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FINANCIAL INSTRUMENTS FOR ENSURING NATIONAL SECURITY: EXPERIENCE OF UKRAINE IN MILITARY CONDITIONS

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Abstract. State security is the main guideline of state policy in the face of global challenges. For Ukraine, it is especially relevant, because during the period of the Russian-Ukrainian war, its foundations and essence experience significant deformations. Since the risks and threats to national security have increased enormously in Ukraine under martial law, its financial component should be formed according to the tools corresponding to the challenges, even ahead of them, since, according to analysts, modern war is a war of finances. The problems faced by the state, the banking system, financial and commodity markets and institutions, corporations and households need new financial instruments to ensure flexibility in financing strategic goals. As of September, the losses of the Ukrainian economy from the war are estimated according to various estimates, from USD 105 billion, or 70% of the average annual GDP over the past 5 years, to USD 600 billion, and this exceeds the level of GDP in 2021 by 3 times. This actualizes the needs of the scientific study of financial instruments with the aim of effective state regulation and equalization in the face of limited and increasing losses of human and material resources, changes in the direction and speed of financial flows, their sources, structure, reproduction and reservation. The study examines financial instruments of a predominantly budgetary direction, as well as the components of national indicators of financial security. It is also important to analyze the share of the state in the economy, the size of which determines the speed of response and the completeness of resistance due to a threat to national security. To achieve the goals of the study, the main legally established risks of financial instruments of the national economy during the period of martial law are systematized. The indicators of the financial security of the state for the period of hybrid and military aggression of the RF (2013-2021) were assessed, and according to open sources of data, which are rather limited, a forecast of these indicators for 2022 was made. On the basis of the Financial Stability Report of the National Bank of Ukraine, the budget innovations of the period of martial law are analyzed. The sources of financing the state budget for the period of the legal regime of martial law and its main directions for 2023 are summarized. It is concluded that the financial system of Ukraine in a short time managed to organize financial flows in accordance with the needs of ensuring national security, form an optimal balance of resources, maintain the volume of financing of basic budget expenditures, attract donor resources and resist the inevitable decline of the economy during the war. The role of donor countries of economic and military assistance, in particular Latvia, in deterring military aggression and ensuring the stability of Ukraine's financial policy was emphasized.

Keywords: Ukraine; Latvia; EU; financing; national security; martial law; State budget; financial indicators; National Bank of Ukraine; food security

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1. Introduction

According to the Concept (Concept, 2012), national security in the financial sector of Ukraine includes security issues in the following areas: budget, management of public debt, state-guaranteed debt and debt of the corporate sector, taxes, finance of the real sector of the economy, banking, foreign exchange market, stock market and non-banking financial sectors. To be effective, the financial sector requires the following qualities: balance, resistance to internal and external threats, the ability to ensure the optimal functioning of the national economy and the economic growth of the state.

Decree of the President of Ukraine No. 64/2022 “On the introduction of martial law in Ukraine” (Decree, 2022) provides for the need to ensure funding for measures related to the introduction of the legal regime of martial law on the territory of Ukraine. In practice, this Decree recognizes that the war and its course depend on the amount of funding and the effective distribution of existing and potential internal and external financial flows.

With the beginning of active hostilities, economic relations underwent severe deformation and the structure of the financial market, public finances, and financial flows of internal and external persuasion changed dramatically. All possibilities of state regulation of financial policy have been mobilized to stabilize the situation. The leading role in this process belongs to the government through legislation in terms of fiscal, customs, investment policy; National Bank of Ukraine; The state budget; financial market stakeholders, etc.

According to the report of the Ministry of Finance (Marchenko, 2022), in 2021, despite the COVID-19 crisis and turbulence in financial markets around the world, Ukraine demonstrated economic resilience: the GDP debt was reduced below 50%, the budget deficit was below 3% in GDP, a certain overfulfillment of the budget in terms of income. The financial balance of Ukraine before the introduction of martial law (February 24, 2022) was ensured by the financial flows of the open economy in the largest volume due to the export of agricultural products, metallurgy and IT services (Karakuts et al., 2022); developed regional interrelations on the overflow of financial capital; balanced state budget; beneficial interaction of agents and stakeholders of the financial market Under the state of martial law, the financial capabilities of the country are significantly weakened, while the need for financing defense and maintaining the country's life has increased significantly and is growing as the infrastructure is destroyed. Enterprises that are located in the war-torn zones practically fell out of the financial flows, while their share in GDP reached more than 50%; Many financial market stakeholders have ceased their activities, logistics and international trade have been disrupted, seaports have been blocked, budget expenditures are directed only to defense and minimally to social protection of the population. Financial instruments bear the greatest burden of the lever of regulating the security of the national economy, so these issues are important for research.

2. Literature review

The state and development of financial instruments for regulating national security, as well as the issue of financial security itself, are being studied by scientists, think tanks, public platforms, which is reflected in the adoption of legislative acts and the preparation of new ones, which together influence the formation of the financial policy of martial law.

The efforts of scientists are aimed at the following areas: Behnassi & Haiba (2022), Benton, Deininger & (2022), Glauben & (2022) - the subject of the consequences of the Russian-Ukrainian war for global food security; Buti & Messori (2022) - as a central fiscal capacity in the combination of the EU domestic and global agenda; Wyrwa (2020) on the review of European Union financial instruments supporting the innovative activity of enterprises in the context of Industry 4.0 in 2021-2027; Grishchenko & Kovtun (2022), Shaleny and others. (2022), Tytarenko & Yatsenko (2022), Tulush etc. (2022) - the state of state support for business during the war; Demianyshyn & Lobodina (2020) - development of the financial mechanism in the context of reforming the financial system; Johnson, Luby, & Moldogaziev (2021) - State and Local Financial Instruments: Policy and Governance Changes; Dropa (2017) - financial instruments for the formation of resources in the context of globalization; Lakatos & Arsenopoulos (2019) - SWOT analysis of a study of EU financial instruments to address energy poverty in households; Mullins & Murphy (2009) - financial globalization, state autonomy and modern financial instruments; Nakamura (2014) long-term financial regulation: monitoring of financial instruments as a complement to the regulation of financial institutions; Wishlade & Michie (2014), Nyikos (2016) - EU financial instruments lessons learned 2007-2013 for the period 2014-2020; Petrukha, Petrukha, & Krupelnyska (2022) - sustainable development goals and triggers for modernizing public finances; Khalatur and others. (2019) - financial instruments and innovations in the business environment: countries of Europe and Ukraine; Essa & Jasim (2022) - A comparative study of the concept of financial instruments.

However, aspects of financial instruments under martial law are not covered enough, since there was no such experience yet, therefore this is the object of our study in order to find effective, comprehensive mechanisms to support the economy, business and society of Ukraine.

2. Research methodology / Materials and Methods

The study is based on the hypothesis that financial instruments are a set of financial methods and levers of regulatory, informational and resource support that contribute to the organization of the planning process, stimulation and rational use of financial resources in order to ensure optimal financial flows, balanced economic development and obtain a beneficial social effect, studied for example by Kvasnytsia & Nekliudova (2020). Financial instruments are aimed at regulating financial flows in the serviced industry, that is, there are financial instruments for the agricultural sector, industry, trade, etc.

The most complete position of assessing national security, and in its composition of financial security, boils down to the fact that (Kharlamova, 2019) global security affects all states, and methods for assessing a particular state of its national security are currently invalid in the context of growing cyclical trends, therefore, such terms should only be used as a policy to protect the national economy from economic and other shocks during global fluctuations. We proceed from the assumption that financial instruments are the organizational embodiment of the resources of the financial market, the finances of the state, corporations and the population.

According to the Concept (Concept, 2012), the state of the financial sector of Ukraine depends on internal and external phenomena and factors (Table 1): the financial and credit policy of the state, the current political situation in the state, the perfection of legislative support for the functioning of the financial system, as well as international obligations of the state and has features for the period of martial law. Presenting information about the existing fiscal risks in the area of public finance increases the degree of soundness of financial policy decisions.

Table 1. Phenomena and factors that may lead to threats to the national security of Ukraine in the financial sector

External factors	Internal factors	External factors	Internal factors
a peaceful time period			
limited access to international financial markets		imperfection of legal regulation in the financial sphere	
significant dependence on export-import activities		uneven distribution of the tax burden	
the deterioration of the state of foreign trade, the growth of the balance of payments deficit, in particular the current account		outflow of capital abroad due to the deterioration of the investment climate	
significant dependence on external creditors		imbalance of the budget system	
the impact of global financial crises on the financial system of the state		insufficient level of reserves	
insufficient development of investment lending to the economy		weak development of the stock market	
period of martial law *			
disruption of international borrowing flows		a significant increase in the NBU discount rate	
difficulty in fulfilling international financial obligations		depletion of reserves	
decrease in the volume of export-import activity		financing of the NBU budget through the issuance of government bonds	
dependence on the decisions of state governments to provide aid		loss of territories and termination of enterprise activity	
the global crisis of the financial sector due to the security and energy crises		a significant reduction in tax revenue	
prohibition to use donor funds for the needs of the army		a significant increase in social support payments for refugees	
		relocation of business abroad	

* added by the authors

Source: Concept (2012)

According to Clause 52 of the first part of Article 2 of the Budget Code of Ukraine, fiscal risks are factors (including contingent liabilities and quasi-fiscal operations) that can lead to a decrease in budget revenues and/or require additional budget expenditures, respectively, cause an increase in the budget deficit and state of (local) debt compared to planned budget indicators. Information about fiscal risks and forms of their manifestation according to budget forecasts for 2023 is given in the Table 2.

Table 2. Information on fiscal risks and forms of their manifestation according to forecasts for 2023

Risks	Forms of risk manifestation
Functioning of the financial sector	the unprofitability of the banking sector, the growth of deductions to reserves, the loss of at least 20% of the loan portfolio as a result of the war and the economic crisis; the risk of collateral loans issued in the temporarily occupied territories
Fiscal risks related to public debt	there is a risk of non-fulfillment of obligations by economic entities of both the state and communal sectors of the economy to creditors for borrowings obtained under state guarantees, to the Ministry of Finance, as a creditor, for loans obtained by the state from international financial organizations
Fiscal risks of economic entities of the state sector of the economy	the emergence of new extraordinary challenges in the activities of state-owned companies, in particular, caused: reduction of production volumes and sales volumes; loss of assets and labor resources; rising prices for energy, raw materials and materials; complication and increase in the cost of logistics; loss of sales markets; significant deterioration of calculations; growth of receivables; shortage of working capital; growing need for loan funds and/or state support; a significant increase in the obligations of state-owned companies under PSO
Fiscal risks of the social sphere	non-fulfillment of the planned indicators of the Pension Fund's own income as a result of: decrease in the number of employees; decrease in the level of solvency; the increase in arrears for the payment of social security contributions and the reimbursement of preferential pensions
Fiscal risks of agriculture and food security	destruction of agricultural infrastructure, destruction of production facilities, storage, transport, energy, processing industry, loss of acreage; reduction of export opportunities of Ukraine and shortage of products on world markets; failure of the stable supply of agricultural products from Ukraine led to a rapid increase in world prices for grain and a decrease in its price on the domestic market, as well as to an increase in the corresponding balances; in the zone of hostilities, agricultural enterprises were physically destroyed, up to 30% of livestock, 25% of berry orchards and 20% of orchards were lost, 5% of land was damaged; the increase in the cost of fertilizers, fuel, and seed materials has led to an increase in the cost of production, which threatens the bankruptcy of enterprises and the rejection of the sowing campaign in 2022/2023

Fiscal risks associated with the elimination of the consequences of emergency situations	in the first half of 2022, 32 emergency situations were registered, of which 15 were man-made, 14 were natural, 2 were social, and 1 was military. In 2022, their increase to 115–135 is possible, while the number of natural resources will be in the range of 88–108. In connection with the armed aggression of the Russian Federation against Ukraine, the State Emergency Situations Service has classified a state-level military emergency from 24.02.2022 on the entire territory
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Source: Information on fiscal risks (2023)

To predict the vector of development of the financial component of national security, dynamic stochastic general equilibrium models are constructed, which makes it possible to study the effects of the influence of the macroeconomic policy applied at the moment on the predicted state of the economy. In the arsenal of modeling there is a fairly wide range of financial policy tools to influence the economic equilibrium. Under martial law, the government's response to economic shocks is probably the most expedient - an exogenous shock - an active stabilization policy aimed at neutralizing the consequences of the shock.

The recognized integral index of national security of Ukraine according to the components proposed by Kachinsky (2013) can take on a value from 0 to 1, in particular: values of 0-0.25 characterize the critical or very low state of the national security of Ukraine (inclusion here and in subsequent ranges of the upper limit); values of 0.25–0.5 indicate a low level of national security; 0.5-0.75 - average level; 0.75-1 - high. For the period 2013-2017. its average value was 0.38 (Kharlamova, 2019), by 2021 it increased to 0.58 (Luchik, 2018).

Indicative sub-indices of financial security are calculated according to the “Methodological recommendations for calculating the level of economic security of Ukraine” (Methodological recommendations, 2013). According to the Methodological Recommendations, the calculation of the integral indicator for each area of security, in particular financial security for the purposes of our study, is carried out according to the formula:

$$I_m = \sum_{i=1}^n d_i y_i \quad (1),$$

I_m - aggregate indicator/subindex of the m-th sphere of financial security, where $m=(1, 2, 3...9)$; d_i - weight coefficient that determines the degree of contribution of the i-th indicator (banking security, security of the non-banking market, debt security, budgetary security, currency security, monetary security) to the integral index of the economic security component; y_i - normalized score of the i-th indicator.

The integral indicator of financial security of Ukraine (I) is calculated by the formula:

$$I = \sum_m d_m y_m \quad (2),$$

where I_m - aggregation indicator/subindex of the m-th sphere of financial security, where $m = (1, 2, 3 \dots 9)$; d_m - weight coefficient, which indicates the level of inclusion of indicator/subindex m-th sphere of financial security in the integral index of financial security of Ukraine; y_m - normalized assessment of the i-th indicator.

On the basis of such a comprehensive methodological approach, the state and transformation of financial indicators of the Ukrainian economy during the period of the legal regime of martial law have been studied.

3. Results and Discussion

Since the beginning of Russia's military aggression and the introduction of martial law in Ukraine, in addition to other losses, losses in the economy have grown catastrophically. As of two quarters and early September, the Ministry of Finance (MinFin, 2022) predicts that the gross domestic product (GDP) of Ukraine may fall by 30-50% due to a full-scale war with the Russian Federation; in absolute terms, in 2021 prices, this would correspond to

UAH 1.6-2.7 trillion (\$56-92 billion) of lost production during the year (Danylyshyn, 2022). For comparison, Ukraine's GDP in 2021 was estimated at \$200 billion, that is, over the 7 months of the war, the damage exceeded GDP by 3 times, despite the fact that the intensity of destruction and losses is increasing. The National Bank of Ukraine (NBU, 2022) forecasts a GDP contraction of at least 1/3; The International Monetary Fund (IMF, 2022) expects the Ukrainian economy to contract by 35%, which is the deepest economic decline in the history of independent Ukraine. Other analysts, in particular the Kyiv School of Economics (KSE, 2022), estimate the destruction of infrastructure alone at \$568-600 billion, and the National Research Center "Institute for Agrarian Economics" (NSC, 2022) estimates losses in the agricultural sector, which produces 12% of GDP and half of the country's export earnings, at least \$58 billion. Such a significant drop concerns not only the Ukrainian economy, the losses are felt all over the world, since they are primarily related to global food and energy security.

The reaction of the financial market to the introduction of martial law through a review of the dynamics of the volume of financial market resources for the conditions of Ukraine in 2018-2022 is given in Table 3. The dynamics of the financial market over this period was heterogeneous, since the end of 2018, only the resources of the banking sector increased by 50%, while other resources either remained unchanged or decreased. Compared to the same period in 2018 (June 30), budget resources in 2022 increased by 40%. Corporate resources at the beginning of 2022 showed an increase of 17% compared to 2018.

