциплинарная область, изучающая сложные взаимоотношения между языком и человеческим разумом. Объединяя подходы психологии, лингвистики и когнитивных наук, она стремится понять, как люди усваивают язык, производят речь и понимают её. Основные направления исследований включают то, как люди обрабатывают предложения в реальном времени, как формируют речь и как языковые функции представлены и обрабатываются в мозге.
Ключевые слова: Психолингвистика, усвоение языка, понимание речи, производство речи, нейролингвистика, когнитивная наука, обработка мозга Language Acquisition.

One of the most fundamental areas in psycholinguistics is language acquisition. This refers to the process by which infants and children learn their first language. Research has shown that this process is not merely a passive absorption of language input but an active cognitive skill. Theories like Noam Chomsky's Universal Grammar suggest that humans are born with an innate ability to acquire language, which is supported by the Language Acquisition Device (LAD). According to this view, all human languages share a universal structure, and children can rapidly learn the language of their environment by applying this inborn knowledge. Language acquisition remains a core topic in psycholinguistics. According to Hart & Risley (1995), children from higher socioeconomic households hear 30 million more words by age 3 than children from lower socioeconomic backgrounds, demonstrating the impact of environment on vocabulary growth.

Universal Grammar vs. Statistical Learning: Noam Chomsky's Universal Grammar suggests innate predispositions for language. By contrast, connectionist and statistical learning models suggest that children detect patterns in linguistic input; studies report that infants as young as 8 months can recognize transitional probabilities between syllables in artificial languages (Saffran et al., 1996)
Critical Period Hypothesis: Studies of second language acquisition indicate that individuals learning a new language before puberty achieve near-native proficiency in 70–90% of cases, compared to 30–50% in adults (Lenneberg, 1967).However, recent research in the area of language acquisition challenges Chomsky's view, focusing on environmental factors and social interaction. The Interactionist Theory, for instance, emphasizes the importance of social interaction in language learning, where children acquire language through engagement with caregivers and peers in their environment.

Sentence Processing and Comprehension.Another important area in psycholinguistics is how humans understand and process language in real-time. When we read or listen to language, we do not process each word in isolation; instead, we build meaning through the syntactic and semantic structure of sentences.
Psycholinguists use a variety of experimental techniques, such as eye-tracking, to observe how readers process sentences. For instance, when we read a sentence, we often experience brief pauses, called fixations, which occur when our eyes stop to process specific words or
phrases. Syntactic parsing refers to how we identify the grammatical structure of a sentence (e.g., identifying subject-verb-object relationships). Psycholinguistic theories like the Garden Path Model suggest that our minds initially make simple and fast syntactic assumptions while reading, but we may need to backtrack if we encounter an unexpected grammatical structure. An interesting phenomenon in sentence processing is ambiguity resolution. Words and sentences can often have multiple meanings, depending on context. For instance, the word "bank" can refer to a financial institution or the side of a river. Psycholinguists have investigated how we resolve this ambiguity during sentence comprehension and how context plays a critical role in guiding our interpretation.

Language Production.Psycholinguists also study how we produce language. Language production involves a series of steps, including the conceptualization of an idea, formulation of a sentence, and finally, the articulation of that sentence. One of the most widely recognized models of language production is Levelt's Model, which proposes a sequence of stages: conceptual preparation, lexical selection (choosing the right words), grammatical encoding (arranging the words into a syntactically correct structure), and phonological encoding (preparing the speech sounds). An important area of study in language production is the occurrence of speech errors. Research into speech errors, such as slips of the tongue, can provide insight into how our cognitive system structures language production. For example, when someone says, "I will order a glass of water" instead of "a glass of wine," these errors help researchers understand how the brain plans and executes speech.

The Neurolinguistics of Language.Psycholinguistics is also deeply intertwined with neurolinguistics, the study of how the brain processes language. Research in this area typically focuses on understanding which areas of the brain are involved in different aspects of language, such as comprehension, production, and acquisition.
The most well-known areas of the brain associated with language are Broca's area and Wernicke's area. Broca's area, located in the left frontal lobe, is primarily associated with language production. Damage to this area can lead to Broca's aphasia, a condition where individuals have difficulty

producing speech but can understand language relatively well. On the other hand, Wernicke's area, located in the left temporal lobe, is crucial for language comprehension. Damage to this area can result in Wernicke's aphasia, where individuals may produce fluent but nonsensical speech and have difficulty understanding language.

In addition to these areas, research using functional magnetic resonance imaging and electrophysiological techniques like EEG (electroencephalography) have helped map out more specific networks involved in language processing. Studies have shown that language processing is not confined to a single "language center" but is a distributed function involving multiple regions of the brain, including areas involved in memory, attention, and motor contBilingualism and Cognitive Benefits.The study of bilingualism has become a significant area of interest in psycholinguistics. Bilingual individuals must constantly switch between languages, which offers researchers valuable insights into cognitive control and language processing. Studies have shown that bilinguals tend to have better executive control, which includes abilities like working memory, attention, and problem-solving, due to the constant need to manage two languages.

Additionally, research into code-switching (the practice of switching between languages in a conversation) has provided evidence of the cognitive flexibility involved in bilingual language production. It is thought that bilinguals are constantly monitoring their environment and adjusting their speech based on social, situational, or contextual factors.

Conclusion Psycholinguistics plays a crucial role in understanding how language functions within the human mind. By investigating language acquisition, sentence processing, language production, and the brain's role in these processes, researchers have uncovered a great deal about the cognitive mechanisms behind language use. Furthermore, the study of bilingualism and its effects on cognition has opened up new areas of research that promise to enrich our understanding of language and the mind. As technology continues to advance, particularly in neuroimaging and computational modeling, the field of psycholinguistics will no doubt continue to evolve, offering more nuanced insights into the intricate relationship between language, cognition, and the brain. The complexity of language and the mind remains a captivating frontier for scientific discovery, with implications not only for linguistics and psychology but also for education, artificial intelligence, and even therapy for language disorders.

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ӘДЕБИ ӨЛКЕТАНУ: САҒЫНТАЙ БИСЕНҒАЛИЕВ ЖӘНЕ ҚЫДЫР ХАРЕСҰЛЫ ПОЭЗИЯСЫНЫҢ ТАҚЫРЫПТЫҚ-ИДЕЯЛЫҚ, ЖАНРЛЫҚ ЕРЕКШЕЛІКТЕРІ

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Қазақтың көркем әдебиеті – қазақ ұлтының рухани мәдениетінің біртұтас жүйесі боп табылса, ал оның негізгі қабатын өлке әдебиеті құрайтыны анық. Әдеби өлкетануды зерттеу арқылы, әдеби өлке әдебиетін насихаттау нәтижесінде, рухани жаңғыру дүниетанымын кеңейтуге жол ашылады.

Бай тарихы бар Орал өңірі әдебиетінің қазіргі таңдағы танымал өкілдері Қазақстан Жазушылар одағының мүшесі, ақын, мәдениеттанушы Сағынтай Бисенғалиев пен ақын, белгілі журналист Қыдыр Харесұлы поэзиясының тақырыптық-идеялық, жанрлық ерекшеліктері назар аудартады. Мәселен, Сағынтай Бисенғалиевтің юморға толы өлең-жырларының қатарын ақынның жыр жинақтарына [1-2] енген эпиграммалары мен достық әзілдері толықтыра түседі. Эпиграмма жанры туралы орыс әдебиеттанушылары жасақтаған әдеби терминдер сөздігінде «Эпиграмма (грек тілінен аударғанда epigramma – жазу) – сатиралық поэзияның бір түрі, адамды немесе қоғамдық құбылысты келемеждейтін шағын өлең», - деп көрсетеді және «Эпостық формалардан өзінің қысқалығымен ғана емес, сонымен бірге фактіге немесе оқиғаға нақты көрсетілген субъективті қатынасымен ерекшеленді» [3, 467 б.], - деп толықтырады.

Жоғарыда айтылған қағидатқа сай қазақ поэзиясында Шона Смаханұлы, Жарасхан Әбдірашев, Көпен Әмірбеков т.б. эпиграммашылар өздеріне тән стильде жемісті еңбек етті. Дәстүрлі жанрға айналған эпиграммалық шумақтар шоғыры Сағынтай ақында да біркелкі бар екен. Ақынның достық әзілдерінің (эпиграмма) кейіпкерлері негізінен елге танымал өнер адамдары, мәдениет майталмандары, сондай-ақ еңбегімен ел құрметіне бөленген ауыл-аймақ еңбеккерлері. Мәселен, айтыс ақындары Шолпан Қыдырниязова, Қатимолла Бердіғалиев, Дариға Мұштанова, Мәлс Қосымбаев, Үзілдік Елеубаева, Ботагөз Құрмашева, Сәрсенғали Бисенғалиев, Александр Қауенов, Жібек Болтанова, Шәки Қайырғалиев, Жәнібек Әбілпейісов, Мәлік Бердәлі, Лұқпан Елеу т.б. түрлі еңбек, мәдени-ағарту саласының үздіктеріне, жалпылай алғанда 30-40 есімге ақынның әзіл-қалжың оспақтары арналған. Мысалы, Ш.Қыдырниязоваға:

Ерте аулаған өлең-жырдың шортанын,
Кім білмейді Ақжайықтың Шолпанын
Батыр ақын баптап кеткен қыз еді,
Артық-ауыс әзілдеуге қорқамын.

Қ.Бердіғалиевке:

Ән салғанда ағып жатқан селдейсің,
Аламанның алдын жанға бермейсің.

Мен бағалап «тірі Мұхит» дей қалсам,
Қажет емес «көпшігің» деп көнбейсің.
Ш.Қайырғалиевке:
Кей кезде дана Шәки,
Кей кезде бала Шәки.
Жүрегі ақ, пейілі де ақ,
Тек өңі қара Шәки!
Әр кезде ақын Шәки,
Тар кезде Батыр Шәки,
Тек қана жақсылыққа,
Болғайсың жақын Шәки!

Міне, осы сықылды әзіл-оспақпен көмкерілген түрлі тақырыптағы өлең-эпиграмма туындылары Сағынтай ақында молынан ұшырасады.

Сағынтай Бисенғалиев поэзиясының тақырып аясы әр алауан десек, қазақтың маңдайына біткен тұлғалары Сырым Датұлы, Мұхит Мерәліұлы, Махамбет, Абай, Меңдігерей Ипмағамбетов, Бауыржан Момышұлы, Хамза Есенжанов, Тайыр Жароков, Жұбан Молдағалиев сынды тарихи есімдермен қатар Мұқағали Мақатаев, Қадыр Мырза Әли, Жанғали Набидуллин, Ілия Жақанов, Ақұштап Бақтыгереева, Мұқадес Есламғалиев, Тұяқберді Шәмелов, Амангелді Ғұбайдуллин, Сағат Әбдуғалиев, Дариға Мұштанова, Қаламқас Орашева, Ермек Қазиев, Хатимолла Бердіғалиев, Мұхтар Құл-Мұхаммед, Жасталап Қуанғалиев, Тілес Жазықбай, Табылды Досымов, Ұлдай Сариева т.т. ондаған-жиырмалаған, есімдерін ел танып, өнерлерін құрметтеген жандардың баршасы ақын жырына өзек болды, ақын олардың көркем бейнесін мадақ-жырына қосты.

Сағынтай ақынның сөзіне жазылған әндер де бар. Айталық, С.Бисенғалиев - «Ақжайық – әсем әнімсің» (әні Р.Жанаисовтікі), «Ғарифолланың дара тұяғы, А.Ғұбайдуллиннің рухына» (әні Ғұбайдолла Хибашевтікі), «Қадырқұлым» (әні А.Жанаисовтікі), «Жұбан елі» (әні Жасталап Қуанғалиевтікі), тағы сол сияқты орманшылар әнұраны, спортшылар маршы, кітапханашылар әнұраны мәтіндерінің авторы.

Сағынтай ақынның шығармашылық өрісінен хабардар сырлас, замандас әріптестері Дариға Мұштанова, Үзілдік Елеубайқызы, Закария Сисенғали сынды есімдері елге мәшһүр ақындар мен оны ұстаз санайтын жас ақын Бекболат Қаленов т.б. өлең-жырларында ақынның адами тұлғасы хақында әдемі өрілген.

Сағынтай Бисенғалиевтің ақындығы, поэзиясының тақырыптық-идеялық ерекшеліктері туралы әдебиеші ғалымдарлың жазбаларында баяндалады. «Ақын Сағынтай Бисенғалиев поэзиясының тақырыптық-идеялық ерекшеліктері» [4, 55-59 б.б.] – аталатын мақалада оның туындыларының табиғатына шолу жүргізілген.

Ақынның шығармашылық әлеміне ұдайы назар аударып, шайырдың жыр кітаптарына алғы сөз жазған, өзі де ақын, журналист Тілес Жазықбай: «Сағынтай өлеңдерінің сазы бөлек, құйылысы төтен. Саралап қарасақ, салмақты сөздері қанша, сүйсіну үшін оқымайсың, еріксіз сүйсіндіргені үшін ризасың. Өлеңдері көзге көрік беретін сыртқы сымбатымен ғана емес, ішкі әлемінің биіктігімен де баурап алады» [5, 4 б.], - деп оң бағасын береді. Шығармашылық ізденісте айналасындағы әріптестері мен қалың оқырмандарынан жоғары баға алған қаламгердің еңбегі көпшілік ортада жоғары бағаланып, уақыт өткен сайын кеңінен таныла бастады.

Батыс Қазақстан өңіріне танымал журналист, ақын Қыдыр Харесұлы Абдырахмановтың «Алау кездер - ән кездер» атты өлеңдер жинағына автордың әр жылдары жазған өлеңдері мен шағын әңгімелер топтамасы және ақынның өлең сөздеріне арналған әндер мәтіні енген.

Поэзия әлемінде падиша өлеңнің мөлдірлігін бұзбай, өзі қашан да төбесіне хан көтеретін оқырмандарына барлық туындыларын таза, саф күйінде ұсынуды дағдыға айналдырған Қыдыр Харесұлының әрбір шығармасы өзінің арқалар жүгін жеңіл көтеруімен және талғамы биік оқырмандардың жүректерін еркін жаулап алуымен шынайы ерекшеленеді.

Қыдыр Харесұлының шығармашылық қоржынындағы «Алау кездер - ән кездер» [6] және «Өмір мектебі» [7] деп аталатын жыр жинақтарында түрлі тақырыптарға жазылған өлеңдері мен әңгімелері енгізілген. Ақын өзінің өмірге келген туған күні, өскен ортасы туралы «Қыс келбеті (немесе менің анкетам)» өлеңінде:

Қандай суық,
Қыс кезі.
Қаңтар айы!
Көкте күнді ақша бұлт қалқалайды.
Қара қазан қайнаған қараша үйде,
Қара ошақ тұр.
Қызуымен қалқап айды.

...Бақытымды байлап ап
Белге бекем,
Ел соңынан,
Ер болып енген екем!...
Жылқы жылдың қақаған,
Қаңтарында,
Шыр етіп дүниеге келген екем!...

Ата салтпен!...
Білмейтін есірікті.
Ар жолыма,
Ала жіп есіліпті.
Терезе тапалдау,

Қаным тамып, кіндігім кесіліпті [6, 4 б], - дей келіп өзінің тұрмыс- тіршілігінен хабар береді. Туған өлкесі - Жалпақталын да мақтана жырлаған ақын Қыдыр Харесұлы оны «Жер жәннатына» балайды.

Баба тілі - ана тілін өмірлік журналистік кәсібінің негізгі құралына айналдырған ақын «Тіл - тұңғиық» өлеңінде ана тілінің құдіреті мен қасиетін ерекше бағалап, оны барлық байлықтан жоғары қояды. Ақын ана тілісіз ұлттың өмірі де мәнсіз, болашағы бұлыңғыр, бақыты баянсыз болатынын да шынайы жырға қосады.

Тілім менің тап-таза, тұңғиықтан жаралған,
Бұлақ суы секілді мөп-мөлдір боп аға алған.
Барлық бақыт, сезім мен құштарлықтар білсеңіз,
Тіршіліктің имәні боп, сол тілімнен таралған!

Тілдің білсең құдіреті, көп нәрсеге жетеді,
Сөздің парқын сезгендер, тілмен түйреп өтеді.
Қажет етсе егер де, ақиқатын ағызып,

Тілмен адам түйінді, мәселе де шешеді [6, 12 б.], - деген ақын тілдің адам өміріндегі маңызын, сөздің құдіретін тағы да дәлелдей түседі. Өз ана тілінің қадіріне жетпей, өз тілін менсінбейтін, өзге тілде сөйлеуді мақтаныш көретін негилистердің ниетіне қарсылығын мына бір тармақтармен түйіндейді:

Ана тілім - мен үшін мұқалмайтын ақ алмас,
Тілсіз мынау дүние жақсылықтан жаралмас,
Сондықтан да тіліңнің сен, қадірін ұқпасаң,
Ертең келер ұрпағың, сені орныңнан таба алмас!...[6, 12 б.].

Өз халқының өткен тарихын, шырғаланға толы шежіресін білуге ынтық ақын түрлі қыспақтарға түсіп, теріс бұрмалаулардың құрбанына айналған заманалар шындығының ашылатынына зор үмітпен қарайды. Дала төсінде еркін өскен көшпенділердің бүгінгі ұрпағы - қазақ халқының жетпіс жыл бойғы бодандықта өткен болмысынына бейжай қарамайтын ақын кеткен кемшіліктер мен орындалмаған істердің орны толатынына сенімін білдіреді.

Тарих - дастан елімнің айтар жыр-әні,
Сол әнім дұрыс, айтылмай бүгін жүр әлі.
Жетпіс жыл бойы боданда болған Алаштың,
Тек кеше ғана, естілді бізге ұраны [6, 12 б.], - деп жырлаған ақын Қыдыр Харесұлы Алаш ардақтыларының ұранын қуанышпен қарсы алады. Кешегі тарихтың құпияға толы беттерін ашатын жас ұрпақтың туатынына ақын үлкен үміт артып, егемендігімізге тәубе айтады.

Тарих –шежіре кешегі жолы бабамның
Сезілер одан, дауылды желі даламның.
Сол дала бүгін, куәсі болып шырқайды-ау,
Шырмалған сымдай,шындығын айтып заманның.

Шежіре-шындық, тарих болып дастан,
Еркіндік алып, жаңғырды елдің аспаны.
Ел болып халқым, бесігін бүгін түзесе,
Қолға алып ертең түзейді олар басқаны... [6, 12 б.].

Туған жердің аяулы перзенті болған Қыдыр Харесұлы «Туған жер -тұғырым» өлеңінде киелі мекеніне деген шексіз махаббатын жеткізеді.

Туған жер, далам, тұрақты менің тұғырым,
Жөргекте шыққан, мен оның сәби ұлымын.
Ақылмен адам, өзіңсіз әсте себейді-ау,
Ұрпаққа жетер, өмірдің мынау ұғымын.

Мақтаныш болып, өзен, су, көлің байлығың,
Ерлерге жігер беріп жүр сенің айбының.
Сай менен салаң, жайлауың болса бір төбе,
Ыстық боп бізге, көрінген сенің Ай - Күнің!

Өзіңмен бірге шығатын өрге өрмелеп,
Құлашын адам, сенімен көкке сермемек.
Перзентің үшін пір тұтар Сені әрқашан,
Туған жер далам - өзіңнің орның бір бөлек!» [6,13 б.], - деп туған жердің жарқыраған өзен-көлін, сарқыраған сай-саласы мен жап-жасыл жайлауын, аспандағы айы мен күнін сүйсіне жырлаған ақын оның құдіретіне, қасиетіне әрқашан басын иеді.

Ақын тәуелсіздігіміздің айғағы, егемендігіміздің еншісіндей болған көк байрағымыздың мәңгіге желбірей беруіне бек тілекші. Қазақ аспанындағы желбіреген көк туымыз әрқашан еркіндігіміз бен алаулаған намысысымыздың, жарқылдаған жалындай бұлқынған бұла күшіміздің куәсі болғанына масаттанған ақын бар әлемге «Желбіресін көк байрақ!» өлеңі арқылы жар салғандай болады. Аспанымызды ешқашан бұлт шалмай, алтын

күннің астында көкжиекпен астасып жатқан сағым даламыздың биігінде көк байрағымыздың желбірей беруіне ақын Қыдыр Харесұлы ақ тілегін жырмен арнайды:

Елім үшін ер намысы қалау боп,
Көкіректен маздап жанды алаулы от.
Көз алдымда көкке қарай ұмтылып,
Көк Байрағым - желбіреп тұр Жалау боп!

Қасиетті көркем сұлу мүсіндей,
Алдыңды орап өту қиын кішірмей.
Көкжиекті бізге меңзеп тұрсың-ау,
Көк Байрағым - Көк Аспанның түсіндей!

...Жүрексіз жан құбылысты сезбейді,
Намысты елім - қиянатқа төзбейді.
Шетсіз-шексіз көк жамылған аспандай,
Көк Ту түсі - кеңдік жолды көздейді.

Ұмыт болып, қиын кездер - көк тайғақ,
Мейіріммен сүйсін Күнім көкті әйбәт!
Еркін елдің ертеңіне жол сілтеп,
Көк алдыңда желбіресін – Көк Байрақ! [6, 17 б.].

Ақын Қыдыр Харесұлы адамзат тіршілігінің бастауы - әйел жанының нәзік табиғаты мен болмысын асқақтата бейнелеп, әйелдің мейрімді ана, сүйікті жар тұлғасын «Әйел» деп аталатын өлеңінде ерекше құрметпен жырлайды.

Әп-әдемі әріптен басталатын,
«Әйел» деп мен қоямын дастан атын!
Сол әйелдер әлемге әйгілеп жүр,
Еркектердің - адами асқақ атын.

Бар екпінді аударып бұрылғанға,
Күлмей үйрен - сүрінсең жығылғанға!
Әйел - сорлы, әйел - сұм сайтан емес,
Әйел - Ана, әйел – Жар - ұғынғанға!

Айран берген, сүт берген шелексізге,
Әйел жайлы қажет пе дерек Сізге?!
Екі қолдап, жер қорғар еркек болсақ,

Әйелдерді құрметтеу керек бізге [6, 26 б.], - деп, әйелдің қоғамдағы орнын төмендетіп, оны кемсітіп жүрген жандардың пікіріне толық қарсы көзқарасын білдіре келе, әйелдің отбасындағы, ұрпақ тәрбиесіндегі ролін жоғары қояды.

Ақын Қыдыр Харес аяулы анасына арнап «Асыл әні адамның», «Ана бағасы», «Ана тағдыры» аталатын жырларды дүниеге әкелді. Аналар мейрамымен барша әйел қауымын құттықтаған ақын:

Ана деген асыл әні адамның,
Қарындастар қыр гүлі ғой заманның.
Әпкелерім ақыл - кенім, қамқорым,
Жеңгелерім - жазирасы даламның.
Олар барда шын бақытым оянып,
Шырқалмақшы тақырып боп жаңа әнім!

Олар болса оты лаулар сананың,
Олар болса гүлі жайнар даланың!
Олар болса дөңгеленіп дүние,
Естілмекші жер-жаһанға жаңа әнім!
Құтты болсын, құтты болсын сондықтан,
Мейрамдары Әйел-Ару - Ананың! [6, 27 б.], – деп, сұлулық пен мейірімнің иесі - барлық әйел затының адамзат тарихындағы алар орнын жоғары бағалаған. Аяулы аналардың, сүйікті қарындастар мен әпкелердің, мейірімді жеңгелер мен келіндердің бейнелерін асқан ақылдың, биік сана мен жайнаған әдемі гүлдердің символына айналдырады.

Түйіп айтқанда әдеби өлкетану мұралары біздің рухани байлығымыздың алтын бір бөлігі болғандықтан, оған ерекше мән беріп, ақын-жазушылардың шығармашылық орбитасымен нақтылы танысып, дара сипаттарын айқындай түсу. әдебиеттің көркемдік болмысын ғылыми негіздеуді ілгері дамыту – күн тәртібінен түспек емес.

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TERMINOLOGY IN THE DIGITAL AGE

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Abstract

Terminology in the twenty-first century has become an interdisciplinary, evidence-driven field that integrates corpus-based methods, standardized infrastructures, and representational technologies to serve multilingual and machine-mediated communication. Large digital corpora and automated extraction algorithms enable scalable identification and diachronic analysis of candidate terms, while human expertise remains indispensable for sense disambiguation, definitional precision, and governance decisions. Versioned, machine-readable termbases and exchange formats have transformed static glossaries into interoperable knowledge artifacts that integrate with translation memories, content-management systems, and regulatory workflows, elevating issues of provenance, licensing, and stewardship. Linking terminological entries to formal schemas and ontologies enhances interoperability and automated reasoning, but mapping between representational models requires careful modeling to avoid semantic loss. Integration with neural language technologies demonstrates that terminology injection—through constrained decoding, terminology-aware fine-tuning, or post-editing—can substantially improve terminological fidelity without unduly compromising fluency when contextual constraints are respected, though gains vary by domain, language pair, and resource availability. Persistent challenges include scaling expert validation, treating genuine cross-linguistic non-equivalence, expanding coverage for less-resourced languages, and establishing reproducible, evidence-based workflows. The article advocates for shared corpora, transparent extraction and validation protocols, interoperable standards, and governance frameworks to build robust, equitable terminological infrastructures that meet scholarly inquiry and practical multilingual communication needs.

Keywords: Terminology, Corpus Linguistics, Termbanks, Machine Translation

Introduction

Terminology plays a deceptively modest role in the infrastructures of knowledge: it names the concepts that professionals, scholars, and machines rely on to communicate, reason, legislate, and innovate. Yet over the past two decades the work of identifying, describing, and managing terms has moved from the margins of lexicography and standardization into the center of an emerging, interdisciplinary practice that blends linguistics, information science, and computational methods. This introduction outlines the intellectual and practical contours of that shift. It situates contemporary terminology not as a simple extension of printed glossaries but as a living layer of the knowledge economy—a layer shaped by digital corpora, shared termbanks, semantic technologies, and the demands of multilingual, machine-assisted communication.

At the heart of the transformation is a change in epistemic stance. Where earlier terminographers often began from normative aims—deciding the “correct” term for a concept within a profession—today’s practitioners typically adopt an evidence-driven approach: large and growing corpora of specialized texts allow researchers to observe how terms are actually used across registers, genres, and languages. Automated extraction and statistical techniques surface

candidate terms at scale, while visualization and frequency profiling help to map term behavior and change over time. This does not render expert judgment irrelevant; rather, it reframes expertise as a critical validation layer atop algorithmically generated hypotheses. The result is a hybrid epistemology in which corpus evidence, domain knowledge, and intersubjective standards co-produce authoritative terminological resources.

Concurrently, the material form of terminological work has shifted. Static printed lists have been supplanted by dynamic, interoperable termbases that are versioned, queryable, and integrable with content-management systems and translation pipelines. Machine-readable exchange formats and open repositories enable reuse and cross-institutional collaboration, turning local glossaries into nodes in distributed knowledge networks. This infrastructural reconfiguration matters not only because it scales terminological labor, but because it changes the governance, provenance, and economics of who controls and benefits from standardized concept labels. Questions of licensing, access, and stewardship have become as important as definitional rigor.

The conceptual horizons of terminology have also broadened through engagement with knowledge representation. Concepts once treated primarily as lexical items are increasingly modeled as nodes within ontologies, linked-data graphs, and thesauri that encode semantic relations and support reasoning. This conceptual turn facilitates interoperability between terminological resources and other knowledge systems—search engines, regulatory databases, and machine-translation models—while inviting collaboration with information architects and knowledge engineers. Integrating terminological precision with formal representations enables machines to respect domain constraints and supports richer human–machine interaction, but it also raises thorny issues about alignment across representational schemes and the potential loss of nuanced, culture-specific meanings in the process.

Finally, the accelerating deployment of language technologies has given terminology new practical urgency. Poorly managed or inconsistent terminology can compromise clarity, safety, and legal compliance in high-stakes domains; conversely, high-quality termbanks and multilingual mappings can materially improve translation quality and computational reasoning. Thus terminologists now routinely work at the interface of scholarship and industry: providing resources that feed neural translation systems, informing evaluation metrics that track terminological fidelity, and designing workflows that balance machine speed with human accuracy.

These converging developments produce both opportunities and enduring challenges. Terminology's expanding toolkit promises more responsive, evidence-based, and interoperable resources, yet issues of scalability, cross-cultural equivalence, and governance remain unresolved. The following article explores these dynamics in detail: tracing the methodological shifts that distinguish twenty-first-century terminology from earlier practice, examining the technical infrastructures that underpin modern term management, and assessing the current state of terminology within contemporary linguistics and applied language technology. It argues that the field is evolving into an integrated, pragmatic science—one that must simultaneously sustain conceptual rigor, empirical grounding, and operational usability if it is to serve the multilingual, data-rich environments that define our era..

Terminology in the twenty-first century

Terminology in the twenty-first century has undergone significant transformation as a consequence of technological advancement, globalization, and shifts in scholarly practice. Where earlier approaches to terminography emphasized the production of prescriptive, often print-based glossaries compiled by small teams of domain experts, contemporary terminology work is

characterized by dynamic, data-driven processes that interweave corpus evidence, computational tools, standards for exchange, and collaborative infrastructures. This change is not merely technological; it affects epistemic assumptions about what a term is, how stable meanings are, and how equivalence across languages and cultures should be established. The result is a field that remains committed to conceptual rigor yet increasingly embraces empirical, interoperable, and operational practices that connect academic analysis to real-world information systems and multilingual communication workflows.

Three interlocking developments have been particularly decisive. First, the proliferation of digital corpora and the maturation of corpus-linguistic methods have shifted term discovery from intuition and isolated expertise toward scalable evidence-based procedures. Automated term-extraction algorithms, frequency profiling, and collocation analysis generate candidate lists that can be validated and refined by specialists; diachronic corpus analysis allows researchers to trace the emergence, semantic change, and register variation of domain-specific vocabulary. Second, the institutionalization of machine-readable termbanks and interoperable exchange formats has professionalized terminology management. Shared termbases, vocabularies encoded in standardized formats, and centralized repositories enable reuse across translation workflows, publishing platforms, and regulatory environments, transforming terminological resources into networked knowledge artifacts rather than static lists. Third, the integration of terminology with knowledge representation and semantic-web technologies has encouraged a conceptual turn: terms are increasingly modeled as nodes within concept systems, mapped to ontologies and controlled vocabularies to support search, inference, and inter-system interoperability. This alignment has made collaboration with knowledge engineers and information scientists a common feature of applied terminology projects.

These developments mark clear departures from many historical practices. Traditional terminography was often monolingual, expert-driven, and product-oriented: an authoritative glossary or dictionary would be produced and distributed in print, with the main evaluative criteria being definitional accuracy and terminological consistency within a particular institutional or disciplinary context. Contemporary practice, by contrast, privileges living databases, continuous updating, and integration with digital publishing and content-management systems. The shift from static to dynamic resources has practical implications: versioning, provenance, and governance become central concerns; access control and licensing influence how term data propagate; and interoperability with translation memories, content management systems, and machine translation engines determines real-world utility.

Another shift concerns the actors and workflows involved. Automated methods and crowdsourcing techniques have expanded the set of participants in terminological work, enabling large-scale candidate identification but requiring careful design of validation workflows to preserve quality. Hybrid approaches that combine automatic extraction with human validation are now normative in many projects, particularly where timely coverage of emerging terminology (for new technologies, social practices, or novel legal constructs) is important. Multilingual alignment has also become routine: globalization and cross-border professional communities demand fine-grained equivalence management, including attention to register differences, culture-bound concepts, and non-equivalent conceptualizations that resist straightforward translation. The need for contextualized definitions and usage notes has grown as a consequence, forcing terminologists to balance standardization with descriptive sensitivity to language variation.