Table 3. Dynamics of financial market resources, budget and resources of Ukrainian corporations for 2018-2022, UAH bln

	31.12.2018	31.12.2019	31.12.2020	31.12.2021	31.03.2022	30.06.2022
Banks	1360	1493	1823	2054	1970	2043
Insurers	63	64	65	65	65	66
Credit unions (r.h.s.)	2	3	2	2	2	2
Finance companies	125	162	188	214	205	204
Pawnshops (r.h.s.)	4	4	4	4	4	3
Budget	928	998	1076	1296	329	628
Resources of corporations	6941	6965	7395	8146	нд	нд

Source: built by the authors on the basis of NBU data, Non-Banking Sector Review (2022)

In 2018, the volume of financial resources of the market (including state budget resources) amounted to UAH 2,476 billion, in 2021 - UAH 3,629 billion, or 47% more. During the first quarter of 2022, resources decreased almost to the level of 2018, but already in the 2nd quarter of 2022 they increased by almost 30% against the level of 2018. At the same time, against the level of 2021, they are only 12% lower, and not 29%, as it was in the first quarter of 2022. Thanks to the relevant measures taken by the Government and the NBU, it was partially possible to stabilize the financial system and the revenues of the State budget, which is the greatest achievement of state regulation under martial law.

The impact of the introduction of martial law on the stability of the financial system of Ukraine (Fig. 1) is expressed in the fact that, thanks to the preliminary measures taken by the NBU to regulate the financial market, the drop in financial flow is less than could be expected under the influence of many shocks.

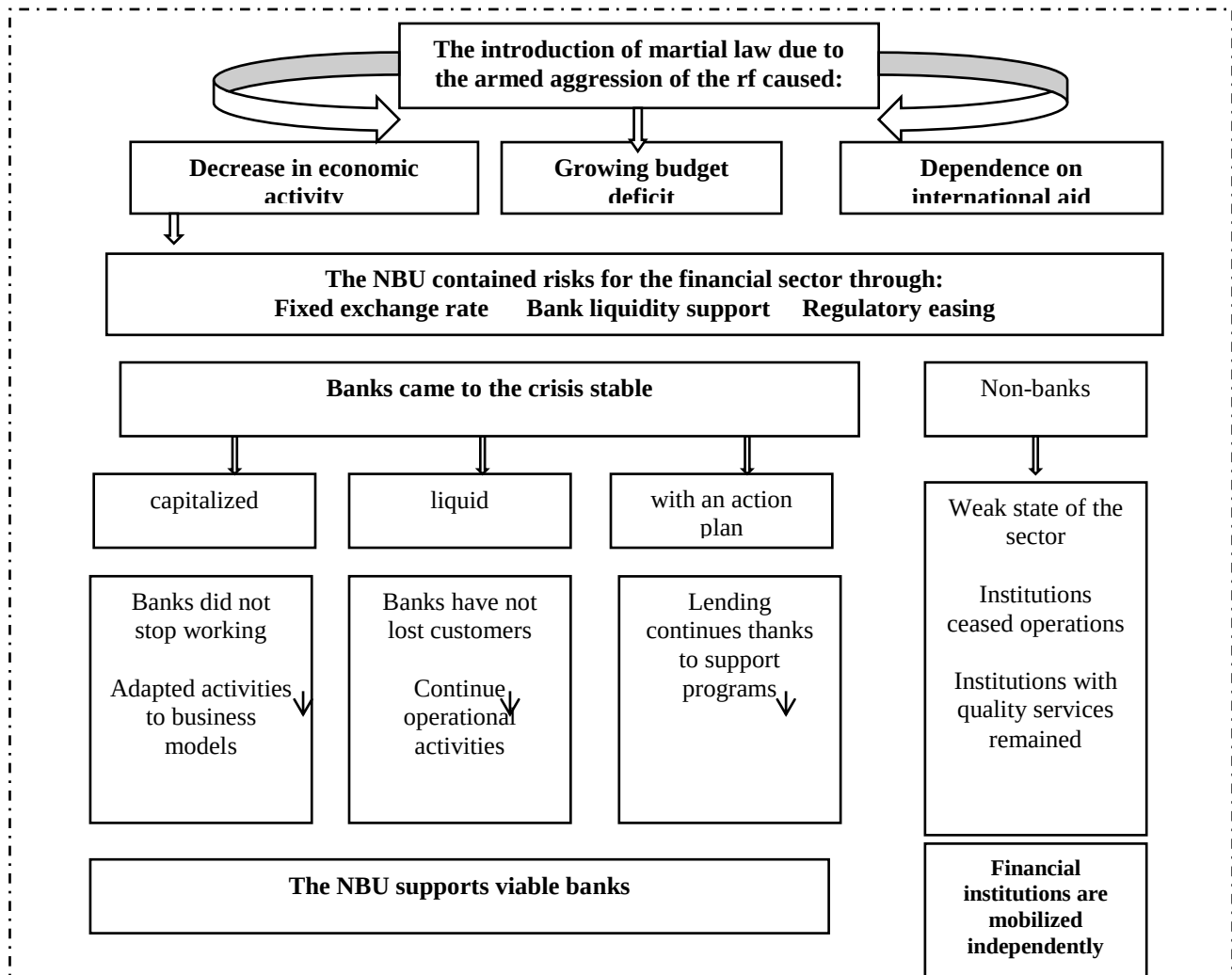


Fig. 1. The impact of the introduction of martial law on the financial system of Ukraine, 2022

Source: Report on the financial stability of the NBU.

The financial crisis of Ukraine, caused by the war, requires the formation of a sufficient amount of financial resources and effective management of financial flows. The government of the country is pursuing a policy of promoting the development of the domestic financial market, which restrains the economic decline, makes it possible to intensify investment processes and overcome the shortage of capital.

As of the beginning of September, financing of the state budget of Ukraine since the beginning of the full-scale war against Ukraine has been carried out for USD 31.951 billion or UAH 988,161 mln. Funding sources are government bonds, the IMF, bilateral agreements and grants (Fig. 2)

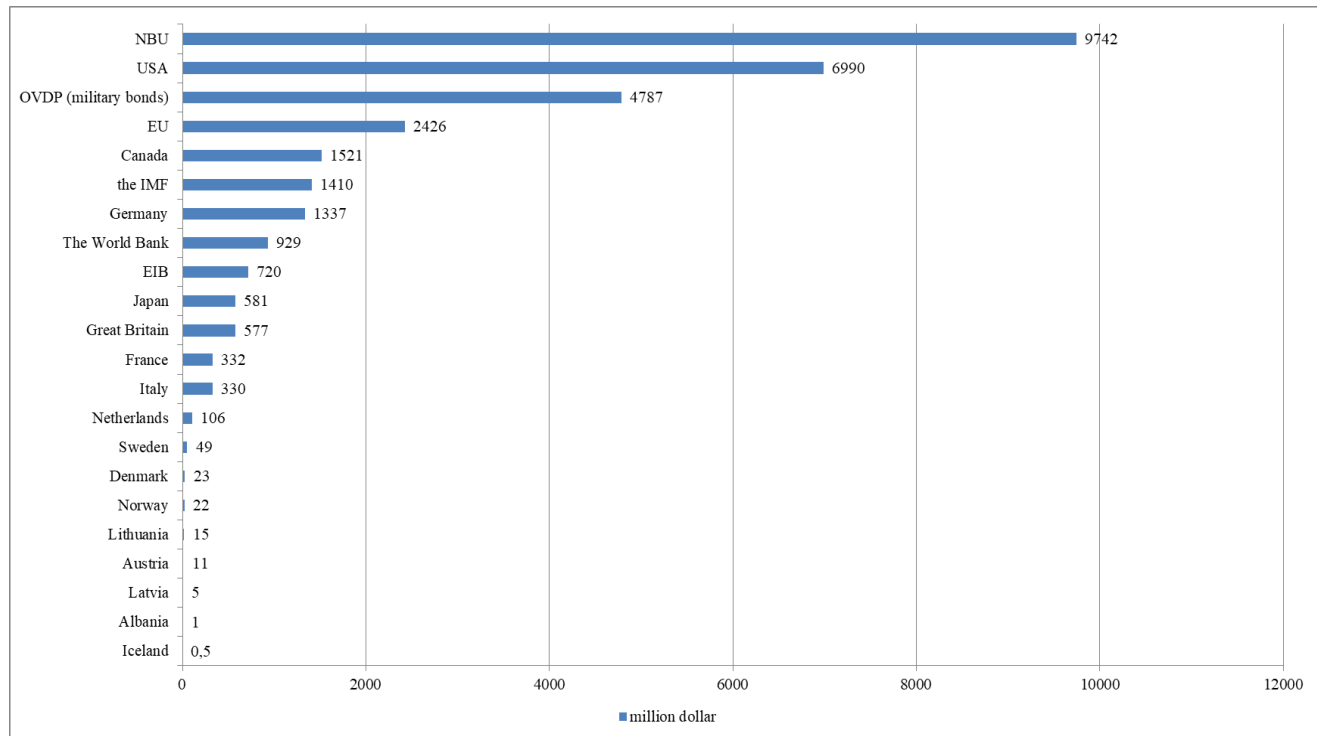


Fig. 2. Funding of the State Budget of Ukraine since the beginning of the full-scale war (as of September 1, 2022)

Source: Ministry of Finance of Ukraine, URL: <https://www.me.gov.ua/?lang=uk-UA>

Ukraine has already received about \$19.4 billion in financial support from foreign partners since February. At the same time, financing as of June 1, 2022 was distributed in the structure shown in Fig. 3, on the left side of which are data on absolute payments, on the right - the share of support in relation to the GDP of each country. The most significant support for the second indicator was received from the governments of Estonia, Latvia, Poland and Lithuania.

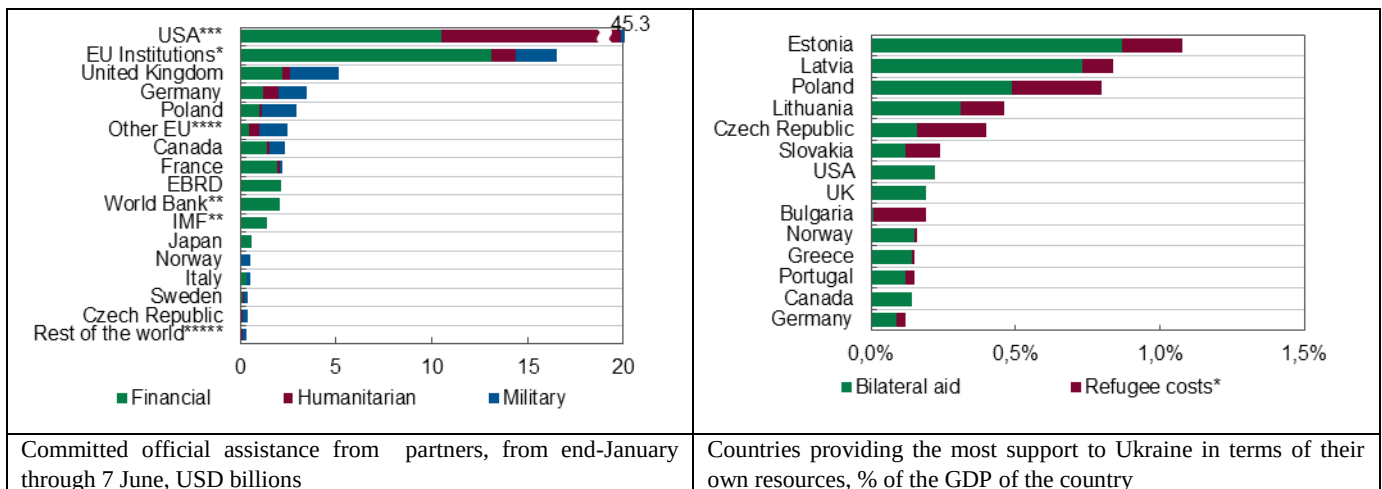


Fig. 3. Committed official assistance from partners

Source: Report on the financial stability of the NBU

In particular, it follows from open sources that by the end of August, Lithuanian military assistance to Ukraine alone will amount to more than 120 million euros, and the total amount of support - economic, financial, humanitarian, including assistance to refugees - will cross the threshold of half a billion euros (Lithuania, 2022). The Government of Lithuania also approved a €10 million assistance package for the reconstruction of Ukraine (Government of Lithuania, 2022).

From international financial organizations and the EU, Ukraine receives concessional loans and grant funding on a non-repayable basis to support the budget of Ukraine during the war. International support funds were directed to the general fund of the State Budget of Ukraine to ensure priority social, humanitarian, health care costs, and support for internally displaced persons. According to the Ministry of Finance (Minister of Finance, 2022), at least half of government spending in the coming months will be covered by external borrowing and grants. By the end of this year, the government expects to receive another €5 billion from the EU, \$4.5 billion from the United States of America and \$1.3 billion from the IMF (Minister of Finance, 2022). Dynamics of individual expenditures and their share in the budget of Ukraine for 2014–2022 is given in Table 4.

Table 4. Dynamics of functional expenses of the State Budget of Ukraine in 2014–2022, UAH million

	12.2014	12.2018	12.2019	12.2020	12.2021	06.2022
Budget expenditures	430217	985851	1075122	1127944	1490258	1036725
Defence spending	27363	97024	106627	120374	127527	334118
Defence expenditure, %	6,34	9,81	9,91	9,28	8,56	32,23
Spending on the economy	34410	63600	72364	168990	180980	26163
Economy in expenses, %	8,00	6,45	6,73	14,98	12,14	2,51
Expenditures on social protection	80558	163865	218628	322720	333280	210372
Social protection in expenditures, %	18,72	16,62	20,34	28,61	22,36	20,27

Source: Compiled according to NBU data. Available: <https://bank.gov.ua/>

As the data in Table. 4, funding for defense spending in 2022 increased by 23.67 p.p. against the level of 2021 and by 25.89 p.p. against the level of 2014 (Leontovych, 2022).

Table 5. Main macro-indicators of economic and social development of Ukraine for budget planning

Indicators	2021 report	2022 plan	2023 forecast
Nominal gross domestic product, billion UAH	5459,6	4688,0	6371,3
Real gross domestic product, growth rate, %	103,4	66,9	102,5
Consumer price index, %	110,0	131,5	130,0
Producer price index, %	162,2	135,6	135,0

Source: Ministry of Finance (2022)

In particular, clause 7 Budget plan 2023–2025 (Ministry of Finance, 2022) defines national security and defense expenditures for the general fund for 2023, based on the expected forecast of cash expenditures for 2022, taking into account the savings in funds for 2023 as a result of updating payments monetary security, provided for by the Government Decree No. 168 dated February 28, 2022.

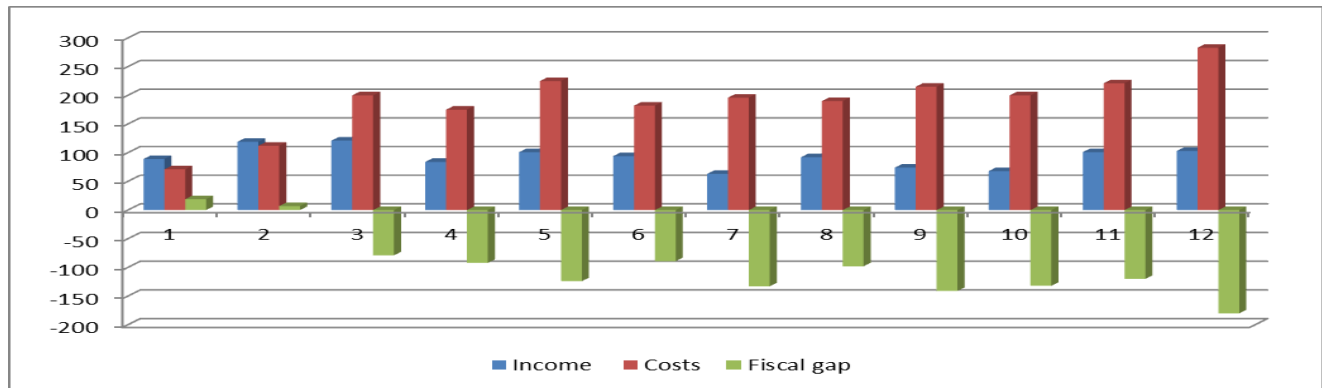


Fig. 4. Expected dynamics of the State Budget of Ukraine in 2022, UAH billion

Source: Kuhar (2022)

Prospects for the post-war recovery of the Ukrainian economy and investment priorities (Kuhar, 2022) predict that the cumulative fiscal gap in the budget of Ukraine in 2022 will be 1.2 UAH trillion (USD 35 billion), Fig. 4.