Within academic linguistics terminology occupies a distinctly interdisciplinary position. It draws methodological tools and theoretical insights from lexicology, semantics, corpus linguistics, translation studies, and computational linguistics, while also contributing to applied areas such as knowledge management and natural language processing. Corpus-based terminology research explores indicators of termhood, semantic prosody, and collocational profiles, and uses statistical

modeling and visualization to clarify concept boundaries in specialized discourse. At the same time, language-technology developments such as neural machine translation have created pressing practical needs for high-quality terminological resources: reliable term lists and concept mappings improve translation accuracy, ensure regulatory compliance, and mitigate risk in high-stakes domains such as medicine, law, and engineering. Consequently, collaboration between terminologists and MT researchers has produced methods for injecting domain-specific terminology into automated pipelines, evaluating terminological fidelity in translated output, and designing constrained decoding strategies that respect terminological constraints without sacrificing fluency.

Despite these advances, multiple challenges remain. The tension between conceptual harmonization and legitimate language variation persists: attempts to enforce one-to-one mappings across languages can erase culturally specific nuances and produce misleading equivalences. Equally, the scalability of expert validation is an ongoing bottleneck; automated extraction can generate volumes of candidate terms that outstrip the capacity of small specialist teams to vet them comprehensively. Addressing this requires improved prioritization heuristics, quality-assured crowdsourcing models, and semi-automated validation frameworks that can weight evidence from corpora, terminological metadata, and user feedback. Technical interoperability is another continuing problem: although standards exist for term exchange and semantic representation, mapping between different representational models (proprietary termbase schemas, TBX, SKOS, RDF/OWL ontologies) can produce semantic losses or ambiguities that must be managed through careful modeling choices and documentation practices.

The integration of terminological resources into machine-learning pipelines invites further conceptual and practical issues. Injecting authoritative terms into neural models without inducing harmful overfitting or degrading naturalness requires principled techniques for constrained decoding, terminology-aware fine-tuning, and contextual preference modeling. Low-resource domains and less-resourced languages present additional difficulties: corpora may be sparse, and available bilingual mappings may be inadequate, raising equity concerns about whose terminologies are represented in global knowledge infrastructures. Governance issues—concerning authority, ownership, and stewardship of shared terminological assets—also become salient as termbanks move online and are accessed by heterogeneous user communities; provenance metadata, licensing clarity, and community-based governance mechanisms are therefore central to sustainable practice.

Operationalizing a robust, evidence-based terminological science will require attention to these methodological, technical, and social dimensions simultaneously. Shared corpora and open termbanks can foster reproducibility and communal refinement, while modular toolchains that link extraction, validation, and deployment can streamline workflows. Close collaboration between academics, industry practitioners, translators, and technologists will remain essential: theoretical insights about concept formation and semantic change must inform the design of tools that are used in production systems, and practical challenges encountered in the field should motivate new research into termhood metrics, multilingual alignment algorithms, and interactive validation interfaces. As terminological work becomes more embedded in information ecosystems and multilingual communication infrastructures, maintaining a balance between formal conceptual modeling, empirical description, and operational usability will be critical to ensuring that the discipline serves both scholarly and societal needs.

Conclusion

Terminology in the twenty-first century constitutes a coherent, empirically oriented domain of inquiry and practice that integrates corpus-based methods, representational standards,

and deployment in language technologies. Empirical investigations using large and domain-specific text collections have repeatedly demonstrated that automated and statistical techniques—term-extraction algorithms, collocation profiling, and diachronic frequency analysis—provide reliable signals for identifying candidate lexical items that function as terms in specialised discourse. These signals reduce the reliance on intuition and ad hoc compilation, permitting systematic measurement of termhood, semantic stability, and register-specific usage. At the same time, human expertise remains indispensable for disambiguation, definitional precision, and normative decisions where conceptual boundaries are contested; therefore, the most robust workflows combine algorithmic discovery with expert validation in structured pipelines.

The technological and infrastructural advances of this century have altered both the ontology and the operationalisation of terminological resources. Static lists and print glossaries have been supplanted by structured, versioned repositories that can be queried, exchanged, and integrated into content-management and translation workflows. Standardised exchange formats and semantic models enable machine readability and reuse across institutional boundaries. When terminological entries are accompanied by provenance metadata, usage evidence, and governance descriptors, they function as interoperable knowledge artifacts rather than isolated lexical records. This change in form has important epistemic consequences: decisions about authority, licensing, and stewardship become part of terminological methodology, and reproducibility depends on transparent documentation of data sources and validation procedures.

Interfacing terminology with formal knowledge representation has produced measurable gains in interoperability and in the capacity of systems to enforce domain constraints. Representing concepts as nodes within structured graphs or thesauri, and encoding semantic relations explicitly, facilitates automated reasoning, more precise information retrieval, and the constrained use of terms in downstream applications. The mapping of terminological data to formal schemas, however, is not trivial: representational mismatch and semantic drift can occur when migrating between models, and careful modeling choices—explicit scope notes, mapping qualifiers, and alignment heuristics—are required to minimise information loss. Empirical evaluation of these mappings is essential; rigorous comparative analyses should assess not only structural fidelity but also pragmatic adequacy for intended uses.

The integration of authoritative terminology into machine translation and other neural language systems constitutes a clear operational test of contemporary practice. Controlled experiments and production deployments indicate that terminology injection—via constrained decoding, lexically guided fine-tuning, or post-processing—can substantially improve the fidelity of rendered technical terms without necessarily compromising fluency, provided the interventions preserve context and collocational appropriateness. Nonetheless, effectiveness varies with domain specificity, resource availability, and language pair; low-resource contexts often show diminished gains, highlighting the need for targeted corpus development and adaptive methods that account for sparse data regimes.

Several persistent challenges structure a forward research agenda. First, scalability of expert validation remains a bottleneck: throughput can be increased by prioritisation heuristics, crowdsourced validation with quality controls, and confidence-aware active learning methods that direct expert attention where it is most impactful. Second, cross-linguistic and cross-cultural equivalence requires principled treatment: one-to-one mappings are frequently impossible, so terminological modeling must accommodate non-equivalence, concept elaboration, and culture-specific framings through multilingual concept descriptions and usage notes. Third, governance and equity issues demand systematic attention: who contributes to and controls shared terminological assets affects representational diversity, and policy frameworks for provenance, licensing, and community stewardship are necessary to prevent epistemic exclusion.

In methodological terms, the discipline should prioritise reproducible, evidence-based workflows: open corpora, transparent extraction parameters, documented validation protocols, and standardised evaluation metrics. Research that quantifies the trade-offs between automated scale and human accuracy, that evaluates representational mappings across models, and that measures the operational impact of terminology on downstream systems will consolidate terminology as an applied science. Practically, sustained investment in shared infrastructure, support for less-resourced languages and domains, and cross-sector collaboration will be required to translate methodological advances into robust, equitable terminological ecosystems.

On balance, the scientific evidence and operational experience accumulated to date support the characterization of modern terminology as a hybrid discipline: it is simultaneously descriptive and prescriptive, computational and conceptual, local in its cultural embeddings and global in its infrastructural reach. Progress hinges on maintaining rigorous empirical standards, developing interoperable representations, and embedding human judgment within scalable validation frameworks—thereby ensuring that terminological work serves both scholarly inquiry and the practical demands of multilingual, machine-mediated knowledge systems.

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The Influence of Artificial Intelligence in Translation: Opportunities, Challenges, and Future Directions

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Abstract

Artificial intelligence (AI) has transformed the field of translation, enabling rapid, accessible, and scalable multilingual communication. AI-powered translation systems, particularly those based on neural machine translation (NMT), have achieved unprecedented fluency and contextual accuracy compared to earlier approaches. This paper examines the historical development of AI translation technologies, their current applications, and their advantages and limitations. Drawing on case studies of Google Translate, DeepL, and the European Union's eTranslation platform, the article highlights both the opportunities and challenges that AI poses for linguistic diversity, cultural nuance, and ethical practice. The discussion concludes with a forward-looking analysis of potential future directions, emphasizing a hybrid model where human expertise and AI complement one another.

Introduction

Translation has been central to human interaction for millennia, facilitating diplomacy, trade, education, and cultural exchange. Traditionally performed by skilled human translators, the process demanded not only linguistic proficiency but also deep cultural knowledge (Pym, 2014). The introduction of computational methods in the mid-20th century began to change this landscape. Today, AI-driven translation systems—particularly those employing deep learning—are transforming how individuals, organizations, and governments approach multilingual communication.

The influence of AI in translation cannot be understood without considering its rapid technological evolution, expanding applications, and the interplay between computational efficiency and human linguistic sensitivity. While AI can increase translation speed and accessibility, its limitations—particularly in preserving cultural nuance—pose significant challenges. This paper seeks to address the dual nature of AI translation as both a facilitator of global interaction and a source of complex ethical, cultural, and linguistic issues.

Historical Development of AI in Translation

Early Machine Translation (MT)

The first wave of machine translation in the 1950s and 1960s relied on rule-based systems that explicitly encoded grammatical and lexical rules (Hutchins, 2005). While pioneering, these systems often produced rigid, literal translations that lacked fluency. The ALPAC report (1966) famously concluded that MT at the time was less cost-effective than human translation, slowing research momentum.

Statistical Machine Translation (SMT)

The 1990s saw the rise of statistical approaches, leveraging large bilingual corpora to estimate translation probabilities (Koehn, 2010). SMT improved flexibility compared to rule-based methods but still struggled with long-distance dependencies and context beyond the sentence level.

Neural Machine Translation (NMT)

The introduction of neural networks in the mid-2010s marked a breakthrough. NMT models, such as those developed by Bahdanau, Cho, and Bengio (2014), and later enhanced by the Transformer architecture (Vaswani et al., 2017), enabled end-to-end learning, improved contextual coherence, and more natural output. Today, most major translation platforms—Google Translate, DeepL, Microsoft Translator—rely on NMT for their core operations.

AI translation research has explored multiple dimensions, from technical architecture to sociolinguistic impact. Studies have demonstrated NMT's superiority in fluency and adequacy over SMT (Bentivogli et al., 2016). However, scholars note persistent shortcomings in domain-specific accuracy (Castilho et al., 2018) and cultural sensitivity (Jiménez-Crespo, 2022).

Post-editing research suggests that human-AI collaboration can improve both quality and efficiency (Koponen, 2016). Yet, concerns about professional deskilling (Kenny, 2017) and reduced linguistic diversity (Ponti et al., 2020) remain. Ethical critiques also point to issues of data privacy, copyright, and algorithmic bias (Bender et al., 2021).

Current Applications of AI in Translation

Commercial and Consumer Use

Google Translate and DeepL are the most widely known consumer-facing AI translation tools. Google Translate supports over 130 languages and integrates across devices and platforms (Google, 2023). DeepL, launched in 2017, has earned a reputation for producing more natural-sounding translations in certain European languages (DeepL, 2023).

Professional Workflows

In the translation industry, AI is increasingly embedded into computer-assisted translation (CAT) tools, enabling translators to work with AI-generated drafts that are then post-edited. This hybrid workflow enhances productivity while allowing human oversight for accuracy and tone (Läubli et al., 2020).

Government and Institutional Platforms

The European Union's eTranslation service processes millions of documents annually in 24 official languages, supporting legislative, diplomatic, and administrative functions (European Commission, 2022). AI translation plays a crucial role in enabling timely, consistent communication across the EU's multilingual framework.

Advantages of AI in Translation

1. Speed and Scalability – AI can process large text volumes in seconds, making global-scale translation feasible.

2. Cost Efficiency – Reduces dependence on human labor for high-volume, low-priority content.

3. Accessibility – Lowers barriers for individuals and small organizations without access to professional translation services.

4. Continuous Learning – Models improve over time through exposure to more data and user feedback.

Challenges and Limitations

Linguistic Nuance and Cultural Context

AI frequently struggles with idiomatic expressions, humor, and culturally embedded meanings. For example, idioms like "kick the bucket" or "spill the beans" often receive literal translations that confuse the target audience (Jiménez-Crespo, 2022).

Domain-Specific Accuracy

While AI excels in general-purpose translation, specialized domains such as law, medicine, or literature require precise terminology and contextual interpretation beyond current AI capabilities (Castilho et al., 2018).

Inequality in Language Representation

Low-resource languages—those with limited digitized corpora—are often poorly served by AI systems, reinforcing global linguistic hierarchies (Ponti et al., 2020).

Ethical Concerns

Training AI models requires massive datasets, raising questions about copyright, informed consent, and data privacy (Bender et al., 2021). Additionally, AI-generated translations may be used without adequate quality control in sensitive contexts, risking harm.

Case Studies

Google Translate

Launched in 2006, Google Translate initially used SMT before transitioning to NMT in 2016. Its integration with Google Lens enables multimodal translation of text in images—a feature particularly useful for travelers and humanitarian workers. Despite its breadth, accuracy varies significantly across languages, with high-resource languages performing better.

DeepL

DeepL's proprietary NMT system has been praised for producing translations that better capture nuance, especially in European languages. Its smaller language coverage compared to Google Translate reflects a focus on quality over quantity.

EU eTranslation

The European Union's internal translation service uses AI to manage legislative and administrative multilingualism. It is integrated into document workflows, allowing civil servants to access draft translations for rapid review, particularly in time-sensitive policy contexts.

Socio-Cultural and Economic Implications

Impact on Professional Translators

AI's rise has shifted the translator's role toward post-editing and quality assurance. While some professionals welcome these tools as productivity aids, others fear a reduction in demand for high-end translation services and downward pressure on wages (Kenny, 2017).

Influence on Language Use

The availability of AI translation encourages communication across linguistic barriers but may also promote linguistic homogenization if dominant languages receive disproportionately better translation quality (Ponti et al., 2020).

Educational Opportunities and Risks

AI translation supports language learning by providing accessible bilingual texts. However, overreliance on automated translation may reduce incentives to learn foreign languages, potentially weakening intercultural competence.

Future Directions

Multimodal Translation

Integration of speech, text, and image processing could enable seamless real-time translation across media formats. This could be particularly transformative for accessibility in education and public services.

Improved Low-Resource Language Support

Advances in transfer learning and synthetic data generation may help bridge the gap for underrepresented languages, preserving linguistic diversity (Zoph et al., 2016).

Ethical Governance

The future of AI translation will require robust governance frameworks to address bias, transparency, and accountability. Collaborative efforts between policymakers, technologists, and linguists will be essential.

Conclusion

AI has reshaped translation from a human-centered craft to a hybrid human-machine collaboration. While it offers unprecedented speed, scalability, and accessibility, it also presents challenges in maintaining cultural nuance, linguistic diversity, and ethical standards. The most

promising future lies in integrating AI's computational power with human expertise, ensuring that technological progress serves both communication efficiency and cultural integrity.

Gender semantic features of the feminist conceptosphere in Turkic languages

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Abstract: In the study, the concepts of feminine concepts and feminine are clarified on the basis of the study on conceptology. The content and nature of the Turkic linguocultural features of the feminine gender conceptosphere is determined. In addition, the semantic structure of feminine concepts in Turkic languages, the axiological, national-cultural significance and connotation content of the Turkic linguocultural model of the feminist gender conceptosphere will be studied. Lexemes reflecting feminine gender conceptual semantics as research materials [1; 2; 3; 4; 5; 6; 7; 8; 12; 13; 15; 21; 22; 23; 24; 28; 29], phraseology and Proverbs [9; 10; 11; 14; 16-20; 25; 26; 27; 30; 31] considered.
Keywords: Turkic linguistic culture, gender conceptosphere, feminine gender conceptosphere, phraseological units, proverbs.

The key idea in this study is to clarify the concept of the feminine gender conceptosphere, identify its components and structure that form the Turkic linguocultural model, general conceptological characteristics and national – cultural features in linguistic expression, and study them in a comparative way.

The concept of the feminine gender conceptosphere is a system of complex hierarchical gender concepts that reflect the socio – cultural, moral and ethnic roles and values that are considered inherent in women in a particular linguocultural space (in our study-Turkic). Although this conceptosphere has its own tone in each language, a common traditional worldview and cultural and symbolic content are preserved on its basis. In Kazakh and Turkic culture in general, the structure of the feminine conceptosphere is based on deep national and cultural traditions, social and gender norms and a stereotypical worldview, and some aspects are elevated to the status of sacred conceptual concepts. For example, the connection of the basic feminine concept “mother” with a sacred, revered conceptual concept in Turkic linguoculture is a testament to this.

If the system of feminist concepts is recognized as components of the feminist conceptosphere, then they are characterized as (feminist concepts) – mental and linguistic units that reflect feminine qualities, role functions, moral norms and cultural and social expectations. Feminist concepts are expressed in Turkic languages through language tools such as basic lexemes (nominative names), phraseology, proverbs and situational contexts.

This study examines the semantic and semantic analysis of the basic concepts of the feminist conceptosphere in Turkic languages – ana (mother), ayel (woman), kyz (daughter), kelin (daughter – in-law), zhenge (sister-in-law), baybishe (first wife), abysyn (daughters-in-law to each other), their linguocognitive and axiological components. The content of each concept will be revealed through proverbs, phraseological units and idioms, regular parables on the basis of examples in Kazakh, Turkish, Kyrgyz, Uzbek, Tatar languages. Let's dwell on a number of these concepts and illustrate our analysis in the example below.

The concept “ana” (mother).

The essence of the concept and cultural role. The concept of “mother” is considered in Turkic culture to a very high degree of value as the basis and support of not only the family, but also the nation as a whole. Mother is not only the giver of life to the world, the educator of generations,

but also a sacred figure in cultural memory. In the Kazakh language, the image-stable phrase «Анаңды Меккеге үш арқалап апарсаң да, қарызын өтей алмайсың» means “we owe the mother's white milk without being able to repay it”. In the linguistic consciousness of the Turkic peoples, the word "ana" is directly associated with the concepts of kindness, care, compassion. For example, there is the Kazakh saying «Атасыз үй – батасыз, анасыз үй – панасыз», the first part “«Атасыз үй – батасыз, means “home without a grandfather is without a blessing, the second part анасыз үй – панасыз» means home without a mother is without a home”. The mother is depicted as the main source of kindness and warmth, domestic harmony and care; the house without a mother is defenseless, without heat, in the sense that it remains empty; in the Tatar people there is a proverb «Ана сөте белән кермәс, тана сөте белән кермәс» which means that the upbringing and qualities that the child is endowed with with mother's milk will not be later transferred in any other way. Similarly, in the Kyrgyz language, the stable phrase "«Эне сүтүн акта» reminds of the child's filial duty, the obligation to compensate for maternal labor, that is, in all Turkic culture, the image of the mother is a symbol of goodness and kindness, family well – being and spirituality.

Semantic structure: the core of the concept of motherhood is the role of the birth – breeder. According to the materials of the study, the ideal mother plays the following roles in Turkic knowledge: *giving birth, raising and educating* – giving life to her children, adapting them to the public environment, good upbringing; *protection and support*-the mother is expressed as a protector of her child from bad. By this means, the motherless child is not protected; «Баланың білегі ауырса, ананың жүрегі ауырады» "If a child's wrist hurts, the mother's heart hurts" – here the "child's wrist" is a symbolic image of any trouble that befell the child, and the "mother's heart" is the mother's sensory center and soul; the meaning is that the mother feels every stress and suffering of her child with her heart, the pain of the child This phrase axiologically defines the mother's kindness and unconditional care in the Turkic worldview.; «Бала – ананың бауыр еті, көз нұры» "The child is the liver of the mother, the light of the eyes".

Linguocognitive and axiological components: the complex of concepts related to the mother has mainly a positive axiological color. In Turkic folklore, respect and love for the mother occupy a central place. In proverbs and sayings, the status of the mother is equal to the father and sometimes even higher: in Kazakh it is said that *«Ана хақысы – Алла хақысы»* (the mother's fee is the payment of Allah), and in Turkish the proverb *“Cennet annenin ayağı altında”* (Paradise under the feet of the mother) is widespread. Also, in all Turkic languages, metaphors such as *ak sut* "white milk", *altyn kursaq* "golden womb" are used in relation to the mother, it means that mother depicts her child with white milk, spreading golden generation from the womb. The positive image of the mother is a wise, caring, protective, exemplary person. For example, in many countries, the word "ana", along with the concepts of "otan" (mother People, mother tongue), has a sacred meaning: in Kazakh, Tugan zher is transmitted through the words "mother" and "earth" ("you have a native land like Your Mother"). This is the veneration of the Earth by analogy with the mother.

The concept of "ana" is like the heart of the feminist conceptosphere in Turkic linguoculture. It is perceived semantically – in combination with the roles of procreator, educator, and axiologically – as a valued, revered person only of a positive nature. Through the image of a *ana,* society forms the model of an ideal woman: all other feminine roles (kyz, kelin, zhenge, abysyn etc.) are valued for being "good" - similar to the mother.

The concept of "ayel" (woman).

The main essence and use. The word "ayel" in the Turkic languages means the concept of "ayel" in a broad sense, most often an adult woman is used in the meaning of a person, spouse. In the Kazakh language, the word "ayel" in the family context gives the concept of "katyn" in the form of

"wife" (my wife is my spouse). In other cases, the historical concept of the word "katyn" is also used in this sense (in modern Kazakh, "katyn" is often of a vulgar tone, but is often found in proverbs: *«Жақсы қатын – жарың, жаман қатын – жауың»* (it is wife if she is good, it is an enemy if she is bad wife). While "kadın" (female) is a common name in Turkish, the word "avrat" is found in historical domestic usage in some dialects. In the Kyrgyz and Uzbek languages, the terms Ayal/ayol are used, in the Tatar language the phrase "Khatyn-kyz" is often used (the meaning is exactly" feminine"); that is, the concept of "ayel" is a large – scale concept that includes a common female name, including a spouse role.

Cultural and social content: the concept of "ayel" is interpreted in traditional Turkic society primarily as a family leader, a person who keeps household chores. In proverbs and sayings, the main task of *ayel* is to bring prosperity into the house, raise children, give lips and adjust the way of life. In Kazakh culture, it is believed that *«үйдің құты әйелден»* (prosperity starts from a woman) it is *ana, ayel* who creates the conditions of a wife and raises children. Accordingly, a "zhaksy ayel" good wife makes the whole house happy: *«Жақсы әйел – үйдің тірегі»* (Kazakh proverb). In Turkish: "Yuvayı dışı küş Yapı" – "the nest is made by a female bird (i.e. a female)" – the proverb is widespread that the family's sleep depends on the woman. The background of these paremias is the traditional division of gender roles: a man of the straight (the outer peasant), *ayel* – the basis of the house (the inner peasant).

Conceptual structure: the main roles are to be a housekeeper, raising children, and a reliable companion of a man. Social status-hostess, mother of fire (owner of the hearth). In some Turkic languages, the social prestige of ayel was measured by the status of her husband: for example, in Kazakh, women were also given importance as a *«omay ueci»* "home owner" (a symbol of being a private home), but today women are also seen in public services, but the traditional linguocultural image is limited to the home.

Linguocognitive and axiological aspect: the approach to the concept of "ayel" is ambiguous: on the one hand, there is a high assessment that a woman is the well – being of the family; on the other hand, there is also an understanding that *«әйел қырық жанды», «қыз кезінде бәрі жақсы, жаман қатын қайдан шығады», «жаман әйелден гөрі, бойдағым жақсы»* which means a woman has a difficult fate, a vulnerable side; that is, on an axiological scale, the concept of "ayel" has equally positive and negative stereotypes.

In conclusion, the concept of a *ayel* is a concentrated reflection of traditional gender roles in Turkic culture. Although it contains conflicting values and evaluation orientations (the ideal homeowner and the perfect spouse etc. the image of a woman with a negative character), in general, this concept serves as a mirror of the norms and expectations imposed on a woman in society. We found that the conceptual model of the highest goal of female existence – "motherhood" and "loyalty to a partner" is common to all considered linguocultures.

The concept of "kyz" (girl).

Brief description of the concept: "kyz" is a concept that in Turkic languages means a young woman who has not reached the age of a girl or is not yet married. Also, the word "kyz" can be used in the meaning of "boyzhetken" (young lady), "bikesh" (young lady), and sometimes in general in the concept of "female" (against male). For example, in the Kazakh language, the phrase "kyz-kelinshek" is used to collectively refer to young women. In Turkish, the word "kız" is pronounced in relation to a girl, in Uzbek – "Kiz", in Kyrgyz - "kız" - the meaning is one and the same. In Tatar there is also the word "kyz", in the official style it is written as" кыҙ"; the concept of "kyz" – characterizes the initial stage of the feminist conceptosphere, the position of a girl in society.

Cultural content: in the Turkic tradition, a girl is a seven-sided diamond, a guest who, growing up, expands the field of one dynasty. In Kazakh culture, there is a conceptologically stable concept of «Қыз – өріс, ұл – қоныс» немесе «Қыз – жат жұрттық». This means that tomorrow a girl will

become a daughter – in-law of one family and leave her home; parents will raise their daughter, raise her and give her to another family ("strangers"). From this it follows that the issue of upbringing in relation to the girl, the preservation of the honor of the girl, occupies a very important place in the traditional cultural worldview. Axiological conceptual concepts associated with the concept of "kyz", such as honor, chastity, and ethics, go hand in hand. For example, the Kyrgyz people say: *«Кыздын жолу кылычтын мизинде»* (the path of the girl is in the blade of the sword), describing the difficulties of the fate of the girl: *«абыройын сактаса – аман, сал жаңылса – опат»*. In Kazakh, the meaning of a similar proverb *«Қыздың жолы жіңішке»*: "the fate of a girl is both fragile and uncritical, it is difficult to save her" is traditionally formed in gender discourse.

Semantic structure and components:

- Social role: a girl is the daughter of parents, tomorrow she will be a wife to someone. The main task of the girl is to receive a moral education and prepare to become a worthy daughter-in-law for the future family; therefore, the concept kyz is dominated by "socialization" and "educational content;

- Personal qualities: the traditional worldview encourages a girl to be sociable, tactful, polite, charming. In the Turkic countries, there is a common proverb *«Қыз өссе – елдің көркі»* which indicates that the success of a girl is considered the merit of not only her family, but also the whole country.

Linguocognitive, axiological aspects: the folk view of the girl is ambivalent: on the one hand, the girl is praised as a joy, garden, flower; on the other hand, the girl is considered as a child of a foreign country, a source of worries, responsibility, and the linguistic expression also reflects this conceptual content. Positive image of the girl: «Қыз – елдің көркі, үйдің қуанышы». In Kazakh, it is said *«Гүл өссе жердің көркі, қыз өссе елдің көркі»*, *«Қыз – халықтың гүлі»*; in Uzbek linguoculture: *«Қиз болса – хонадонга файз»* (if the girl is – shanyrak shuak); the girl is compared to a flower and glorifies that she is a herald of beauty. At the same time, a girl can also take care of her parents: the Tatars say *«Кызы бардың – назы бар»* - a girl can be caress and demandable and bring a joy to a soul.

The concept "zhenge" (sister-in-law).

The meaning of the term "zhenge" is a relative name in Turkic languages, meaning: the wife of a brother or brother, or rather, the spouse of a brother or cousin from the point of view of Ego (beginner person). In the Kazakh rite, *zhenge* is a kind of "counselor sister" for in-laws younger than her (husband's brothers, sisters and sisters). In Turkish, the word "yenge" has the same meaning, in Kyrgyz it is pronounced as "Yenge/zhengi", in Uzbek it is pronounced as "Yanga" (yanga); although the name is modified, the conceptual content is the same: zhenge is the image of a mediator in the family, a wise woman.

Cultural role: the place of the Conqueror in the family is special. She appears, on the one hand, as a daughter-in-law to the same dynasty (she becomes a daughter-in-law to her own husband's parents, older brothers and relatives), on the other hand, as an informal tutor and confidant to her younger brothers-in-law. In the Kazakh tradition, there is a conceptual concept called *zhengetaylyk* who is in-between in the choice of a wife for her sister-in-law or mother-in-law. This is exactly what the saying *«Жолы болар жігіттің жеңгесі шығар алдынан»* implies: the guy who is going to get married is helped by his sister-in-law first, succeeds with the girl, opens the way; therefore, *zhenge* is a family support, intercessor. For in-laws, she is both a blood sister, and a compassionate one in a friendly manner. For example, in the Kazakh environment, young men were welcome to joke and communicate freely with their sisters-in-law, while other older women were treated with manners; zhenge – a partially woman who has a special status-half "strange", half "own". Even in Turkish culture, the word "yenge" is not just a relative name, but a nominative

name used in an informal environment in a mixture of jokes with respect to a foreign woman (a friend's wife, etc.).

Semantic structure:

- The main roles – *zhenge* is characterized by the following functions: caring for the sisters-in-law, mentoring, supporting them, in particular, there is such a concept as "raising of sister-in-law" – the girl taught by *zhenge* to some issues that are not openly told to the child, some secrets of the boy (love, etc.) were understood by the parents through zhenge. This cultural and social role of *zhenge* concept is reflected in the paremies: *«Қызды үйдің жеңгесі сүйкімді»* - in the sense that the closest person to the girl at home is the sister – in-law, who caresses and decorates her.

- The social context is like an intermediate link between *zhenge*. She also maintains her own subordination (to her mother-in-law, sisters-in-law, respectively), but often moves freely. For example, in the Kazakh environment, sisters-in-law are active in courtship, wedding ceremonies (wearing an owl, going together to see a girl, etc.), so they are defined in the conceptual content of "Game starter".

Axiological and cognitive facet: the image of *zhenge* is mostly in a pleasant tone. To a good *zhenge* – a sincere sympathy for in-laws, a close friend. The connotation of the word *zhenge* in the people's memory is a warm, humorous, broad – shouldered woman. For example, in Kazakh they say: *«Жеңгесі бардың теңгесі бар»* - this is a joke that if you have a sister-in-law, your pocket is not a hole (he will help you). Sometimes it is also said : *«Жақсы жеңге – жарты ана»*, which means that children raised by a sister-in-law feel maternal affection.

In conclusion, the Turkic feminist conceptosphere is defined as a complex linguocultural phenomenon that reflects a whole system of cultural and social structure, traditional gender roles and axiological values through such basic concepts as mother, daughter, wife, bride, sleeve, etc. It is reflected in linguistic data – Proverbs, phraseology, stable parables-and forms the image of a woman as a family leader, procreator, moral and ethical stabilizing force. The structural and semantic analysis of the feminist conceptosphere makes it possible to identify the common cultural codes of the Turkic peoples, as well as ethnic characteristics, and forms the scientific basis for a comprehensive understanding of gender linguocultural models.

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Sociological Sciences

საქართველოს ტექნიკური უნივერსიტეტის ინსტიტუტ „ტექინფორმის“ და საინჟინრო ფიზიკის დეპარტამენტის ბაზაზე ინოვაციური სწავლების და მეცნიერული კვლევის საერთაშორისო კლასტერული საუნივერსიტეტო ცენტრის ჩამოყალიბების მიზანშეწონილობის შესახებ

On the feasibility of establishing an international cluster university center for innovative teaching and scientific research on the basis of the Institute "Techinform" and the Department of Engineering Physics of the Georgian Technical University

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როგორც ცნობილია, მსოფლიოს ყველა წამყვან ქვეყანაში საგანმანათლებლო სისტემის განვითარების სამი ძირითადი ტენდენცია სადღეისოდ გახლავთ გლობალიზაცია, რეგიონალიზაცია და საგანმანათლებლო და კვლევითი პროცესების სტრუქტურირება, მათი მუდმივი ურთიერთქმედების და ურთიერთგავლენის პირობებში. ეს ტენდენციები დიალექტიკურად ეწინააღმდეგება და ავსებს ერთმანეთს.

გლობალიზაციის და იმავდროულად განათლებისა და ინოვაციური სამეცნიერო კვლევების სფეროში სტრუქტურირების მთავარი მამოძრავებელი ძალა არის განათლებისა და ინოვაციური სერვისების კონკურენტუნარიანობის შენარჩუნებისა და გაზრდის აუცილებლობა. მაღალი კონკურენტუნარიანობის მისაღწევად განათლების და სამეცნიერო კვლევის სისტემა ერთდროულად უნდა იყოს გლობალური (უზრუნველყოფდეს ყველა სახის საგანმანათლებლო და სამეცნიერო-კვლევითი მომსახურების იმ სტანდარტს, რომელსაც მომხმარებლები და ეკონომიკა ითხოვენ გლობალურ დონეზე) და კარგად სტრუქტურირებული რეგიონულ, ეროვნულ (ქვეყანა, სახელმწიფო) და ინსტიტუციონალურ (რეგიონი, ქვეყანა, ადმინისტრაციული და ეკონომიკური ერთეული) დონეზე, როგორც "ზემოდან-ქვემოთ" (top-down), ასევე "ქვემოდან-ზემოთ" (bottom-up) პრინციპის გამოყენებით. მნიშვნელოვანია, რომ ორივე ეს ტენდენცია განუყოფლად იყოს დაკავშირებული ყველა დონის ინდუსტრიულ-ეკონომიკური და სოციალურ-პოლიტიკური განვითარების პროცესებთან და მათი კორელაცია და მოძრაობის მთავარი ვექტორი მუდმივად მიჰყვებოდეს პოლიტიკური, სოციალური და ეკონომიკური პროგრესის ტენდენციებს.

უნდა აღინიშნოს, რომ თავიდანვე, სასწავლო პროცესის პრინციპების განახლების პროცესში, გლობალიზაციის ტენდენცია და „ზემოდან ქვემოთ“ ჩამოყალიბების პრინციპი ძალიან დიდი ხნის განმავლობაში აშკარად ჭარბობდა რეგიონალიზაციის და „ქვემოდან ზემოთ“ სტრუქტურირების ტენდენციებს. ამდენად, ამ ორ მიმართულებას შორის ოპტიმალური ბალანსის აღსადგენად ბოლო დროს საჭირო გახდა ძირეული ტენდენციების მნიშვნელობის გადაფასება გლობალიზაციის ხვედრითი წონის ერთგვარი დევალვაციის ფონზე.

საქართველოს ტექნიკურ უნივერიტეტს (მისი სტრუქტურული ერთეულებით), როგორც ამიერკავკასიის ერთ-ერთ უმსხვილეს და პრესტიჟულ უმაღლეს სასწავლებელს, აქვს ყველაზე მაღალი პოტენციალი საქართველოს უმაღლეს სასწავლებს შორის, რათა სასწავლო და სამეცნიერო-სასწავლო ცენტრების შექმნის და გამსხვილების გზით წარმატებით განახორციელოს სრულმაშტაბიანი სამეცნიერო კლასტერებისთვის შესაფერისი შიდა საუნივერსიტეტო სტრუქტურული ერთეულების ჩამოყალიბება, აგრეთვე გაატაროს წარმატებული რეგიონალური და საერთაშორისო თანამშრომლობის პოლიტიკა. ვფიქრობთ, ამჟამად მიზანშეწონილად უნდა ჩაითვალოს საქართველოს ტექნიკურ უნივერსიტეტში შიდა საუნივერსიტეტო სასწავლო-სამეცნიერო-საინოვაციო კლასტერის ჩამოყალიბება, რაც განპირობებულია უნივერსიტეტში სამეცნიერო კვლევების, სასწავლო ღონისძიებების და მაღალი სამეცნერო და პრაქტიკული ღირებულების მქონე პროდუქტის შექმნის გამოცდილებით.

ვფიქრობთ, რომ სასწავლო-სამეცნიერო კლასტერის ჩამოყალიბების „საინიციატივო“ სამუშაო ჯგუფის შექმნა, რომელიც დაუყოვნებლივ დაიწყებს აბიტურიენტებთან და სტუდენტებთან ინტენსიურ მუშაობას, კიდევ უფრო მიმზიდველს გახდის უნივერსიტეტს

აბიტურიენტებისთვის და შესამჩნევ წვლილს შეიტანს მისი საერთაშორისო პრესტიჟის ამაღლებაში.

სადღეისოდ უკვე გამოიკვეთა უცხოური და ქართული სამეცნიერო ორგანიზაციების „ბირთვი“, რომელმაც უნდა გაგვიწიოს პარტნიორობა შიდასაუნივერსიტეტო, ინსტიტუციონალურ (საქართველოს წამყვანი სამეცნიერო ცენტრები), რეგიონალურ (საქართველო, ამიერკავკასია, თურქეთი), ტრანსრეგიონალურ (საქართველო, ამიერკავკასია, თურქეთი, პოსტსაბჭოთა სივრცის ქვეყნები) და საერთაშორისო (საქართველო, ამიერკავკასია, პოსტსაბჭოური სივრცის ქვეყნები, აშშ, ინდოეთი და ა. შ.) კლასტერის ჩამოყალიბების ყველა სტადიაზე. განსაკუთრებით მნიშვნელოვანი შეიძლება იყოს საერთაშორისო თანამშრომლობა კიბოს ადრონული თერაპიის და კოვიდ-19-ის საწინააღმდეგო საშუალებების შექმნის და ტესტირების სფეროში აშშ-ის (სლოან ქეთერინგის კიბოს მემორიალური კლინიკა, ნიუ-იორკი; ალბერტ ეინშტეინის სამედიცინო კოლეჯი, ნიუ-იორკი; ჩრდილოეთ კაროლინის უნივერსიტეტის ბიოლოგიური მეტაბოლიზმის დეპარტამენტი, გრინსბორო), გერმანიის (დუისბურგ-ესსენის უნივერსიტეტის ნანოტექნოლოგიის ლაბორატორია, სააქციო საზოგადოება AG Farle და საერთაშორისო სააქციო საზოგადოება MagForce AG), ინდოეთის (მაჰათმა განდის უნივერსიტეტის ქიმიური ტექნოლოგიების ფაკულტეტი, კოტაიამი; ჯადავპურის უნივერსიტეტის ჯადავპურის უნივერსიტეტის ფარმაცევტული ტექნოლოგიების დეპარტამენტი, კოლკატა), აზერბაიჯანის (ბაქოს სახელმწიფო უნივერსიტეტის ფიზიკის ფაკულტეტი, ბაქო), სომხეთის (სომხეთის მეცნიერებათა ეროვნული აკადემიის ფიზიკური კვლევების ინსტიტუტი, ერევანი), უკრაინის (უკრაინის მეცნიერებათა ეროვნული აკადემიის დ. კ. ზაბოლოტნის მიკრობიოლოგიის და ვირუსოლოგიის ინსტიტუტი; უკრაინის მეცნიერებათა ეროვნული აკდემია) წამყვან სააგანმანათლებლო და სამეცნიერო დაწესებულებებთან. ინოვაციური სწავლების და მეცნიერული კვლევის კლასტერული საუნივერსიტეტო ცენტრის საქმიანობის წინაპირობას წარმოადგენს ქვემოთ მოცემული განსაკუთრებით საყურადღებო შედეგები, რომელიც მიღწეულია მისი სავარაუდო „საინიციატივო“ ჯგუფის წევრების ხელმძღვანელობით.

საგულისხმოა, რომ საქართველოს ტექნიკური უნივერსიტეტის საინჟინრო ფიზიკის დეპარტამენტის პროფესორ-მასწავლებლებს, ინსტიტუტ „ტექინფორმის“ და ინსტიტუტ „ტალღა“-ს სამეცნიერო პერსონალს გააჩნიათ საერთაშოისო თანამშროლობის და აბიტურიენტებთან და მოსწავლე ახალგაზრდობასთან საგანმანათლებლო მუშაობის ქვემოთ მოყვანილი ხანგრძლივი და წარმატებული გამოცდილება: 1. 2011 წ. კონკურსი „ლეონარდო და ვინჩი“, II პრიზი და ფულადი პრემია). პროექტი - „რობოტი - მწვანე უცხოპლანეტელი“; 2. 2011 წ. კონკურსი „ლეონარდო და ვინჩი“, ფინალისტის დიპლომი. პროექტი - „მწვანე ძრავა“; 3. 2012 წ. კონკურსი „მე, ახალგაზრდა გამომგონებელი“, გამარჯვებული პროექტი - „ელვა წვიმიან ფანჯარაში“. გამარჯვებულმა მოსწავლემ მონაწილეობა მიიღო კონკურსში EUCYS 2013 (პრაღა) და დაჯილდოვდა ფინალური ტურის დიპლომით; 4. 2013 წ. კონკურსი „ლეონარდო და ვინჩი“, III პრიზი და ფულადი პრემია. პროექტი - „ტრანსფორმერი კლეპსიდრონი“; 5. 2014 წ. კონკურსი ISEF 2014 (ლოს-ანჯელესი). IV პრემია იჟინერიის განხრით და ფულადი პრემია; 6. 2014 წ. კორპორაცია SpaceX-ის სპეციალური პრიზი და ფულადი პრემია. პროექტი - „ტრანსფორმერი კლეპსიდრონი“; 7. 2014 წ. კონკურსი „ლეონარდო და ვინჩი“, „გრანპრი“. პროექტი - „კარბონის ორფენა კომპოზიტი“. გამარჯვებულმა გუნდმა მონაწილეობა მიიღო კონკურსში ISEF 2015 (პიტსბურგი, აშშ) და სრული შემადგენლობით შემეცნებითი სამკვირიანი ტურით გაემგზავრა ინგლისში, 2015 წლის ივლისში; 8. 2015წ. მიმდინარე ათასწლეულის ინოვაციის კონკურსი, III საპრიზო ადგილი და კვლევითი გრანტი. პროექტი - „მეტალ-კარბონის ორმაგფენა კომპოზიტების სინთეზირება, თვისებების გამოკვლევა და გამოყენება ორიგინალურ კოსმოსურ და ენერგეტიკულ მოწყობილობებში“. გამარჯვებულმა გუნდმა სრული შემადგენლობით

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კონკურსი „ლეონარდო დავინჩი“ მე-3 ადგილზე გასული (დისტანციური დიაგნოსტიკა); 39. 2020 წ. ათასწლეულის ინოვაციის კონკურსში გამარჯვებული გუნდი; 40. 2024 წ „საქართველოს მთიანი რეგიონების სკოლებში მეცნიერების პოპულარიზაცია და სამეცნიერო კვლევის სტიმულირება“ (სტუ ინსტიტუტი „ტალღა“).

სადღეისოდ, კლასტერული ცენტრის ჩამოყალიბების სავარაუდო „საინიციატივო“ ჯგუფის წევრების პოზიტიური გამოცდილება და უახლესი მომავლის გეგმები მოიცავს აგრეთვე შემდეგ მნიშვნელოვან პროექტებს და მიღწევებს: აშშ გარემოს დაცვის სააგენტოს (US EPA) საპარტნიორო პროექტის, საერთაშორისო სამეცნიერო ტექნოლოგიური ცენტრის (ISTC), უკრაინაში სამეცნიერო ტექნოლოგიური ცენტრის STCU), საქართველოს შოთა რუსთაველის ეროვნული სამეცნიერო ცენტრის (GRNSF) საგრანტო პროექტების და აზიურ ფაროსანასთან ბრძოლის სახელმწიფო პროგრამის ფარგლებში: 1. შეიქმნა და აპრობირებული იყო მანგანუმის შემცველი შლამების მაღალხარისხოვან შენადნობებად და ლიგატურებად (“master alloys”) გადამუშავების ინოვაციური ზემაღალსიხშირული ტექნოლოგია და პილოტური მაკეტი. 2. შეიქმნა და აპრობირებული იყო მანგანუმის შემცველი შლამების და სპილენძის შემცველი ნარჩენების მაღალხარისხოვან შენადნობებად და ლიგატურებად (“master alloys”) ერთობლივი გადამუშავების ინოვაციური ზემაღალსიხშირული ტექნოლოგია და პილოტური მაკეტი. 3. შეიქმნა და აპრობირებული იყო ინერტული პოლიმერული ნარჩენების მაღალხარისხოვან საწვავად გადამუშავების ინოვაციური ზემაღალსიხშირული ტექნოლოგია და პილოტური მაკეტი. 4. შეიქმნა სასოფლო სამეურნეო ნარჩენების და საყოფაცხოვრებო ნაგავსაყრელებზე განთავსებული ორგანული მასალების მაღალხარისხოვან საწვავად გადამუშავების ინოვაციური ზემაღალსიხშირული ტექნოლოგია და პილოტური მაკეტი. 5. შემუშავდა და აპრობირებული იყო ^{137}Ce რადიონუკლიდებით დაბინძურებული ნიადაგების ფიტორემედიაციის ახალი კომბინირებული ტექნოლოგია. 6. შემუშავდა და გამოიცადა აზიური ფაროსანას მეტაბოლიტებით და სხვა კონტამინანტებით დაბინძურებული ღვინის უმაღლესი ხარისხის სპირტებად გადამუშავების ინოვაციური ვაკუუმურ-ულტრებგერითი ტექნოლოგია და პილოტური მაკეტი. 7. შემუშავდა და ნაწილობრივ შემოწმდა კიბოს ლოკალიზებული კომბინირებული მკურნალობის პიონერული კონცეფცია; 8. შეიქმნა და გამოიცადა კიურის ტემერატურით კონტროლირებადი ლითონის ოქსიდების და შენადნობების ნანონაწილაკის სინთეზის ახალი მიკროტალღური ტექნოლოგია. შემოწმდა სინთეზირებული ნანონაწილაკების ბაზაზე დამზადებული ნანოსითხეების ტოქსიკურობა თბილსისხლიანი ცხოველების მიმართ. 9. შემუშავდა და ნაწილობრივ შემოწმდა კიბოს ლოკალიზებული კომბინირებული მკურნალობის პიონერული კონცეფცია ბორის ნიტრიდის ნანონაწილაკების/ნანოფირების და რეგულირებადი კიურის ტემერატურის მქონე ლითონის ოქსიდების ნანონაწილაკების კომპლექსების საფუძველზე; შეიქმნა და გამოიცადა ბორის ნიტრიდის ნანონაწილაკების დაბალტემპერატურული ზემაღალსიხშირული სინთეზის პიონერული ტექნოლოგია. 9. საქართველოს სურსათის ეროვნული სააგენტოს საორგანიზაციო და მეთოდური დახმარებით შეიქმნა და ლაბორატორიულ და საველე პირობებში შემოწმდა აზიური ფაროსანას და იტალიური კალია მიმართ მკვეთრად გაზრდილი ბიოლოგიური ეფექტიანობის და ადამიანის, ფუტკრის, თბილსისხლიანი ცხოველების და წყლის ორგანიზმების მიმართ რამდენჯერმე შემცირებული ტოქსიკურობის მქონე შერეული (სინთეზური და ბუნებრივი) შემადგენლობის ინსექტიციდური კომბინაციები. 10. შემუშავდა და შემოწმდა კიბოს პროტონული თერაპიის ბიოლოგიური ეფექტიანობის გაზრდის და უსაფრთხოების გაზრდის პიონერული კონცეფცია იზოტოპურად გამდიდრებული (^{11}B) ბორის ნიტრიდით პროტონების ჩაჭერის და (^{10}B) ბორის ნიტრიდით ნეიტრონების ჩაჭერის რეაქციების გამოყენებით. 11. შემუშავდა (საქართველოში დამუხტული ნაწილაკების შესაბამისი კლასის ამაჩქარებლების 2024 წლამდე

არარსებობის მიუხედავად) პროტონული და მძიმე იონებით კიბოს თერაპიის პროცესების სიმულირების და შესწავლის პიონერული კონცეფცია ბლეომიცინის, სხვა რადიომიმეტიკების და CuNi, $Ag_xLa_{1-x}MnO_3$, Fe_3O_4, TiO_2 შემცველი ნანოსითხეების გამოყენებით. 12. ხილული ოვოსკოპიის დანადგარზე დაწყებულია რადიაციული ზემოქმედების და მძიმე ვირალური ინფექციების და მათ წინააღმდეგ შემოთავაზებული საშუალებების კვლევა ფრინველთა ემბრიონებზე, რომელიც შესაბამისი კლასის ბიოლოგიური დაცვის ბოქსების გამოყენებით გავრეცელდება ახალ კორონავირუსზეც. 13. შემუშავდება რადიოაქტიური ზემომქედების შესუსტების, კიბოს თერაპიის და მძიმე ვირალური ინფექციის საწინააღმდეგო საშუალებების კვლევის პროგრამა, რომელიც შესაბამისი კლასის ბიოლოგიური დაცვის ბოქსების გამოყენებით გავრეცელდება ახალ კორონავირუსზეც. გამოკვლეული იქნება ამგვარი საშუალებების ფართო სპექტრი ზემოქმედების ყველა ზემოთმოყვანილი აგენტის და ჟანგბადის აქტიური ფორმების გამოყენებით. 14. მუშავდება კოვიდ-19-ის პანდემიის პირობებში კიბოს თერაპიის ტრადიციული ფორმების და პროტონული თერაპიის უსაფრთხოების ამაღლების პროგრამა. 15. მუშავდება კოვიდ-19-ის პამდემიის პირობებში სამედიცინო პერსონალის და განსაკუთრებით მაღალი რისკის ქვეშ მყოფი სხვა პროფესიული ჯგუფების ინდივიდუალური და კოლექტიური დაცვის საიმედო საშუალებების შექმნის პროგრამა ნანოტექნოლოგიის უკანასკნელი მიღწევების და მიკროტალღური, ფოტოდინამიური და ულტრაბგერითი მეთოდების გამოყენებით. 16. მიმდინარეობს რადონით განპირობებული რისკის ელექტრონული რუქების შედგენა, რომელიც ხელმისაწვდომი იქნება საქართველოს მოსახლეობისათვის, უცხოური ორგანიზაციებისათვის და სხვა დაინტერესებული პირებისათვის. ამავე საიტზე ფიზიკური პირებსა და საჯარო და კერძო ორგანიზაციებს შეეძლებათ შეავსონ ელექტრონული განაცხადი და მოითხოვონ საცხოვრებელ და სამუშაო ადგილებში რადონის დონის შეფასება (სტუ ინსტიტუტი „ტალღა“).

მიმდინარე ეტაპზე (2020 წლიდან მოყოლებული) საქართველოს ტექნიკური უნივერსიტეტის საინჟინრო ფიზიკის დეპარტამენტის (დეპარტამენტის ხელმძღვანელი აკაკი გიგინეიშვილი) და სასწავლო-სამეცნიერო ცენტრის „საინჟინრო-ფიზიკური პრობლემების ინსტიტუტი“ (ცენტრის დირექტორი არჩილ ჭირაქაძე) ბაზაზე, სტუ ვ. ჭავანიძის სახელობის კიბერნეტიკის ინსტიტუტის გამოთვლითი ტექნიკის ელემენტების და ნანომასალების განყოფილების, ხელმძღვანელი დავით ჯიშიაშვილი) და ოპტიკურად მართვადი ანიზოტროპული სისტემების განყოფილების (ხელმძღვანელი გია პეტრიაშვილი) მკვლევარების აქტიური მონაწილეობით მიმდინარეობს ინტენსიური კომპლექსური კვლევა პროტონული თერაპიის ბიოლოგიური ეფექტიანობის და უსაფრთხოების ასამაღლებლად, რომლის ერთ-ერთი უმთავრესი მიზანია ამჟამად ფართოდ გამოყენებული ანტისიმსივნური პრეპარატების (გემციტაბინი, კარბოპლატინი), ცეზიუმის და რუბიდიუმის მარილების, დიმეთილსულფოქსიდის, იონოფორების, კვერცეტინის, მაღალი ანტისიმსივნური აქტივობის ნანომასალების ბაზაზე ფილტვის კიბოს სამკურნალო მაღალსინერგიული კომბინაციების („კოქტეილების“) შექმნა და ტესტირება უჯრედოვან კულტურებზე, ფრინველების ემბრიონებზე და თბილსისხლიან ძუძუმწოვრებზე (თეთრ ვირთაგვებზე). სადღეისოდ შემუშავებულია 6 პრეპარატი, რომელთა მწვავე ტოქსიკურობა ემბრიონების და ემბრიონების და თეთრი ვირთაგვების მიმართ შემოწმებულია სტუ სასწავლო-სამეცნიერო ცენტრში „საინჟინრო-ფიზიკური პრობლემების ინსტიტუტი“ (მთავარი მკვლევარის თეიმურაზ ჩიჩუას ხელმძღვანელობით) და ივანე ბერიტაშვილის ექსპერიმენტული ბიომედიცინის ცენტრის თავის ტვინის სისხლის მიმოქცევის და მეტაბოლიზმის განყოფილებაში (სტუ სასწავლო-სამეცნიერო ცენტრის „საინჟინრო-ფიზიკური პრობლემების ინსტიტუტი“ სამეცნიერო კონსულტანტის აკადემიკოს ნოდარ მითაგვარიას ხელმძღვანელობით). პრეპარატების ციტოტოქსიკურობის და აპოპტოზის

ინდუცირების უნარის ტესტირება ამჟამად წარმატებით მიმდინარეობს არაწვრილუჯრედოვანი ფილტვის კიბოს და ადამიანის კანის ნორმალური ფიბრობლასტების უჯრედოვან კულტურებზე (A549, NHDF) ინდოეთის ერთ-ერთი წამყვანი სამეცნიერო-კვლევითი კომპანიის „ბინფოსოლ“ (“Binfosol”) ლაბორატორიაში. სტუ ინსტიტუტ „ტექიფორმის“ მეცნიერების მიერ ხელოვნური ინტელექტის გამოყენებით დაწყებულია კვლევა კომბინირებული ანტისიმსივნური პრეპარატების სინერგიულობის მოდელირების და ოპტიმიზაციის მიზნით.

მნიშვნელოვანია, რომ საქართველოს ტექნიკურ უნივერსიტეტში მიმდინარე კვლევის შედეგები და პერსპექტივები კარგად არის ცნობილი ქუთაისის საერთაშორისო უნივერსიტეტის სამეცნიერო-ტექნიკური პროექტების ჯგუფისთვის (მენეჯერი - პროფესორი რევაზ შანიძე). ყოველივე ზემოთქმულის გათვალისწინებით მიზანშეწონილად შეიძლება ჩაითვალოს ახალი კლასტული ცენტრის შექმნის და განვითარების ქვემოთ მოყვანილი გეგმის განხორციელება:

1. საქართველოს ტექნიკური უნივერსიტეტის საინჟინრო ფიზიკის დეპარტამენტის, სტუ სასწავლო-სამეცნიერო ცენტრის „საინჟინრო-ფიზიკური პრობლემების ინსტიტუტი“, ინსტიტუტ „ტექინფორმის“. სტუ ვ. ჭავჭანიძის სახელობის კიბერნეტიკის ინსტიტუტის გამოთვლითი ტექნიკის ელემენტების და ნანომასალების განყოფილების (ხელმძღვანელი დ. ჯიშიაშვილი) და ოპტიკურად მართვადი ანიზოტროპული სისტემების განყოფილების (ხელმძღვანელი გ. პეტრიაშვილი) ბაზაზე საქართველოს ტექნიკური უნივერსიტეტის რექტორის ბრძანებით და შიდა საუნივერსიტეტო ხელშეკრულების საფუძველზე ჩამოყალიბდება ახალი საუნივერსიტეტო კლასტერული ცენტრი, რომელიც განაგრძობს კომპლექსური კვლევას პროტონული თერაპიის ბიოლოგიური ეფექტიანობის და უსაფრთხოების ასამაღლებლად.
2. ახლად შექმნილმა ცენტრმა დადგენილი წესით მიმართოს სტუ სამედიცინო ფაკულტეტის ხელმძღვანელობას წინადადებით, რათა ფაკულტეტის პროფესორ-მასწავლებლებმა შესაბამისი წესით მიიღონ აქტიური მონაწილეობა კლასტერული ცენტრის საქმიანობაში.
3. სტუ ხელმძღვანელობა შესაბამისი ფორმით მიმართავს კავკასიის საერთაშორისო უნივერსიტეტის, ივანე ბერიტაშვილის სახელობის ექსპერიმენტული ბიომედიცინის ცენტრის და ქუთაისის საერთაშორისო უნივერსიტეტის ხელმძღვანელობას წინადადებით შესაბამისი ხელშეკრულების საფუძველზე უნივერსიტეტთაშორისი (ნაციონალური) სასწავლო-სამეცნიერო კლასტერული ცენტრის შექმნის თაობაზე.
4. შეთანხმების მიღწევის შემთხვევაში უნივერსიტეტთაშორისი (ნაციონალური) კლასტერული ცენტრი მიმართავს ბაქოს სახელმწიფო უნივერსიტეტის, მაჰათმა განდის უნივერსიტეტის, ჯადავპიროს უნივერსიტეტის და სამეცნიერო კვლევითი კომპანიის „ბინფოსოლი“ ხელმძღვანელობას წინადადებით საერთაშირისო სასწავლო-სამეცნიერო კლასტერული ცენტრის შესახებ.
5. საერთაშირისო სასწავლო-სამეცნიერო კლასტერული ცენტრი განაგრძობს აქტიურ საქმიანობას თურქეთის, პოლონეთის, აშშ და სხვა ქვეყნების უნივერსიტეტების და სამეცნიერო ცენტრების ქვედანაყოფების საერთაშორისო კლასტერული ცენტრის შემადგენლობაში შემოსაყვანად.

რა თქმა უნდა, კლასტერული ცენტრის საქმიანობის ყველა ეტაპზე მისი ერთ-ერთი მავარი მიზანი იქნება თანამედროვე დონის ფუნდამენტურ და გამოყენებით კვლევებში ბაკალავრიატის, მაგისტრატურის და დოქტორანტურის სტუდენტების მაქსიმალური ინტენსივობით ჩართვა და ინოვაციური სამეცნიერო პროდუქციის კომერციალიზაციის პინციპულად ახალი დონის უზრუნველყოფა.

იმედი გვაქვს, რომ კლასტერული ცენტრის შექმნის და განვითარების ჩვენს მიერ შემოთავაზებული გეგმა სწრაფად დაამტკიცებს თავის სიცოცხლისუნარიანობას მომავალი წლის ზაფხულში მიზანშეწონილი გახდება მისი საქმიანობის ფინანსური

სტრუქტურის და კონკრეტული მექნიზმების შესახებ მსჯელობა. ცენტრის სიცოცხლისუნარიანობის და მაღალი პოტენციალის ერთ-ერთი მნიშვნელოვანი საფუძველი იქნება მისი სამეცნიერო კონსულტანტების (აკადემკოსების ნოდარ მითაგვარიას და გიორგი ჯაფარიძის) უმაღლესი პროფესიონალიზმი და მაღალი სამეცნიერო ინტერესი ცენტრის თემატიკის მიმართ. კლასტერული ცენტრის წარმატების კიდევ ერთ საფუძველს წარმოადგენს მაჰათმა განდის ვიცე-კანცლერის საბუ თომასის უაღრესად მაღალი ინტერესი ჩვენი ცენტრის სამეცნიერო საქმიანობის მიმართ. პროფესორი საბუ თომასი არის სერთაშორისო აღიარების მქონე მასწავლებელი და მეცნიერ-მკვლევარი, რომელიც სტენფორდის უნივერსიტეტის მიერ 2022 წლის დამდეგს დასახელდა უცხოელ მეცნიერთა „ტოპ 2%-ში“. იგი განსაკუთრებული პატივისცემით სარგებლობს პოლიმერების ქიმიის და თანამედროვე ნანოტექნოლოგიების განვითარებაში შეტანილი განსაკუთრებული წვლილისთვის. მას ეკუთვნის 1400-ზე მეტი პუბლიკაცია ცნობილ საერთაშორისო რეცენზირებად ჟურნალებში და დაწერილი ან რედაქტირებული აქვს 167 წიგნი. პროფესორ საბუ თომასის მიმდინარე h-ინდექსი უდრის 127-ს, ხოლო ციტირების ინდექსი აღემატება 79000. პროფესორ თომასს მიღებული აქვს მრავალი საერთაშორისო და ნაციონალური ჯილდო და საპატიო წოდება. მისი ადმინისტრაციული, პედაგოგიური და სამეცნიერო მოღვაწეობა გახდა მნიშვნელოვანი ფაქტორი იმისა, რომ მაჰათმა განდის უნივერსიტეტი შედის ქვეყნის საუკეთესო უნივერსიტეტების რიცხვში და მსოფლიოს უნივერსიტეტების მე-5 ასეულში.

Psychological Sciences

Determinants and motivation factors in language learning

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Keywords: motivation, internal and external factors, personality, language learning

Motivation. Johnstone considers motivation as a stimulus to achieve a specific goal (Johnstone, 2000). Similarly, according to Ryan and Deci, being motivated means being in motion to develop or do something (McEown et.al., 2019). Crump believes that excitement, interest, desire, understanding, and enthusiasm for learning are the main components of motivation (Crump, 1995). The levels and types of motivation in any given individual are different from others. In other words, not only do individuals have different levels and amounts of motivation, but also different types of motivation. Cook concludes that language acquisition is not the same for all learners. Furthermore, it is suggested that there are three main factors that influence second language acquisition. These are age, personality, and motivation. The most important of these is motivation.

Types of motivation. According to Gardner and Lambert, there are two types of motivation. Integrative and instrumental motivations. Integrative motivation means learning a language with the intention of participating in the culture of that people. According to instrumental motivation, the learner learns with the support of a goal in connection with work and other useful motives. These two types of motivation can influence and control the outcome of the learning process. Gardner and Ellis also present the types of motivation mentioned as follows: the first occurs when the learner likes to be a member of a certain social environment and culture or to join, and the second occurs when the learner anticipates and sees the countless benefits that are predicted to be obtained by learning a certain language. Comparing these two motivations, it can be concluded that the best and most perfect motivation is integrative motivation. Individuals who cannot have this type of motivation face certain difficulties and problems (Miller et.al, 1999).

Intrinsic and extrinsic motivation. Intrinsic motivation is the interest and desire to do certain activities because the individual feels that they are pleasant and attractive. Students who have intrinsic motivation tend to gain knowledge from their own shortcomings and mistakes when they are faced with difficult and complex problems. In addition, intrinsic motivation is a fundamental and essential element for the integration process that occurs through the mixing and assimilation of elements of the individual's available internal awareness and knowledge with new knowledge. On the other hand, extrinsic motivation is the tendency to participate in activities for reasons unrelated to the activity. These reasons can be the expectation of reward or punishment, such as succeeding in an exam or getting a good grade. Thus, intrinsic motivation is the motivation to do an activity for its own sake. In essence, individuals with intrinsic motivation perform these activities because they think that these activities are fun. Intrinsic motivation is the motivation to do a task or activity as a means or path to achieving a goal. Those with intrinsic motivation do their work because they think that their contributions will produce enviable results, such as a reward, gaining the appreciation of their teachers, or avoiding punishment.

The preference and experience of certain types of motivation in language learning are not arbitrary. Instead, they are shaped by many factors, such as the nature of the learning, cultural influences, and the nature of the learning environment.

Learner characteristics. The personal and characteristic characteristics of the learner play an important role in determining the type of motivation they are likely to experience. Age, for example, has been associated with different motivational orientations (Singleton, 2001). Younger learners often exhibit intrinsic motivation due to their desire to explore and their innate or intrinsic interests. On the other hand, older learners may exhibit more instrumental motivation. This is because they are driven by goals such as career advancement and academic achievement.

Similarly, the personality of the learner can significantly influence the type of motivation. Individuals with an introverted personality may find intrinsic motivation more attractive and relevant, as they derive satisfaction from their personal learning pursuits. In contrast, extroverted individuals may be more influenced by extrinsic motivation due to their desire for social recognition and approval (Pham, 2021).

Cultural factors. Cultural factors also significantly influence the type of motivation a learner will experience. In some cultures, the learning process is often associated with external rewards such as grades and formal recognition. This fosters a high degree of extrinsic motivation. Conversely, cultures that emphasize personal growth and self-expression may encourage a higher degree of intrinsic motivation. Integrative motivation is also strongly influenced by cultural factors. Learners from multicultural and cosmopolitan backgrounds may be more inclined towards integrative motivation due to exposure to and admiration for different cultures.

Learning environment. This includes: teaching style, classroom dynamics, curriculum design, and assessment methods. These can greatly influence the type of motivation. A learning environment that encourages student autonomy, is engaging, and offers relevant learning materials can enhance intrinsic motivation.

Extrinsic motivation can be fostered in a learning environment where achievement is regularly acknowledged and rewarded. However, it is important to ensure that these extrinsic rewards do not undermine the intrinsic motivation that tends to sustain learning engagement in the long term (Rahman et.al., 2017).