While the optimal mix of funding sources is often a matter of long-term considerations, the short-term macroeconomic implications of war financing are now important for Ukraine (Horodnichenko, & Talavera, 2022). An analysis of the impact of shocks of the macroeconomic environment on budgetary indicators for each of the shocks is presented in Table 3. This estimate is a preliminary-oriented calculation of the impact of only changes in real GDP on the budget revenues without taking into account the impact of other factors based on the value of elasticity coefficients for each type of income in terms of GDP calculated for Ukraine for the period 2004-2016 (*Fiscal risk information*, 2022).

Table 6. Effect of changes in budget indicators in 2022 in case of materialization of risks in the macroeconomic environment, UAH bln

Variables	Increasing threats to the national economy from the rf	Exit of non-residents from OVDP	Curtailment of foreign investments	Low credit activity of banks	Insolvency of subjects of economic activity	Low yields
Budget revenues	2,4	-1,2	-8,5 -	1,2	-1,1	-8,5
Personal income tax	-0,6	-0,3	-2,0	-0,3	-0,2	-2,0
VAT on imports	-0,9	-0,5	-3,3	-0,5	-1,1	-3,3
Income tax	-0,5	-0,2	-1,6	-0,2	-0,2	-1,6
Import duty	-0,1	-0,1	-0,4	-0,1	-0,1	-0,4
Excise	-0,2	-0,1	-0,8	-0,1	-0,1	-0,8

Source: calculations of the Ministry of Finance of Ukraine. *Fiscal risk information* (2022)

According to the Ministry of Economy of Ukraine (*Information on Fiscal Risks*, 2022), the following fiscal risks will exist in the current year and 2023 that will affect the state of public finances:

- the uncertainty of the duration and intensity of the military conflict, which may result in an increase in human losses and subsequent forced migration of the population, a significant decrease in the volume of foreign trade, continued destruction of important infrastructure facilities, an increase in losses in economic and production potentials, an increase in the costs of industrial logistics, a decrease in the level of their competitiveness and investment attractiveness;
- the lack of financial assistance from international financial organizations and donor countries can lead to additional money emission, reduction of budget expenditures, respectively, consumption of the general

government sector, reduction of budget support for business, which will have a negative impact on both the volume of demand in the economy and the volume of production, which will affect the price dynamics;

- non-compliance with the agreement reached on the unblocking of three ports on the Black Sea by the Russian Federation, which will lead to a decrease in foreign trade and may provoke a global food crisis;
- a significant reduction in full-time employees in the public administration can lead to an increase in unemployment, additional temporary pressure on the payroll of public institutions through significant short-term cash payments to employees, the outflow of highly intelligent labor force abroad, and a shortage of human capital;
- obtaining a lower yield of grain crops due, in particular, to crop losses due to the destruction by the aggressor country of both crops in the fields and places of storage of the harvested crop, which will lead to a decrease in the export capacity of the agricultural sector and, accordingly, foreign exchange earnings from exports, a decline in production in the processing industry, a shortage of food products in the domestic market and an increase in consumer prices for food products, which occupy a significant share in the consumer basket;
- non-sale of objects of large and small privatization due to lack of demand due to the deterioration of the investment climate in the country as a result of the aggression of the Russian Federation;
- the unfolding of the global economic crisis ("debt bubble") may lead to an additional drop in prices for export raw materials, a reduction in production, a decrease in the number of jobs, an appreciation of the US dollar, etc.

The Draft State Budget for 2023 (Draft State Budget for 2023) is built on the basis of a macroeconomic forecast that provides for nominal GDP growth of 37% (real growth rate - 4.6%, deflator - 30.7%). Despite the high growth rates of nominal GDP, the projected budget revenues for 2023 (excluding grants) are 10% less than the planned figures for 2022.

In the draft State Budget for 2023 (Draft State Budget 2023), support for defense capacity remains a priority, and total defense spending will exceed UAH 1.1 trillion, which is 40 times higher than in 2014. Almost all taxes and non-tax revenues collected by the state will be used for these purposes. Ukraine plans to raise funds from foreign partners to finance other expenses.

In 2020, fiscal security turned out to be the most vulnerable, demonstrating a drop from over 70% in 2019 to 40% in 2020. Since then, the situation has only worsened, and there are no data for a reliable calculation of 2021 and Q1 2022 yet, and we have established based on review of open data and their interpretation. Financial security over the same period decreased from 42% to 40%, which was facilitated by the timely implementation of security measures for the Government at the NBU. The calculated individual sub-indices (Marko, Radchenko, Melnichuk 2021) of financial security are shown in Table 7.

Table 7. Selective indicators of financial security of Ukraine for 2013-2022, %

Indicators	Value of indicators by year									
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022*
Bank security	53	29	19	23	35	38	43	44	46	28
Security of the non-banking market	49	46	34	32	30	31	32	30	27	16
Debt security	65	37	36	51	59	60	63	41	40	12
Budget security	58	56	64	62	64	65	67	43	47	36
Currency security	44	26	36	38	40	42	50	48	51	28
Monetary and credit security	59	70	46	69	65	59	56	61	59	32
Financial security	50	40	35	38	40	43	42	40	42	24

* preliminary forecast, due to the lack of macroeconomic statistical data

Source: compiled according to the data of the Ministry of Economy, 2022

There is a decrease in financial security sub-indices for all components. By the end of 2020, the most stable sub-indicator was monetary and foreign exchange security; the level of budgetary and debt security, as well as the security of the non-banking sector, significantly decreased. However, it should be noted that the calculation of the summary values of the sub-indices is carried out on the basis of a normative assessment and a smoothing constant, which is determined separately for each indicator by an expert, which reduces the reliability of the calculations and reveals significant disagreements in various scientific sources, even those that are taken as the basis for calculations.

Since the basic criteria of the Concept were adopted long before the hybrid (2014) and full-scale (2022) wars, it is necessary to form its new principles in connection with the current practice of financing under the legal regime of martial law.

According to experts, the total need for financing the recovery of the Ukrainian economy will be about USA 1 trillion.



Fig. 5. Approximate structure of financing sources for the economic reconstruction of Ukraine USA billion

Source: Danylyshyn (2022)

The challenges that Ukraine is now facing need to strengthen the state's ability to carry out stabilization measures. And this is possible only with an increase in the share of the state in the economy. This indicator is calculated as the share of expenditures in the State budget for government activities in relation to the gross product. The calculation of the indicator is given in Table 8.

Table 8. Dynamics of the indicator of the share of the state in the economy 2014-2022, UAH billion, %

	8.2022	12.2021	12.2020	12.2019	12.2015	12.2014
Budget expenditures: <i>State functions</i>	129	206	164	168	103	68
<i>Defense</i>	533	127	120	106	52	27
<i>Economy</i>	33	180	169	72	37	34
Total:	1450	1490	1288	1075	576	430
GDP	745	5460	4194	3974	1979	1568
Share of state expenditures in GDP, %	17	38	39	42	52	43

Source: compiled according to the data of the Ministry of Economy (2022)

Empirical evidence unequivocally proves that countries with a low state share are more vulnerable to extraordinary shocks and sovereign debt crises (Danylyshyn, 2022).

To build a strategy for post-war recovery, the World Bank, the government of Ukraine and the European Commission presented an analytical report "The Rapid Damage and Needs Assessment (RDNA)" (The Rapid Damage, 2022), which draws conclusions about the losses of Ukraine from the war and determines the country's needs for reconstruction and restoration.

Conclusions

During the period of the russian-Ukrainian war, national security is the main guideline of state policy in the financial sector. The growth of risks and threats to national security necessitates financial instruments to stay ahead of challenges.

Significant losses of the Ukrainian economy from the war, already exceeding the level of GDP in 2021, need state regulation and equalization through financial instruments, primarily banking and budgetary areas, according to the components of national indicators of financial security. The indicators of the financial security of the state for the period of hybrid and military aggression of the russian federation (2013-2021) were assessed, and according to open sources of data, which are rather limited, a forecast of these indicators for 2022 was made. From 50% in 2013, financial security has dropped to 24% in 2022.

An analysis of the state's share in the economy testifies to the possibility and speed of responding to threats to national security. The higher this indicator, the greater the share of the state in the economy and, accordingly, the higher the possibility of regulation, especially in times of crisis. For Ukraine, this share was 43% in 2014 and decreased to 17% in 2022 (according to preliminary data).

Thus, the war has a colossal destructive effect on the economy of Ukraine and the whole world, it is even important to trace the real losses. The damage affects investment, trade and the financial market, the level of GDP growth, external debt balances, the redistribution of exports and imports, and all these components are related to budget planning. However, in spite of everything, the budget of the legal regime of martial law should harmonize revenues and expenditures, focusing primarily on vital items for the preservation of the state, population, and economy.

In general, the financial system of Ukraine in a short time managed to organize financial flows in accordance with the needs of ensuring national security, form an optimal balance of resources, maintain the volume of financing of basic budget expenditures, attract donor resources and resist the inevitable decline of the economy during the war. This state was achieved thanks to the help of donor countries, in particular, Latvia.

Measures of financial regulation of national security in a state of martial law are reduced to promoting the preservation and stabilization of critical areas, primarily the defense sector and social spending.

The state's ability to finance defense and other areas depends on the speed of economic recovery and Ukraine's integration into the European economic space. Among the sources of filling the budget, international aid prevails and, to a lesser extent, tax revenues. To this end, measures are being taken to stimulate the attraction of international borrowing and domestic demand for services, the resumption of entrepreneurship, and the promotion of doing business.

In the geostrategic perspective, the national security of Ukraine depends on the ability to balance between the world centers of power and finance and has the need to develop in accordance with the chosen guidelines of strategic partnership.

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INCLUSIVE PARTICIPATION IN INFORMATION AND COMMUNICATION TECHNOLOGIES (ICTS) PROCESSES FOR SMART SERVICES IN THE CITY OF JOHANNESBURG

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Abstract: Governments everywhere must focus on rethinking service delivery as inclusive involvement in Information and Communication Technologies (ICTs) procedures for smart services has become unavoidable. Metropolitan municipalities in South Africa have joined the technology revolution that embraces smart services delivery through various ICTs and advances the idea of e-governance using the Stakeholder Inclusive Approach. To comprehend how the City of Johannesburg (CoJ) encourages inclusion in smart services, the researchers use an explorative qualitative design that works well with the inclusive stakeholder approach, which supports a collaborative process in ICT adoption. The study discovered through qualitative thematic analysis that inclusiveness is a comprehensive process that considers the demands of different stakeholders in the adoption and implementation of ICT. One issue that leads to ICT efficiencies in the CoJ is data fragmentation from numerous municipal agencies. Inclusionary participation has been widespread in virtual Integrated Development Planning (IDP) forums and other cutting-edge services provided by the CoJ. There have been some exceptional examples of free wifi supply. The study's conclusion reiterates the importance of comprehensive inclusion in ICT adoption and implementation as it links communities with the municipality and stresses the need for city officials to commit to upskilling programmes to improve the delivery of public goods and services delivery.

Keywords: Inclusive Participation; ICT processes; Smart Services; City of Johannesburg

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Additional disciplines: public administration/management

1. Introduction

Reforms in public administration are necessary to improve the calibre of public services. ICT has proliferated in Africa and can enhance marginalized citizens' livelihoods through smart service provision (Bello, Renai, Hassan, Akadiri & Itari, 2022). However, for the successful, efficient, and seamless delivery of services in South Africa, another paradigm shift—technological reform—is required. African countries, particularly South Africa, need this paradigm change, as it closes the ICT and information dissemination gap faced by traditional, tribal, and rural groups that are often geographically dispersed (Vyas-Doorgapersad, 2011:243 in Maseko, 2018:30).

The digital divide associated with ICT was confirmed in a study conducted by Karam (2019:154) who view the African continent as marginally divided along race, gender and class hence ICT penetration in can widen the existing social and economic inequalities. O'Callaghan (2018) study noted that smart service delivery through ICT is linked to the broader e-governance discourse where governance is going 'smarty'; to render public goods and services while anticipating positive economic turnaround or bad outcomes. Whereas inclusive participation in smart services is encouraged, critical scholars warned of the impending digital divide (Carlson and Isaacs, 2018:247) triggered by ICTs across countries and communities (Chetty et al., 2018). South Africa is a country marred by existing socio-economic disparities. Collins et al. (2016:68) warn of the minimal inclusion in smart services. Low-income families may not have access to digital devices, meaning they are excluded from attaining smart services, which local government may offer. In South Africa, the inclusion of smart services using ICTs is propagated in the National Development Plan Vision 2030, where revamping infrastructures for economic development is emphasized to run an industrial and increasingly service-based economy.

The ICT action plan prioritizes building a national, regional, and municipal fibre-optic network to support broadband access, with public funds supplementing private investment to meet social goals. The Skills Development Act of 1998 aims to improve public officials' skills in South Africa. The National Integrated ICT Policy White Paper (2016:1) sees ICTs as tools for socio-economic development. ICTs encompass computing and information technology, fixed and wireless telephones, data communications, audio and visual material, broadcasting, the Internet, and traditional ways of communication and post-delivery.

Nevertheless, South Africa's ICT strategy must outline municipalities' capabilities to exploit e-governance prospects. Local municipalities face many problems that could hinder service delivery through smart services. Robinson (2015:15) argues that to drive municipal smart services, strict adherence to New Public Management (NPM) principles that solve disjointedness and disintegration with a "whole-of-government" approach and that digital municipal governance is required to ensure efficacy and transparency. This observation stems from various service delivery challenges in South African municipalities (Kemp, 2020). Although recent research accredits ICT-enabled governance in local municipalities as relevant to service delivery improvement, other studies dispute that. For instance, Tomor et al. (2019); Yaetano & Royo (2015) refute the capacity of ICTs to change state-citizen relationships in service delivery holistically. This argument is drawn from the exclusion of citizens in ICT options and implementation processes in many local governments. Further utilizing digital tools can be affected by limited citizen participation. The poor or citizens without access to smart digital devices are excluded from providing their input in government affairs.

Mdlongwa (2014:39) laments the absence of inclusive participation as an obstacle to attaining inclusive participation in smart service delivery using ICTs. In most cases, service delivery could be improved because communities still determine who or how to turn to when faced with service provision problems in their constituency. Since understanding legal rights or the procedures to be followed is a plight for many communities, municipal officials can operate with impunity in the knowledge that no one will question them when they violate the rights of citizens (Mdlongwa, 2014:39). It can be argued that if unresolved such 'unholy' tendencies can deter inclusive participation whenever ICT project adoption and implementation arise in local municipalities.

Masibigiri (2022) also conducted a study on the same topic exploring service delivery challenges at the grass- roots level. Stating the opinions of Reddy (2016:7), Masibigiri (2022:18) stressed that "to date, several government initiatives have been introduced to address service delivery challenges and the dysfunctionality of municipalities, but none have led to any significant improvement in the local governance emergency."

Community members, meanwhile, have been unnerved to the point of violence due to poor service delivery. The article hypothesizes that service delivery challenges may be linked to the need for more inclusive participation in

general and ICT processes. This challenge may affect the delivery of smart services in the City of Johannesburg, a case under study. Guided by the Stakeholder Inclusive approach that promotes stakeholder involvement, this study answers the following questions:

- Is there any stakeholder inclusivity in ICT adoption in the CoJ?
- Which ICTs programmes have been used to promote stakeholder inclusivity in ICT adoption in the CoJ?
- What are the implementation gaps in ICT-related programmes to improve employee participation in smart service delivery in the CoJ?

After the introduction, the following section discusses the theoretical and empirical literature, followed by a discussion section on inclusive participation in ICT processes and a discussion on ICTs and Smart services. The fourth section contextualizes smart cities to show how they influence smart service delivery, followed by the methodology adopted for this study. The sixth section presents and discusses the qualitative findings of this study, while the last section concludes and offers recommendations and directions for further research.

2. Theoretical and Empirical Literature

The article adopts the Stakeholder Inclusive approach as a theoretical framework. Stakeholder inclusivity implies that organizations give stakeholders a right to be heard and simultaneously accept the responsibility to account for them (Slabbert, 2015:8). The article further adopts a stakeholder engagement tool to achieve stakeholder inclusivity. Stakeholder engagement represents the organization's endeavours to involve strategic stakeholders in decision-making, [and] to encourage participation in organizational activities (Slabbert, 2015:8). The Organisation for Economic Co-operation and Development (OECD)(2022:2) agrees with the idea and emphasizes that stakeholder inclusiveness in terms of involvement is an essential part of an inclusive and transparent policymaking process. It is a structured approach to interacting with stakeholders at any moment in the policy cycle about any policy decisions and the design and delivery of public services.