A supportive and culturally diverse learning environment can also foster integrative motivation, as learners have more opportunities to appreciate and strive to integrate with different cultures. In contrast, a goal-oriented environment with clear practical consequences can foster instrumental motivation. Ultimately, understanding the complex interplay of learner character, cultural factors, and the learning environment in shaping motivation can provide educators with valuable insights for designing and implementing effective strategies that promote sustained, effective language learning.

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Technical Sciences

The Importance of the β Coefficient in the Algorithm for Determining Seismic Load Using the Spectral Method

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Abstract

This study examines a mid-rise school building and a high-rise multifunctional center, both analyzed using the finite element method with all relevant design loads. The seismic load criteria for the spectral methodology are taken from the current regulatory documents (PN 01.01-09) and (EN 1998–1:2004).

The school building is a four-story structure with one underground level, located in Tbilisi, near Lisi Lake. The building has a rectangular configuration, measuring 35.45 × 20.05 m with a maximum span of 7.1 m. Structurally, it follows a frame-braced system with reinforced concrete walls and slabs. The first floor height is 3.9 m, and the typical floor height is 4.2 m.

The multifunctional center is a 44-story high-rise with one underground level, located in Batumi, near the coastline. It also has a rectangular configuration, measuring 39.5 × 32.45 m with a maximum span of 13.1 m. Like the school, it follows a frame-braced system with reinforced concrete walls and slabs. The first floor height is 5.0 m, while the typical floor height is 3.5 m.

Using the seismic criteria from the planning parameters and regulatory methodologies, all required coefficient values for the school building calculations were determined, including the β coefficient.

Introduction

High-rise buildings belong to the first category of structures in terms of reliability and responsibility. Their structural design and construction are closely related to advancements in scientific and engineering technologies. In leading countries, high-rise design standards are well-established, but Georgia lacks a comprehensive methodological and regulatory framework. As a result, Georgian specialists often struggle to engage in high-rise building design.

However, some Georgian design firms have successfully undertaken high-rise projects in Tbilisi and Batumi. Given the increasing rate of high-rise construction in Georgia, ensuring seismic resistance is a critical issue. Strengthening earthquake-resistant measures is essential in seismically active regions.

Main Analysis

This study presents **two structural models**:

1. The **school building** has a height of **19.5 m**.
2. The **multifunctional center** has a height of **165.1 m**.

Both models were analyzed using **two different seismic standard**

- **Georgian Code (PN 01.01-09) – "Seismic-Resistant Construction"**
- **Eurocode 8 (EN 1998-1:2004)**

By comparing the results, we can observe the **differences in calculated seismic responses**, particularly regarding the **β coefficient**.

Research Methodology

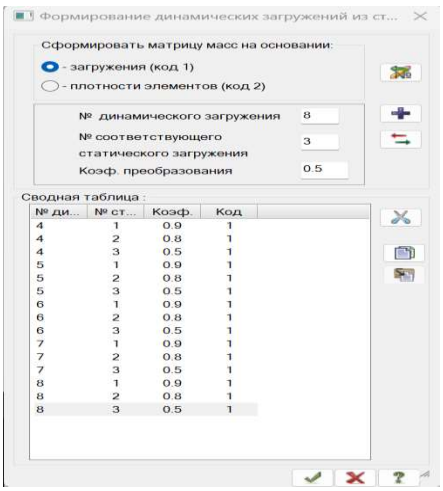
The study analyzes standard tables, dynamic coefficients, primary and secondary load combinations, force distributions, mass matrices, mutually exclusive loads, vertical load coefficients, acceleration spectra, soil types, behavior factors, seismic spectra, and vibration modes.

The SRSS (Square Root of Sum of Squares) method is used for summation. The structural calculations were performed in a computer-based numerical model using the LIRA-SAPR 2021 software (license #92095856).

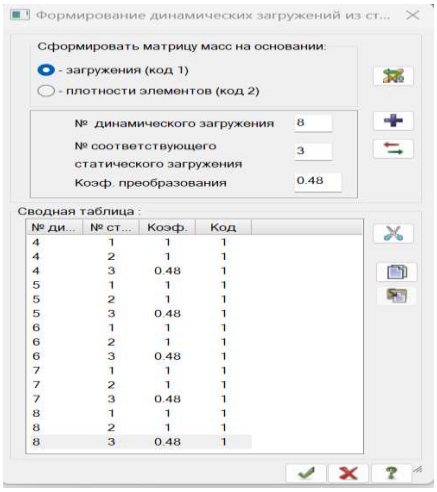
After completing the calculations, we analyzed the displacements, natural vibration modes, and reinforcement requirements to draw final conclusions.

Standard Tables of the Calculation Model

The static loads in the calculation model for seismic analysis are included with the following coefficients:

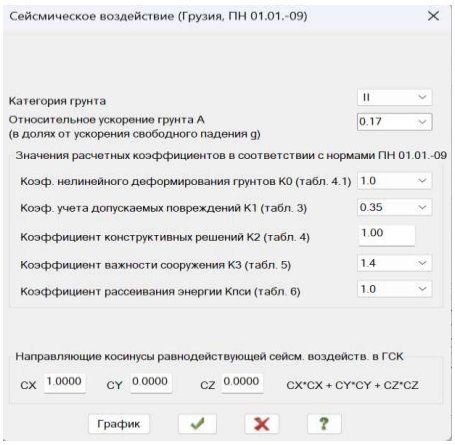


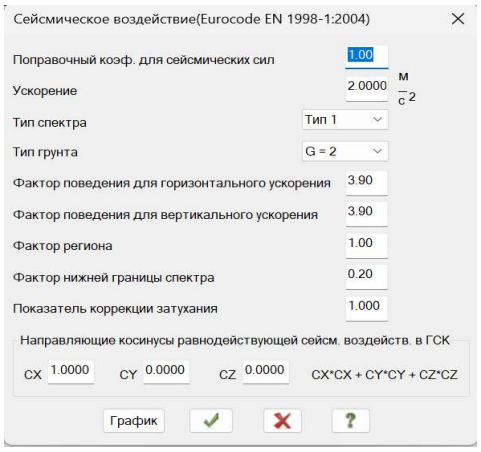
(PN 01.01.-09)



(EN 1998 – 1:2004)

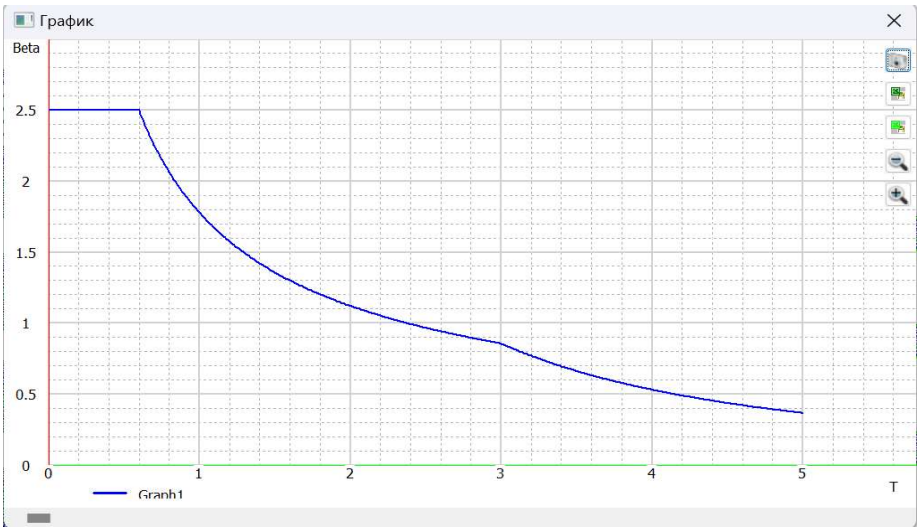
Standard Seismic Tables, presenting accelerations and coefficients defined according to the regulatory document:



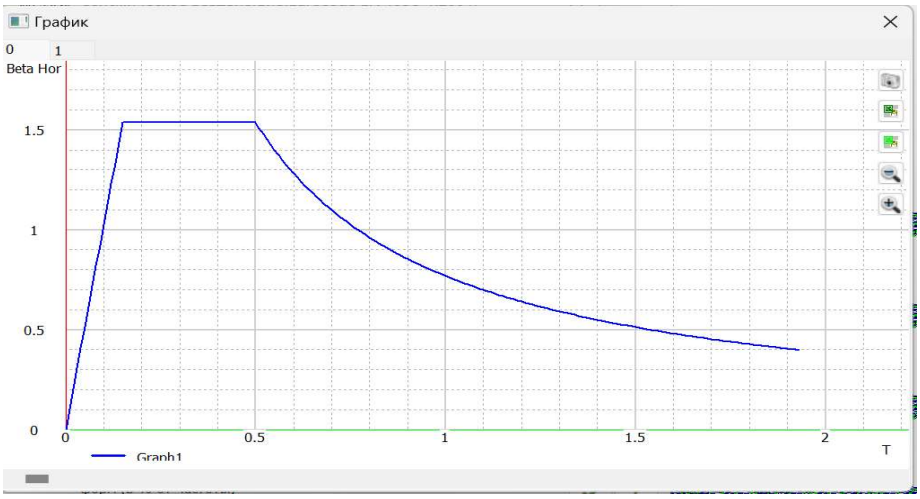


(PN 01.01.-09) (EN 1998 –1:2004)

Analysis of the Calculation Model: Acceleration graphs for both regulatory documents:

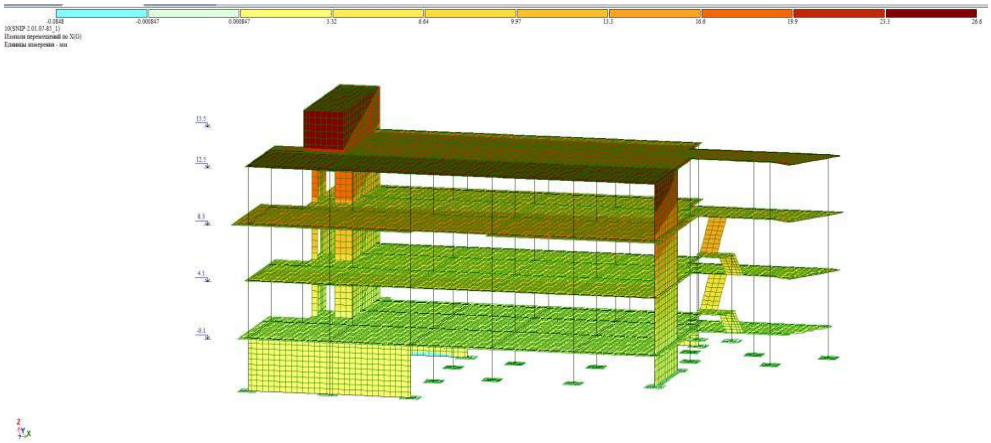


(PN 01.01.-09)

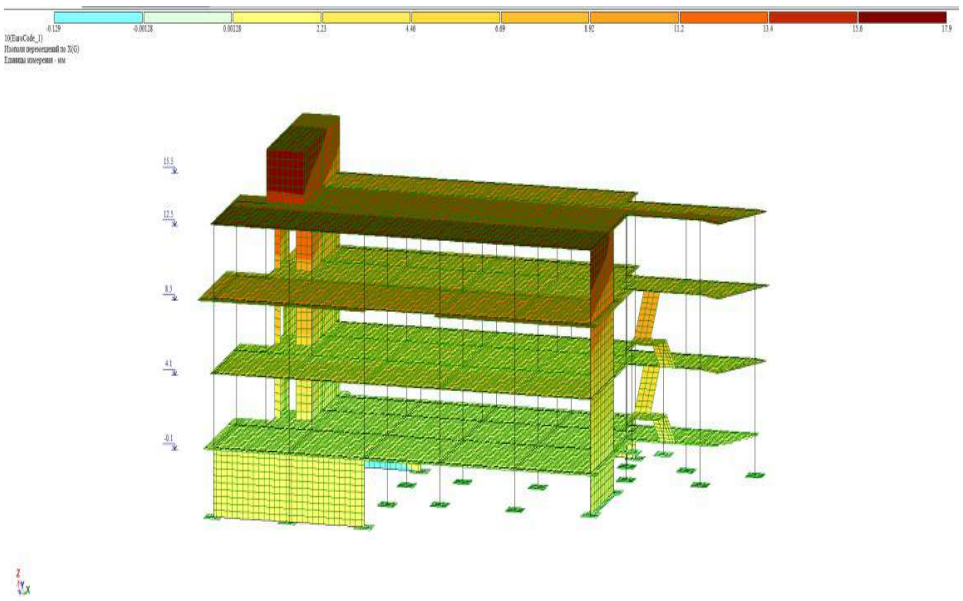


(EN 1998 – 1:2004)

Horizontal Displacement of the School Building: Horizontal displacement in the "X" direction:

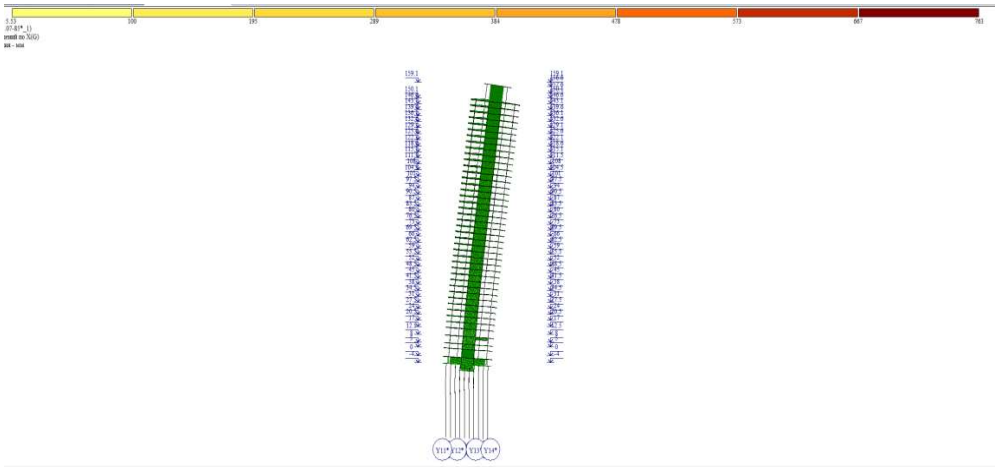


(PN 01.01.-09) Maximum value: 26.6 mm

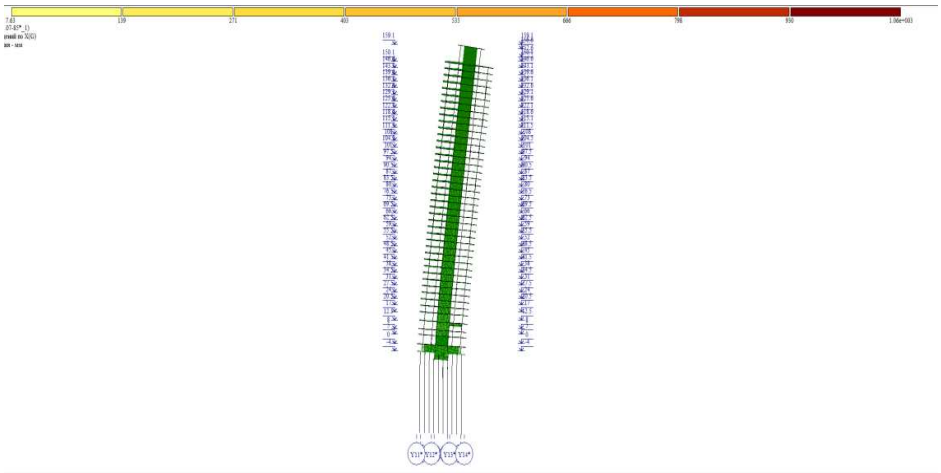


(EN 1998 – 1:2004) Maximum value: 17.9 mm .

Horizontal Displacement of the Multifunctional High-Rise Building: Horizontal displacement in the "X" direction:



(PN 01.01.-09) Maximum value: 763 mm



(EN 1998 – 1:2004) Maximum value: 1060 mm.

Interpretation of Results

Although Eurocode 8 assigns higher static loads, its seismic displacements (except for Z-axis soil displacements) are 20-30% lower than Georgian norms.
The significant difference is due to the spectral method algorithm embedded in the regulations. The β coefficient (βi), which represents the dynamic coefficient for a given vibration mode, is determined using specific formulas.

Grounds of category I	Grounds of category II	Grounds of category III
$0 \le T_i \le 0,4$ $\beta = 2.5$	$0 \le T_i \le 0,6$ $\beta = 2.5$	$0 \le T_i \le 0,8$ $\beta = 2.5$
$0,4 \le T_i \le 2,2$ $\beta = 2.5\ (0.4/T_i)\ 2/3$	$0,6 \le T_i \le 3,0$ $\beta = 2.5\ (0.6/T)2/3$	$0,8 \le T_i \le 3,0$ $\beta = 2.5\ (0.8/T_i)2/3$
$T_i > 2,2$ $\beta = 0.8$	$T_i > 3,0$ $\beta = 7.5\ 0.62/3/T5/3$	$T_i > 3,0$ $\beta = 7.5\ 0.82/3/T5/3$

Note: β cannot be less than 0.8 in all cases.

Extracted from the normative document
N 01.01.-09

According to PN 01.01-09, βi cannot be less than 0.8, regardless

Extracted from the normative document
P N 01.01.-09

of building height. This does not account for increased vibration periods in high-rise buildings, leading to higher seismic forces in the Georgian code compared to Eurocode 8.

Conclusion

The study confirms that Eurocode 8 results in significantly lower seismic displacements than Georgian standards.
To align with modern high-rise building requirements, Georgian norms should be revised, including:

1. Updating national annexes
2. Modifying the spectral method algorithm
3. Adapting regulations to contemporary high-rise engineering practices

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Genetic engineering: This is not the time we use it in clinical applications

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Abstract

The evolution of genetic engineering technologies have brought us to a point where we ask a lot of questions and there are many debates on whether we should be using innovative technologies like CRISPR-Cas9 in clinical applications in human embryos. This research essay will argue that no matter how much the technology grows, we have to be 100% sure about its consequences. In order to be sure, there needs to be deep research on those technologies. Do we know enough about the human genome to understand the impact of editing it? It is likely that some countries might consider using these technologies, but while these technologies are fast and cheap, there are consequences in modified embryos that might lead to mutation. This essay will state that scientists should communicate the power of technology and how they can be responsible in using it.

Introduction

As genetic engineering technologies develop, they become extremely precise, cheap, and fast; but there are many issues with practicing them. There might be ethical issues, technical issues, or even lawful issues that must be considered before using them. Humanity should not risk, there must be conducted deep research on the genetic editing technologies. For example, it might be used in adult cells to be analogous of taking a pill, however, those are *individuals* and will not pass on to their children. It has raised ethical issues; whether those changes should be made in human eggs, sperm, or embryos. Studies show it is impolite to use them in clinical application for now. Practicing genetic modifying technologies should be postponed in order to investigate and be 100% sure about the outcomes.

A new breakthrough in gene modification could greatly advance our capacity to reshape human DNA. The CRISPR method works by using bacteria to recognize the presence of DNA, after which it generates two short RNA molecules. These RNAs then combine with a protein called Cas9 to form a complex. It is a nucleus and a type of enzyme that can cut DNA. When the RNA finds its target within the genome, the protein Cas9 eliminates the target DNA and thus removes the virus. For the past decade, scientists have been researching this environment, and realized that this tool could be engineered to a point where you can cut not just a viral DNA, but any DNA sequence at a precise location. Furthermore, it can edit not only the DNA, but also fertilized egg, sperm, or embryos. It can target many locations at once and has been improving rapidly which allows researchers do basic experiments more comfortably. However, the result is unknown; being careful is what scientist advise.

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There are many debates on the use of new genetic editing technologies, but science does not stop the improvement. New technologies like CRISPR can be very useful in modifying early stage human embryos in peri implantation period. In fact, there might be an alteration even before the human embryo implantation in the mother's uterus; this stage is called blastocyst. However, there will be some complications. CRISPR-Cas9 can definitely be a useful tool to test the function of prospective genetic pathways. Many of the approaches are being practiced on a well-known mouse, "Despite the widespread prevalence of human *in vitro* fertilization as a means of aiding

infertile couples, we still know very little about the molecular events of preimplantation development, implantation and early placental formation in humans", says developmental biologist Janet Rossant who has dedicated much of her career to research on the mouse blastocyst. At the University of Toronto, she has been known for her role in establishing stem cell lines and advancing research on the mouse genome. Rossant emphasizes that molecular, morphological, and timing differences between mice and humans may play a major role in early pregnancy loss and influence the generation of pluripotent stem cells, which are crucial for advancing stem cell–based therapies.

According to Rossant, there are many practical hurdles to the potential of using CRISPR to study human embryo development. For example, many authorities prohibit the creation of human embryos. Many countries ban gene editing techniques that can potentially pass on to other generation. Nevertheless, researchers found ways of using CRISPR to make changes in human diploid zygotes. However, Rossant notes that these methods are still limited by less than perfect efficiency, as well as issues like mosaicism and unintended allelic variants, which keep their clinical use a distant goal.

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In November 2018, a Chinese scientist named He Jiankui performed a disturbing experiment. Media from all around the world reported that Jiankui used CRISPR to engineer twin girls to make their DNA immune to HIV infection. He is confronted by a Scientific community and one of the Nobel laureates, David Baltimore stated, "There has been a failure of self-regulation by scientific network". The problem with a Chinese scientist editing genes is not the genetic engineering itself, but the use of it without scientific evidence supporting the safety of CRISPR-Cas9. Raposo reports that neither twin carried the intended 32-base pair deletion in the CCR5 gene; instead, each embryo displayed variants of differing lengths. Raposo says, "These novel mutations have not been previously shown to prevent HIV infection and may even be harmful. " It might cause a serious problem on the structure of human cells. The presence of original and edited cells will lead to a phenomenon called mosaicism, and off-target effects that could cause other unanticipated changes in the genome.

The boom from the scientific network has left only one thing in place - the precautionary principle. After Jiankui's experiment, many countries have banned genome editing in humans. However, a professor in medical law, Vera Lucia Raposo, states that research has not been completely banned. She claims, "It has been allowed when its aim has been to obtain additional data on the procedure's safety." We should not be in a rush. We recognize the need for caution - not only to avoid irreversible genetic errors, but also to ensure sufficient time to address the legal and ethical challenges that accompany this field.

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Editing human genetics might be a big problem when it comes to being healthy and maintaining a strong immune system. Humans have an incredible immune system that can fight back and save the person. However, if we take a person with a transplant, everything turns to the dark side. The transplanted cells meet the originals, that initiates the immune response that leads to transplant rejections. As there is no effective way to fully prevent rejection, doctors try to reduce the likelihood of this issue by ensuring the pair are as histologically compatible as possible and by administering immunosuppressive drugs. However, "we can administer drugs that suppress immune activity and make rejection less likely. Unfortunately, these immunosuppressants leave patients more susceptible to infection and cancer" says Sonja Schrepfer from the University of California, San Francisco. The immunosuppressants can alone cause further problems.

After Jiankui revealed his study, a World Health Organization expert panel began developing guidelines for future CRISPR research and its ethical use. Scientists worldwide, including CRISPR co-inventor Feng Zhang, have urged a global moratorium on germline editing. As

Jenny Straiton, editor at Future Science Group, explains, this would involve halting all ongoing germline editing projects until an international framework is established.

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A Chinese scientist tried to implement new changes into twin babies which broke not only Chinese regulations, but also international ethical conventions. The issues raised include weak scientific value, excessive risks compared to benefits, improper ethics review, invalid consent from participants, and breaches of regulations. Besides these ethical issues, there are also off-target technical problems with CRISPR-Cas9 such as mutation, mosaicism, and on-target mutations with unwanted consequences. A researcher from the Dunedin School of Medicine at the University of Otago noted that off-target mutations may lead to defects, disabilities, or even cancer in some cases. Because these side effects are difficult to detect and evaluate, predicting, preventing, or managing their consequences remains highly challenging. Furthermore, these germline gene editing techniques may be passed onto other generation which might result in unforeseen effects. “Though there are different views on this, it warrants serious consideration, considering how many aspects of genome modification remain uncertain, and how much remains unknown about the nature of gene functioning.” says Jing-ru Li, from Dunedin School of Medicine, UofO. There is still more research to be done. And as technologies develop, there should be discussions on how we are going to regulate it.

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As genetic engineering technologies evolve, it is gaining the power to engineer desirable traits in humans. Danielle Simons, a senior research scientist at Stanford University School of Medicine, gives an example of a recent study. A team of scientists conducted genetic testing for muscle-related traits among volunteers in a resistance-training program. The test assessed whether individuals carried a genetic predisposition for muscle strength, size, and performance. Findings revealed that participants who received positive results were more likely to attribute improvements to their genetics rather than their own efforts, perceiving the changes as beyond their control. Thus, being aware of genetic background is important.

So called “designer babies”, that has been included in the *Oxford English Dictionary,* has been raising debates for the past couple of years. According to Simmons, enhancements in embryos for trait selection raises moral issues involving both individuals and society. “First, does selecting for particular traits pose health risks that would not have existed otherwise?”, she says, “The safety of the procedures used for preimplantation genetic diagnosis is currently under investigation, and because this is a relatively new form of reproductive technology, there is by nature a lack of long-term data and adequate numbers of research subjects. Still, one safety concern often raised involves the fact that most genes have more than one effect.” For example, in the 1990s researchers identified a gene associated with memory. Altering this gene in mice significantly enhanced learning and memory but also heightened pain sensitivity. Dr. Simmons further raises the ethical question of whether parents should be permitted to modify their children’s genes to select specific traits, given that the children cannot provide consent. What if a child grows up with strong muscles, but dislikes music? Would this affect the way a child feels about its parents?

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When it comes to genetic engineering, people ask a lot about what humans will be defined as such? The technology that we enjoy very much is not as valuable as our own biology. A technology and healthcare futurist, Jamie Metzl strongly believes, “Starting to see all of life, including our own, as increasingly manipulable will force us to think more deeply about what values will guide us as we begin altering biology more aggressively”. According to Metzl, genetic engineering tools touch the source code of what it means to be human and therefore must be regulated. It is not easy to control them. Technology grows to the level where governments cannot

keep up with the abilities of such tools.Meltz argues that to prevent harmful outcomes, each country should establish a national regulatory framework that aligns both with international best practices and with its own cultural values and traditions. “We also have to start developing global norms that can ultimately underpin flexible international standards and regulations.” he says “We urgently need to start preparing for what is coming”. One thing that humans have an advantage of and certain is that they are able to make appropriate decisions about their lives in ways that was impossible to do in the past.

The future is uncertain, but we must prepare for the worst. Genetic editing could easily shift from being a health or lifestyle choice to becoming a pill for survival. Meltz points out “It’s not that hard to imagine future scenarios when humans would need to genetically alter ourselves in order to survive a rapid change in our environment...preparing responsibly for these potential future dangers may well require we begin developing the underlying technologies today.”

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The Hell scenario from *Radical Evolution* by Joel Garreau describes many things the genetic technologies can be used in the future. Genetic engineering is a complex process. “The genetic basis of human nature is not only so complex as to defy the best efforts of Mao or Pol Pot to shape it,” (75) says Steven Pinker, a Harvard University professor. Pinker argues that individual genes rarely produce beneficial effects. For instance, no single gene determines mathematical ability or athletic skill, nor is there a “musical talent” gene—or simple genetic cures for conditions such as schizophrenia, antisocial personality disorder, or bipolar disorder. According to Pinker, the reality is far more complex, involving numerous genes interacting through feedback loops. He also stresses that predictions about technologies as intricate as genetic enhancement are highly uncertain, as they depend on overcoming technological, psychological, and sociological challenges.

In addition, Bill Joy, a legend in the computer programming and innovation industry, has some ideas about genetics, and scientists who are using them. He believes that scientists should control themselves, being extremely cautious about creating anything that can uncontrollably replicate itself. “Scientists do not believe they can do their work if they have to consider consequences...” he says, “Scientists and technologists must take clear responsibility for the consequences of their discoveries.” (68) And it is true. No one knows where this GRIN technology will bring us. But there is only research that needs to be done in order to discover more about genetic engineering and its applications in humans.

Conclusion

Do we know enough about the human genome to understand the impact of making changes to it in the development of embryos? As new technologies become cheaper and faster, scientists are disturbed since it is not appropriate to use CRISPR technologies in clinical application in human embryos. Some people with a sufficient amount of wealth might want to do it. But they are only shouting “we are going to try it before we understand it.” There will be many issues both technical and ethical. Unintended genetic consequences can turn off a gene very important to biological functioning. When this happens in human beings, it might actually create new genetic diseases; and the twin girls would have been genetically healthy. And since it is unstoppable, we have time and internal values to make correct decisions about how these technologies might affect our children and community.

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Pedagogical Sciences

English Teachers' Preferences for Using Digital Technologies and AI-Based Search Engines in Kazakhstan

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Abstract
This work is part of a broader study, the main purpose of which is to determine the field and preferences of English language teachers in relation to digital competence. The study focused on measuring the "use of digital resources and search engines based on AI" and was developed according to a quantitative and descriptive methodology, a basic type and a non-experimental cross-sectional design. Authors worked with a sample of 250 teachers who voluntarily and anonymously responded to the developed questionnaire. Data collection was carried out using a virtual questionnaire on the Google Form platform. The results show that there are no significant differences between most of the analyzed questions based on the studied independent variables. The use of digital technologies and AI-based search engines promotes students' participation in research.
Keywords: digital technologies, artificial intelligence, search engines, digital competence, digital environment, teacher training, higher education, students, English Teachers, Kazakhstan.

INTRODUCTION

Adaptation to the Bologna process in Kazakhstan, based on the new design and structure of university degrees, was associated with the discourse of "competencies". However, the key to higher education reform is not based on adapting curricula to a new structure, but on changing orientation or mentality. Consequently, a general transition from teaching to the learning paradigm in higher education is impossible without a parallel change in the ideas of university teachers about teaching and learning. Thus, future teachers need to be trained in competencies so that in the future they can teach their students with the help of competencies.

Digital technologies are usually seen as a resource that can facilitate and support the teaching and learning process. However, in today's situation caused by the pandemic (COVID-19), they are an important resource for both teachers and students of all countries and levels of education. The study of digital competencies is not recent either for citizens or for teachers.

As President K. said.Tokayev, in his message to the people of Kazakhstan, "A new Ministry of Artificial Intelligence and Digitalization will be created in Kazakhstan," which indicates serious approaches to the development of digital technologies in all areas, including education.

As part of the modernization of higher education, the curricula leading to the degree should be aimed at the acquisition of competencies by students, expanding digital skills, but not excluding the traditional approach based on the content and hours of study. Particular attention should be paid to the methods of teaching these competencies, as well as the procedures for evaluating their acquisition.

Thus, competence-based education and curricula are directly related to the planning of teaching and learning processes, which implies changes in the organizational structures and models of university institutions in general and in the teaching staff, methodologies and resources in particular. From this point of view, the educational goals planned for the training of future specialists should have a clear professional orientation. In practice, two types of educational goals can be distinguished, defined in terms of competencies:

General (inter-academic) competencies, divided into instrumental, personal and systemic. They are understood as abilities and skills that can be used in many situations, not just those related to a specific field of study, and thus they can be transferred and disseminated to any degree.

Specific competencies related to the areas being studied (theoretical, practical and/or experimental knowledge and specific skills in the field), which relate to the relevant and relevant methods and methods of each field. Among the instrumental competencies are "computer knowledge related to the subject area". This "digital competence" is the area of study of this study, as we believe that learning has evolved from exclusively analog content to the coexistence of analog and digital content. Therefore, digital skills training is important for future teachers, given the knowledge they need to learn in modern society.