Stakeholders can be a person or a group. In this article, stakeholders comprise internal and external citizens of the CoJ. The project developers and owners may appear more credible by approaching stakeholder involvement and engagement with diversity. Acceptance of a proposal can rise if all members of society are considered. The development of a common, binding mission may also be aided. Everyone's sense of duty, ownership and belonging may increase if they comprehend how the development would benefit them. This increases the project's long-term sustainability, as highlighted by the Global Infrastructure Hub (GIH) (2021:2). In addition, the GIH (2021:2) emphasizes that by looking at individual results, stakeholders might consider the effect that the project has on the society and the economy. The project will more effectively meet their requirements if vulnerable stakeholders or those advocating for the interests of vulnerable groups have a say in how it is ultimately designed. There will probably be more support and buy-in for a project if the developer proactively makes steps to meet demands. Stakeholder involvement may cause long-term behavioural changes and affect people's perceptions at the policy or project level. A higher level of involvement raises awareness and indicates a greater social responsibility.

2.1. Inclusive participation in ICT processes for smart services

Inclusive participation means giving people a voice and presence in social life and in democratic processes, which enables socially just processes and outcomes (IGI Global 2022:1). Constantly fostering a group committed to identifying and resolving public issues is what "inclusion" is all about, while "participation" highlights the need of public input on the substance of programs and policies (Quick & Feldman, 2011:272). Inclusive participation can thus be considered as the involvement of "public employees, experts, the public, and politicians in collaboratively addressing public problems" (Quick & Feldman, 2011:274).

Politicians, policymakers, civil society organizations, and citizens have been considering how collective public decisions should be made in the twenty-first century considering the growing complexity of policymaking and the inability to find solutions to some of the most critical policy issues. There is a need for novel approaches to reach a consensus and act (OECD, 2020:2). This is particularly true for values-based issues, which require trade-offs and demand long-term solutions. The OECD has gathered evidence that citizen participation in public decision-making can generate better policies, promote democracy, and create confidence (OECD, 2020:2).

Inclusive participation can be conducted at employee participation (internal citizens) and community participation (external citizens). The current article only focuses on employee participation. The community participation aspect will be explored in future editions. However, it is important to note that for both citizens, successful inclusive citizen participation involves the following (The Hague Academy, 2022:3):

1. Empowered citizens: Citizens who can organize themselves and have the necessary abilities, knowledge, and attitudes to participate.
2. Effectively implemented laws, regulations, and policies that enable participation and social accountability.
3. Commitment to genuine inclusive participation by the government (political leadership and civil service) and citizens: willingness to incorporate citizens' needs and suggestions in the policy.
4. The identification, understanding and involvement of all relevant stakeholders, particularly marginalized and vulnerable groups.
5. A well-planned process with clear objectives and sufficient allocation of resources (financial and human). All stakeholders should understand the plan and its limitations.
6. A transparent government: the publication of understandable and useable information.
7. Trust between government and citizens.

A participatory democracy that demands that local inclusion, equal opportunities for all, and a gender perspective in local policy be implemented to remove prejudice can be seen as having inclusive citizen involvement as one of its essential components (Council of Europe [CoE] 2022:1). This inclusion is required at every level affecting people's lives, hence can be categorized as social, economic, human, financial, and technological inclusion. Tomor et al. (2019:3) argue that public engagement in ICT development in urban areas fosters what he refers to as a democratic and legitimate decision-making process; hence citizen inclusive is regarded as an intelligence gathering. His view support citizens' inclusion in a decision affecting them, which is also supported by Voorberg et al. (2015), who view citizens as bearers and users of local knowledge and expertise, which is vital in resource allocation. Citizen inclusion, as added by Tomor et al. (2019:4), is fundamental as it assists cities in an explosion of new ICTs that promote public engagement in development issues. As the Fourth Industrial Revolution (4IR) has gathered momentum in many countries, ensuring ICT-enabled governance instils a sense of ownership as communities can participate knowing the dialogue with a service provider mainly council authorities, may benefit their lives while promoting socio-economic sustainability. To achieve a collaborative relationship, the socio-technical approach that aligns with technology development is crucial for local government as citizens' voice is considered in ICT development, making it easy to address community service provision issues (Meijer & Thaens, 2016). Deriving inspiration from these arguments, the current article is focused on technological inclusion. The other categories of inclusion will form part of future publications.

2.2. ICTs and Smart services

ICTs are required to offer digitalized services through electronic mode. These services are called e-services. These services aim to bring comfort and convenience to the everyday lives of community members. The municipalities with the resources and infrastructure to offer these e-services are transformed into smart cities and can provide smart services. These highlighted significant concepts are explained below.

Although many aspects of a "smart city" have been discovered, a consensus on a definition remains elusive. Among these are a "smart economy" (concerning competitiveness), "smart mobility" (concerning accessibility and connectivity), "smart environment" (concerning natural resources), "smart human capital" (affecting people), "smart living" (concerning the quality of one's daily life), and "smart" (Giffinger, Fertner, Krammar, Kalasek, Pichler-Milanovic and Meijers, 2007: 45). These attributes of smart cities as Maseko (2018:3) posited are based on traditional regional and neo-classical theories of urban development and growth.

ICT utilizes "digitalized means to create a networked society, networked cities and networked governance associated with ICTs" (Castells, 2008, in Sadoway & Shekhar, 2014:1). The application of ICTs enables municipalities to become smart cities, resulting in smart residents, smart mobility, smart networks, smart grids, smart parking, and smart energy, to name a few consequences. The goal is to establish a municipality with the necessary digital tools to provide citizens with smart services. As explained by Ncamphalala (2019:6) in Vyas-Doorgapersad & Shava (2021:43), ICT, therefore, can be considered as a paradigm shift in public administration whereby the governance paradigm (1990 to date) is the current paradigm through which Public Administration and service delivery are being studied and performed, respectively has become solidly linked to e-governance through to rapid globalization and 21st-century information and communications technology (ICT) advancement. ICTs can improve the efficiency of service delivery. Few research works were conducted that authenticate this statement. A study by Maseko (2018) in the CoJ has put into practice an intelligent city strategy to improve Johannesburg's capacity to offer simple and easy-to-use services and be effective and transparently responsive. The CoJ concentrates on [several] essential smart city initiatives, as explored by Maseko (2018:103). One of the effective programmes is called "creation of a fully functional integrated Intelligent Operations Centre for well-coordinated, integrated and responsive service delivery [highlights that] the goal is to establish a cutting-edge data analysis centre to assist municipal administration in making better decisions and to offer a 360-degree picture of strategic and operational challenges through efficient information gathering, processing, and dissemination (Maseko 2018:103). The overall aim is to improve service delivery. Governmental institutions at all levels of governance, such as service providers, can enhance service delivery by interacting with their citizens through technology platforms. Notably, those who use these services could speak with a helpful governing body privately to voice concerns and get answers to questions, as emphasized by Maseko and Vyas-Doorgapersad (2018:176). This interaction is important for successful inclusive participation.

A further study by Ncamphalala (2019) in the City of Ekurhuleni (CoE) revealed various potential advantages of ICT inclusion as it promotes smart governance in local municipalities. This is attributable to the multiple benefits of technology connected to more effective service delivery. The study concludes that there are several ways in which data ICTs have a cross-cutting impact on municipal government. According to the data gathered, ICTs have the potential to significantly alter municipal government at the macro level by enhancing issue diagnostics, billing system solutions, queue removal, and official community interaction, as highlighted by Ncamphalala (2019:106). Smart governance refers to the participation of a range of stakeholders in decision-making and the provision of public services. It also refers to using new technologies, such as social media, the Internet, open data, citizen sensors, and serious games, to improve communication between urban governments and their constituents (Weiss, 2000:799, in Ncamphalala & Vyas-Doorgapersad, 2019: 207-208).

An advanced study on ICTs and smart services was conducted by Soga (2022) in the Cities of Tshwane and Johannesburg. While quoting Twizeyimana and Andersson (2019:175-177), the results of Soga (2022:75) indicate the benefits of e-government, which include "improvement in public service quality; increased government capacity to provide public services; better management and use of public economic resources; reduction of government operational costs; increased transparency and openness on the part of government; effectiveness of government policies; increased convenience and wellbeing of the public; government efficiency; empowerment of citizens; and increased and improved communication between governments and citizens."

These advantages are important components of inclusive participation, ensuring that the flow of information and the feedback responses between the government and the governed is improved for efficient service delivery.

Since ICT inclusion is part of the broader e-governance paradigm, Masibigiri (2022:66) affirms that e-governance necessitates novel approaches to management, discussion, and decision-making regarding public resources, as well as expanded opportunities for citizens to receive and provide feedback on and participate in the development of public programs and services. This is achieved with the use of e-administration, which is a technological element of e-governance. According to Balancing Act's News, cited in Kwadeli (2011:3) and Masibigiri (2022:66), E-administration refers to any of several technologies that convert paper procedures into electronic activities in a traditional workplace to create a paperless office. Thus, using ICT, e-administration improves productivity and performance and indicates a shift in perspective in public administration.

Inclusive participation refers to a change in how the government operates, which the public can access and engage in governance for better service delivery. Community members who were previously excluded from administrative activities now have the right to speak up, contribute input, and play a vital part in decision-making processes, as Sefuli (2012:2) states. ICT systems that allow e-government processes make this type of engagement feasible. For instance, citizens may visit the government website, leave comments, or express issues. Sefuli (2012:2) also highlighted that the most advanced form of digitalized government is e-government, which offers the public internet tools to communicate with their representatives and speeds up service delivery. E- government also fosters a dialogue between the government and the governed, encouraging the idea of [inclusive] citizen participation.

2.3. Smart cities

The definition of smart cities in the literature varies, although three common elements emerge among scholars when describing these terms. These include smart people, smart technology and smart collaboration (Meijer & Rodriguez Bolivar, 2016). The key argument from these scholars' study is that the smartness of a city is associated with its attractiveness to adequate human and financial resources. At the same time, ICT collaborations are enabled to advance smart service delivery. Pereira et al. (2018:144) asserts that Smart cities are ICT-based urban innovations that employ ICTs to deliver improved urban services and deal with growing urban problems due to urbanization without well-being-focused policies. Shava and Vyas-Doorgapersad (2022:280) advanced the understanding of smart cities by stating that such a city is a technologically connected urban area that employs ICT to achieve efficiency in urban infrastructure, services, grid transportation, waste management, mobility and parking, including water treatment. This definition is made with the belief that smart cities in South Africa are expected and designed to help curb urban ills such as rapid urbanization, population growth and the rise in informal settlements. This study accepts the earlier definition by Meijer and Rodriguez Bolivar (2016), which places smart cities at the focal point of implementing smart services to render public goods and services.

As growing urban metro, CoJ is expected to render smart services in various economic sections such as transport, health and education. Good examples of such smart services implemented in the CoJ include the transportation systems where Gauteng, an effective metro rail system, is used to transport citizens between the two major metros of City of Tshwane and City of Johannesburg. Various smart services are being rendered through CoJ portal where e-billing is key in allowing citizens to pay for their rates online. President Ramaphosa in South Africa has reiterated the quest for smart cities to improve the delivery of public goods and services. At the same time, citizens remain digitally connected to the Internet, where services and other business opportunities can be obtained. In South Africa, metropolitan municipalities are undertaking smart city initiatives to increase public happiness, accelerate industry development, and promote a stable society. It attempts to unite governments, corporations, individuals, and public products and services through a Unified Management Model. The plans include improving infrastructure, utilities, health, environment, transportation, education facilities, and resources.

Public services include administrative, civil, crisis, rescue, and recovery (City of Johannesburg, 2016). Similarly, Gasco (2016) concurs that smart city governance requires innovative decision-making models, collaborative networks and new government capacities, while Timeus et al. (2020) warn that local government capacities and decision-making are critical to a city's smartness. Despite the whole strand of research in the area, there is still a need to fill a gap in understanding how the City of Johannesburg (CoJ) encourages inclusion in smart services.

3. Methodology

As a method of inquiry to understand how the CoJ promotes inclusivity in smart services, the researchers employ an explorative qualitative design. This design blends well with the Inclusive Stakeholder approach, which advocates for a consultative process in ICT adoption and implementation. Bangani (2019:30) adds that such an approach is interpretive and naturalistic toward its subject matter. This assists researchers in understanding the natural setting by interpreting the phenomena that bring meaning to them. Explorative qualitative research designs offer textual descriptions. The study compiled information through interviews (primary sources) and literature reviews (secondary sources) from the multiple benefits of qualitative research. Relevant literature sources that encompass IDP reports, peer-reviewed articles, dissertations, and websites were used to support the discussion of the findings.

Interviews were conducted with the purposively identified eight (8) municipal officials who worked in the CoJ in 2022. A pseudonym was provided to capture responses as P1-P8 (CoJ) representing participants. The study participants' recruitment included male and female municipal officials with a decision-making portfolio in the CoJ. Inclusion is significant to understanding the situation from a strategic point of view. The interviews lasted one hour each, and the responses were audio recorded with the participants' permission. Permission was obtained from the CoJ to conduct interviews with municipal personnel. The College of Business and Economic Research Ethics Committee (CBEREC) at the University of Johannesburg also cleared the study. The participants signed the consent forms. The interviews were conducted via Teams and over the telephone, avoiding face-to-face contact while observing the COVID-19 Health protocols. Thematic analysis was employed to analyze qualitative data as per the paper's objectives.

4. Results and discussion

This section thematically presents qualitative findings from CoJ municipal officials who were the key participants.

4.1. Understanding inclusive participation in ICT processes for smart services

Inclusive participation as a term has yet to gain a universal meaning. However, common scholarship on the subject agrees that inclusivity entails involving all relevant stakeholders in decision-making processes that affect them. The stakeholder theory of inclusivity, as posited by Slabbert (2015:8), provides for organizations to give stakeholders a right to be heard and simultaneously accept the responsibility to account for them. Manda and Backhouse (2018:465) suggest that to achieve smart service delivery, the digital inclusion of stakeholders must understand how people should have the skills to access digital technologies. Real et al. (2014) study reasons that, while inclusive participation is advocated for in smart service delivery, digital inclusion of policies and actions is fundamental for addressing digital illiteracy and division problems. Communities can include ICT adoption when they understand the power of ICTs and how they can promote various community groups' social and economic emancipation. From these preceding discussions, the researchers saw it fit to ask participants about their understanding of inclusive participation in ICT adoption in the CoJ. The response is stated below:

Not sure, but I think it includes people with disability [as well]. What is pressing for the CoJ is universal uptake of the system / not certain departments in silos – which impinges on good data management. To promote inclusive participation, we previously engaged in the ‘train the trainers’ approach (Participant 1). The participant further stressed that the process might become challenging due to a lack of coordination and commitment. A study conducted in South Africa by Aruleba and Jere (2020) confirms that coordination and commitment in ICT projects as detrimental to inclusivity in South African state departments. Stakeholder inclusion in ICT adoption to attain smart service delivery in the CoJ is understood by study participants as an encompassing concept that integrates various groups of communities and people in societies, such as the disabled. Training municipal officials on sound data management were reported to significantly promote inclusivity across departments, which some participants believe can drive smart services in the CoJ. Matli and Ngoepe (2020) concur that equipping public officials with technical skills enhances their capabilities and is fundamental for driving smart service delivery in South Africa. Still, on the same question of how inclusive participation is understood in the CoJ, participant 2 added:

This is a complicated question since Smart City is a cross-cutting/integrated programme. This includes GICT [Global Institute of Cyber Technology], Smart City, CGIS [Corporate Geo-Informatics], Entities, and Departments, e.g., Public Safety and Health (Participant 2).

The participant emphasized that smart services not only mean technology but speak to new ideas and models that can be used to improve the delivery of services in our municipality. The study of Ragnedda (2019) corroborates these views stating that smart service provision in a state institution is crucial for improving the delivery of services in an efficient and accountable manner. The above assertion has provided distinct lenses for approaching inclusivity in smart services at the local government level. As a broad concept, smartly rendering public services require coordinating various stakeholders and departments, as noted in the findings. The absence of integration can result in poor service delivery in communities, contrary to the Stakeholder Inclusive approach that advocates for coordination and integration. This is supported by Kud (2021), who perceives research on ICT as fragmented since it fails to integrate technology use in the functioning of public administration. Although his view dismisses technology use in government, the study findings show that CoJ strongly emphasizes technology use in service provision, although gaps in the implementation phase exist. Other studies (Legacy, Metzger, Steele & Gualini, 2019: 273) disregard inclusive citizen participation in ICT as a fallacy citing data manipulation in authoritarian regimes; hence stakeholder views cannot be adequately addressed.

4.2. ICTs adopted by the CoJ to promote inclusive participation in smart services

Van der Walddt (2020) study has shown some factors that may determine e-governance: regulatory framework, administrative leadership, financial resources, and ICT infrastructure. These factors are crucial as they help assess inclusivity in ICT adoption and implementation.

The study of Ghareeb et al. (2019) lamented the absence of ICT infrastructure and visionary leadership as a setback to inclusivity in ICT development. Local municipalities in South Africa are regarded as the closest spheres to the citizens; therefore, they are local; ICT projects are expected to be driven by them, although limited capacity and resources are the challenges (Shava & Vyas-Doorgapersad, 2021).

As a metropolitan municipality serving a vast client base, the CoJ has entered the technological fray where digital technologies have been adopted through its Smart City office to ensure employees' inclusivity toward smart service delivery. This is confirmed by one of the participants who affirms that: We have roll-out out free wifi to enable citizens in various communities to be smartly connected to city activities. This strategy was inclusive and promoted effective – education as learners could access their online homework and interact with one another on various social media platforms. From this free Joburg WIFI, online libraries are being run, and so are the expanded e-learning programmes (Participant 3).

While the assertion confirms the CoJ's efforts to promote inclusivity in ICT adoption, another participant reiterates that:

Through the implementation of free wifi, the CoJ promotes inclusivity by enlightening the residents on the need to participate in virtual IDP forums. This is important because the IDP is the most viable connecting tool between communities and the CoJ; hence, I can safely appraise the municipality for its efforts in this case (Participant 4). Another participant added:

We have online portals & applications such as– ESP [Emigrant Support Programme] Planning submissions, Debt relief, and account queries to promote inclusivity. These online platforms help citizens electronically obtain smart services from their homes (Participant 5). The preceding assertions confirm the efforts of the CoJ to promote stakeholder inclusivity in ICT adoption. Nonetheless, the IDP report (2021-2022) for the CoJ promoting inclusivity in ICT implementation uses the growing digital divide and community inequalities. While the COVID-19 pandemic equally contributes to the current plight, inclusivity is a complex task to achieve as misconceptions surrounding ICT and related digital technologies of the 4IR still grip communities and city officials, some regard adopting modern ICTs might trigger severe job losses.

These sentiments corroborate the study by Shava and Vyas-Doorgapersad (2021), which revealed the fears of automation in the CoJ as it could potentially threaten existing office jobs. Inclusivity in ICT is widespread in South African municipalities; integrating communities through IDP forums, and other digital engagements such as Imbizos is rampant. From this discussion, it is clear that ICT integration gaps require the CoJ to enhance its stakeholder engagement approach, which is vital for improving service provision.

4.3. Implementation gaps in ICT-related programmes for smart services

The use of ICT in a government department is used to address various service delivery issues while ensuring efficiency and effectiveness. Sutcliffe & Bannister (2020:4) noted that local governments employ technology to do things differently and improve service provision. The study participants were asked what challenges affect ICT-related programmes in the CoJ. One of the participants revealed that:

In our municipality, there is wide fragmentation and poor coordination among city departments, which dismisses the notion of inclusiveness in ICT. For instance, City power has data, GSPCR [Group Strategy, Policy Coordination & Relations], M&E [Monitoring & Evaluation] has data, Development Planning has data, CRUM [Citizen Relationship and Urban Management] & call centres have data, and subscriptions to external data portals are not all collated. If this various department is to coordinate and include each other in City projects, we can have a well-run City that is integrative. (Participant 6). While commenting on the implementation gaps, another participant added:

There is a need for an integrated system, clearly defined process pathways for information to be shared, [and] organization (Participant 7). AI structure and culture – hard and soft [to be established]. The CoJ Data Management Strategy – architecture should be able to support this. The National Treasury City Support Programme is working on a tailored data storage system for cities (nationally) to improve integrated reporting and intelligence decision-making (Participant 8). The above assertion indicates that despite any potential gaps identified by the preceding participant, the CoJ is excelling in ensuring smart services, as noted by the coordination of various institutions to ensure that data management, for instance, is improved for the provision of smart services. When questioned about inclusivity in skills development programmes, one participant admits that:

Upskilling bureaucrats is burdensome but necessary. The process involves procurement which has administrative hurdles and cost implications. In this case, the city must do more with less diminished resources, especially in the post-COVID-19 era (Participant 1).

Deducing from the above assertion, promoting ICT inclusion in bureaucratic institutions such as municipalities is a mammoth task enveloped in the cloud of new opportunities regarding public service delivery. The difficulties in ascertaining training programmes among bureaucrats are supported by Luthuli et al. (2019), who note that training development could be stronger in municipalities in South Africa due to poor coordination between workplace skills plans and developments. This argument corroborates the study findings as ICT programmers mean to capacitate local government officials' need for endorsement among officials who are the drivers of development programmes at the local government level.

Given this mounting evidence against the efficiency of ICT in service delivery, the study argues that local municipalities in South Africa should have inclusive ICT training programmes that consider community involvement as they are the end recipients of municipal service delivery actions. Harnessing such a relationship is fundamental for attaining maximum responsiveness of bureaucrats and communities in ICT programs seeking to transform the service delivery landscape.

4.4. Implementation of ICT-related policies to promote employee and community participation in smart service delivery

Smart service delivery in governments is connected to the smart city ideology. Yin et al. (2015) claim that smart service delivery seeks to enhance citizens' quality of life using data-centred technology and value-based information that produces knowledge. At the centre of smart service delivery is the enabling legal framework that ensures that South African municipalities subscribe to such legislation, which stipulates the need to provide goods and services smartly. One of the participants holds that:

The CoJ has tried to comply with the National Integrated ICT Policy White Paper 2016, which advocates for wide ICT use in government. This policy is widely used in the adoption and implementation of ICTs to improve the delivery of services. However, the CoJ does not employ a one size fits all ICT policy as it depends on which area of service delivery municipal officials require ICT training (Participant 2).

This assertion provides a precise analysis that, although a suitable policy environment, adopting ICTs sometimes depends on what such ICT will be used for. However, the common belief in literature is that ICTs are a prerequisite for attaining smart service delivery. The study by Kumar et al. (2020) revealed that the policy environment helps promote community participation in ICTs adoption; hence the integrative processes can help identify knowledge gaps, the need for human and financial resources, and how a municipality can reinforce its governance structures to ensure that ICTs are used to the benefit of communities being served. While this analysis is robust in the CoJ, as noted in the literature, modern ICTs are being adopted to ensure quality service provision, one of the objectives spelt in its CoJ IDP of 2021.

5. Conclusion and Recommendations

The study sought to address the presence of stakeholder inclusivity in ICT adoption and the ICT programmes used to promote stakeholder inclusivity in ICT, including the implementation gaps in ICT-related programmes to improve employee participation in smart service delivery in the CoJ. The analysis of study findings indicates that inclusivity in ICT adoption is one prominent aspect propagated by the Inclusive Stakeholder approach. The literature analysis has shown that inclusivity in the CoJ is practised mainly through Integrated Development Plans (IDP) forums where the municipality announces the relevant technologies used to attain smart service delivery to communities. While this is another dimension of inclusivity, empirical findings have shown the various efforts embarked on by the smart city office of CoJ to promote inclusivity in various municipal departments through the increased use of ICT to leverage service delivery. Apart from remarkable efforts to promote inclusive participation in ICT adoption and implementation, the study has pointed to various challenges that require attention. One downside of encouraging inclusive ICT adoption in smart services is the temptation to embrace the

newest digital technologies without proper engagement with the relevant department that may want to employ such technology. The findings pointed out there is no universal adoption of ICTs in the CoJ as this relies on the department and leadership or strategic decision-making levels and whether a certain ICT is required. Attending ICT training sessions is unique across departments; hence inclusivity may be invisible in smart services.

Nevertheless, relevant literature from the CoJ IDP Review report 2021/22 has shown that various efforts have been undertaken to ensure services are rendered using modern ICT as the CoJ strives to become a smart city. The CoJ implemented the ICT Standard, Policies and Procedures (SPPs) in 2017, which sets out the principles and standards that determine the acceptable use of computing resources of the CoJ. The SPP aims to enhance efficiency in business by using computing resources and related ICTs while safeguarding computing assets from damage (CoJ, 2017). Digital divide and existing inequalities are some setbacks, although efforts are being made to install free wifi in city hotspots and other public community centres such as libraries. This is done to ensure citizens actively engage the municipality in service provision. The findings are imperative to local municipalities in South Africa as they demonstrate the need for employee inclusivity in ICT implementation which is critical for enhancing public service delivery.

Based on the conclusion drawn from the study, the CoJ is recommended to adopt a holistic approach that promotes stakeholder inclusivity in ICT adoption programmes. Municipal officials must become innovative, implement strategic governance systems, and embrace smart service provision by adopting modern ICTs in various service delivery sectors. The government must create a conducive regulatory and policy environment that promotes creativity, accountability, and responsiveness to stakeholder requests for ICT that can be employed to facilitate socio-economic development.

Further, the South African government should encourage governance platforms and a growing technological trend allowing stakeholders to provide hi-tech digital solutions and ideas easily accessible via the Internet. Such a wide collaboration and embracement of diversified ideas and ICT solutions promote inclusivity and help the quest for CoJ to become a smart city that is resilient and effective in redefining smart services. The study recommendations can be applied to various local municipalities in South Africa experiencing challenges related to stakeholder inclusivity in ICT. Few limitations were experienced in the study. The research relied more on interviews to tap into municipal officials' narratives regarding inclusive ICT participation in the CoJ. The study did not include surveys that could have been fundamental to interrogating citizens' views on inclusive participation in ICT for effective public service delivery. Also, participants were not easily available due to tight work schedules. Therefore, the study findings cannot be generalized to all urban municipalities in South Africa. Therefore, future studies can explore the politics or governance of smart cities to see how bureaucracy can be deconstructed to allow innovation and participation of stakeholders in smart service provision using digital technologies.

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RESEARCH, DEVELOPMENT AND INNOVATION IN BUSINESS ENTERPRISES: EXPERIENCE FROM EGYPT*

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Abstract. This paper addresses the linkages between research and development (R&D) and innovation on the one hand and the socioeconomic impact of research, development and innovation (RDI) on the other hand. More specifically, the paper suggests a two-stage methodology directed to analyse the performance of RDI in business enterprises and assess their development impact. A conceptual four-dimensional model and an integrated analytical framework were developed. This approach is complemented by the development of a statistical survey mainly designed to generate appropriate indicators for analysing the vital role of RDI in business enterprises. The survey results revealed several analytical points as well as specific imbalances of RDI system in business enterprises that need to be addressed by policymakers. Furthermore, the analytical results stress the need for Egyptian business enterprises to enhance and diversify their cooperation with other RDI-producing institutions to benefit from comparative advantages and improve the quality of RDI outputs.

Keywords: Research; Development and Innovation (RDI); Business Enterprises; conceptual model of RDI; Developmental Impact of RDI

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JEL Classifications: O3. 055

1. Introduction

Research and development (R&D) comprise "creative work undertaken on a systematic basis to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications" (OECD, 2015). Innovation, on the other hand, is viewed as "creative activity leading to the development of new product or process which differs significantly from the product previously delivered to consumers, or the process previously used by the company or the industry" (OECD/Eurostat, 2018). Based on the

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above definitions and rationale, scientific research, development, and innovation systems (RDI) represent a central issue in knowledge generation, dissemination and application processes in support of development.

Furthermore, innovative products and processes introduce new or significantly improved goods and services to be used in the product markets. They, therefore, represent an important factor supporting the acceleration of economic growth and the achievement of sustainable development of a country. Given the recent advancements in knowledge markets and the surge in intelligent digital technologies associated with the fourth industrial revolution, scientific research and innovation became a cornerstone of the transformation of knowledge societies and their economies in the twenty-first century.

Given its observed impact on transforming countries into a knowledge society and economy, and its recent increasing role in keeping pace with the fourth industrial revolution and its digital transformation trend, the RDI conceptual model has witnessed sensible changes and acquired new features. RDI became today an integral part of most sustainable development national strategies. These recent developments required changes in the original design and structure of RDI analysis and contribution to the production sectors.

2. Review of literature

Over the last ten years, the literature review on the topic of research, development and innovation has been a frequent research method. Several topics have been raised and discussed: Harmonic innovation as a virtuous evolution for the community development (Zangara et al., 2023), innovation magnitude of manufacturing industry (Rezk et al., 2016), or Business model innovation themes of emerging market enterprises (Luo et al., 2022). Similarly, a systematic literature review on the impact of R&D in industries is extensive, covering a wide range of topics: study the significant R&D investments in the presence of a positive and lagged effect of R&D investments in the high-tech industry (Chen et al., 2019), The Impact of R&D expenditure on firm performance in manufacturing industry (Öztürk & Zeren, 2015), The Impact of Government Subsidies on Private R&D and Firm Performance (Jin et al., 2018) among others.

Despite the numerous studies of the performance of RDI in business enterprises (Beld, 2014, Yigitcanlar et al., 2018, Kim et al., 2014), existing evidence are inconclusive to find specific ways for assess of development impact. Prior studies have explored the interrelationship between R&D investment, financial leverage, and a firm's R&D innovation success (O'Connell et al., 2022), or examination the drivers of university-firm R&D collaboration while at the same time assessing the determinants of innovation in the industry by analysing firm R&D collaborations with partners different from universities (Maietta, 2015) or comparing the impact of two policy instruments that may induce firms in developing countries to invest in R&D activities (Fernández-Sastre & Montalvo-Quizhpi, 2019) or investigates the mediating role of innovation performance in the effects of R&D intensity and R&D internationalization on firm performance (Leung & Sharma, 2021). Thus, a more approach that assess the impact of RDI on development of industry and their relation to economy is needed.

Management and economics, two areas close to science, are directly related to the study of innovation. The first seeks to understand the internal aspects of innovation, while the second aims to understand the implications of its evolution within companies (Kemp et al., 2003, Taques et al., 2021).

As shown in figure (1), the four-dimensional model represents approaches to analyse RDI performance and evaluate its impact on knowledge transformation in a country. The dimensions include; i) Inputs for producing RDI, ii) Alternative RDI output categories, iii) RDI pertaining to a specific sector in the production sphere of the national economy, based on the international standard industrial classification (ISIC) scheme (UNDESA, 2008) and iv) Modes of RDI cooperation between business enterprises and other national institutions, mainly RDI

producing institutions (such as universities and research centres), industrial clusters for innovation, and other social and manufacturing societies (UNDP/MBRF, 2021).

Regarding the "first category", RDI as a production function uses inputs related to gross spending on RDI, RDI human capital and sources of financing its activities. Examples of these input measures include spending per researcher, gross expenditure on RDI as a per cent of gross domestic product (GDP), number of researchers per thousand labour force, gross expenditure on research and development (GERD) financed by business enterprises (Khorshid, 2015, 2018).

Innovation in the production activities or business sector (as part of total RDI) is analysed in detail in Oslo manuals (OECD/ Eurostat, 2018). The experience has shown that innovation generated by R&D institutions and business enterprises represents the most significant part of its outputs. Finally, RDI, in general and innovation, in particular, are also produced outside the research and development centres, and the production sphere of the economy. This generally happens with societies characterised by a high percentage of creative, highly skilled and educated labour. This innovation sub-model is entitled "societal innovation". As a source of producing innovation, these institutions require a modern technology environment that coop with the knowledge era and the fourth industrial revolution of the twenty-one century and a favourable enabling economic and social setting (UNDP 2016, 2017, Cornell University, INSEAD and WIPO, 2020).