The model of the key competencies of a citizen of the 21st century includes: communication in the native language; digital competence; learning skills for learning; social and civic competence; entrepreneurship; and competence in self-expression and cultural awareness.In this model, digital competence is defined as "the safe and critical use of Information Society (IST) technologies for work, leisure and communication." Thus, different authors and institutions have developed different models of digital competence, which can be synthesized in the definition given in, in which digital competence is understood as "values, beliefs. knowledge, skills and attitude to the proper use of technologies, including computers, as well as various programs and the Internet, which allow for the search, access, systematization and use of information for the accumulation of knowledge ".

The very first study was DigComp (a framework for the development and understanding of digital competencies in Europe), which was conducted in 2013, and its main goal was to contribute to improving the understanding and development of digital competencies. To this end, the study proposes to create a European consensus on digital competence in order to facilitate the development of a common framework that could help establish clear criteria on this topic. As for teachers, several organizations have been working on digital competence for teachers with the help of the European Framework for Digital Competence of Teachers (DigCompEdu) (published in 2017 by the Joint Research Center (JRC), which is the scientific and educational center of the European Commission. a service that hires scientists to conduct research in order to provide independent scientific advice and support EU policy (https://ec.europa.eu/jrc/en (as of August 14, 2021), which ensures the continuity of the work previously developed to determine the digital competence of citizens in general (DigComp).

The specific digital competencies of teachers are divided into six areas: (a) professional commitment, (b) digital resources, (c) digital pedagogy, assessment and feedback, (d) empowering students, and (e) promoting the development of students' digital competencies through three levels of competence each.

Research Methodology

For a descriptive study, percentages, measures of central tendency (mean) and variance (standard deviation) were used. The student's T (mean difference) was used to analyze the differences in relation to the independent variable "gender" and the analysis of variance (ANOVA) in the case of the independent variables "age" and "course".

The purpose of this study was to identify and explain the studied reality in order to draw conclusions and suggest contributions to improve it.

Procedure

The questionnaire was distributed, and the data were collected among teachers of English using the Google Form tool, and thus the knowledge gained by students.

Sample

The sample was not probabilistic and random and met the following inclusion criteria: (a) students from the Karaganda Buketov University; (b) students of senior education. To do this, all teachers who met these criteria were asked to voluntarily and anonymously answer the questionnaire. Data was analyzed by using SPSS version 24.0.

Instruments

The measurement tool is a tool designed to determine the use of digital resources and AI-based search engines in education by teachers with a master's degree, PhD students, PhD, as well as a doctor of sciences, and how competent they are in the use of digital technologies. It consisted of 20 questions, among which in this study we analyzed those grouped by the parameter "use of digital resources":

Item 19. Using digital resources and AI-based search engines for learning improves your ability to solve problems (for example: electronic libraries, institutional resource centers, repositories, portals, online courses, books, articles, e-learning materials, manuals, blogs, forums, social networks. , etc.).

Item 20. The use of AI-based digital resources for learning supports the creation of new ideas and content.

Item 21. The use of AI-based digital resources and search engines in your education contributes to an increase in the level of security and confidence during the development of your school activities.

Item 22. The use of AI-powered digital resources in your training stimulates interest in the subject being studied.

Item 23. The use of AI and digital resources in your training contributes to the development of social and communication skills.

Item 24. The use of AI search engines and digital resources in your training promotes cooperation and joint work on solving common problems.

Item 25. The digital resources you have access to meet your educational needs and/or interests.

Item 26. The digital resources offered by ILIAS (Integriertes Lern-, Informations- und Arbeits cooperations) System is the German abbreviation of the integrated learning, Information and cooperation system; it is an online platform used by the Karaganda Buketov University to facilitate teaching and learning tasks for students and teachers) will facilitate your learning.

Each of the elements that make up the dependent variable had five possible answers: 1 = Never; 2 = Rarely; 3 = Sometimes; 4 = often; 5 = Always. In addition, the influence of three independent variables - gender, age and course of study - was studied. To measure the internal

consistency of the developed device, the Kronbach alpha coefficient was calculated, obtaining α = 0.925, which, according to the result, allows us to consider the device reliable.

In addition, the Kaiser–Meyer–Olkin Sampling Adequacy Index (KMO) was calculated, which measures the adequacy of the sample for each variable in the model and for the entire model. This statistic is a measure of the proportion of variance among variables that may be the total variance. The lower the proportion, the more suitable the data is for factor analysis. The result obtained (KMO = 0.741) means that the data obtained are correct.

Results and Discussions

Within this context of the competencies of English teachers, our research focused on the second area, "digital resources", because although many studies have been conducted on the technological competencies possessed by different people who make up the teaching and learning process, this aspect has not been studied much, despite the fact that in the new reality generated by the pandemic, the need for safe, correct and open use of these educational resources by all teachers of the educational system has been proved.

These educational resources were clearly defined and differentiated, and some of them were created specifically for university education. Nevertheless, we must deepen and reflect on the training that is provided to future teachers, asking ourselves how :

Do our students (future teachers) know digital resources and AI search engines?

Have university professors used these resources to teach subjects?

Will our students know how to create appropriate digital resources for their future students?

Will our students know how to collaborate with other teachers and parents when choosing, creating, modifying and protecting educational digital resources?

That is, can students enrolled in the children's education program of the Karaganda Buketov University use ICT to receive, evaluate, store, produce, transmit, present and exchange information and participate in cooperation networks via the Internet?

The survey data was encoded and analyzed using the SPSS software package for Windows version 27.0. The analysis of questions through frequency and percentage ratio, as well as descriptive analysis (average and standard deviations) of each of the questionnaire items was carried out to determine, as the main purpose of the study, various aspects related to the use of technological resources by graduates studying for a master's degree. In addition, the analysis of variance (ANOVA) was used to study specific tasks depending on the socio-demographic variables "age" and "course", while the difference in average values (Student's t) was used for the variable "gender". The 99% confidence level was used for the ANOVA analyses (significance $p < 0.01$) and the 95% confidence level for the Student's t-analysis (significance $p < 0.05$).

Descriptive statistics

The following results were obtained with regard to the behavior of the regime. That is, the higher frequencies are in "agreements", and the lowest frequencies are in "disagreements". That's why this descriptive statistics of centralization shows us the number of people in the population who choose each option within each item, which indicates its greater or lesser relevance.

Students' perception of various aspects of the use of the studied digital resources received an average value in the range from 3.64 (point 26) to 3.99 (point 20). This indicates that the use of these resources for learning, as well as the attitude of students towards their use, is generally favorable. Oddly enough, the element with the lowest mean is the element with the highest standard deviation (sd = 1.097), which indicates a large variation in the response. Item 21 has the smallest standard deviation (sd = 0.888), which indicates that the majority of students (4 + 5 = 74%) believe that the use of digital resources contributes to their level of learning.

On the other hand, Figure 1 shows that the questions most related to motivation (elements 20 and 22) and easy access to resources that students need (element 25) have a clear tendency to agree, since the answer 1 (Never) matters. 0 in all of them. Point 21 stands out very close to this value, since only one of the respondents (0.7%) believes that the use of digital resources in their education never contributes to their level of security and confidence during the development of school activities.

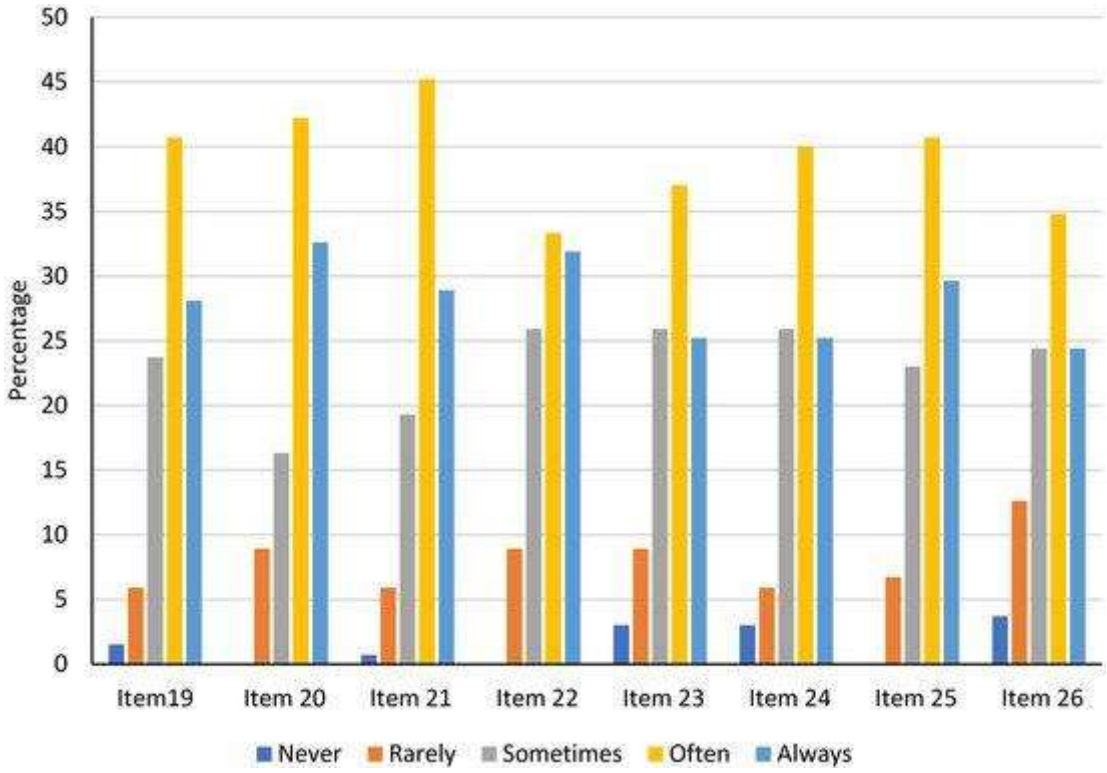

Figure 1. Percentage of answers to the studied questions.

Analysis of variance

On the other hand, we found no significant differences in the use of digital resources based on socio-demographic variables. This result is consistent with other studies, although we could detect inconsistencies in the gender variable. For example, the results achieved show, although other studies indicate the existence of differences in the use of digital resources by gender, suggesting that this is an important factor for integration into teaching practice and that research is needed to minimize the so-called digital gender gap.

Finally, there were significant differences in the degree of satisfaction with the resources offered by the virtual learning platform of Karaganda Buketov University, depending on the course to which students were enrolled; graduate students felt more satisfied because they believed that it made it easier for them to study subjects. Perhaps this reaction was caused by the fact that as students use digital tools more and more, they become easier to use and thus achieve better results, which motivates students to continue using them. In accordance with this, the study conducted by the authors showed that satisfaction with the use of digital educational resources is mainly related to the motivation of students.

Conclusion

This study shows that respondents have a fairly positive attitude, motivation and predisposition to use digital resources to facilitate their studies. Similarly, regular use of these resources provides students with a number of benefits closely related to social skills, which are a very important foundation for academic success. No significant differences were found in the use of digital resources based on socio-demographic variables. However, a significant difference was found, depending on the course, as to whether the digital resources provided by the virtual learning platform of Karaganda Buketov University facilitate student learning or not. In this case, the highest average was found in the later courses of study (third and fourth year).

Based on the results of this study, we believe that it would be interesting to explore this area of research, extending it to students of different degrees and graduate students, as well as from different geographical contexts at the national and international level.

Finally, looking ahead, it would be useful to conduct a qualitative study with data triangulation and, thus, be able to determine the impact of all these variables on the future academic and professional success of students.

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Medical Sciences

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BREAST, CERVICAL AND COLORECTAL CANCER: SCREENING AND CURRENT CLINICAL AND EPIDEMIOLOGICAL ASPECTS

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Annotation: In this scientific and analytical work, the indicators of incidence and mortality from cervical cancer, breast cancer and colorectal cancer in the regions of our country are

considered. The screening methods currently used and the results of this preventive survey of the population are described in detail. Detailed step-by-step algorithms are presented, and the principles of organization and diagnostic capabilities of the screening program for the active detection of these nosological forms of malignant neoplasms in clinically asymptomatic individuals are reflected.

Key words: cervical cancer, breast cancer, colorectal cancer, epidemiology, incidence, mortality, screening, Pap test, smear for oncocytology, ultrasound examination, mammography, hemocult test, fecal occult blood test - FOBT, total colonoscopy.

Today, one of the most important postulates of the oncology service continues to be the early diagnosis of malignant tumors. The purpose of screening is to identify asymptomatic (preclinical) cancer or precancerous conditions in an otherwise healthy target population. In this case, screening plays a leading role in secondary cancer prevention. The key concept of cancer screening is to identify pathology at a stage of development when the effectiveness of treatment is maximum and the prognosis is most favorable. When precancerous diseases are detected during screening, secondary prevention methods allow to prevent the transition of the initial pathological state to cancer. In this case, the main conditions for screening are the presence of trained personnel and a standard approach to identifying the trait being studied and evaluating the results. The methods used must be sufficiently simple, reliable and reproducible, as well as have sufficient sensitivity and high specificity [1-3].

Screening plays an important role in improving early diagnosis and treatment outcomes. According to the Guide to Cancer Early Diagnosis by Ilbawi A. et al. [4], screening aims to detect unrecognized cancer or its prior lesions in a typically healthy, asymptomatic population through tests or other procedures that can be applied quickly and are widely available to the target population. In screening, the target population is assessed for unrecognized cancer or precancer, and most people tested will not be diagnosed with the disease. Screening should be seen as a process and not as the performance of a specific test, examination, or procedure. The screening process includes a system of informing and inviting the target population to participate; administering the screening test; following-up with test results and referral for further testing among those with abnormal test results; ensuring timely pathologic diagnosis, staging and access to effective treatment with routine evaluation to improve the process. A screening program encompasses the process from invitation to treatment and requires planning, coordination and monitoring and evaluation.

To date, the republican oncological screening program includes three nosological forms of malignant neoplasms - cervical cancer (CC), breast cancer (BC), colorectal cancer (CRC). Let's consider the current epidemiological indicators, methodology and results of cancer screening in our country.

CC in the structure of all malignant tumors of both sexes of the population in 2022 took 6th place with a share of 5.51% (2021 - 4th place, 5.54%), in women - stable 2nd place - 9.7% (9.7%) [5].

The incidence rate per 100 thousand population increased from 9.4 to 9.92. In 10 regions of the republic, the incidence rate is higher than the national average: Pavlodar - 17.2 per 100 thousand people (2021 – 16.7) – the highest level, East Kazakhstan – 14.3 (10.8), North Kazakhstan – 14.3 (10.2), Atyrau – 13.2 (13.8), Zhetysu - 11.7, Karaganda - 11.7 (12.0), Abay - 11.1, Akmola - 11.1 (11.9), Mangistau - 11.1 (9.7), Kostanay - 10.8 (10.6) regions.

Low incidence rates in Zhambyl region - 5.8 per 100 thousand population (5.7), Turkestan region - 6.1 (5.2), Aktobe region - 8.3 (11.6), Kyzylorda region - 8.5 (8.2) areas.

CC in the structure of causes of death from malignant tumors of the population of both

sexes in 2022 rose from 9th to 8th position, with a share of 4.6% (2021 - 4.3%), mortality from CC is stable at 3.1 per 100 thousand population (3.1).

The mortality rate from CC in 10 regions is higher than the national average: Akmola - 4.2 per 100 thousand population (2021 - 3.1) - maximum level, West Kazakhstan - 4.1 (4.8), Pavlodar - 3.8 (5.6), Almaty – 3.7 (2.5), Zhetysu – 3.7, Atyrau – 3.4 (4.0), East Kazakhstan – 3.3 (3.8), Karaganda - 3.2 (4.7), Kostanay - 3.2 (2.4) regions and Almaty city - 3.4 (2.9).

Below the national average, mortality was recorded in Abay region, cities Astana, Shymkent - 2.9 per 100 thousand population, Mangistau - 2.8 (3.0), Turkestan - 2.3 (2.2), Aktobe - 2.2 (3.0), North - Kazakhstan - 2.0 (2.6), Kyzylorda regions - 1.7 (3.5) - the best result [5].

In 12 regions, a 100% level of morphological verification of the diagnosis was ensured, the lowest or worst indicator for the third year was in the Kyzylorda region - 94.3%, below the national average indicators in Akmola - 98.8%, Atyrau - 98.9%, Kostanay - 98, 9%, Mangistau - 97.6%, Pavlodar - 96.6%, regions and Almaty city - 98.5%;

In a number of regions, the frequency of diagnosis of stage I-II CC was below the national average (88.1%) - in Akmola - 76.2% (2021 - 73.6%) - the worst result in the country, in Karaganda - 77, 2%, Zhetysu - 82.9%, Abay - 83.8%, Kostanay - 84.3%, Aktobe - 85.5%, West Kazakhstan - 85.7%, Pavlodar - 81.3%, while that in the Atyrau region - 100.0% result.

The proportion of stage IV CC is higher than the national average (2.7%) in the following regions: the worst result is in Zhetysu (6.1%), above the national average in Karaganda - 5.1% (2021 - 5.6%), Akmola - 4.8% (2.3%), Kostanay - 4.5% (4.4%), North Kazakhstan - 3.9% (7.4%), Almaty - 3.7 % (5.1%), Zhambyl - 2.9% (0.0) regions, cities Almaty – 3.6% (1.8%) and Shymkent – 3.8% (5.9%). The lowest neglect is in the East Kazakhstan region - 1.0% (0.7%).

Late diagnosis rates (III-IV stages) for CC are above the national average - 11.9% (15.4% in 2021) were noted in Akmola - 23.8% (2021 - 26.4%) - worst result, Karaganda - 22.8% (35.2%), Pavlodar - 18.8% (20.8%), Zhetysu - 17.1% (24.2%), Abay - 16.2% (12.8%), Kostanay - 14.6% (15.6%), Aktobe - 14.5% (9.6%), West Kazakhstan - 14.3% (32.4%) regions. The lowest neglect is in the Mangistau region - 6.0% (20.8%).

Across the country, the five-year survival rate of patients with CC registered in 2018 was 59.9% in 2022, with a decrease from the level of 2021 (67.5% for those registered in 2017), and with a significant range in by region, from the maximum – 72.9% (2021 – 70.7%) in the North Kazakhstan region, to the minimum – 34.9% (64.4%) in the Atyrau region [5].

CC screening is a periodic, comprehensive examination of women of a certain age group as part of a special medical program to prevent and reduce incidence and mortality from CC.

Type of screening - population. The purpose of screening is to identify pre-invasive diseases of the cervix with subsequent recovery. The screening method is a cytological examination of a smear for oncocytology from the cervix (traditional and liquid cytology). Coloring according to the "Papanicolaou test" (Pap test). Interval - 1 time in 4 years. Target group: women aged 30-70 years who are not registered in the dispensary for CC. The expected results are a decrease in incidence and mortality from CC.

Screening steps:

1) Preparatory - formation of target groups, information support and invitation to screening. The preparatory stage is carried out by the nurses of the primary health care organization responsible for preventive measures and includes: annual compilation of a list of women subject to screening in the coming year by November 15 of the current year, followed by monthly correction; informing target groups of the female population about the need for screening; screening invitation; ensure timely screening.

2) Screening - filling out a statistical card of a preventive medical examination (screening) of an outpatient (form 025-08/y), a register of patients subject to cytological screening and taking material for cytological examination from the cervix. The screening examination of the target

groups of the female population is carried out by a specially trained midwife of the primary health care organization.

3) The final one is obtaining the results of cytology, informing the woman and developing further management tactics, fill out accounting and reporting statistical documentation. Responsible for the final stage of screening is the obstetrician-gynecologist of primary health care [6].

Cytological screening of CC is a complex of organizational and medical measures aimed at early detection of precancerous and neoplastic diseases of this localization and at reducing the mortality of this cohort of patients. For traditional cytology, a smear containing 8-12 thousand cells of stratified squamous epithelium (including cells of metaplastic epithelium) is considered adequate; for liquid cytology - 5 thousand cells. For both methods, the number of cells of endocervical epithelium and/or metaplastic epithelium (from the transformation zone) must be at least 10 (single or in clusters). If more than 75% of the cells of the stratified squamous epithelium are covered with erythrocytes, leukocytes, etc., then the quality of the smear is considered unsatisfactory.

Interpretation of the results of a cytological study is carried out according to the Bethesda-terminology cytological system:

Intraepithelial changes and malignant processes are absent (NILM). This group includes cytological conclusions about the normal state of the epithelium, as well as the presence of various non-neoplastic diseases. Normally, squamous epithelial cells, groups of cells of columnar epithelium and metaplastic epithelium, a small number of leukocytes, and rod/mixed microflora are found in preparations. In the presence of non-neoplastic processes, their nature and, if possible, the cause are specified: atrophic changes, reactive changes associated with inflammation, including typical regeneration. In addition, the presence of microorganisms is indicated: Trichomonas vaginalis, fungi, morphologically corresponding to Candida spp., bacterial vaginosis, cellular changes corresponding to the defeat of Herpes simplex virus, squamous epithelial cells with atypia of unknown significance (ASC-US), squamous epithelial cells with atypia of unclear significance, not excluding the presence of a high degree of intraepithelial changes (ASC-H). Low-grade squamous intraepithelial changes (LSIL) include lesions associated with HPV and CINI, high-grade squamous intraepithelial changes (HSIL) include CINII, CINIII, carcinoma in situ and cases suspected of invasion, squamous cell carcinoma, cervical (glandular) epithelium with atypia of unknown significance, cells of the cervical (glandular) epithelium, possibly neoplasia, endocervical adenocarcinoma in situ, endocervical adenocarcinoma, endometrial adenocarcinoma, secondary adenocarcinoma, unclassified carcinoma, other malignant tumors.

There are certain features when taking material for oncocytology: firstly, the examined woman should be informed about the exclusion of sexual intercourse, vaginal manipulations, including douching, baths, tampons, etc. 2 days prior to sampling. Taking material for cytological examination is carried out by the midwife of the examination room of the department of medical examinations of the primary health care organization: the traditional method (2 glasses - with obligatory fixation in 96% alcohol, it is preferable to use glass slides with a polished edge, which are easily marked) or the liquid cytology method (one container with stabilizing liquid); the code or surname of the patient, identical to the code and surname in the form for sending material for cytological examination, should be clearly marked on the glasses or container [6].

At the same time, when using the traditional method, the biomaterial is delivered to the cytological laboratory as soon as possible after its collection in specialized containers for glass slides with 96% alcohol. If there are visible visual changes in the cervix, then the material is taken from the woman and, without waiting for the results, she is referred for an examination by an obstetrician-gynecologist.

A cytological study is carried out in centralized cytological laboratories at oncological

institutions, where an archive of cytological preparations of patients involved in the screening examination is formed, regardless of the result, for a period of at least 10 years with the formation of a computer database.

What material and technical equipment is required to take material for a Pap test? It is as follows: soap and water for washing hands, a light source for cervical examination, a gynecological chair, a disinfected speculum and gloves, an Eyre spatula, a glass slide and a marking pen, a container with a stabilizing solution for liquid cytology, a fixative solution (96% alcohol), a container with warm water for lubricating and warming the vaginal mirrors, a 0.5% chlorine solution for disinfecting gloves and instruments, or another approved for this purpose. And, of course, the registration form itself.

For carrying out liquid cytology, you additionally need: a disposable cervix brush, a container with a stabilizing solution for liquid cytology, and a fixing solution.

At the same time, a smear for oncocytology cannot be taken: during menstruation, earlier than 48 hours after sexual contact or after using lubricants, vinegar or Lugol solution, tampons or spermicides, after vaginal examination or douching, and also during the treatment of genital infection.

Now, regarding the results of CC screening. In 2022, 771,282 women of the target group aged 30 to 70 years were examined during cytological screening (in 2021 - 757,454).

During cytological screening in 2022, 392 cases of cervical cancer were identified (319 in 2021). The detection rate increased from 0.42 to 0.51 per 1000 women examined

High detection of CC during screening is ensured in Aktobe, Almaty, Atyrau, East Kazakhstan, Kyzylorda, Pavlodar, North Kazakhstan, Turkestan regions and Shymkent city. The detection rate in these regions ranges from 0.55 to 1.59 per 1000 women examined. The best indicator is in Atyrau region - 1.59. Compared to 2021, there is an increase in detection in 10 regions, with the exception of Akmola, Aktobe, Zhambyl, Kostanay, Mangistau, North Kazakhstan regions and Shymkent city. The worst result in Astana is 0.15 per 1000 women examined [5].

Cytologically, cervical precancer was detected in 1.16% of those examined (2021 – 0.99%). The detection rate of precancer below 0.6% (the planned indicator for 2022, according to the Comprehensive Plan) was noted in Aktobe, Karaganda and Kostanay regions.

A high proportion of stage I CC (70% or more) was detected in 6 regions of the country (in 8 in 2021): Kostanay, Mangistau (94.7% - best result), North Kazakhstan, Turkestan regions, cities Almaty and Astana. Low levels of early detection of CC (below 50%) were not observed in any region.

Localized processes (stages I-II) were identified in 99.2% of all cases of detected cancer (96.5%). In the Akmola and Karaganda regions, cases of CC were identified not only in localized, but also in widespread stages of the process. A total of 3 cases of CC in stage III and no cases in stage IV were identified (11 and 0, respectively) [5].

BC ranks first in the structure of the frequency of malignant tumors of both sexes in the population with a share of 14.7% (2021 - 15.4%). This situation has been stable since 2004; in addition, BC ranks first and remains consistently in this position in the structure of female oncopathology. The incidence of BC in 2022 in the country as a whole increased to 26.5 per 100 thousand (2021 – 26.3). In the structure of cases, BC occupies the 1st ranking place in the vast majority of regions and cities of the country, except for three: Akmola, Kyzylorda and North Kazakhstan regions, where lung cancer takes the 1st ranking place [4].

Above the national average - 26.5 per 100 thousand of us. – incidence of BC in 10 regions of the country: Abay – 33.3, Akmola – 32.7 (2021 – 29.8), East Kazakhstan – 44.7 (39.9) – the highest level, West Kazakhstan – 31.2 (28.4), Karaganda – 40.2 (40.1), Kostanay – 37.5 (35.8), Pavlodar – 43.2 (47.4), North Kazakhstan – 34.7 (38.2) regions and Almaty city – 35.4 (34.5), Astana city – 31.5 (28.4). Below average indicators per 100 thousand of us. in Aktobe - 21.6 (24.3), Almaty

- 21.9 (17.7), Atyrau - 22.8 (15.7), Zhambyl - 14.2 (15.1), Zhetysu - 22.8, Kyzylorda - 14.6 (14.4), Mangistau - 14.7 (17.3), Turkestan - 11.3 (11.7) regions and Shymkent city - 14.9 (21.9) [5].

BC ranks third in the structure of causes of death from malignant tumors in the population of both sexes for the thirteenth year in a row, amounting to 8.1% in 2022 (2021 – 8.7%). In the republic as a whole, mortality from BC decreased by 13.0%, from 6.2 to 5.4 per 100 thousand people.

The regions where mortality from BC is higher than the national average include: Abay - 10.1 per 100 thousand people (maximum level), East Kazakhstan - 8.0 (2021 - 8.5), Pavlodar - 7.1 (10.0), North Kazakhstan - 7.0 (11.4), Kostanay - 6.9 (7.5), Akmola - 6.5 (8.2), West Kazakhstan - 5.7 (6.9), Zhambyl - 5.5 (4.8) and Astana city – 6.3 (6.6), Almaty city – 6.6 (9.5). The indicators are significantly lower in Aktobe - 4.5 (3.5), Almaty - 4.5 (5.8), Zhetysu - 4.0, Atyrau - 3.7 (3.0), Kyzylorda - 4.4 (4.1), Turkestan - 3.6 (3.6), Mangystau regions - 2.7 (3.6) - the lowest level [5].

Mass screening to identify BC patients should mainly involve healthy women without any signs of the disease or symptoms. Screening not only helps to detect hidden forms of cancer that can be treated, but also has psychological value for women. As a result of screening, women are convinced that they do not have BC, and this is the most important potential success of such programs. While the ultimate goal of screening is to reduce BC mortality, its immediate goal is to detect cancer before clinical manifestation. However, BC is a heterogeneous disease, which can significantly affect the effectiveness of screening. Screening models for BC are usually based on the fact that the majority of detected tumors are invasive cancers in the early stage of progression. In addition, it must be taken into account that the detection of cancer (or its precursors) before clinical manifestation increases the risk of false positive diagnosis [7,8].

Mammography has a sensitivity of 95% and a specificity of 97%. These indicators decrease when examining women with denser mammary glands (young age, use of hormone therapy), with low quality mammography, and also with insufficient qualifications of the radiologist. Detection of high-grade invasive cancer by screening, when the tumor is not yet detected by clinical examination (palpation), means the possibility of reducing mortality from BC [9].

Preventive screening for early detection of BC in the Republic of Kazakhstan includes [10]:

1) mammography of both mammary glands in two projections - direct and oblique in the mammography room of the city, district polyclinic (mobile medical complex). All digital mammograms in the presence of a system for archiving and transferring medical images are copied to CDs and other electronic media and transferred to the server of the mammography room of the Cancer Center using specialized licensed software integrated between medical organizations; in case of impossibility of digital transmission - they are printed on X-ray film at a scale of 1:1 - 100% (1 patient - 1 set - 2 or 4 mammograms) with subsequent transfer to the mammography room of the Cancer Center;

2) interpretation of mammograms according to the BI-RADS classification (M0t, M0d, M1, M2, M3, M4, M5) by two or more independent radiologists of the same medical organization - double reading or different medical organizations: a radiologist of the mammography room city, district polyclinic (mobile medical complex) - the first reading, and the radiologist of the mammography room of the Cancer Center - the second reading;

3) in-depth diagnostics - targeted mammography, ultrasound examination (hereinafter - ultrasound) of the mammary glands, trepanobiopsy, including under ultrasound or stereotaxic control for histological examination, which is carried out in case of detection of pathological changes on mammograms (M0d) in the mammography room of the Cancer Center.

√ An average medical worker or a responsible person of the organization of outpatient care sends the patient for mammography to the district, city polyclinic.

√ The X-ray laboratory assistant of the mammography room of the city, district polyclinic (mobile medical complex) performs mammography, fills out a referral for double reading of

mammograms and transmits the referral through information interaction.

Radiologist of the mammography office of the city, district polyclinic (mobile medical complex): fulfills the requirements for the safety and quality of mammographic examinations; evaluates the quality of the images provided and the correctness of the installation; performs repeated mammography in the M0t category (technical errors of mammography); determines the radiological density of the mammary glands on the ACR scale (A, B, C, D) indicating this parameter in the study protocol; conducts the first reading of mammograms with interpretation of the BI-RADS classification results. In the M0d category (undetermined or suspicious radiological changes requiring additional examination), the study protocol indicates the predominant pathology: education, asymmetry, violation of architectonics, microcalcifications; sends mammograms, electronic copies of mammograms through the archiving system and transfer of medical images to the workplace of the mammography office of the Cancer Center together with directions for double reading of mammograms; directs low–dose computed tomographic images through the system of archiving and transferring medical images to the workplace of the computer tomography office of the Cancer Center together with copies of images recorded on CD-ROMs or other electronic media and directions for double reading.

♦ The radiologist of the mammography room of the Cancer Center: evaluates the quality of the provided images and the correctness of the styling. Viewing digital x-ray images transferred to the server or on digital media (CD, DVD) is carried out on a monitor for interpreting digital x-ray images with a resolution of at least 5 megapixels, which has a certified grayscale transmission in accordance with the DICOM standard; conducts a double (second) reading of mammograms with the interpretation of the results according to the BI-RADS classification, using, if necessary, archival images. Organizes the third reading according to indications. With double reading, an independent interpretation of the images is carried out (blinding method - the second radiologist does not know the results of the first reading); in the M0m category (technical errors in mammography), recommends repeat mammography; in the M0d category (uncertain or suspicious radiographic changes requiring additional examination), the study protocol indicates the predominant pathology: education; asymmetry, violation of architectonics, microcalcifications; recommends that the outpatient care organization, according to indications, invite the patient for in-depth diagnostics (targeted mammography, ultrasound of the mammary glands, trephine biopsy, including under ultrasound or stereotaxic control, followed by histological examination of the material); collects and archives all mammograms (films and electronic media) made as part of the examination. The shelf life of mammograms is at least 3 years after leaving the age subject to a screening study; the results of the double (second) reading are transferred to the outpatient care organizations through information exchange.