The "second dimension of RDI" conceptual framework shown in figure (1) depends on the nature and diversified structure of its expected outputs and development impact. Here, we can identify three categories of outputs; the first is concerned with R&D outputs such as publication counts, citation statistics, quality of research outcomes and patents by origin. The second category is related to knowledge impact and diffusion. This second category includes intellectual property receipts, the growth rate of production output per labour, and computer software spending on R&D. Finally, the last category of this RDI output dimension includes creative and cultural goods and services, intangible assets and online creativity. It is worth noting here that this second dimension reflects to a great extent the modern view of evaluating the impact of RDI, in the twenty-one century (Cornell University, INSEAD and WIPO, 2020).

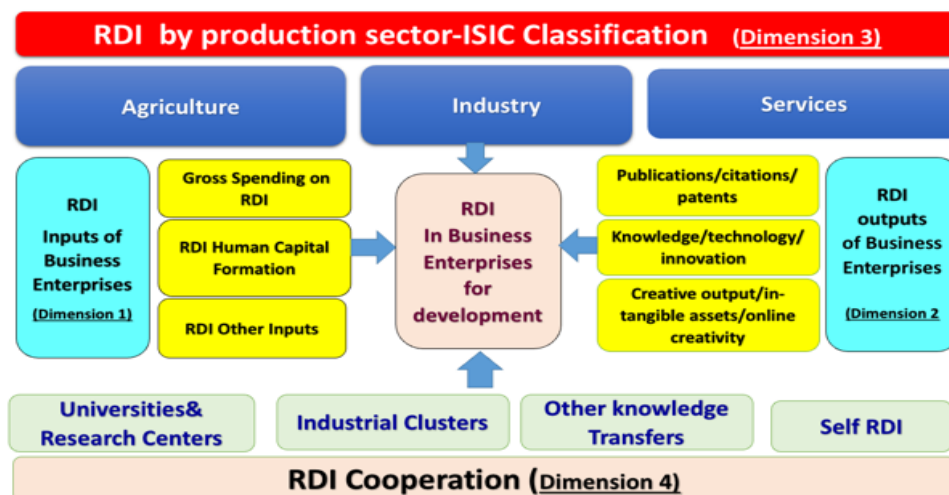


Figure 1. The Four-dimension conceptual model for assessing RDI in Industrial Enterprises

Source: the authors

As shown in figure (1), research and innovation can be classified similarly according to the production sector of the economy. This “third dimension of RDI” addresses development and innovation in a selected economic sector or production activity based on ISIC classification scheme. Despite the various breakdowns of economic activity, the most used sectoral division in RDI-based research identifies private and public industrial activities, general government sectors, households sector and non-profit institutions serving the households sector (NPISHS). For our study, ISIC disaggregation is determined by the number of production sectors covered by our statistical survey. The elements of the study concentrated on our application to the establishments pertaining to the economic activity in the governorates of Greater Cairo.

The last and “fourth dimension” of RDI conceptual model is classified by the research cooperation schemes or agreements. These classifications include four categories of research and innovation projects. The first is explained by RDI projects executed jointly by the business enterprise and research-producing institutions such as universities, research centres or scientific networks. The second category concerns RDI organised by industrial clusters composed of products and services enterprises (Khorshid, 2022, OECD, 2019). The third category addresses research projects carried out by the business enterprise that benefits from alternative knowledge transfer channels such as; intellectual property rights, research mobility of university professors to support enterprises on part-time bases, engagement of new highly skilled and educated graduates, published scientific research, the outcome of scientific conferences, virtual research networks and facility sharing with universities and research centres. Finally, the last category, assumes that the business enterprise will carry out the desired RDI activities on its own or without external support.

3. Methodology

3.1. Survey design and sample selection

The statistical survey is designed considering the above conceptual model for analysing RDI impact on the performance and functioning of business enterprises in Egypt, as well as the economic structure and geographic nature of the governorates of Great Cairo. The breakdown of various manufacturing sectors and enterprises of the sample was based on three main criteria; i) the rules governing the International Standard Industrial Classification of All Economic Activities (Revision 4) issued by the United Nations - Department of Economic and Social Affairs (UNDESA, 2008), ii) the number of workers in the production enterprise, as well as, iii) the sectoral contribution of the economic sector to GDP. Two constraints affected the sample selection process. The first constraint is that the number of employees should not be less than 25 workers. The second constraint was based on ranking the relative importance of each economic activity with respect to its contribution to the gross domestic product or GDP (self-financing RDI Projects).

The Centre for Statistical Surveys of the Faculty of Economics and Political Science at Cairo University was responsible for surveying to assess the role of research, development and innovation in the business enterprises of the Egyptian economy, according to the scientific rules and methodological methods used in this regard (OECD / Eurostat, 2018 and UNESCO/UIS, 2014). Data were collected in 2018 from (441) establishments in nine production sectors: foodstuffs, textiles and apparel, chemicals, pharmaceutical and pharmaceuticals, computers, electronic and optical products, electrical equipment, information and communication, finance, insurance, accounting and legal activities, and activities pertaining to the field of human health.

3.2. Specific Features of the Sample

Given the above criteria for the design and representativity of the sample, table (1) shows the number of business enterprises allocated to different production sectors based on ISIC classification. The sample structure shows that the textile and clothing activity occupied the largest share of the selected business enterprises, with a number reaching (130) establishments and (29.5) per cent of the sample size. The activity of human health came in

second place with (97) establishments and (22) per cent, followed by the establishment pertaining to the food manufacturing production sector with (86) enterprises and (19.5) per cent. With respect to the manufacturing of computers, electronic and optical manufacturing sector, the sample size was at most (5) establishments with (1.1) per cent of the sample. Table (2) shows the distribution of the sales volume in million EGP of the sampled establishments by economic activity. (Ismail et al., 2020; UNESCO Institute of Statistics, 2014)

Table 1. Distribution of the selected sample establishments according to the economic activity

Production activities	No. of Establishments
Manufacture of food products	86
Manufacture of textiles and apparel	130
Manufacture of chemical materials and products	62
Manufacture of pharmaceutical and pharmaceutical products	12
Manufacture of computers and electronic and optical products	5
Manufacture of electrical equipment	18
Information and Communication (Computer Programming - Information Services)	6
Financial activities, insurance activities, legal activities, and accounting activities	25
Activities in the field of human health	97
Total number of establishments	441

Source: Survey results.

Table 2. Distribution of the selected establishments according to the volume of sales (in Million EGP)

Activities										
	Health activities	Financial, insurance and accounting activities	Computers, electronic and optical products	Electrical Equipment	Information and communications	Textiles and apparel	Pharmaceuticals and pharmaceuticals	Food	Chemicals	Grand Total
Less than 50 thousand	1.04%	4.00%	20.00%			6.25%		2.50%		2.90%
500-50 thousand	30.21%	56.00%			16.67%	20.54%		8.75%	3.23%	18.36%
500 thousand - 2 million	52.08%	28.00%	40.00%	31.25%	50.00%	26.79%	41.67%	28.75%	38.71%	35.99%
10-2 million	12.50%	12.00%	20.00%	25.00%	33.33%	22.32%	41.67%	26.25%	29.03%	21.98%
More than 10 million	4.17%		20.00%	43.75%		24.11%	16.67%	33.75%	29.03%	20.77%
Grand Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.01%	100.01%	100.00%	100.00%	100.00%

Source: Survey results

4. Analytical Results

Analytical results based on the statistical survey are organised in light of the dimensions of RDI conceptual model explained in section (1) of the paper. We begin with the analysis of RDI inputs (Dimension 1) and then with RDI outputs (Dimension 2), taking into consideration RDI-specific characteristics and the nature of the production sector in Egypt (Dimension 3). Finally, following dimension 4, research cooperation between business enterprises and other domestic institutions (universities, research centres, etc.) is assessed. As we have explained in the above sections, sample size consists of (441) establishments collected from the governorates of Greater Cairo and grouped into nine economic activities which are foodstuffs, textiles and clothing, chemicals, pharmaceutical and pharmaceutical materials, computers, electronic and optical products, electrical equipment, information and

communication, financial and insurance services, accounting, legal services and human health activities.(Ismail et al., 2020; Khorshid, 2022).

4.1. Dimension 1: Research, development and innovation inputs

Based on the developed RDI conceptual model, dimension 1 emerges from treating RDI as a production function, with inputs to be provided by business enterprises and partly imported from other institutions, and outputs ensuring the desired quality and satisfying market demand for research and innovation services. Inputs of RDI are broadly composed of gross spending on the production process, cost of human research capital, and other expenditure items (such as the purchase of industrial designs, patents and property income).

RDI Human Capital

Figure (2) summarises the human capital composition, including research and development workers. Based on the survey results, the total number of employees in the business enterprises is computed as (59,463) persons. The research, development and innovation workforce reaches (4,292) employees, with an estimated share reaching (7.2) per cent of the total labour force, on average, across all economic sectors. These RDI employees are generally characterised by being highly educated, skilled and competent. This percentage share is relatively low compared to advanced industrial and developing countries. It captures an essential structural imbalance in Egypt's labour market. Based on recent analytical indicators of the Egyptian science, technology and innovation observatory (ESTIO) of the academy of scientific research and technology (ASRT) in (2019), (60) per cent of research and development human capital is working in the higher education sector, (32) per cent of researchers are engaged in the public research centre of the government sector. Private Business enterprises and other non-government non-profit institutions are left with only (6 to 8) per cent of the aggregate research labour force. It is worth noting that the percentage share of researchers in the business sector of advanced industrial countries such as Japan, the USA, and Germany represent 79, 70 and 60 per cent, respectively.

Furthermore, Egypt occupies the (58) country rank in the indicator measuring the percentage share of researchers working in production enterprises in the global knowledge index (GKI) produced by UNDP and Mohamed Ben. Rashid knowledge association (UNDP, 2021), with a performance measure, computed only as (19.6) per cent. Finally, research workers in Egypt per million persons account for (1,500) persons, whereas Lebanon, Tunis, and Morocco realised (3,400, 3,100 and 2,200) persons per million inhabitants, respectively.

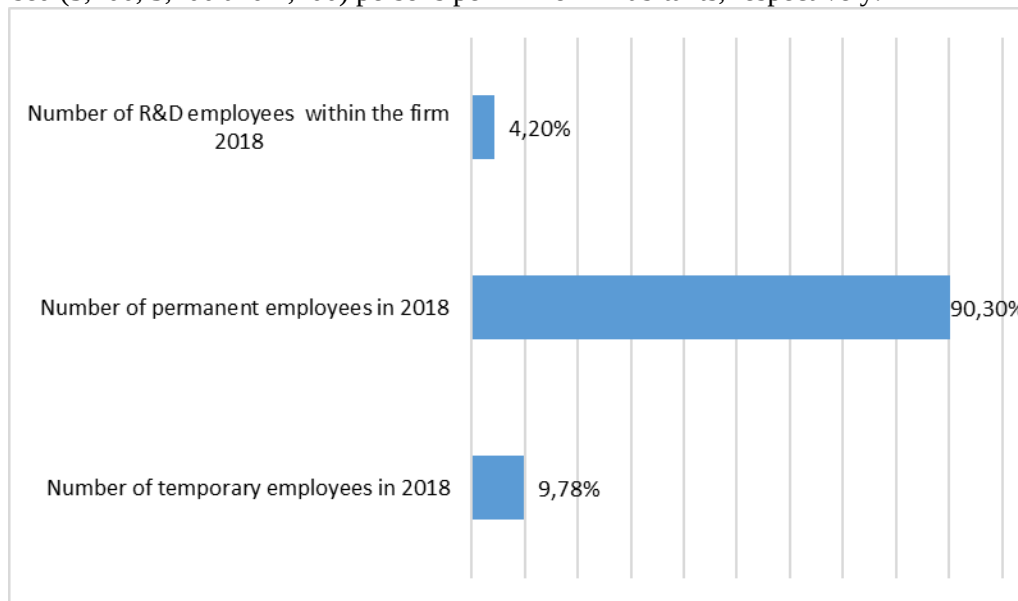


Figure 2. Distribution of employees between RDI and other activities (%)

Spending on Research, Development and Innovation

Figure (3) shows the breakdown of spending on RDI. It includes three expenditure types; operating costs, investment spending on physical assets, and investment on intangible assets. Operating costs include compensation of RDI employees and intermediate consumption. Investments in physical assets comprise purchases of computer equipment and measurement instruments and the cost of building and construction. The remaining cost items concern investment in intangible assets. In the knowledge era of the current century, intangible assets represent a considerable part of the total production assets of a manufacturing enterprise. In most developed countries with the advanced industrial sector and high levels of technology inputs, intangible assets account for around (40 to 50) per cent of their total production assets (Khorshid et al., 2019; UNDP, 2021). Intangible assets are divided into three categories: i) informatics and database systems, ii) intellectual property products and iii) Economic competencies such as training and re-orientation activities, production of trademarks, marketing systems and management and organisational innovations. The essential component of intangible assets in the twenty-first century is intellectual property rights. These assets are considerably dependent on innovation initiatives and activities. They include four sub-components: intellectual property income, research and development, patents and industrial designs, and creative and cultural products. Not here that the new trends in estimating innovation reflected in the global innovation index (WIPO, 2021) consider creative and cultural outputs as part of the innovation composite index.

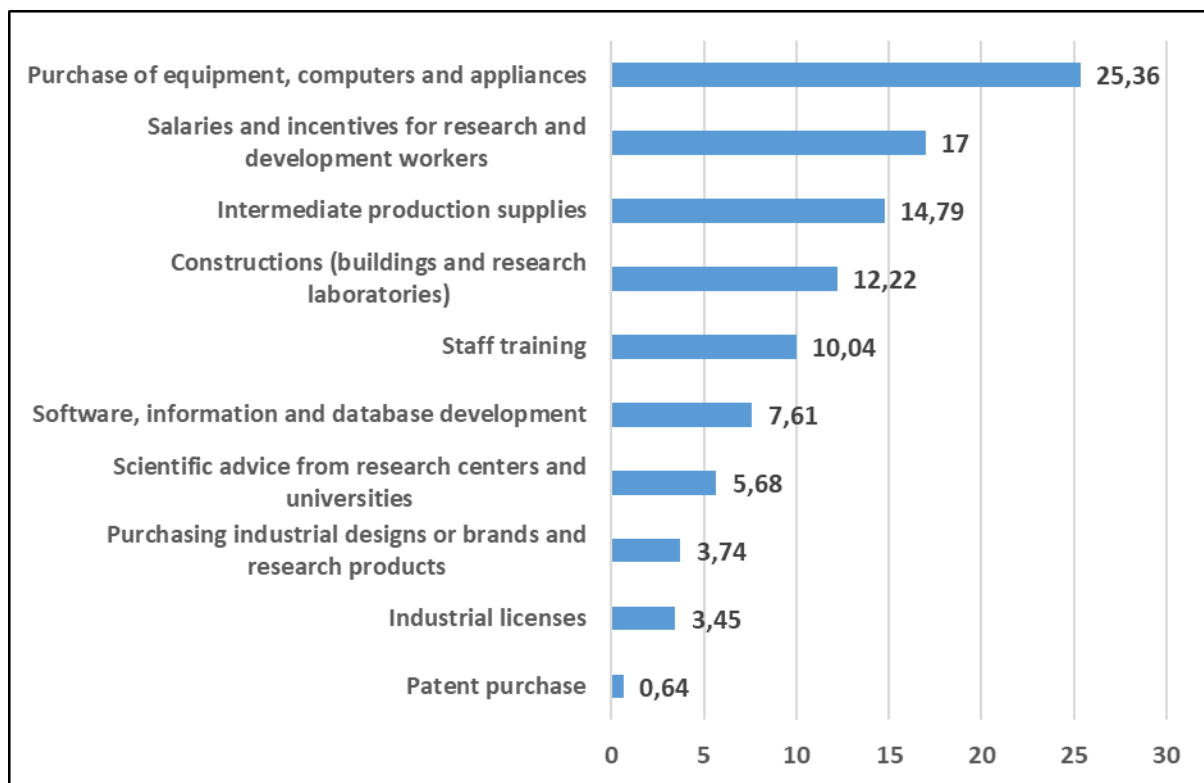


Figure 3. Breakdown of Expenditure items on RDI

The spending structure of the business enterprise represented in the collected sample reflects a number of analytical points. Investment in intangible assets to produce innovative goods and services and significantly improve manufacturing, managerial and marketing operations is relatively limited, except for staff training, which accounts for (12) per cent of total spending. Spending on R&D provided by research centres and universities is less than (6%). Purchase or acquisition of all intangible assets, such as informatics and database developments, research consultation, and purchases of industrial designs, trademarks, and patents, account only for about (15)

per cent of the gross RDI expenditure of the firm. The most significant part of spending on RDI are purchases of computers and other equipment (25%), compensations of the research labour force (17%) and intermediate inputs (15%).

4.2. Dimension 2: Research, Development and Innovation outputs

Structure of Outputs:

Based on the conceptual model described in section 1, RDI outputs of industrial corporations can be evaluated on three fronts. The first concerns publications, citations and patents, which are produced jointly by universities, research centres and business enterprises. The second output front is more oriented towards knowledge and technology outputs. Finally, the last output front deals mainly with innovation, including creative and cultural outputs, intangible assets and online creativity (OECD 2008, WIPO 2021; World Bank 2022). Figure (4) summarises the average number of RDI outputs from Egypt's business enterprises based on the survey results for 2016 and 2018.

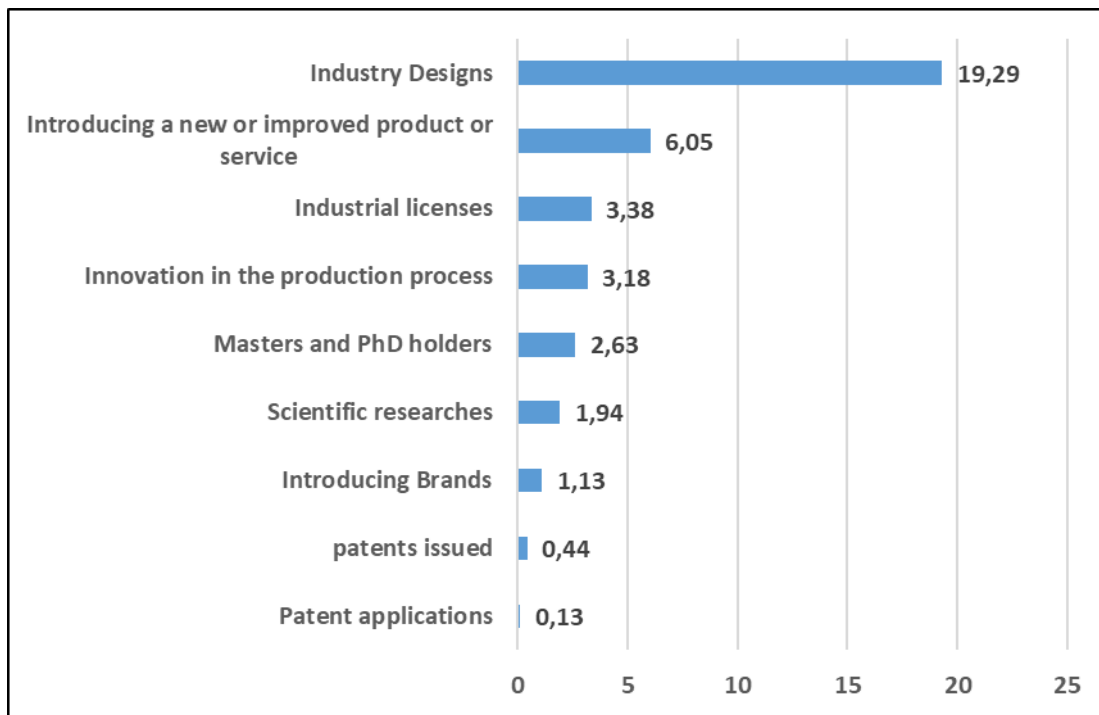


Figure 4. Average RDI outputs of Egyptian business enterprises

The survey results stress that the highest output type is industrial designs as a component of the enterprise's intangible assets. Their average number account for (19.29) designs across the business sectors covered by the statistical survey. The second-highest average number of outputs are new (or significantly improved) commodities or services representing part of the enterprise's innovation activities. This innovative output type is computed as (6.05) units per the surveyed period. The third RDI output is the acquisition of the licensed property income and the innovation of the production process, with average numbers accounting for (3.38) and (3.18), respectively. Other RDI output types, such as published research, patents or commercial marks, are extremely limited. These results stress finally the need to enhance RDI outputs of business enterprises and diversify the scope of their outputs.

Economic Return:

Despite the modest ability of the sampled establishments to innovate, export and produce intangible assets, investment in research, development and innovation has achieved a positive economic return. Figure (5) captures the economic impact of RDI activities on the performance of the sampled business enterprises. The most important economic impact of RDI is the considerable increase in the sales of goods and services, which account for (39) per cent on average. An increase in the enterprise's production capacity can be observed, which reaches (32) per cent on average.

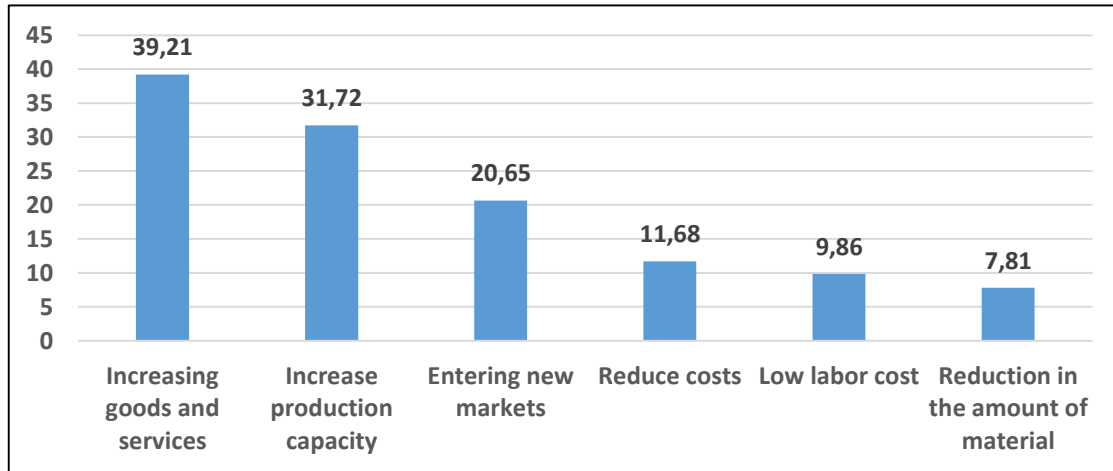


Figure 5. Economic return of RDI on business enterprises (%)

The penetration into new commodity markets represents the third RDI economic effect, with an increase of (21) per cent. Finally, the impact on reducing production and labour costs is considerably less than the increase in sales volume (Pradeep et al., 2017).

RDI Barriers:

In figure (6), barriers facing the business enterprises to carry out RDI activities and benefit from their positive impact on productivity are summarised. Based on the results of the survey, the financing needs represent the most important barrier to carrying out RDI activities in business enterprises with a probability of (39) per cent, followed by the no need for its adoption, with an associated probability of about (24) per cent. This second result can also be interpreted by the fact that managers may not be generally convinced of the benefits of applying RDI in business enterprises. Economic market fluctuations and volatility are a third barrier to carrying out RDI in business enterprises, with a relative probability of (16.5) per cent. Another significant barrier to RDI is the need for qualified researchers or knowledge workers (with 6.1 per cent) and structural distortions created by the increasing number of business enterprises in the economy's informal sector.

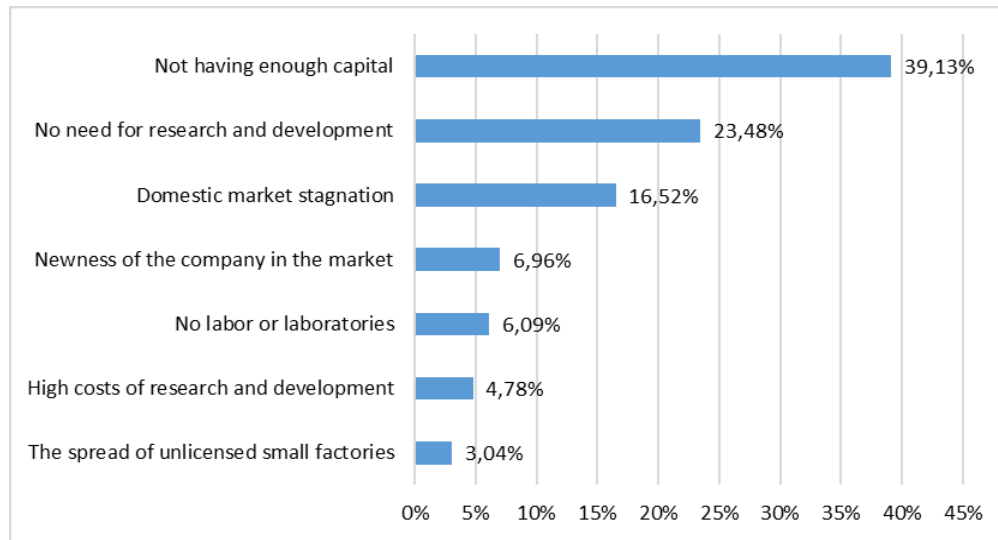


Figure 6. Barriers affecting RDI performance (%)

4.3. Dimension 3: Breakdown by Production Activity

In this section, RDI performance in different production sectors is assessed to identify the industries that rely more on RDI to enhance the productivity and competitiveness of their outputs and the need for other sectors to apply more research and experimental development as well as innovation initiatives. Table (7) records higher education graduates as a per cent of total employees by production sector. Given that researchers generally have a higher education degree, they can represent a proxy for the percentage share of RDI workers. Results from the survey stress the superiority of financial, insurance, accounting and legal services concerning the percentage share of higher education graduates, which account for (83) per cent of their workers. Information, communication, and health care are the second and third sectors concerning the percentage of higher education graduates, with (67) and (63) per cent, respectively. Other sectors, such as Pharmacy and medicines, as well as computers and electronic products, include (45) and (40) per cent of their employees with higher education degrees.

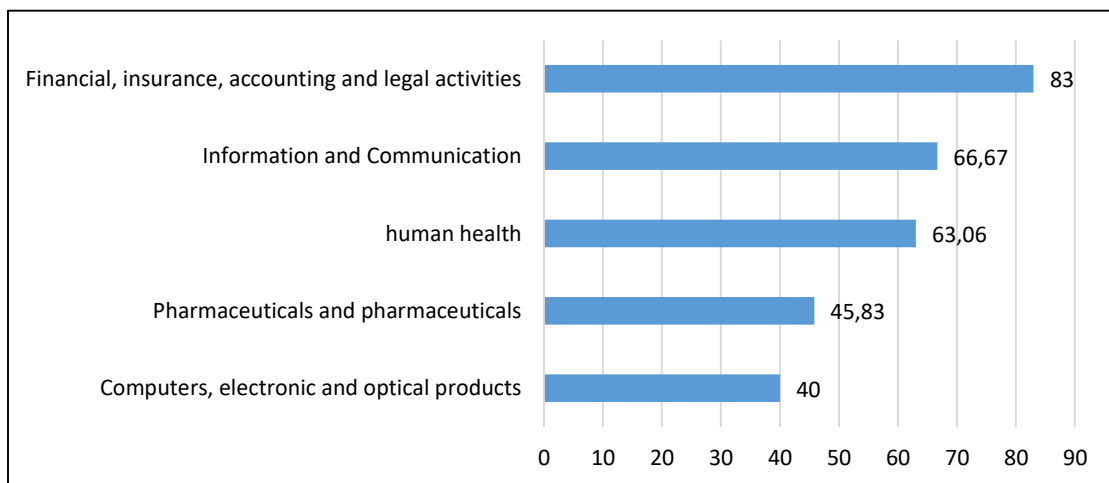


Figure 7. Per cent of higher education graduates in total employees by sector

Figure (8) illustrates gross expenditure on R&D activities as a per cent of sales in business enterprises by production sector. The information and Communication sector comes on top of the list with a share reaching (20) per cent. Given its responsibility to implement Egypt's national digital transformation strategy, the sector needs relatively advanced research and innovation activities. Furthermore, the financial, insurance and juridical sectors and health care system follow with an expenditure share varying from (19 to 20) per cent. The remaining sectors' spending patterns vary from (9 to 14) per cent on average.

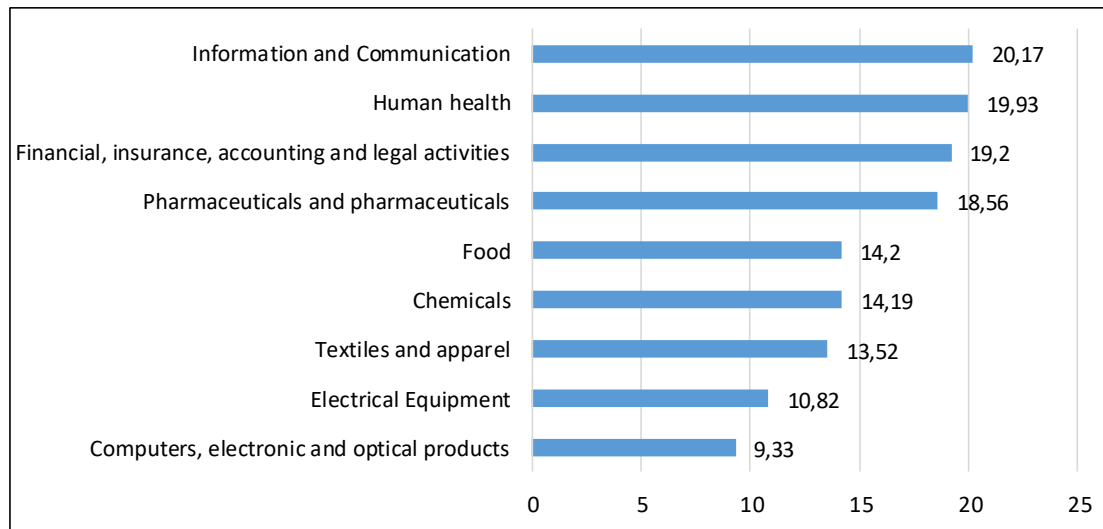


Figure 8. Expenditure on R&D as a per cent of volume of sales

Numerous theoretical and applied studies have stressed the positive correlation between innovation and the volume of exports. Innovation improves the quality of products or introduces new or significantly improved technologies and organisational and marketing policies. This positive relation results generally in an increase in productivity and competitiveness, which are the critical variables for penetrating new markets and generating new or significantly improved products. On the other hand, exports motivate companies to improve their innovation performance (Fonchamnyo & Wujung, 2016; Aghion, et.al. 2018). The survey results show, however, a modest ability of the sampled establishments to generate exports and compete in the global markets, since (59) per cent of these establishments direct about (87) per cent of their sales to the local market. The percentage of their exports to total sales is at most (13) per cent on average.

However, export performance varies within sectors, as shown in Figure (9). The percentage of exports to total sales ranges between (15) to (33) per cent on average, representing a reasonable percentage of shares. These sectors with reasonable performance include information and communication, pharmaceutical and pharmaceutical materials, computers, electronic and optical products, health care, and chemicals (Figure 9).