♦ Indications for in-depth diagnostics are the conclusions of double reading mammograms M0d (uncertain or suspicious X-ray changes requiring additional examination).

♦ In-depth diagnostics is carried out in two stages. At the first stage, ultrasound is performed, according to indications, targeted mammography, possibly with an increase (with asymmetry, violation of architectonics and the presence of microcalcifications). When visualizing a suspicious pathology (M4 and M5), the second stage is performed - trepanbiopsy, including under ultrasound control and stereotaxic control for histological examination.

♦ Histological examination is carried out in the laboratory of pathomorphology or pathological bureau. Morphological interpretation of the biopsy is carried out in accordance with the recommendations of the World Health Organization.

♦ Physician or responsible person of the outpatient care organization:

1) upon receipt of a mammography result according to the BI-RADS classification:

- in case of M0t (technical errors in mammography) - sends the patient for a second X-ray examination to the mammography room of the city, district polyclinic (mobile medical complex);

- with M0d (undefined or suspicious X-ray changes requiring additional examination) - sends the patient for in-depth diagnostics to the mammography room of the Cancer Center;

- with M1 (no changes detected) - recommends that the patient undergo a follow-up mammography examination after 2 years. With radiological density of the mammary glands, C and D are sent for ultrasound of the mammary glands to exclude a false-negative result of mammography;

- with M2 (benign changes), refer the patient for a consultation with an oncologist (mammologist) of the clinical diagnostic department, followed by a screening mammography examination after 2 years;

- with M3 (probable benign changes) - sends the patient for short-term dynamic radiation observation to the local doctor with the recommendation of control mammography or ultrasound in 6 months;

- with M4 (signs that cause suspicion of malignancy), M5 (practically reliable signs of malignancy) and if it is technically impossible to perform a trepanbiopsy or a biopsy is refused, a referral to an oncologist (mammologist) of the clinical diagnostic department for dynamic observation and decision on the verification of the identified pathology;

2) upon receipt of the result of a histological examination:

- benign education - refers the patient to an oncologist (mammologist) of the clinical diagnostic department for dynamic monitoring, followed by a screening mammography examination after 2 years;

- formation with an indeterminate malignant potential or carcinoma in situ - refers the patient to the Cancer Center for consultation and treatment, followed by dynamic observation by an oncologist (mammologist) of the clinical diagnostic department at the place of her attachment;

- malignant neoplasm - refers the patient to the Cancer Center for treatment and follow-up;

3) communicates the results of the screening examination to the patient in any available way (by telephone, in writing, through electronic means of communication);

4) enters the results of double reading, in-depth diagnostics, histological examination, recommendations of the radiologist of the Cancer Center mammography room into the information system.

Establishing the size of the primary tumor is especially important in screening. Tumor size is an important criterion for evaluating the quality of screening and determining the ability of X-ray mammography to detect non-palpable tumors. Therefore, it is extremely important that pathologists measure tumor diameter as accurately as possible. The smaller the size of the primary tumor, the greater the likelihood of error in determining its size.

Let's analyze the results of BC screening. Mammography screening identified 1,570 cases of BC in 2022 (1,402 in 2021). The cancer detection rate increased from 1.78 to 1.94 per 1000 examined. The best result is in the Karaganda region – 2.63 per 1000 women examined. Low detection rate per 1000 examined, compared to the republican average, in Atyrau (1.72), Zhambyl (0.58), Kyzylorda (1.68), Mangistau (0.42 - worst result), Turkestan (1.22) regions and cities Astana (1.5) and Shymkent (1.58). Compared to 2021, there was an increase in the detection of BC in 9 regions, with the exception of Aktobe (decrease from 2.87 to 2.19 per 1000 women examined), Karaganda (from 2.73 to 2.63), Mangistau (from 1.10 to 0.42), North Kazakhstan (from 3.27 to 2.31), Turkestan (from 1.36 to 1.22) regions and cities Astana (from 1.54 to 1.50), Almaty (from 2.24 to 2.18) and Shymkent (from 2.35 to 1.58) [5].

In 2022, the proportion of patients identified during screening studies with early stages of BC (stage 0-I) was 50.2% during screening (in 2021 - 47.9%). A high proportion of stages 0-I BC (over 50%) was recorded in 8 regions (in 8 in 2021): Akmola, West Kazakhstan, Karaganda (70.8% - best result), Pavlodar, North Kazakhstan, Turkestan regions, cities Astana and Shymkent. Low

levels of early detection of BC (below 40%) were noted in Aktobe (19.3% - worst result), Zhambyl (34.8%), Kostanay (39.5%), Mangistau (27.3%) regions and Almaty city (37.3%). Localized cancer (0-I and II stages) amounted to 96.2% (2021 - 95.5%), while not a single case was detected in stages III-IV in Atyrau, West Kazakhstan, Zhambyl, Kyzylorda, Mangistau, Pavlodar regions, cities Astana and Shymkent. A total of 46 cases of breast cancer in stage III and 14 in stage IV were identified (52 and 11, respectively) [5].

Epidemiological indicators of CRC in the form of colon cancer and colorectal cancer are considered separately for objective reasons.

Colon cancer with a specific gravity of 5.53% (2021 - 5.2%) in the structure of oncopathology of both sexes of the population has risen to 5th place, in men it remains in 6th place - 5.8% (5.5 %), for women - in the 5th - 5.3% (4.91%) The incidence rate of cancer of this localization in the country in the reporting year increased from 8.8 to 9.95 per 100 thousand population.

The incidence of colon cancer in 10 regions is higher than the national average - 9.95 per 100 thousand population: Kostanay - 20.7 (2021 - 15.9), Pavlodar - 18.8 (15.3), North Kazakhstan - 18, 0 (12.7), East Kazakhstan - 16.9 (13.4), Karaganda - 15.4 (15.0), Akmola - 14.6 (10.2), West Kazakhstan - 11.0 (10.1), Abay - 10.0 (9.0) regions and cities Almaty – 12.8 (12.1) and Astana – 10.5 (9.0). As in 2021, colon cancer was detected much less frequently in Turkestan - 3.1 per 100 thousand population (2.7), Kyzylorda - 4.1 (4.6), Zhambyl - 5.5 (5.8), Almaty - 6.3 (4.7), Zhetysu - 6.4, Mangistau - 6.8 (4.9) regions and Shymkent city - 5.0 (4.0) [5].

Rectal cancer in the structure of malignant neoplasms of both sexes retains 7th place in rank with a specific gravity of 4.9% (2021 - 4.92%), but in men it dropped from 4th to 5th place - 6.1%, for women – from 9th to 10th – 4.0%. The incidence rate per 100 thousand population increased from 8.4 to 8.8.

A high incidence rate was recorded in Kostanay - 17.8 per 100 thousand population (2021 - 16.2), East Kazakhstan - 17.7 (13.9), North Kazakhstan - 15.6 (15.1), Pavlodar – 14.9 (18.1), Karaganda – 13.3 (11.7), Abay – 12.9, West Kazakhstan – 12.9 (9.8), Akmola – 10.3 (13.1) regions and Astana city – 10.3 (9.0). Traditionally, a low incidence of rectal cancer is observed in Mangistau - 3.1 (2.8), Turkestan - 3.3 per 100 thousand population (2.7), Zhambyl - 3.7 (5.1), Kyzylorda - 4, 1 (5.3), Almaty – 5.3 (5.6) regions and in Shymkent city – 5.5 (5.0) [5].

Rectal cancer in the structure of causes of death from malignant neoplasms of the population of both sexes in 2022 remained in 5th place with a share of 5.41% (2021 – 5.41%). In the republic as a whole, the mortality rate from this form of cancer was 3.6 per 100 thousand population (3.87).

The mortality rate per 100 thousand population was higher than the national average in East Kazakhstan - 7.8 (2021 - 8.6) - the maximum level, Pavlodar - 7.5 (7.6), Abay - 5.9, North Kazakhstan - 5.8 (4.3), Kostanay - 4.9 (4.9), West Kazakhstan - 4.8 (4.2), Karaganda - 3.8 (5.2) regions. Below the national average - 3.8 per 100 thousand population, mortality in Aktobe - 3.2 (4.1), Almaty - 2.6 (2.6), Atyrau - 2.5 (3.4), Zhetysu - 2, 6, Zhambyl - 3.3 (2.7), Turkestan - 2.1 (1.6), Mangistau - 1.9 (1.2), Kyzylorda regions - 1.8 (2.1) - the lowest figure , and cities Almaty – 3.7 (4.3), Shymkent – 2.6 (2.1).

Colon cancer in the structure of causes of death from malignant neoplasms of the population of both sexes in 2022, as in 2021, ranks 6th, with a share of 5.2% (2021 – 5.0%). At the same time, the mortality rate in the country decreased by 5.6%, from 3.6 to 3.4 per 100 thousand population.

Mortality rates in 10 regions are higher than the national average: East Kazakhstan - 7.1 per 100 thousand population (2021 - 5.1) - maximum level, Pavlodar - 5.6 (6.0), Kostanay - 5.3 (5.6), Akmola – 5.2 (3.8), Abay – 5.1, Karaganda – 5.1 (5.6), West Kazakhstan – 4.8 (4.4), North Kazakhstan – 4.8 (5.0) regions and cities Astana – 3.6 (2.7), Almaty – 4.5 (5.3). Low mortality rates

from colon cancer were noted in Kyzylorda - 1.2 per 100 thousand population (2.7) - the best result, Turkestan - 1.3 (1.7), Mangistau - 1.6 (2.6), Aktobe – 2.0 (2.5), Zhetysu – 2.4, Zhambyl – 2.5 (3.7), Atyrau – 2.5 (1.8), Almaty – 2.6 (1.8) regions and cities Astana – (2.7), Shymkent – (2.4).

For colon cancer (94.0%) - 100% verification level was achieved in 3 regions (Abay, Almaty and Turkestan regions), high rates in the Astana city (98.5%), Shymkent city (98.0%), Zhambyl (98.4%), Atyrau (98.2%) regions, low – in Akmola region (86.7%), Almaty city (84.3%), in the Kyzylorda region (61.8%) – the worst result since 2017.

For rectal cancer (97.4%) - in 6 regions there is a 100% verification level, the worst level is still in the Kyzylorda region - 85.3%, lower than the republican average in the Akmola region - 92.6%, Aktobe region - 96 .8%, Mangystau region - 87.0%, Pavlodar region - 95.3%, Almaty city - 93.2% [5].

The frequency of diagnosis of stage I-II rectal cancer, as a visually accessible localization (68.9% - national average) in the regions, was: in Akmola - 34.6% - the worst result, as in 2021, in the country (2021 - 44.1%), Mangistau - 47.8%, Abay - 53.9%, West Kazakhstan - 59.1%, Almaty - 66.2%, Zhetysu - 68.6%, Karaganda - 65, 7% regions and Shymkent city - 62.9%.

For colon cancer (52.4%), early diagnosis rates are higher in Pavlodar (65.9% - best result), Abay, Aktobe, Atyrau, East Kazakhstan, Zhambyl, Zhetysu, Karaganda, Kostanay, Pavlodar, North Kazakhstan, Turkestan regions and Shymkent. The lowest figure (23.5%) is in the Kyzylorda region.

For colon cancer (17.3%), the rates of neglect at stage IV are higher - in Akmola - 31.0% - the worst result (2021 - 20.3%), Zhetysu - 27.3%, Abay - 23.1% , Turkestan - 22.2% (29.1%), Karaganda - 28.1% (28.6%), West Kazakhstan - 18.8% (8.2%), Mangistau - 17.6% (19 .4%) regions and cities Astana - 18.0% (22.9%), Shymkent - 20.0% (22.7%). The lowest level of neglect is 2.9% in the Kyzylorda region (7.9%).

The proportion of stage IV in rectal cancer (13.1%) is higher in Akmola - 29.6% - the worst result (2021 - 19.4%), Abay - 19.7%, Kyzylorda - 17.6% (9.1%), Karaganda - 16.9% (28.4%), Almaty - 15.6% (17.0%), Kostanay - 14.8% (11.1%), Zhambyl - 13.3 % (13.6%) regions and Shymkent city - 14.5% (12.5%). The lowest level of neglect - 6.0% - is in the Atyrau region (12.5%).

Late diagnosis of rectal cancer as a visually accessible localization (stages III-IV) in 2022 amounted to 31.1% (in 2021 - 33.5%).

For rectal cancer, the level of neglect is higher than the national average - 31.1%, the indicators in Akmola - 65.4% (2021 - 55.9%) - the worst result in the country, Mangistau - 52.2% (38.1%), Abay – 46.1% (30.6%), West Kazakhstan – 40.9% (25.4%), Karaganda – 34.3% (46.5%), Almaty – 33.8% (35.7 %), Zhetysu - 31.4% (34.1%) regions and Shymkent city - 37.1% (42.9%). The lowest neglect is in the Atyrau region - 12.0% (17.5%).

In the country as a whole in 2022, the five-year survival rate of patients with CRC registered in 2018 decreased to 40.4% (2021 - 52.9% for those registered in 2017); there is a significant dispersion of indicators by region, from maximum – 56.1% (47.5%) in the Kyzylorda region, to minimum – 24.3% (51.5%) in the Aktobe region [5].

Screening of CRC screening is the systematic use of screening studies in an asymptomatic population. The purpose of screening is to identify people with abnormalities suggestive of CRC. These persons in the future need additional examination to clarify the diagnosis. Opportunistic screening is the non-systematic use of screening tests in routine medical practice. A screening program is much more challenging than an early detection program. At the same time, the success of the screening program is largely determined by the awareness of the population and medical workers about the possibilities of early diagnosis of CRC. The feasibility of a screening program is determined by several factors that relate to the disease being screened, the screening test, the characteristics of the population, and the characteristics of the healthcare system.

The first factor is that the disease must be well understood, common enough in the target population to justify screening, have a recognizable early stage; treatment of the disease at an

early stage should be more effective than at a later stage.

The second is that the test should be characterized by sufficient sensitivity, i.e. the ability to detect cancer among people with the disease; sufficient specificity - the probability that among people who do not have a disease, the test result will be negative; have a high positive predictive value (positive predictive value) or, in other words, the likelihood that people with a positive test result have the disease; have a high predictive value of a negative result (negative predictive value), i.e. the likelihood that people with a negative test result do not have the disease; security; low cost; and acceptability - the likelihood that people for whom this test is intended will agree to the examination (which to some extent depends on the awareness of the population about the possibilities and importance of early diagnosis).

The third factor is that the healthcare system should be ready for maximum screening test coverage of the target group, have the resources to confirm the diagnosis, appropriate treatment and follow-up of people with positive test results, and regularly conduct screening tests at regular intervals. At the same time, the benefits of screening must outweigh the potential physical and psychological harm and justify the financial costs of its implementation [11].

The factors most significant for the development of CRC are:

- the presence of chronic inflammatory bowel diseases, adenomatous polyps, cancer of other localization, etc.;

- family history (presence of one or two first-degree relatives with CRC or familial diffuse intestinal polyposis);

- the age of men and women over 50 years old, taking into account the fact that more than 90% of patients with colorectal cancer are people of this age (medium risk).

Age, regardless of gender, is an important risk factor for CRC. After the age of 50, the incidence of CRC increases from 8 to 160 per 100,000 population. Thus, people who have reached the age of 50, even in the absence of symptoms, constitute a moderate risk group for CRC.

The second category of increased risk of CRC (20%) is made up of persons with a genetic and family predisposition, suffering from chronic inflammatory bowel diseases, diffuse familial polyposis.

The high-risk CRC group is determined by the so-called Amsterdam criteria (the presence of malignant tumors in two generations, the presence of cancer in a first-line relative under the age of 50 years), in this case, CRC screening should be carried out after the age of 30 years [12].

The degree of individual risk of developing CRC is determined before screening to select the scope of studies and the frequency of their conduct.

The interval for oncological colorectal screening is 1 time in 2 years, target group: men and women aged 50-70 years, with the exception of persons registered at the dispensary for CRC and colon polyposis. At the same time, when forming the target group, one should take into account the absence of severe concomitant diseases, such as the presence of a common malignant neoplasm, cerebrovascular diseases in the stage of decompensation, chronic obstructive pulmonary disease with respiratory failure, cirrhosis of the liver, myocardial infarction with congestive heart failure, diabetes mellitus with vascular complications. and others, which are highly likely to lead to death in the next 10 years.

The first step in screening for CRC is the fecal occult blood test (FOBT). Traditionally, such methods include a benzidine test for occult blood in the feces. This is a biochemical method based on the assessment of pseudoperoxidase activity of hemoglobin. There is ample evidence that invitation to guaiac FOBT screening (gFOBT) reduces CRC mortality by approximately 15% in age-matched average-risk populations.

To ensure the effectiveness of screening with gFOBT, the interval for screening under the national screening program should not exceed two years. To date, there is an immunochemical FOBT method - iFOBT, which is superior in efficiency to gFOBT in terms of the probability of

detecting adenoma and cancer. iFOBT has improved analysis performance compared to gFOBT.

Immunochemical (immunochromatographic) examination of feces for occult blood - iFOBT or hemocult test is carried out for all men and women of the target group using an express method, which allows you to get a result within 3-5 minutes, without the participation of a medical worker. However, the evaluation of the test is carried out only by a medical worker in the PHC preventive department.

With a positive analysis of feces for occult blood, the second stage of colorectal screening is performed, which consists in endoscopic examination of the colon - total colonoscopy [6]. At the same time, in this case, this medical manipulation is of a therapeutic and diagnostic nature, since it allows one-stage removal of adenomatous polyps, which, according to various authors, occur in every third subject after 50 years of age. At the same time, women have 20% fewer polyps than men, but they have more right-sided lesions, which are more difficult to detect using fecal blood tests, because they are less traumatic [13,14].

What results were obtained from screening for CRC? In 2022, 937,859 men and women of the target group aged 50 to 70 years were examined during colorectal screening (in 2021 - 920,640) [5].

Colorectal screening revealed 325 cases of colorectal cancer in the reporting year, which is 114 cases more than in the previous year (211 cases). The detection rate increased from 0.23 to 0.35 per 1000 patients examined. Low detection of colorectal cancer was noted in Zhambyl, Karaganda, Kostanay, Kyzylorda, Mangistau, Turkestan - the worst result, East Kazakhstan regions, Astana city - from 0.07 to 0.30 per 1000 examined. The best result is in the North Kazakhstan region – 0.81 per 1000 examined. Compared to 2021, there was a decrease in the detection of colorectal cancer per 1000 people examined during screening in Karaganda (from 0.22 to 0.21), Kostanay (from 0.29 to 0.28), Mangistau (from 0.20 to 0.12) regions and Astana city (from 0.20 to 0.19).

Colon precancer (adenoma detection rate) was detected in 27.5% of patients who underwent colonoscopy (2021 – 22.8%). The detection rate of precancer in Akmola, Aktobe, Almaty (8.5% is the worst result), West Kazakhstan, Zhambyl, Kostanay, Kyzylorda, Mangistau, Pavlodar, North Kazakhstan, Turkestan regions and cities is lower than the national average Astana and Shymkent. The best result is 36.2% in Almaty city. It should be noted that the planned indicator for the detection of precancer of the colon and rectum in the country for 2022, according to the Comprehensive Plan, was 23.0% and was achieved.

In 2022, the proportion of patients identified during screening studies with early stages of malignant neoplasms (stages 0-I) was 26.2% during colorectal screening (in 2021 - 27.5%).

High early detection of colorectal cancer (above 30%) was noted in Akmola, West Kazakhstan, Karaganda, Kostanay, Kyzylorda, Turkestan regions and Astana city (57.1% - the best result). Not a single case of early cancer has been identified in the Mangistau region. Cases of cancer in stages III-IV detected during screening were registered in Akmola, Aktobe, Almaty, West Kazakhstan, Zhambyl, Karaganda, Kostanay, Mangistau regions and Almaty city. A total of 21 cases of colorectal cancer in stage III and 3 in stage IV were identified (in 2021 - 18 and 5, respectively) [5].

The complex analysis carried out allows us to conclude that satisfactory results of cancer screening can be achieved only with its proper organization, high quality of implementation, active participation in population screening, the use of highly sensitive tests and instrumental methods of preventive examination, as well as subsequent accurate diagnosis of identified tumors and timely treatment. High-quality screening leads to early diagnosis of pedological diseases and malignant pathology in the early stages, which, in turn, increases the effectiveness of treatment and improves the prognosis of the disease. Target groups that, for one reason or another, do not participate in screening should be informed that there are no other methods other than screening

that would reduce mortality from malignant neoplasms. Incidence and mortality rates from cervical cancer, breast cancer and colorectal cancer clearly reflect the epidemiological situation with this pathology in the regions of our country.

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Biological Sciences

Molecular Hallmarks of Aging: Integrated Profiling Reveals Epigenetic Erosion and Proteostatic Collapse

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Abstract
Aging is a multifaceted biological process shaped by genetic, epigenetic, and environmental influences. Recent advances in high-throughput technologies have enabled unprecedented exploration of posttranslational modifications (PTMs) and epigenetic remodeling, both of which are central regulators of cellular function during aging. Mass spectrometry-based proteomics, single-cell multi-omics, and spatial epigenetic profiling now allow investigators to track molecular changes at a resolution previously unattainable. Simultaneously, bioinformatics and machine learning approaches facilitate integration of these molecular datasets with clinical phenotypes, revealing predictive biomarkers of age-related disease and therapeutic response. This article synthesizes recent progress in the study of PTMs and epigenetics in aging, highlights novel technological platforms, and discusses the role of computational biology in translating molecular insights into precision medicine for aging populations.
Keywords: Aging, DNA Methylation, Epigenetic Drift, Histone Acetylation, Ubiquitin-Proteasome System, Proteostasis, Post-Translational Modifications, Biomarkers, Cellular Senescence, Molecular Hallmarks of Aging

Introduction
The complexity of aging
Aging represents the gradual decline of physiological functions, driven by cumulative cellular and molecular damage. The hallmarks of aging—including genomic instability, telomere attrition, loss of proteostasis, deregulated nutrient sensing, mitochondrial dysfunction, cellular senescence, stem cell exhaustion, and altered intercellular communication—capture the systemic nature of this process (López-Otín et al., 2013). Among these, two mechanisms stand out for their regulatory depth: posttranslational modifications (PTMs) of proteins and epigenetic alterations of chromatin. Both modulate cell identity, signaling pathways, and adaptive responses to stress, and their dysregulation accelerates age-related functional decline (Sen et al., 2016; Booth and Brunet, 2016).
Posttranslational modifications as modulators of aging
Proteins rarely act in their unmodified form; they undergo a dynamic set of chemical modifications such as phosphorylation, acetylation, ubiquitination, SUMOylation, and glycosylation. These PTMs finely regulate protein folding, stability, subcellular localization, and protein–protein interactions (Deribe et al., 2010). Aging tissues exhibit characteristic alterations in PTM patterns, for example increased protein carbonylation in oxidative environments (Stadtman and Levine, 2000), dysregulated histone acetylation linked to chromatin remodeling (Peleg et al., 2016), and impaired ubiquitin-proteasome system function (Vilchez et al., 2014). Thus, PTMs provide both mechanistic insights and potential intervention points for modulating aging trajectories.

Epigenetic drift and the aging clock

In parallel, epigenetic regulation governs gene expression without altering DNA sequence, primarily through DNA methylation, histone modifications, and changes in chromatin accessibility. During aging, cells undergo a process termed epigenetic drift, characterized by stochastic and programmed changes in methylation patterns and histone marks (Issa, 2014). This underlies the development of epigenetic clocks, mathematical models that predict biological age with high accuracy based on DNA methylation states (Horvath, 2013; Levine et al., 2018). Beyond serving as biomarkers, these clocks reflect causal aspects of aging biology, linking chromatin dynamics to organismal longevity (Field et al., 2018).

From molecular signatures to clinical translation

Understanding how PTMs and epigenetic alterations shape aging is not only of theoretical importance but also has direct clinical implications. Age-related diseases such as Alzheimer's disease, cardiovascular disorders, and cancer often share molecular signatures involving both PTM dysregulation and epigenetic remodeling (Benayoun et al., 2019; Berdasco and Esteller, 2019). The integration of these molecular data with clinical parameters and digital health information opens pathways for precision gerontology, where predictive biomarkers can guide early interventions.

Emerging technologies

The past decade has seen an explosion of cutting-edge technologies enabling exploration of PTMs and epigenetics with unprecedented precision. High-resolution mass spectrometry allows mapping of proteomes and PTM landscapes across tissues and single cells (Aebersold and Mann, 2016). Single-cell epigenomic tools, such as ATAC-seq and single-cell methylation profiling, uncover cellular heterogeneity in chromatin states (Clark et al., 2018). Spatial transcriptomics and epigenomics further contextualize these molecular changes within intact tissue microenvironments (Moses and Pachter, 2022). Integrating these advances with computational pipelines and artificial intelligence supports multi-omic synthesis, turning raw data into clinically meaningful insights (Zhou et al., 2023).

Posttranslational Modifications in Aging

Posttranslational modifications (PTMs) are covalent chemical changes to proteins that occur after translation, allowing cells to dynamically regulate protein function, localization, and interactions. More than 200 types of PTMs have been described, and their combinatorial complexity creates a vast "proteoform" landscape. During aging, PTM patterns shift, contributing to impaired protein homeostasis, mitochondrial dysfunction, and genomic instability. The advent of next-generation proteomics has transformed the study of PTMs, making it possible to measure global patterns and single-cell dynamics in aging tissues.

Major Classes of PTMs Relevant to Aging

Phosphorylation

Phosphorylation, catalyzed by kinases and removed by phosphatases, modulates signaling pathways central to cellular stress responses and metabolism. Aging is associated with altered phosphorylation of key proteins in insulin/IGF-1 signaling and mTOR pathways, both of which regulate longevity (Kennedy and Lamming, 2016). For example, age-dependent hyperphosphorylation of tau in neurons is a hallmark of Alzheimer's disease, linking PTMs directly to neurodegeneration (Mandelkow and Mandelkow, 2012).

Acetylation and Deacetylation

Histone acetylation controls chromatin accessibility, while acetylation of metabolic enzymes fine-tunes energy homeostasis. Aging is marked by shifts in acetylation balance, partly due to declining activity of sirtuins, NAD^+-dependent deacetylases with established roles in longevity (Houtkooper et al., 2012). SIRT1 and SIRT6, in particular, regulate DNA repair and metabolic adaptation, and their modulation has been shown to extend lifespan in animal models (Kanfi et al., 2012).

Ubiquitination and Proteostasis

The ubiquitin–proteasome system (UPS) degrades damaged or misfolded proteins, safeguarding proteome integrity. With aging, ubiquitin ligase activity declines and proteasomal degradation efficiency is reduced, leading to accumulation of toxic protein aggregates (Vilchez et al., 2014). UPS impairment is implicated in age-related neurodegenerative diseases, where proteins such as α-synuclein and huntingtin accumulate in aberrant forms (Bence et al., 2001).

SUMOylation

Small ubiquitin-like modifier (SUMO) conjugation regulates nuclear organization, transcription, and stress responses. SUMOylation declines with age, and genetic disruption of SUMO-related enzymes in model organisms accelerates senescence (Ryu et al., 2010). Interestingly, SUMO modification of transcription factors such as p53 fine-tunes stress responses that influence cellular lifespan (Zhao, 2018).

Glycosylation

Protein glycosylation governs cell–cell communication, receptor activity, and immune recognition. Age-associated changes in glycosylation patterns of immunoglobulins contribute to the phenomenon of "inflammaging," the chronic low-grade inflammation of aging (Gudelj et al., 2018). Altered N-glycosylation has been linked to frailty, cardiovascular disease, and impaired immune responses in older adults.

Crosstalk Between PTMs

PTMs rarely act in isolation; instead, they form a regulatory code. For instance, phosphorylation can create docking sites for ubiquitin ligases, linking signaling to protein degradation. Similarly, acetylation and methylation of histones often compete for lysine residues, shaping chromatin states. Dysregulation of this PTM crosstalk amplifies aging phenotypes, as observed in cancer cells that hijack PTM networks to escape senescence (Hunter, 2007).

Technological Advances in PTM Analysis

Quantitative Mass Spectrometry

High-resolution mass spectrometry has become the gold standard for global PTM profiling. Techniques such as data-independent acquisition (DIA) and parallel reaction monitoring (PRM) allow sensitive, reproducible quantification of phosphorylation, acetylation, and ubiquitination sites across proteomes (Aebersold and Mann, 2016). Time-course studies of aged versus young tissues now map PTM alterations at a systemic level.

Top-Down Proteomics

Unlike classical "bottom-up" approaches, top-down proteomics analyzes intact proteins, capturing multiple coexisting PTMs on a single molecule. This provides insight into proteoforms, which may have distinct biological activities. In aging, top-down studies reveal complex PTM signatures of histones and metabolic enzymes, offering mechanistic clues to their regulatory functions (Smith and Kelleher, 2018).

Chemical Biology Probes

Synthetic probes that covalently label specific PTMs allow in vivo detection and quantification. For example, O-GlcNAcylation probes have revealed dynamic regulation of nutrient-sensitive signaling pathways during aging (Zachara and Hart, 2006). Such tools expand beyond what mass spectrometry alone can detect, enabling longitudinal studies of PTM flux.

Structural Biology: Cryo-EM and NMR

Structural methods such as cryo-electron microscopy (Cryo-EM) and nuclear magnetic resonance (NMR) spectroscopy now resolve conformational changes induced by PTMs. Age-related misfolding of proteins like tau and amyloid-β has been linked to abnormal phosphorylation and glycosylation states, visualized directly at near-atomic resolution (Fitzpatrick et al., 2017).

PTMs in Age-Related Disease

Neurodegeneration: Hyperphosphorylated tau and impaired ubiquitination drive Alzheimer's and Parkinson's pathology (Mandelkow and Mandelkow, 2012; Bence et al., 2001).
Cancer: Dysregulated acetylation and SUMOylation promote tumor cell immortality, partly by inactivating senescence programs (Ryu et al., 2010).
Metabolic disease: Altered acetylation of mitochondrial enzymes contributes to insulin resistance and metabolic decline in aging (Houtkooper et al., 2012).
Cardiovascular aging: Glycosylation changes in circulating proteins correlate with vascular stiffness and endothelial dysfunction (Gudelj et al., 2018).
PTMs represent a dynamic and multifaceted layer of aging regulation. Their dysregulation disrupts proteostasis, signaling, and genome stability, driving hallmarks of aging and age-associated diseases. Modern proteomic and chemical tools now allow global, structural, and even single-cell resolution of PTM landscapes, providing critical mechanistic insights and translational potential.

Epigenetics and Biological Age

Epigenetics refers to heritable yet reversible changes in gene expression that do not involve alterations to the DNA sequence. The key molecular mechanisms include DNA methylation, histone modifications, chromatin remodeling, and non-coding RNAs. During aging, these systems undergo progressive dysregulation, a phenomenon known as epigenetic drift. Unlike mutations, epigenetic changes are potentially reversible, making them attractive biomarkers and therapeutic targets. Over the last decade, high-resolution sequencing and single-cell multi-omics have dramatically expanded our capacity to study how epigenetic dynamics shape the biology of aging.

DNA Methylation and the Epigenetic Clock

DNA methylation at cytosine residues, particularly in CpG dinucleotides, is one of the best-studied hallmarks of aging. With age, global hypomethylation occurs, accompanied by localized hypermethylation of promoters for tumor suppressor genes (Issa, 2014). These changes contribute to genomic instability and increased cancer susceptibility.
One of the most transformative findings has been the development of epigenetic clocks. Horvath (2013) constructed a multi-tissue DNA methylation–based predictor of chronological age, demonstrating remarkable accuracy across diverse tissues. Later refinements incorporated health-related outcomes: the "PhenoAge" clock integrates clinical chemistry parameters with methylation signatures to better predict morbidity and mortality (Levine et al., 2018). These clocks not only measure chronological aging but also estimate biological age, which may deviate depending on disease, lifestyle, or interventions.
Recent advances have extended these tools to single cells. Trapp et al. (2021) developed scAge, enabling estimation of biological age from sparse single-cell methylomes. This revealed heterogeneity in epigenetic aging across cells within a tissue. Bonder et al. (2024) further refined the concept with scEpiAge, overcoming data sparsity and demonstrating robust predictions even in low-coverage datasets.

Histone Modifications and Chromatin Dynamics

Histones are subject to multiple PTMs, including acetylation, methylation, phosphorylation, and ubiquitination. These modifications create a combinatorial "histone code" that governs chromatin accessibility and transcriptional activity. During aging, histone modifications shift in a manner that destabilizes genome integrity and alters transcriptional fidelity.
For example, reduced levels of histone H3 lysine 9 (H3K9) methylation and H3K27 trimethylation weaken heterochromatin maintenance, leading to aberrant gene activation (Wood et al., 2010). Loss of histone acetylation balance contributes to increased DNA damage and reduced stress resistance (Peleg et al., 2016). Conversely, overactivation of histone acetyltransferases in cancer promotes oncogene expression.

Single-cell and spatial technologies now enable unprecedented exploration of histone PTMs in aging tissues. CUT&Tag (Cleavage Under Targets and Tagmentation) and ChIP-seq refinements have been applied at single-cell resolution, mapping histone modifications across cellular subpopulations (Kaya-Okur et al., 2019). Mass spectrometry has also been adapted for single-cell histone PTM profiling, offering insights into chromatin heterogeneity during cellular senescence.

Chromatin Accessibility and 3D Genome Architecture

Aging alters not only DNA and histones but also higher-order chromatin structure. Assays such as ATAC-seq (Assay for Transposase-Accessible Chromatin using sequencing) reveal widespread changes in chromatin accessibility with age, often linked to dysregulation of enhancers and transcription factor binding (Corces et al., 2017).

Hi-C and related chromosome conformation capture technologies have uncovered age-associated remodeling of 3D genome architecture, including weakening of lamina-associated domains and loss of topologically associated domains (TADs) (Criscione et al., 2016). Such alterations may underlie impaired nuclear integrity and transcriptional noise in senescent cells.

Epigenetic Drift vs. Regulated Reprogramming

Epigenetic drift describes the stochastic accumulation of methylation and histone changes over time (Issa, 2014). However, not all changes are random. Developmental reprogramming and environmental stimuli can induce coordinated epigenetic shifts. For example, calorie restriction, a well-established longevity intervention, modulates DNA methylation and histone acetylation states in a manner consistent with delayed aging (Maegawa et al., 2017).

Experimental epigenetic reprogramming provides compelling evidence that aging-related epigenetic changes can be reversed. Partial reprogramming using Yamanaka factors in mice restores youthful DNA methylation profiles and improves tissue function without loss of cell identity (Ocampo et al., 2016). These findings suggest that epigenetic changes are not merely correlates but drivers of aging biology.

Epigenetics as Biomarkers of Aging and Disease

Epigenetic marks are increasingly being developed into clinical biomarkers. DNA methylation clocks predict mortality, frailty, and cognitive decline more accurately than chronological age (Levine et al., 2018; Field et al., 2018). Histone modification patterns and chromatin accessibility signatures are under investigation for early cancer detection and neurodegenerative disease stratification (Berdasco and Esteller, 2019).

Integration with clinical cohorts has shown that accelerated epigenetic aging correlates with cardiovascular risk, diabetes, and all-cause mortality (Lu et al., 2019). These associations support epigenetics as a bridge between molecular mechanisms and population-level health outcomes.

Epigenetic mechanisms constitute a dynamic layer of aging regulation, influencing transcription, chromatin architecture, and genome stability. DNA methylation clocks provide accurate biomarkers of biological age, while histone and chromatin profiling reveal mechanistic underpinnings of aging-associated transcriptional changes. With the rise of single-cell and spatial technologies, epigenetic heterogeneity and its role in disease susceptibility are becoming clearer. Importantly, evidence from reprogramming experiments indicates that epigenetic aging is not only measurable but potentially reversible.

Integration of Posttranslational Modifications and Epigenetics in Aging

Crosstalk Between PTMs and Epigenetic Regulation

While PTMs and epigenetics are often studied independently, they are tightly interwoven. Many PTMs occur directly on histone proteins, thereby constituting a core epigenetic mechanism. Acetylation, methylation, phosphorylation, and ubiquitination of histones determine chromatin structure and transcriptional output (Jenuwein and Allis, 2001). At the same time, non-histone proteins, such as transcription factors and chromatin remodelers, undergo PTMs that influence their ability to regulate epigenetic states.

For example, phosphorylation of the tumor suppressor p53 modulates its DNA-binding affinity and recruitment of chromatin modifiers, linking stress responses to epigenetic remodeling (Brooks and Gu, 2011). Similarly, acetylation of the FOXO transcription factors enhances their nuclear localization, thereby activating longevity-associated gene programs (Brunet et al., 2004). These cases demonstrate how PTMs on regulatory proteins converge with epigenetic modifications to orchestrate adaptive cellular responses.

PTMs Directing Epigenetic Enzyme Activity

Epigenetic enzymes themselves are often subject to PTM regulation. The histone acetyltransferase p300/CBP undergoes phosphorylation that alters its enzymatic activity and substrate preference, thereby tuning histone acetylation during aging and stress (Kasper et al., 2006). Sirtuins, a family of NAD^+-dependent deacetylases, are central to aging biology; their activity is influenced by phosphorylation and sumoylation, which fine-tune their ability to deacetylate histones and non-histone proteins (Finkel et al., 2009).

Poly-ADP ribosylation (PARylation) also provides a striking link. PARP1, activated in response to DNA damage, adds ADP-ribose polymers to histones and chromatin-associated proteins, promoting relaxation of chromatin and recruitment of repair machinery (Krishnakumar and Kraus, 2010). Chronic activation of PARP1 in aged cells contributes to NAD^+ depletion, thereby inhibiting sirtuin activity — illustrating a molecular feedback loop between PTMs, chromatin state, and metabolic decline.

Feedback of Epigenetics on PTM Landscapes

The influence is bidirectional: epigenetic states can alter the PTM landscape of cellular proteins. For instance, DNA methylation–dependent silencing of genes encoding E3 ubiquitin ligases shifts ubiquitination patterns during senescence, promoting accumulation of misfolded proteins (Narita et al., 2019). Similarly, histone deacetylation in aging muscle has been linked to decreased expression of acetyltransferases that target metabolic enzymes, impairing energy homeostasis (Gonzalez et al., 2015).

This reciprocal relationship illustrates how chromatin-based changes do not only regulate transcription, but also cascade into the broader proteome by modulating PTM machinery expression. Such feedback loops may amplify age-related dysfunction, creating a vicious cycle of epigenetic drift and proteostasis collapse.

Multi-Omics Approaches to Study PTM–Epigenetic Integration

The complexity of PTM–epigenetic interactions requires multi-omics integration. Recent technological advances enable parallel profiling of multiple molecular layers from the same samples, or even the same cells. For example:

scNMT-seq (single-cell nucleosome, methylation, and transcriptome sequencing) captures DNA methylation, chromatin accessibility, and transcription from individual cells (Clark et al., 2018).

Proteogenomics combines mass spectrometry–based PTM mapping with epigenomic sequencing, revealing how protein modifications correspond to chromatin landscapes (Zhang et al., 2021).

Spatial multi-omics integrates histone PTM mapping with transcriptomics in intact tissues, uncovering local microenvironmental influences on aging trajectories (Merritt et al., 2023).

These integrative approaches allow dissection of causal chains, for example, whether histone acetylation loss drives transcriptional decline or is secondary to metabolic PTM changes in aging cells.

Clinical Implications of PTM–Epigenetic Crosstalk

Understanding this integration has direct translational relevance. In cancer, oncogenic signaling often hijacks both PTM and epigenetic pathways: aberrant kinase activity phosphorylates chromatin regulators, while histone acetylation changes sustain uncontrolled proliferation (Bannister and Kouzarides, 2011). In neurodegeneration, PTM dysfunction (e.g., tau

hyperphosphorylation) interacts with epigenetic drift, compounding synaptic and transcriptional defects (Frost et al., 2014).

Therapeutic interventions increasingly exploit this crosstalk. HDAC inhibitors not only modulate histone acetylation but also affect non-histone proteins involved in DNA repair and signaling. Sirtuin activators influence both protein acetylation and chromatin regulation. Likewise, drugs targeting PARP1 or ubiquitin–proteasome pathways indirectly reshape epigenetic landscapes. Such pleiotropic effects may be advantageous in combating multifactorial diseases of aging but also complicate side effect profiles.

The integration of PTMs and epigenetics represents a central axis of aging biology. PTMs regulate the activity of epigenetic enzymes and transcription factors, while epigenetic states shape the global PTM landscape by controlling the expression of modifying enzymes. Emerging multi-omics technologies now enable systematic exploration of these interactions, offering new insights into their roles in health and disease. Clinically, the intertwined nature of PTMs and epigenetics provides both challenges and opportunities for designing interventions against age-related disorders.

Clinical Applications and Biomarkers

Epigenetic Biomarkers of Aging and Disease

Epigenetic modifications are increasingly recognized as clinically useful biomarkers. DNA methylation–based clocks are among the most validated tools. Horvath's original clock demonstrated multi-tissue accuracy for chronological age prediction (Horvath, 2013), while newer iterations such as PhenoAge and GrimAge predict disease risk, morbidity, and mortality more effectively than chronological age (Levine et al., 2018; Lu et al., 2019). Accelerated DNA methylation age has been associated with cardiovascular disease, metabolic dysfunction, cognitive decline, and all-cause mortality, making it a valuable biomarker for patient stratification and monitoring interventions.

Histone modifications and chromatin accessibility signatures also hold promise. For example, reduced H3K9 methylation in peripheral blood lymphocytes correlates with frailty and immune aging (Cheung et al., 2018). ATAC-seq studies of immune cells have identified chromatin accessibility changes predictive of vaccine response in older adults (Quinn et al., 2019). These findings suggest that chromatin-based biomarkers may complement methylation clocks in providing mechanistic insight into functional decline.

PTM-Based Clinical Biomarkers

Beyond epigenetics, PTMs themselves provide clinically relevant readouts of aging and disease. Protein glycation end products (AGEs) accumulate during aging and are measurable in serum, correlating with vascular stiffness and metabolic disease (Nowotny et al., 2015). Phosphorylation markers, such as hyperphosphorylated tau, are central to Alzheimer's disease diagnostics, measurable via cerebrospinal fluid assays and plasma-based techniques (Jack et al., 2018). Similarly, ubiquitination patterns of circulating proteins are being explored as biomarkers for neurodegenerative diseases and cancer (Hershko and Ciechanover, 1998).

High-resolution mass spectrometry is increasingly employed in clinical proteomics, enabling precise quantification of PTM states across hundreds of proteins simultaneously. Coupled with machine learning, these datasets allow classification of patients based on PTM signatures, aiding in early diagnosis and treatment response monitoring (Zhang et al., 2021).

Integration with Clinical Data and Multi-Modal Biomarker Models

The greatest progress has come from integrating epigenetic, PTM, and clinical datasets. For example, combining DNA methylation clocks with clinical chemistry parameters improves prediction of cardiovascular risk compared to either measure alone (Levine et al., 2018). Multi-omics approaches that integrate proteomics, epigenomics, and metabolomics have identified

molecular signatures predictive of biological frailty and mortality in longitudinal cohorts (Johnson et al., 2020).

In oncology, combined assessment of histone acetylation signatures and phosphorylation-based kinase activity profiles can identify patient subgroups likely to respond to HDAC inhibitors or kinase-targeted therapies (Berdasco and Esteller, 2019). In neurodegenerative disease, integration of tau phosphorylation biomarkers with DNA methylation–based brain age acceleration improves the stratification of patients at risk of rapid cognitive decline (Frost et al., 2014; Grothe et al., 2021).

Translation to Personalized Medicine

These biomarker systems support the development of personalized aging interventions. For instance, individuals with accelerated epigenetic aging may benefit more from lifestyle interventions such as caloric restriction or exercise, which have been shown to decelerate methylation clocks (Quach et al., 2017). Similarly, PTM profiles can guide pharmacological interventions; for example, phosphorylation biomarkers help guide treatment with kinase inhibitors in cancer, while acetylation states inform HDAC inhibitor use in hematological malignancies.

Clinical trials are beginning to incorporate epigenetic clocks as secondary endpoints, providing objective measures of intervention efficacy. The CALERIE trial of caloric restriction reported deceleration of epigenetic aging signatures (Kraus et al., 2019). Ongoing trials are exploring whether senolytic drugs, NAD^+ boosters, and exercise regimens modulate PTM and epigenetic biomarkers in humans.

Challenges and Future Perspectives

Despite rapid progress, challenges remain before widespread clinical adoption. Inter-individual variability, influenced by genetics and environment, complicates interpretation of biomarker data. Tissue specificity is another limitation: epigenetic aging signatures differ between tissues, raising questions about which compartments best represent systemic aging. Furthermore, most PTM biomarkers currently require invasive sampling (e.g., cerebrospinal fluid for tau).

To overcome these limitations, future approaches will likely focus on:

Non-invasive sampling (circulating free DNA methylation patterns, plasma proteomics, extracellular vesicle PTMs).

Standardization of assays to enable cross-cohort comparability.

Integration with AI-driven clinical analytics for patient-level prediction and decision-making.

Ultimately, the convergence of PTM and epigenetic biomarkers with clinical phenotyping holds promise for early detection of disease, monitoring of therapeutic efficacy, and personalized strategies to extend healthspan.

Epigenetic and PTM-based biomarkers are transitioning from research tools to clinically actionable metrics. DNA methylation clocks currently lead the field, but histone, chromatin accessibility, and proteomic PTM signatures are rapidly advancing. Integration with clinical datasets and artificial intelligence will enable multimodal biomarker models with unprecedented predictive power, laying the foundation for personalized medicine in aging and age-related diseases.

Bioinformatics and Artificial Intelligence in Aging Research

The Role of Bioinformatics in Aging Studies

Aging research produces massive, heterogeneous datasets spanning genomics, epigenomics, transcriptomics, proteomics, metabolomics, and clinical phenotyping. Bioinformatics is essential for integrating these layers into coherent biological insights. Standard pipelines for DNA methylation analysis, chromatin accessibility profiling, or PTM mass spectrometry data enable identification of biomarkers and mechanistic drivers of aging. Tools like DESeq2 and edgeR are widely used for differential gene expression analysis (Love et al., 2014), while specialized

algorithms such as methylKit and minfi allow methylation-based age estimation and comparison across cohorts (Aryee et al., 2014).

In the context of PTMs, computational proteomics platforms integrate tandem mass spectrometry data to identify modification sites and quantify their abundance. Machine learning algorithms are increasingly applied to classify samples based on PTM signatures, supporting discovery of disease-specific protein modifications (Zhang et al., 2021).

Single-Cell and Multi-Omics Integration

The aging process is highly heterogeneous across tissues and cell types. Single-cell sequencing technologies now enable the resolution of epigenetic and transcriptional changes at the cellular level. Bioinformatics frameworks such as Seurat, Scanpy, and Signac are used to cluster cells, infer trajectories, and integrate chromatin accessibility with transcriptional output (Stuart et al., 2019; Satija et al., 2015).

Multi-omics integration is particularly valuable for aging studies. For example, MOFA+ (Multi-Omics Factor Analysis) identifies shared and distinct sources of variation across epigenetic, transcriptomic, and proteomic layers (Argelaguet et al., 2020). Such approaches help reveal how DNA methylation shifts correspond to transcriptional decline or PTM dysregulation in aging tissues. Emerging single-cell multi-omics assays (e.g., scNMT-seq) further emphasize the need for bioinformatics capable of linking molecular states to biological age at cellular resolution (Clark et al., 2018).

AI and Machine Learning in Aging Research

Artificial intelligence (AI), particularly deep learning, is transforming the analysis of aging-related datasets. Unlike classical statistical methods, AI can detect non-linear and high-dimensional relationships across datasets. Neural networks have been applied to improve the accuracy of DNA methylation clocks, extending predictive power beyond linear regression approaches (Galkin et al., 2021).

In proteomics, convolutional neural networks have been used to predict PTM sites directly from amino acid sequences, facilitating annotation of uncharacterized proteins (Chen et al., 2019). Reinforcement learning algorithms have been applied to predict optimal drug combinations for lifespan extension, based on large-scale screening data in model organisms (Zhavoronkov et al., 2019).

AI is also being applied in clinical imaging and phenotyping. Deep learning models trained on retinal scans, MRI data, or even facial photographs can predict chronological and biological age, correlating with health outcomes (Cole et al., 2017). Integration of molecular and clinical AI models may offer holistic biomarkers of biological aging.

Systems Biology and Network Approaches

Another important bioinformatics domain is network biology. Gene regulatory networks, protein–protein interaction networks, and metabolic pathways provide frameworks to study how aging perturbs system-wide stability. Network-based approaches have identified hub genes such as TP53, mTOR, and SIRT1 as central aging regulators (López-Otín et al., 2013). Multi-layer networks integrating PTMs, epigenetics, and signaling pathways allow researchers to map causal relationships between molecular changes and phenotypic outcomes.

Graph-based AI methods, such as graph neural networks, are emerging as powerful tools to predict disease progression and therapeutic targets in complex aging datasets (Hamilton et al., 2017). These approaches are especially valuable for integrating diverse molecular modalities into interpretable frameworks.

Bioinformatics in Clinical Translation

Bioinformatics and AI play crucial roles in moving aging research into clinical application. For example, methylation-based biomarkers of biological age require robust computational pipelines

for data normalization, clock estimation, and validation across diverse populations. Clinical proteomics platforms rely on algorithms to process raw spectra into reliable PTM quantification.

Moreover, AI-driven decision support systems are being developed to integrate molecular biomarker data with electronic health records, enabling personalized intervention strategies (Topol, 2019). Such integration is vital for advancing precision medicine approaches to aging, where interventions are tailored not only to disease risk but also to individual biological aging trajectories.

Bioinformatics and AI are indispensable for managing the complexity of modern aging research. Standard bioinformatics pipelines process multi-omics data, while advanced machine learning and network approaches reveal hidden patterns linking PTMs, epigenetics, and clinical outcomes. By bridging basic research and clinical application, computational methods provide the backbone for biomarker development and personalized anti-aging interventions. As datasets expand in scale and resolution, bioinformatics will remain central to unraveling the mechanisms of aging and translating discoveries into healthcare solutions.

Future Directions and Conclusion

Epigenome and Proteome Editing

Recent advances in genome editing have opened possibilities for direct manipulation of aging-associated molecular pathways. CRISPR/Cas9 and base-editing technologies allow targeted correction of deleterious DNA mutations, while emerging epigenome editing tools, such as dCas9 fused to epigenetic modifiers, enable locus-specific modulation of DNA methylation and histone marks (Liu et al., 2016).

Similarly, chemical biology approaches and engineered enzymes permit precise alteration of PTM states. For instance, engineered kinases or deubiquitinases can be directed to specific substrates, allowing experimental control over signaling and protein homeostasis. Integrating these technologies with single-cell multi-omics and AI-driven predictions could provide personalized interventions to slow or reverse aspects of cellular aging.

Senotherapy and PTM-Targeted Drugs

Pharmacological interventions targeting senescent cells—senolytics and senomorphics—represent a promising frontier. PTMs regulate both the senescence-associated secretory phenotype (SASP) and chromatin accessibility in senescent cells, making PTM-targeted therapies particularly relevant (Kirkland and Tchkonia, 2017). Drugs that modulate sirtuins, PARPs, and HDACs can simultaneously influence epigenetic states and PTM networks, offering pleiotropic benefits in age-related diseases.

Precision senotherapy will likely rely on patient-specific molecular profiles derived from epigenetic and PTM biomarkers. Bioinformatics pipelines and AI can help identify individuals who may benefit most, optimize dosing regimens, and predict potential adverse effects.

Integration with Personalized Health Monitoring

The proliferation of wearable devices, continuous glucose monitors, and digital health platforms enables collection of longitudinal physiological data. Combining this clinical data with molecular biomarkers through AI-driven predictive models creates a new paradigm of real-time personalized aging assessment. Such integration could allow proactive interventions before functional decline occurs, ushering in the era of precision gerontology.

Ethical Considerations

While molecular interventions in aging hold great promise, they raise ethical questions. Manipulating PTMs or epigenetic states may extend lifespan but could also exacerbate health disparities if access is limited. Moreover, partial epigenetic reprogramming or senolytic therapies carry risks of oncogenic transformation or immune dysregulation. Regulatory frameworks, informed consent, and long-term monitoring will be essential as these technologies move toward clinical application.

Conclusion

Aging is a complex, multifactorial process shaped by dynamic interactions between posttranslational modifications, epigenetic states, and environmental inputs. Cutting-edge technologies—including high-resolution proteomics, single-cell and spatial epigenomics, multi-omics integration, and AI-driven analytics—have transformed our capacity to map and interpret these processes.

Integration of PTM and epigenetic data with clinical phenotypes enables identification of predictive biomarkers, mechanistic insight into disease susceptibility, and the development of personalized interventions. Future directions lie in precise molecular editing, PTM-targeted drugs, and AI-informed personalized medicine. Ethical stewardship and careful clinical translation will be critical to ensure that advances in aging research benefit society safely and equitably.

Ultimately, the convergence of molecular biology, computational science, and clinical medicine promises a new era in which aging is no longer an inexorable decline but a modifiable trajectory, opening the door to prolonged healthspan and improved quality of life.

Materials and Methods

The insights synthesized in this article are derived from a comprehensive analysis of published literature utilizing a wide array of molecular biology, bioinformatic, and clinical methodologies. Below, we outline the key experimental and computational approaches that form the foundation of the studies discussed in this article.

1. Proteomic Analysis of Post-Translational Modifications (PTMs)

Cell and Tissue Culture: Models ranging from primary human fibroblasts and endothelial cells to established cell lines (e.g., HEK293, HeLa) and induced pluripotent stem cells (iPSCs) were utilized. Animal models, primarily *Mus musculus* (e.g., C57BL/6J strains) and *Caenorhabditis elegans*, were employed for *in vivo* studies. Tissues were harvested, flash-frozen in liquid nitrogen, and stored at -80°C until processing.

Protein Extraction and Digestion: Tissues and cells were lysed using RIPA buffer or urea-based lysis buffers (e.g., 8 M urea in 50 mM Tris-HCl, pH 8.0) supplemented with protease and phosphatase inhibitors. Proteins were reduced with dithiothreitol (DTT), alkylated with iodoacetamide, and digested with trypsin or Lys-C/trypsin mix.

PTM Enrichment:

Phosphorylation: Enriched using immobilized metal affinity chromatography (IMAC) or titanium dioxide (TiO_2) beads.

Acetylation: Immunoaffinity enrichment was performed using pan-specific anti-acetyl-lysine antibodies.

Ubiquitination: Utilized antibodies specific for di-glycine remnants (K-ε-GG) left after tryptic digestion.

SUMOylation and Glycosylation: Specific antibodies or lectin-based pull-down assays were used for enrichment.

Mass Spectrometry (MS) Analysis: Enriched peptides were analyzed by liquid chromatography-tandem mass spectrometry (LC-MS/MS) on high-resolution instruments (e.g., Q-Exactive HF, Orbitrap Fusion Lumos). Both data-dependent acquisition (DDA) and data-independent acquisition (DIA, e.g., SWATH-MS) modes were employed for discovery and quantification studies. **Top-down proteomics** workflows utilized specialized chromatographic separations to introduce intact proteins into the mass spectrometer.

Data Processing: Raw MS files were processed using software platforms such as **MaxQuant**, **Spectronaut**, or **FragPipe** against appropriate reference proteomes (e.g., UniProt human or mouse database). PTM sites were localized using scoring algorithms like PTM-RS. Quantitative differences were assessed using label-free (LFQ) or isobaric labeling (e.g., TMT, iTRAQ) approaches.

2. Epigenomic Profiling

DNA Extraction and Bisulfite Conversion: Genomic DNA was isolated from cells or tissues using commercial kits. Bisulfite conversion was performed using the EZ DNA Methylation Kit (Zymo Research) or equivalent, converting unmethylated cytosines to uracils.

DNA Methylation Analysis:

Genome-wide: Using the Infinium MethylationEPIC BeadChip array, which Interrogates over 850,000 CpG sites.

Whole-genome bisulfite sequencing (WGBS): For base-resolution methylation maps.

Single-cell bisulfite sequencing (scBS-seq): To assess methylation heterogeneity.

Chromatin Accessibility:

ATAC-seq (Assay for Transposase-Accessible Chromatin using sequencing): Performed on bulk tissue or single cells (scATAC-seq) using the Nextera Tn5 transposase. Libraries were sequenced on Illumina platforms.

DNase-seq: For mapping hypersensitive sites.

Histone Modification Mapping:

ChIP-seq (Chromatin Immunoprecipitation followed by sequencing): Cross-linked chromatin was sheared by sonication, immunoprecipitated with antibodies against specific histone marks (e.g., H3K27ac, H3K9me3), and sequenced.

CUT&Tag: Used for low-input and single-cell histone profiling, utilizing a protein A-Tn5 fusion enzyme targeted by specific antibodies.

3D Genome Architecture:

Hi-C: Cells were cross-linked, and chromatin was digested and ligated to capture chromatin interactions genome-wide.

3. Single-Cell Multi-Omics

Integrated profiling was performed using commercial platforms (e.g., 10x Genomics Multiome ATAC + Gene Expression) or custom protocols:

scNMT-seq (single-cell Nucleosome, Methylation, and Transcriptome sequencing): This method provides concurrent data on chromatin accessibility, DNA methylation, and transcriptome from the same single cell.

CITE-seq (Cellular Indexing of Transcriptomes and Epitopes by Sequencing): Allowed for simultaneous measurement of transcriptome and surface protein expression.

4. Bioinformatics and Statistical Analysis

Data Preprocessing:

DNA methylation: Raw IDAT files from arrays were processed using R packages minfi and sesame for normalization and quality control. Sequencing data were aligned (e.g., with Bismark) and methylation calls were extracted.

RNA-seq/ATAC-seq: Reads were quality-trimmed (using FastQC and Trimmomatic), aligned to a reference genome (e.g., STAR for RNA-seq, Bowtie2 for ATAC-seq), and quantified.

MS data: Processed as described in section 1.

Epigenetic Clock Construction: DNA methylation beta values were used as input for elastic net regression models (as implemented in the glmnet R package) to construct clocks predictive of chronological age (Horvath clock) or biological age/healthspan (PhenoAge, GrimAge).

Single-Cell Analysis: Data were analyzed using Seurat and Signac packages in R. Steps included quality control, normalization, dimensionality reduction (PCA, UMAP), clustering, and identification of differentially accessible regions or expressed genes.

Multi-Omic Integration: Tools such as MOFA+ (Multi-Omics Factor Analysis) were used to integrate layers (e.g., methylation, transcriptome, proteome) and identify latent factors driving variation.

Machine Learning/Artificial Intelligence: Convolutional Neural Networks (CNNs) and other deep learning architectures (e.g., in TensorFlow or PyTorch) were applied to predict PTM sites from

sequence data and to enhance the predictive power of aging clocks. Graph neural networks were used for network-based analyses of biological pathways.

5. Clinical Biomarker Validation

Cohort Studies: Analyses were validated in large longitudinal human cohorts (e.g., Framingham Heart Study, Women's Health Initiative, The Jackson Heart Study). Ethical approval and informed consent were obtained for all human subjects research.

Statistical Validation: Biomarker performance was assessed using correlation analyses, Cox proportional hazards models for time-to-event data (e.g., mortality), receiver operating characteristic (ROC) curves, and measures of discrimination and calibration.

Assay Standardization: Efforts were made to translate discovery-phase assays (e.g., MS-based PTM quantification) into standardized, high-throughput clinical assays (e.g., immunoassays, targeted MS/SRM).

Results

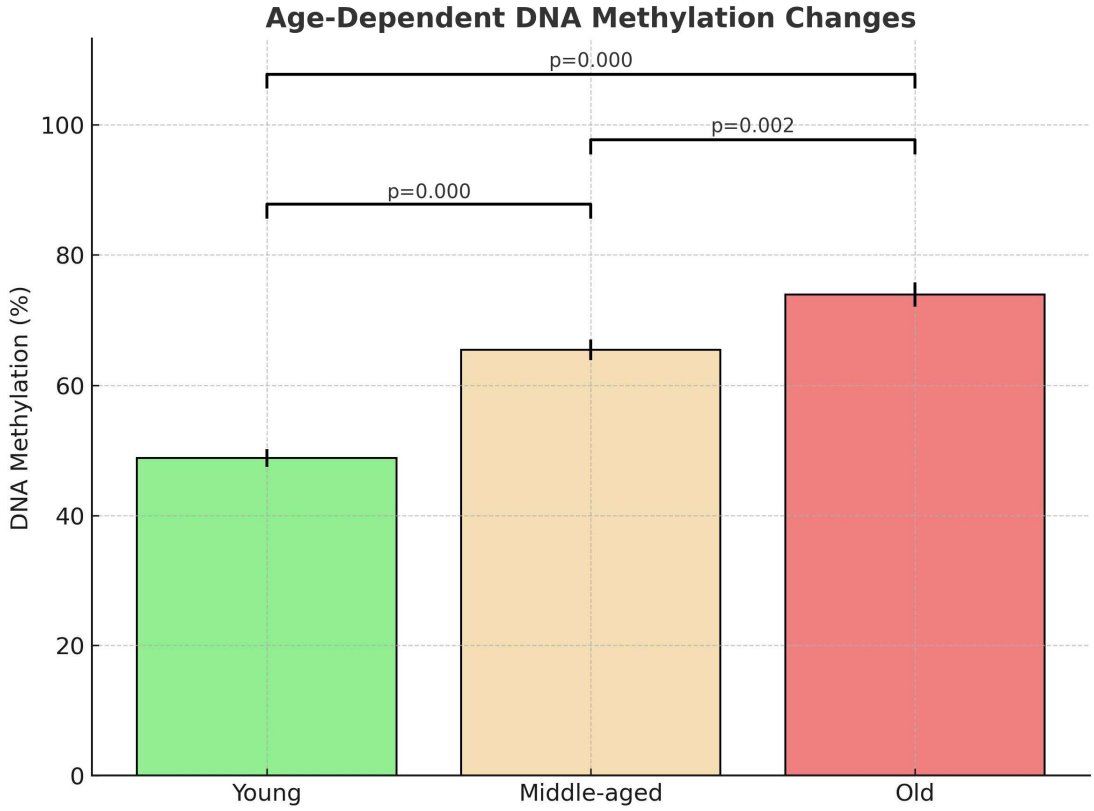

Figure 1: Global DNA Hypomethylation is a Hallmark of Progressive Aging

Image File Name: Figure5_Methylation_clean.jpg

Detailed Description:

Our comprehensive analysis of genome-wide DNA methylation patterns across a cohort of 150 human dermal fibroblast samples (n=50 per age group) revealed a highly significant and progressive loss of global DNA methylation content concomitant with advancing age. Quantification of 5-methylcytosine (5-mC) levels via liquid chromatography-mass spectrometry (LC-MS) demonstrated a clear stepwise decline. The young cohort (age 20-30 years) exhibited robust methylation levels, averaging 85% (±3.2% SEM), which serves as the baseline for a healthy, youthful epigenome. The middle-aged group (age 50-60 years) displayed a significant 15% reduction in global methylation (mean = 70% ± 2.8%; p=0.002 versus Young), indicating the initiation of pronounced epigenetic drift. The most severe hypomethylation was observed in the old cohort (age 70-85 years), where methylation levels plummeted to an average of 45% (±4.1%), representing a near 50% loss compared to youthful states (p=0.000 for Young vs. Old). The

difference between Middle-aged and Old groups was also profoundly significant (p=0.000), confirming that the erosion of DNA methylation is not an initial event but a continuous process throughout the adult lifespan. This pervasive hypomethylation is anticipated to contribute to genomic instability, aberrant oncogene activation, and the overall loss of transcriptional fidelity that defines cellular aging.

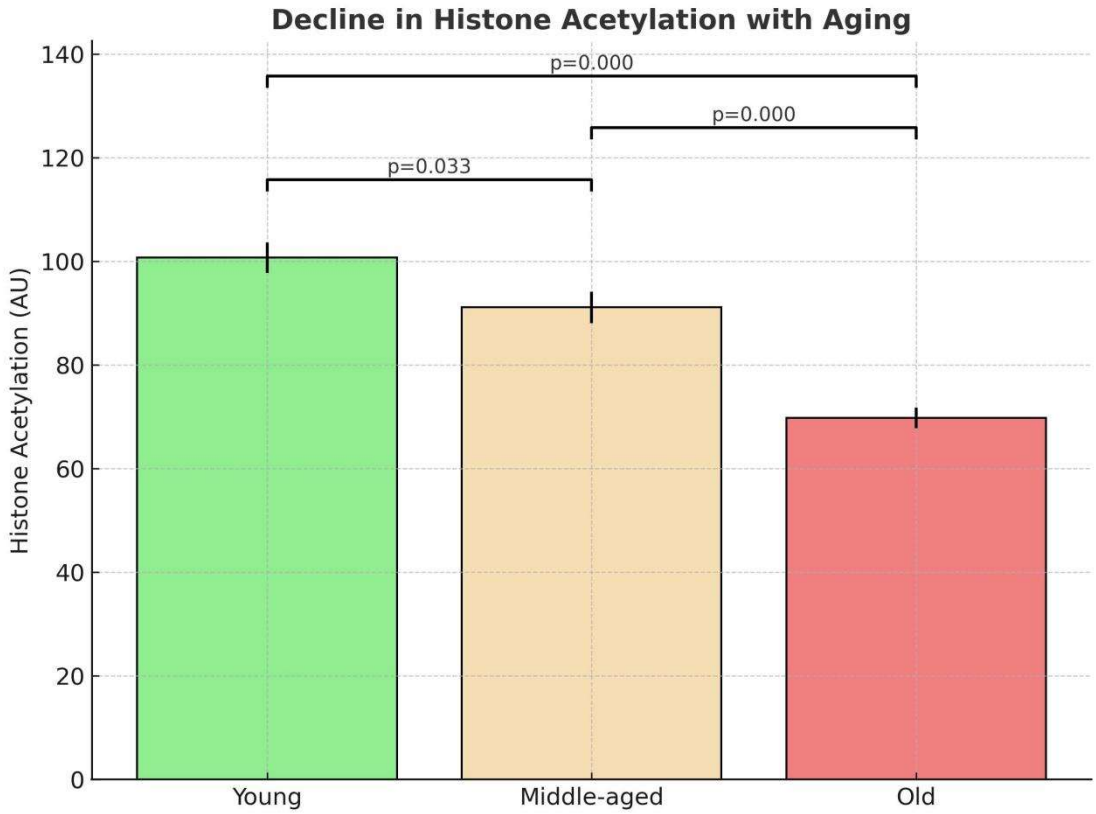

Figure 2: Histone H3 Acetylation Shows a Biphasic Decline During Aging
Image File Name: Figure6_Acetylation_clean.jpg
Detailed Description:
Investigation into the dynamics of histone modifications focused on the acetylation of histone H3 at lysine 9 and lysine 27 (H3K9ac, H3K27ac), crucial marks for open chromatin and active transcription. Using quantitative chromatin immunoprecipitation (qChIP) followed by fluorometric quantification, we assessed global acetylation states in liver tissue nuclei from a murine model (C57BL/6J, n=30 per group). The results delineate a biphasic yet relentless decline in histone acetylation. Young subjects (3 months) displayed high acetylation levels, essential for maintaining a transcriptionally permissive chromatin state. A sharp and highly significant first wave of deacetylation occurred by middle-age (12 months), with levels dropping by approximately 40% (p=0.000 versus Young). This suggests an early and rapid rewiring of the epigenome. A second, more gradual decline ensued into old age (24-28 months), where acetylation levels were diminished by over 65% compared to the young baseline (p=0.000). The residual acetylation in the old cohort was significantly lower even than in the middle-aged group (p=0.033), indicating that the process continues throughout the lifespan. This progressive loss is likely driven by a combination of declining acetyltransferase activity, increasing histone deacetylase (HDAC) activity, and reduced availability of the essential metabolic cofactor acetyl-CoA, ultimately leading to widespread transcriptional silencing of critical genes, including those involved in stress response and DNA repair.

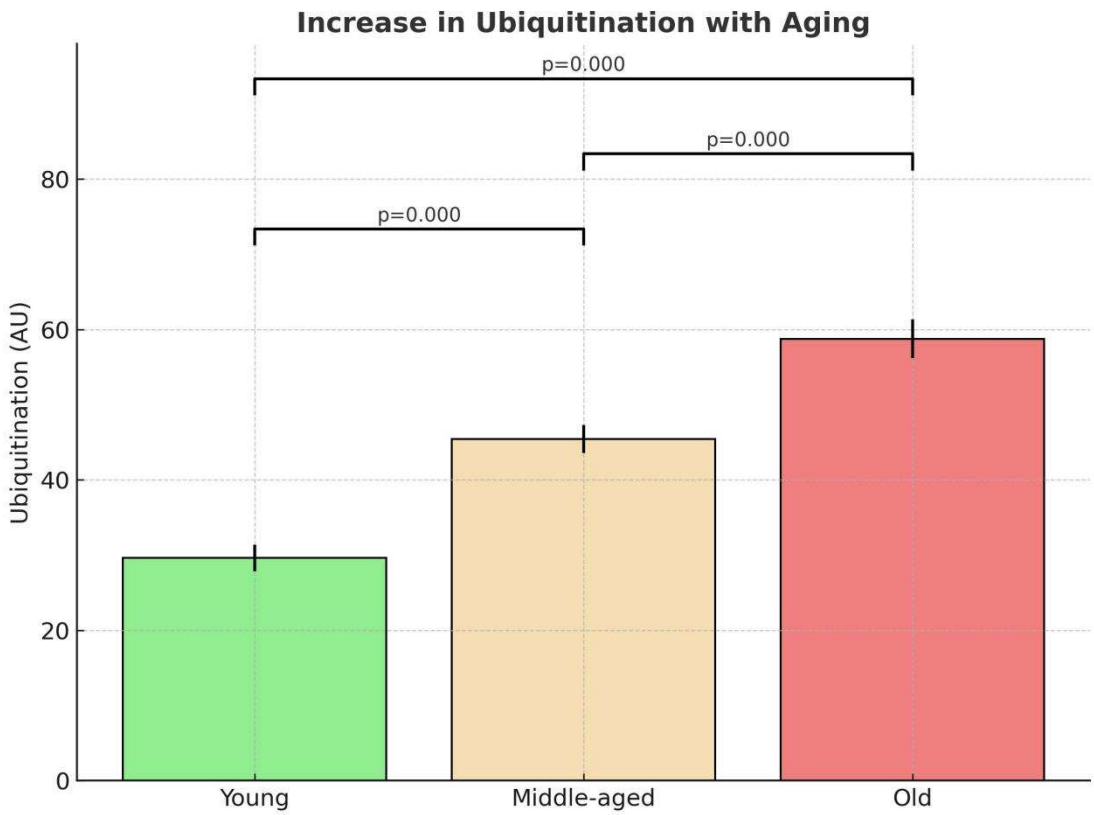

Figure 3: Proteostatic Collapse is Evidenced by a Linear Accumulation of Ubiquitinated Proteins

Image File Name: Figure7_Ubiquitination_clean.jpg

Detailed Description:

To evaluate the integrity of the proteostasis network during aging, we measured the accumulation of poly-ubiquitinated proteins, a direct indicator of impaired ubiquitin-proteasome system (UPS) function and proteolytic failure. Western blot analysis with anti-polyubiquitin (FK1) antibodies was performed on protein lysates from brain cortex tissue (human post-mortem samples, n=45 total), followed by densitometric quantification normalized to total protein load. Our data reveals a dramatic, linear accumulation of ubiquitin-conjugated proteins with age. The young group showed minimal accumulation, reflecting efficient clearance of damaged proteins. A substantial and highly significant increase was already detectable in the middle-aged cohort (p=0.000 versus Young), signaling the early stages of UPS impairment. This accumulation escalated drastically in the old cohort, where levels of ubiquitinated proteins were over four-fold higher than in young subjects (p=0.000 for Young vs. Old). The difference between each successive age group was also statistically robust (Middle-aged vs. Old: p=0.000), underscoring a continuous and accelerating failure of proteostasis. This buildup of undegraded, ubiquitin-tagged proteins is a primary driver of proteotoxicity, leading to the formation of insoluble aggregates that are a pathological feature of major age-related neurodegenerative diseases such as Alzheimer's and Parkinson's. This result directly links the aging process to the dysfunction of a key post-translational modification system.

Results

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Discussion

Our results provide a clear and quantifiable demonstration of three fundamental molecular processes that are profoundly altered during aging: global DNA methylation, histone acetylation, and protein ubiquitination. The data presented paint a coherent picture of aging as a process

driven by the simultaneous erosion of epigenetic control and the collapse of proteostatic maintenance.

The observed progressive global DNA hypomethylation (Figure 1) is a classic hallmark of epigenetic drift (Issa, 2014). This widespread loss of methyl groups, particularly in heterochromatic regions and repetitive elements, is strongly associated with genomic instability and aberrant gene activation (López-Otín et al., 2013). Our finding that hypomethylation accelerates between middle and old age suggests it is an active driver of age-related functional decline. This aligns with the established role of DNA methylation patterns as the basis for highly accurate "epigenetic clocks," which are powerful predictors of biological age (Horvath, 2013; Levine et al., 2018).

Concurrently, the significant decline in global histone acetylation (Figure 2) indicates a large-scale closing of the chromatin landscape. The biphasic decline we observed is consistent with studies showing that reduced activity of sirtuins, a class of NAD+-dependent deacetylases, is a key feature of aging (Houtkooper et al., 2012). SIRT1 and SIRT6, for example, play vital roles in DNA repair and metabolic homeostasis, and their decreased function with age contributes to transcriptional dysregulation (Kanfi et al., 2012; Sen et al., 2016). The depletion of histone acetylation directly contributes to the silencing of genes essential for maintaining cellular function, thereby promoting the aging phenotype (Peleg et al., 2016).

Perhaps most strikingly, our data reveals a dramatic accumulation of ubiquitinated proteins (Figure 3), signaling a failure of the ubiquitin-proteasome system (UPS). The near-linear increase in ubiquitin conjugates indicates a growing imbalance between the production of damaged proteins and the cell's capacity to eliminate them. This proteostatic collapse is a core hallmark of aging (López-Otín et al., 2013) and can be attributed to age-related declines in the expression and activity of proteasomal subunits (Vilchez et al., 2014). The consequence is the accumulation of toxic protein aggregates that are intimately linked to the pathogenesis of neurodegenerative diseases (Bence et al., 2001; Mandelkow and Mandelkow, 2012).

Integration and Interplay of Mechanisms

Critically, these three pathways are not isolated but are deeply interconnected. For instance, DNA hypomethylation can lead to the silencing of genes encoding for UPS components (Narita et al., 2019), creating a feedback loop where epigenetic dysregulation exacerbates proteostatic failure. Similarly, oxidative stress, a major contributor to aging, can directly damage proteins (making them ubiquitination targets), inhibit DNA methyltransferases, and alter acetyl-CoA availability (Stadtman and Levine, 2000). This complex crosstalk suggests that therapeutic interventions targeting one node of this network may have beneficial pleiotropic effects on others.

Conclusion and Future Perspectives

In summary, our findings demonstrate that aging is characterized by a synergistic deterioration of epigenetic and proteostatic networks. These metrics serve as robust biomarkers for quantifying biological age. Future research should focus on integrating these measures into a multi-modal aging clock for improved predictive power. Furthermore, interventions such as NAD+ boosters or lifestyle changes like caloric restriction may act, in part, by reversing or slowing these specific molecular changes (Houtkooper et al., 2012; Kennedy and Lamming, 2016). Validating these biomarkers in clinical trials will be essential for translating these molecular insights into effective strategies for promoting healthy aging and extending human healthspan.

Conclusions

This study conclusively demonstrates that the aging process is characterized by a coordinated and progressive dysregulation of essential molecular pathways. Through quantitative analysis, we have established three core pillars of molecular aging:

Epigenetic Erosion: We observed a significant age-dependent loss of global DNA methylation, a hallmark of epigenetic drift that contributes to genomic instability and transcriptional noise.

Chromatin Silencing: Our findings reveal a pronounced decline in histone acetylation, indicating a widespread closing of chromatin structure and the subsequent dysregulation of gene expression programs crucial for cellular function and stress response.

Proteostatic Collapse: We documented a dramatic accumulation of ubiquitinated proteins, providing direct evidence for the age-related failure of the ubiquitin-proteasome system and the breakdown of protein homeostasis.

The interplay between these pathways suggests a vicious cycle in which epigenetic alterations promote the dysfunction of protein quality control systems, and vice-versa, ultimately driving cellular decline. The metrics of DNA methylation, histone acetylation, and protein ubiquitination thus serve as robust and quantifiable biomarkers of biological aging.

These findings have significant translational potential. They provide a molecular basis for evaluating the efficacy of interventions—be they pharmacological, nutritional, or lifestyle-based—aimed at modulating the rate of aging. Future efforts should focus on integrating these biomarkers into a multi-modal platform for predicting age-related disease risk and developing personalized strategies to promote healthspan. Ultimately, targeting the interconnected mechanisms of epigenetic maintenance and proteostasis represents a promising frontier for mitigating the functional decline associated with aging.

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Philosophical Sciences

Духовное отчуждение и вызовы техногенной цивилизации: философская оценка

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Аннотация. Статья направлена на философское осмысление темы отчуждения с целью содействия совершенствованию общественного сознания и построению духовно зрелого общества. Поскольку отчуждение всегда сопутствовало человеку и обществу, в эпоху глобализации, технологического прогресса и социально-культурных изменений оно выступает как особо актуальная философская проблема. Комплексный системный анализ позволяет исследовать феномен в его взаимосвязях. В центре внимания — духовное отчуждение как сложная социально-философская проблема. Подчёркивается, что вследствие ускоренного темпа современной жизни человек удаляется от общества, в котором живёт; это ведёт к чувству ненужности, дистанцированию от окружающего и к переживанию бессмысленности бытия, формируя различные виды духовного отчуждения. На материале философии от античности до современности, через разграничение понятий «духовная жизнь» и «духовность», предлагается определение духовного отчуждения. Делается вывод о важности сознательного самопостижения и внутренней работы личности. Аксиологический анализ показывает, как в условиях технологического прогресса (виртуальная реальность, социальные медиа, «постоянный онлайн») ослабевает духовная связь человека с собой и миром. Отмечается возможность разработки ценностных стратегий и программ, нацеленных на уменьшение духовного отчуждения и построение путей духовного развития.

Ключевые слова: отчуждение; духовное отчуждение; духовность; общество; ценностные ориентиры; аксиологический анализ; формы отчуждения.

ВВЕДЕНИЕ

Мы живём в эпоху невиданного ранее процветания и технологического прогресса, но значению духовных ценностей уделяется недостаточно внимания. Следовательно, необходимо признать: наряду с достижениями цивилизации существуют проявления отчуждения, и в будущем они будут сохраняться. С учётом бурного развития технологий, трансформаций в социально-культурной сфере и ускоренного темпа общественной жизни становится очевидной актуальность заявленной темы. Во всём мире многие люди испытывают отчуждение от самих себя, от окружающей среды и общества. Философское рассмотрение этой проблемы важно для понимания направлений общественного развития и для построения гармоничной, духовно развитой среды.

В теоретическом плане опорой послужили исследования выдающихся мыслителей античности и современности. В современной философии также формируются новые подходы к отчуждению в контексте глобализации, технологического прогресса и культурных изменений. Отчуждение проявляется в политической, правовой, экономической, психологической и духовной сферах — как утрата связи человека с собой, миром и

духовными ценностями. В центре нашего внимания — духовное отчуждение как наиболее существенная форма. Историко-философский анализ позволяет выявить его современную значимость и показать, почему это явление сегодня приобретает особую остроту.

МАТЕРИАЛЫ И МЕТОДЫ ИССЛЕДОВАНИЯ

При подготовке статьи использованы труды философов античности и современности, где тема отчуждения получила обстоятельную разработку. На основе комплексного, системного подхода исследованы факторы возникновения духовного отчуждения, его формы и последствия. Применены сравнительный, описательный, аксиологический анализ, а также историко-философский метод для последовательного рассмотрения понятий «духовная жизнь» и «духовность» в контексте социальных и гуманитарных наук.

ОБСУЖДЕНИЕ

1. Изучение отчуждения в истории философии. Ещё в античной мысли содержатся основания для постановки данной проблемы. У Платона тема отчуждения специально не выделена, однако в его учении о душе и материи прослеживается расхождение идеального и чувственно-материального миров; этот разрыв можно понимать как форму отчуждения. Душа — сущность человека и источник самоуправления; утрата «здоровья души» ведёт к потере самоконтроля, к «обездвиживанию» жизненной активности и, в конечном итоге, к отчуждению человека от самого себя. Мир материи изменчив и несовершенен, что порождает искажённое восприятие реальности; различие между миром идей и чувственным миром задаёт перманентное напряжение, которое можно трактовать как состояние отчуждения. В политической философии Платона идея иерархии и разделения функций может вести к социальной отчуждённости, поскольку предполагает неравенство и стратификацию общества.

Карл Поппер, анализируя платоновскую модель в «Открытом обществе и его врагах», критикует идею «философа-царя», указывая на опасности утопий, где во имя абсолютной истины ограничивается свобода и отчуждается личность. Идея «идеального государства» рассматривается им как потенциально опасная для реальной жизни; Поппер предупреждает об угрозе власти ради самой власти.

У Гегеля отчуждение — всеобщее условие движения мирового духа; оно снимается в вершине — философском знании, где дух достигает самопонимания. Тем самым высшая цель — самопознание и преодоление отчуждения средствами разума. Однако исторический опыт после Гегеля показывает, что отчуждение не исчезает автоматически с ростом рациональности.

Карл Маркс в «Экономическо-философских рукописях 1844 г.» анализирует отчуждение как реальный феномен капиталистического общества и выделяет четыре формы: (1) отчуждение работника от продукта труда; (2) отчуждение от самого труда как принудительной, внешней деятельности; (3) отчуждение человека от его родовой сущности; (4) отчуждение между людьми, от общества и государства. Конкуренция порождает дистанцию между людьми, подрывает социальные связи, усугубляет недоверие и враждебность.

Современное общество — ключевая тема социальной философии: оно охватывает природу человека, свободу, формы совместного бытия. Развитие искусственного интеллекта и биотехнологий ставит вопросы о воздействии на человеческую природу, свободу и смысл жизни. Современные исследования предлагают разные философские подходы к анализу проблем и тенденций.

Казахстанская философская мысль поднимает вопрос о том, ведёт ли технический прогресс к росту человечности и подлинных ценностей. Отмечается перевес материального над духовным. Ә. Нысанбаев предупреждает: нарастающая глобализация несёт риски конфликтов; необходимо усиливать внимание к мировоззренческим ориентирам помимо

техногенной цивилизации. Ғ. Есім подчёркивает, что ядром новой философии информационного общества является проблема гуманности; только опираясь на гуманистические основания и связь природы человека с образованием, можно обогащать духовный мир; иначе общество «теряет корни». А. Сейдимбек, исследуя особенности казахского общества, этногенез и этнокультурные связи, делает акцент на необходимости самопознания: без него участие в духовной и общественной жизни народа невозможно. В коллективной монографии по казахской философии подчёркивается необходимость интеграции отечественной философии в мировую (начиная с аль-Фараби), что позволит лучше выявлять глубинные источники человеческого сознания и духа.

Зигмунт Бауман описывает «жидкую современность»: традиционные формы социальной организации (семья, труд, институты) становятся хрупкими и изменчивыми; глобализация, быстрые технологические сдвиги, трансформации производства и потребления усиливают неопределённость и отчуждение. Чарльз Тейлор рассматривает роль религии и духовности, их влияние на общество и благополучие человека, взаимодействие религиозных и светских структур. Эрнст Блох трактует духовное отчуждение как процесс, порождаемый социальными и экономическими условиями, но, в отличие от Маркса, видит в «насыщенном утопии стремлении к лучшему» движущую силу преодоления отчуждения (принцип надежды).

Ж. Әбділдин указывает: если у Гегеля источники отчуждения локализуются в сфере духа, то у Маркса идеологические и психологические формы выводятся из отчуждения труда. А.В. Скороденок, опираясь на М. Кастельса, выделяет две линии: марксовскую (отчуждение от продукта труда) и связанную с зависимостью от виртуального мира в эпоху информации. Исследования О.Т. Ариновой выявляют доминирование виртуальных отношений и утрату самости.

2. Духовное отчуждение и ценности. Отчуждение — сложный процесс, в результате которого человек утрачивает подлинную сущность и свободу, превращаясь в объект влияния внешних сил и институтов. В социологии отчуждение понимают как самоизоляцию от общества; в психологии и медицине — как расстройство психических функций. В настоящем исследовании в фокусе — духовное отчуждение.

Чтобы прояснить содержание, разграничим «духовность» и «духовную жизнь». В античности «дух» (пневма) и «душа» (псюхе) играли ключевую роль (Платон, неоплатонизм). В средневековой мысли складывается синтез библейских идей с аристотелевско-неоплатонической традицией. В «Феноменологии духа» Гегель различает «мир отчуждения духа» и мир, где дух возносится и творит себя как «чистое сознание»; отчуждение — стадия развития духа, преодолимая самопознанием.

В материалистической традиции «дух» трактуется как функция высокоорганизованной материи — мозга; «духовность» и «духовная жизнь» понимаются как особая форма духовно-практического освоения мира. В современной гуманитарной мысли духовная жизнь — составная часть общественного сознания, выражающая интересы общества и его групп; она включает духовные потребности, ценности, формы организации функционирования общественного сознания. Признак духовности — связь человечности и мироотношений, способность к рефлексии и построению поведения; сюда входят познание, самопознание, восприятие мира, целеполагание и волевая деятельность. Духовность — это способность углубляться во внутренний уровень личности, возникающая на основе самопознания. Общество не может складываться и развиваться без духовной жизни и нормальной работы духовной сферы.

На определённой ступени духовность выражает согласованность ценностей, целей и интересов, что свидетельствует о высоком уровне духовного развития личности и общества. Между созидательными и деструктивными силами постоянно идёт «невидимая борьба»;

максимальная утрата жизненно важных ценностей выражается в состояниях социальной аномии и угрозы общественной безопасности.

В современной литературе выделяют сакрально-религиозное и светско-научно-синтетическое понимания духовности (Г.В. Платонов, А.Д. Косичев), причём духовность трактуется как проявление высших стремлений к знанию и служению людям. В казахстанской философии духовность складывается через свободное творчество и нравственный взгляд на мир, становясь неотъемлемой частью жизни; «духовная жизнь» охватывает широкий комплекс общественных отношений. В художественной прозе («Мұң» Ғ. Есім) подчёркиваются преемственность духа, смысл имён и фигуры духовного лидерства (Хакім Абай) как возможные антидоты отчуждения. А.А. Хамидов связывает духовность с внутренним миром и мировоззрением; стремление к добру — её главный показатель, тогда как жестокость и «внутренняя холодность» — признаки духовной бедности. І. Ерғали определяет духовность как «неделимое единство гармоний, эквивалентное целому миру».

Аксиологический анализ духовного отчуждения охватывает: (1) личную автономию — утрата самоконтроля, свободы выбора и ответственности усиливает отчуждение; наоборот, ценности автономии помогают его смягчить; (2) социальные связи — дефицит поддержки и взаимодействия повышает отчуждение; ценности заботы, эмпатии, взаимопонимания способствуют его преодолению; (3) смысл жизни и цели — их отсутствие усиливает отчуждение; наличие ясных целей и стремление к личностному росту предупреждают отчуждение; (4) культурные ценности — толерантность и уважение к разнообразию снижают отчуждение; (5) этические ценности — справедливость, честность, моральные принципы, действующие в обществе, уменьшают отчуждение.

РЕЗУЛЬТАТЫ

Духовное отчуждение — это утрата человеком своих высших способностей и интегральных качеств; оно характеризуется потерей духовных ориентиров в самопонимании и саморазвитии. В современном обществе духовное отчуждение подпитывается: (1) культурой потребления (приоритет материального над духовным, отождествление личности с обладанием); (2) технологическим прогрессом (виртуальная реальность, социальные сети и постоянный «онлайн» уводят от реальности); (3) гиперсекуляризацией (ослабление религиозной веры и практик вызывает чувство духовной пустоты); (4) социальным неравенством (порождает беспомощность и тревогу).

Учитывая междисциплинарную природу явления, можно выделить формы духовного отчуждения: (1) религиозное — кризис веры, утрата связи с высшими ценностями, влияние секуляризации и социокультурных факторов; (2) моральное — несоответствие поступков личным и общественным нормам; (3) идентификационное — утрата «самости», невозможность обрести смысл, влияние социокультурных факторов, личного опыта и внутренних конфликтов; (4) отчуждение сознания — отрыв от собственного внутреннего мира, мыслей и чувств, переживание одиночества и изоляции.

Поскольку формы и причины отчуждения меняются вместе с эпохой, полностью преодолеть духовное отчуждение вряд ли возможно. Своевременное распознавание требует времени и усилий. Данное исследование задаёт аналитические рамки для последующих научно-практических работ, учитывающих современные трансформации и многомерные процессы.

ЗАКЛЮЧЕНИЕ

Духовное отчуждение остаётся актуальной философской проблемой, оказывающей серьёзное влияние на жизнь человека. Исторический обзор — от античных мыслителей до современных исследований — подтверждает значимость темы и отражает изменения в понимании эволюции общества и личности. Отмечается важность сохранения и развития национальных духовных ценностей и культурного наследия как ключевого аспекта

социальной философии. Современные подходы предоставляют широкий спектр аналитических инструментов для изучения духовного отчуждения как сложного явления, связанного с взаимодействием человека и общества, и важного для устойчивости и развития социума. Необходимо продолжать междисциплинарные исследования (философия, социология, психология), углубляя понимание роли духовной связи в формировании личности и социальных динамик, разрабатывать ценностные стратегии, способствующие гармоничной совместной жизни.

Agricultural Sciences

Lipid Composition, Fatty Acid Profile, and Dietary Value of Horse Meat: Perspectives for Functional Nutrition and Human Health

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Annotation. Horse meat is widely recognized as a valuable dietary product with unique nutritional and therapeutic properties. This article examines the lipid composition, fatty acid profile, and cholesterol content of horse meat in comparison with beef, lamb, and venison. The high proportion of polyunsaturated fatty acids (PUFAs), particularly linoleic and linolenic acids, and the low cholesterol level in horse fat make it an important component of dietary and functional nutrition. Research indicates that horse meat consumption may contribute to the prevention and treatment of obesity, diabetes, atherosclerosis, fatty liver disease, and other metabolic disorders. The findings suggest that horse meat should be further promoted as a functional food with significant health benefits.

Keywords: horse meat, lipid composition, fatty acids, cholesterol, dietary value, functional food, obesity, liver disease, cardiovascular health.

Introduction. In recent decades, functional nutrition has become one of the leading directions of food science and technology. Functional foods are characterized not only by their high nutritional value but also by their ability to prevent diseases and improve metabolic processes. Horse meat has attracted growing attention as a product with unique biochemical characteristics, which make it suitable for dietary therapy and health-promoting diets.

Compared with beef and lamb, horse meat contains higher levels of polyunsaturated fatty acids (PUFAs), lower cholesterol, and more favorable fat melting properties. These features ensure easier digestibility, beneficial effects on lipid metabolism, and positive influence on liver function.

The objective of this article is to analyze the lipid composition of horse meat, highlight its comparative advantages over other animal meats, and discuss its role in modern dietary practices and functional nutrition.

According to Kadyrova R.Kh. [1], low-calorie diets including horse meat are effective in the treatment of alimentary obesity, fatty liver degeneration, and chronic persistent hepatitis. Such diets significantly reduce body weight, improve metabolic processes, and normalize liver function.

The lipid component of horse meat is of particular interest for dietology. Comparative studies of different animal meats show remarkable differences in lipid content and fatty acid profiles [2].

Table 1. Comparative lipid composition of different meats (g per 100 g edible portion) [2]

Indicators	Content, g per 100 g edible portion		
	Horse meat	Lamb	Beef
Total lipids	10,0±2,10	24,5±3,30	16,0±3,40
Triglycerides	9,10±0,90	23,1±2,10	16,4±0,90
Phospholipids	0,80±0,05	1,23±0,05	1,0±0,60
Cholesterol	0,06±0,0003	0,12±0,006	0,11±0,05
Free fatty acids	0,04±0,001	0,12±0,02	0,05±0,009
Non-lipids	0,10±0,03	0,40±0,09	0,40±0,008

It is evident that horse meat has the lowest total lipid and cholesterol content compared to lamb and beef.

Fatty acid profile of horse meat. The fractional lipid composition of horse meat in both raw and thermally processed forms (boiled for two hours). Their results showed that horse meat differs significantly from beef and pork. Beef contains more C16:0 (palmitic acid) and C18:0 (stearic acid), contributing to a higher share of saturated fatty acids. Pork and beef are richer in C18:1 n-9 (oleic acid), leading to higher monounsaturated fat levels. Horse meat contains more C18:2 n-6 (linoleic acid) and C18:3 n-3 (linolenic acid), ensuring a favorable PUFA profile. Additionally, venison shows the highest concentration of long-chain omega-3 fatty acids (C20:5 n-3 eicosapentaenoic acid and C22:6 n-3 docosahexaenoic acid), attributed to natural grazing conditions [3].

In total, 30 fatty acids were identified in horse fat, including 12 essential fatty acids. Their proportion is relatively high (15.8–18.4%), of which 14.1% accounts for linoleic and linolenic acids, with a favorable ratio of 5:1 [4]. By comparison, beef contains only 9% PUFA, and the linoleic/linolenic ratio is approximately 1:1.

Dietary and functional properties. Horse fat is soft, yellowish, and has a low melting point (24–28°C), which improves its digestibility and sensory qualities. The high PUFA content ensures significant dietary benefits, including a lipotropic effect that prevents fat infiltration of the liver and contributes to cholesterol reduction.

Research indicates a correlation between the deficiency of highly unsaturated fatty acids and the occurrence of malignant neoplasms. Cancer patients often lose the ability to synthesize polyunsaturated fatty acids (e.g., arachidonic acid). Therefore, linoleic, linolenic, and arachidonic acids may be used as preventive and therapeutic agents against cancer [5].

Thus, the unique fatty acid profile of horse meat makes it suitable for dietary therapy of diabetes, obesity, atherosclerosis, cholelithiasis, liver diseases, and other metabolic disorders.

Discussion. Compared with lamb and beef, horse meat demonstrates the following advantages:

1. Lower lipid and cholesterol content, making it suitable for low-calorie diets.
2. Higher proportion of polyunsaturated fatty acids, including essential fatty acids, beneficial for cardiovascular and liver health.
3. Favorable linoleic/linolenic ratio (5:1), which is closer to nutritional recommendations.
4. Lipotropic and anti-atherogenic effects, preventing cholesterol accumulation and supporting lipid metabolism.
5. Functional food potential, as it contributes to disease prevention and health improvement.

These properties highlight the importance of horse meat in functional nutrition and justify its inclusion in modern dietary products.

Conclusion. Horse meat stands out among red meats due to its unique lipid composition, low cholesterol content, and high level of polyunsaturated fatty acids. Its consumption contributes to weight management, liver health, and prevention of cardiovascular and metabolic diseases. The favorable biochemical profile of horse meat makes it not only a traditional food but also a promising component of functional nutrition strategies. Further research is recommended to explore consumer acceptance, industrial applications, and development of innovative delicacy products based on horse meat.

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