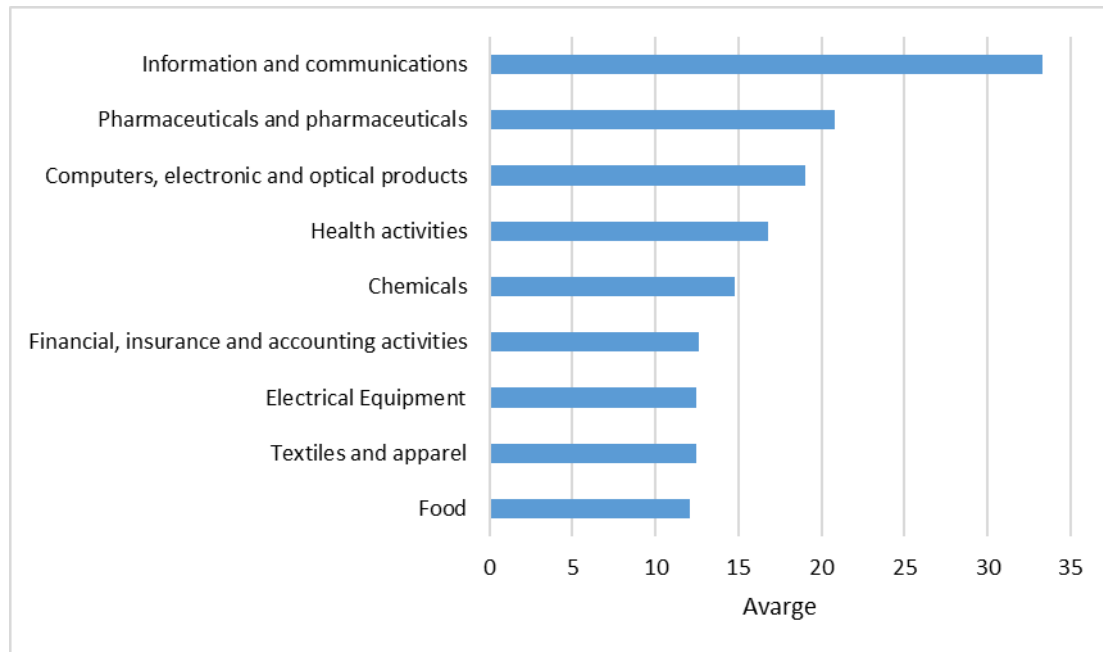


Figure 9. Average volume of Exports as a per cent of sales (%)

4.4. Dimension 4: RDI Cooperation with other institutions

Given the structural features of Egypt's R&D Human Resources based on official data of (2020), with more than (70) per cent of researchers working in universities, around (15) per cent occupied in government research centres, and a remaining limited number accounting for (6 -8) per cent researchers employed in the production sector and other civil society institutions, RDI in business enterprises would necessarily need both technical support and sometimes financing from other domestic and/or foreign institutions. Figures (10) and (11) summarise the survey results concerned with sources of finance and type of research cooperation.

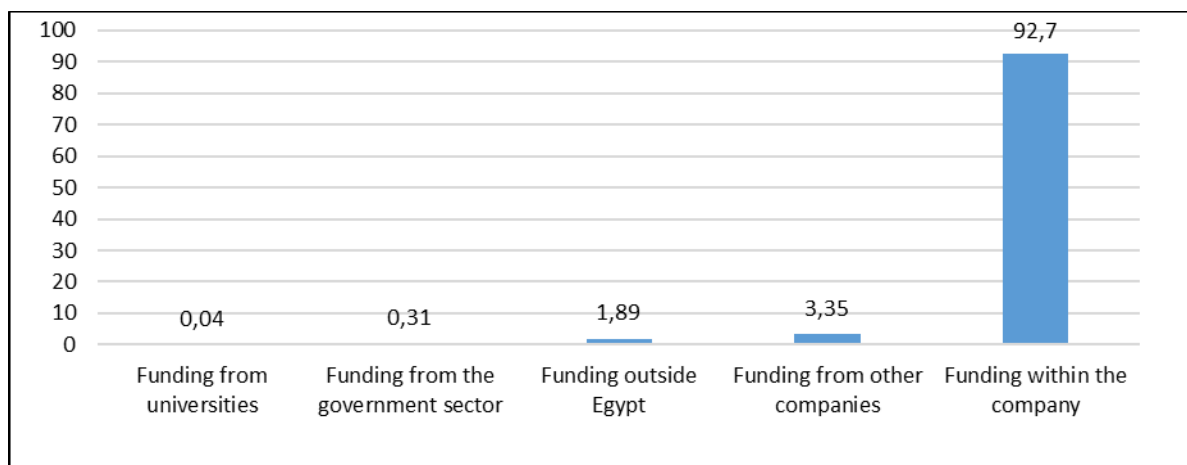


Figure 10. Sources of financing RDI Projects

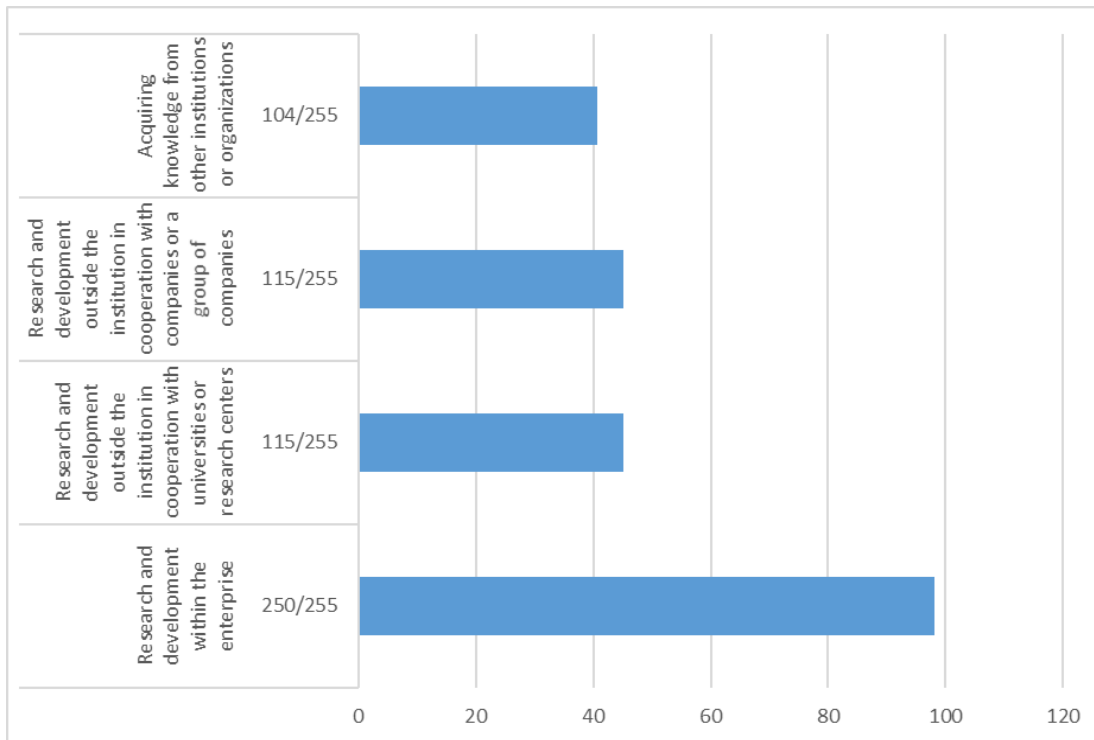


Figure 11. Research Cooperation with domestic institutions

Results from the survey (figure 10) reflect, however, a reversed point of view and different opinion: i) more than (90) per cent of the survey responses suggest that research and innovation financing is the primary responsibility of the business enterprise itself, ii) other sources of finance are negligible since they do not exceed (3.5) per cent of the sampled enterprises, iii) the contribution of the outside world in financing RDI activities in Egypt does not exceed (2) per cent at most. Research cooperation modes based on the results of the survey can be summarised as follows; i) most of the sampled companies (98 per cent) have their research activities with no external support or cooperation, ii) about (45) per cent of the surveyed business enterprises relies however upon carrying out their research and innovation projects either on universities or a cluster of other production companies, iii) in executing their research and innovation projects, (40) per cent of the business enterprises use some knowledge transfer channels such as the outcome of published papers, scientific conferences, joint research projects, intellectual property rights and facility sharing with universities and research centres. These results stress that Egyptian business enterprises need to enhance their cooperation with other RDI-producing institutions to benefit from comparative advantages and improve the quality of RDI outputs. In principle, working with research and innovation centres and universities accelerates the acquisition of new knowledge and increases the stock of knowledge of business enterprises. (Khorshid, 2020; Alam et al., 2019).

5. Summary and Conclusion

This paper suggested a two-stage methodology designed to assess the performance and impact of research, development and innovation (RDI) in business enterprises. The methodology begins with establishing a conceptual model or an integrated analytical framework that captures the increasing role of RDI system in the knowledge era of the twenty-one century, as well as its wide socioeconomic development impact on a country, and then with the development of a statistical survey that is particularly used to generate appropriate analytical and planning indicators for estimating the role and impact of RDI. Based on the above rationale, the conceptual modelling approaches to analyse RDI performance in business enterprises and evaluate its impact on knowledge

transformation is concretised by four specific dimensions. These dimensions include i) Inputs for producing RDI, ii) Alternative RDI output categories, iii) RDI pertaining to a specific sector in the production sphere of the national economy, and iv) Modes of RDI cooperation between business enterprises and other national institutions (mainly RDI producing institutions such as universities and research centres), industrial clusters for innovation, and other social societies.

The performance indicators of the Egyptian economy's research, development and innovation (RDI) are collected and analysed at the enterprise level using a comprehensive statistical survey. The survey elements are selected from the governorates of Greater Cairo, following the International Standard Industrial Classification of economic activities (Revision 4), reflecting the contribution of economic activities to the gross domestic product of a country. The selected establishments comprise a representative sample of manufacturing and services enterprises with a minimum number of workers per establishment accounting for 25 persons.

The survey results revealed several analytical points and specific imbalances of RDI system in business enterprises that need to be addressed by policy makers. First, based on the full-time-equivalent (FTE) estimation approach, the number of RDI knowledge workers is relatively small, and its ratio to the total labour force is limited. The ratio of knowledge workers varies, however, from one economic sector to another, considering the used production techniques on the one hand and the adopted policy measures to enhance RDI activities on the other hand. A major structural imbalance in the RDI sector of Egypt, based on official indicators from ESTIO, 2019, is that around (60) per cent of research and development human capital is working in the higher education sector, (32) per cent of researchers are engaged in government research centres. Private Business enterprises and other non-government non-profit institutions are left with only (6 to 8) per cent of the aggregate research labour force. It is worth noting that the percentage share of researchers in the business sector of advanced industrial countries such as Japan, the USA, and Germany vary from (60 to 80) per cent of the aggregate researcher labour force, respectively. This imbalance applies as well to the output of RDI. Furthermore, the analytical results show that the employees of the production enterprises represented in the survey generally need more skills to produce innovation. This drawback requires adopting a comprehensive policy package for training, re-orientation and capacity building within a clearly defined life-long-learning (LLL) strategy.

Second, investment in intangible assets to produce innovative goods and services and significantly improve manufacturing, managerial and marketing operations is relatively limited, except for staff training. Spending of the sampled enterprises on R&D provided by research centres and universities is less than (6%), on average. Purchase or acquisition of intangible assets, such as informatics and database developments, research consultation, industrial designs, trademarks, and patents, accounts only for about (15) per cent of the gross RDI expenditure of the firm. Note here that intangible assets in most advanced RDI-producing countries account for (40-50) per cent of the total value of the productive assets. Most of the remaining spending on RDI is purchases of computers and other equipment (25%), compensations of research employees (17%), and consumption of intermediate goods (15%).

Third, with respect to RDI outputs, the highest output type is industrial designs which represent a component of the enterprise's intangible assets. The remaining RDI products generated by the sampled business enterprises, including new (or significantly improved) commodities or services, licensed property income, innovation of the production process, patents and commercial marks (which represent part of the enterprise's innovation activities) account for a small percentage of their outputs. These results stress the need to enhance RDI outputs of business enterprises and diversify the scope of their outputs, towards more creative and innovative activities.

Fourth, despite the modest capacity of the sampled enterprises to innovate, export and produce intangible assets, investments in RDI show moderate positive economic return. The most important economic impact of RDI is the considerable increase in the size of goods and services produced, which account for (39) per cent on average. The

penetration into new commodity markets represents the third RDI economic effect, with an increase of (21) per cent. The impact of reducing production and labour cost is less than the increase in sales volume.

Fifth, based on the results of the survey, financing needs represent the most important barrier to applying RDI in business enterprises (with a probability of (39) per cent), followed by the fact that managers might not necessarily be convinced of its relevance and benefits (with an associated probability of about (24) per cent). There is also a common feeling inside the enterprise that fluctuations and volatility of economic markets is a third barrier for carrying out RDI in business enterprises with (16.5) per cent relative probability. Another significant barrier to RDI is the need for qualified researchers or knowledge workers (with 6.1 per cent probability). The last and most important barrier is the increased percentage share of several business enterprises in the economy's informal sector, where RDI culture is practically absent.

Sixth, numerous theoretical and applied studies have highlighted the positive correlation between innovation and exports. Given the modest performance of the selected sample of Egyptian enterprises concerning innovation capacity, the results confirm their limited ability to generate exports and compete in the global markets. ((59) per cent of these establishments direct (87) per cent of their sales to the domestic markets).

Seventh, results from the survey suggest that more than (90) per cent of the sampled business enterprises rely mainly on self-financing of research and innovation. Other sources of finance are negligible since they are, at most (3.5) per cent of the number of sampled enterprises. Furthermore, the contribution of the outside world to finance RDI activities in Egypt is at most (2) per cent at most. On the other hand, most of the sampled business enterprises (98 per cent) have their research activities with no external support or cooperation. In addition to their self-financed own RDI projects, about (45) per cent of the surveyed business enterprises rely on carrying out their research and innovation projects either with universities or clusters of other production companies. Furthermore, in executing their research and innovation projects, (40) per cent of the business enterprises benefit from knowledge transfer channels such as published papers, scientific conferences, joint research projects, intellectual property rights, facility sharing with universities and capacity building. These results stress that Egyptian business enterprises need to enhance and diversify their cooperation with other RDI-producing institutions to benefit from comparative advantages and improve the quality of RDI outputs.

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AGGLOMERATION BENEFITS AND COSTS OF INVESTING IN URBAN TRANSPORT INFRASTRUCTURE*

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Abstract. Theory and evidence suggest that a city owes its existence to an agglomeration benefit. An investment in urban transportation infrastructure may increase this benefit. While some years ago the agglomeration benefit of urban transportation was just a vague idea, recently its size has been estimated and the idea has gained concreteness and respectability. However, the theoretical literature has emphasized the agglomeration benefit that arises through immigration and higher population, while the empirical literature has emphasized the benefit that arises from effective density at constant population. A third strand of the literature has discussed transportation of goods. We bring together these theoretical and empirical literatures, and discuss which agglomeration benefits and costs are relevant for major categories of urban passenger and freight transport investment.

Keywords: transport; agglomeration; effective density; cost-benefit analysis

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1. Introduction

A city exists because it offers economic advantages. It provides specialized inputs and sustains specialized industries. It inspires entrepreneurs and is a magnet for talent. It supports increasing returns to scale industries and allows sharing of public goods. Up to a point, the advantages of cities are greater than the well-known disadvantages of e.g., congestion, pollution, crime and the cost of housing.

Urban transport infrastructure is an essential part of a city. Transport infrastructure increases the proximity between people, businesses and goods, and contributes to the city's advantages and disadvantages. Transport makes an urban area more "city-like". Yet, a transport planner may find the contribution of an investment in transport infrastructure to be elusive. How does traditional cost-benefit analysis internalize agglomeration

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benefits? Do all transport investments generate equal effects? Are agglomeration benefits more important than the contribution to congestion and pollution?

In the literature on urban economics one distinguishes between agglomeration benefits (sometimes called ‘wider economic benefits’) associated with market imperfections, and user benefits. However, there are gaps in our understanding of how urban transport investments engage with these ideas. The theoretical literature uses concepts and indicators that are not entirely satisfactory from a practical point of view, and the empirical literatures uses concepts that are not clearly based in theory.

In this paper we aim to bring together the theoretical and empirical analysis of these issues. In particular, we provide a micro-foundation for the concept of effective density, or market potential, which is often used in empirical work. The micro-foundation allows us to distinguish between agglomeration benefits in a stable population as opposed to those that depend on migration to a city. The previous literature on impacts of transportation investments has only emphasized agglomeration benefits arising from immigration. We show that these are in fact smaller than immigration’s external costs.

In a modern city there are several forms of physical transport: Commuters travel to work in the morning, and back in the afternoon. Business travellers go back and forth on errands and to meetings during work hours. Leisure travel is for shopping and football practice and all the other things that households do in their spare time. Then there is transport of goods, freight, of which we will recognize two kinds: Transport of final goods that are consumed and transport of intermediate goods used to make final goods. To the extent that investments targets specific purposes of transport, there are different constituents of benefits and costs that come into play. We demonstrate how agglomeration benefits and user benefits enter and exit as we consider transport of different kinds.

2. Previous literature

The theoretical literature on benefits of urban transport infrastructure is derived from the literature on urban areas and cities. Existing models treat transport modes and transport costs differently. Some emphasize transport of commuters. Agglomeration benefits enter these models through migration and higher population. Others emphasize transport of goods, often modelled in terms of iceberg costs. In these models, agglomeration benefits sometimes do not arise at all.

An important early contribution is Duranton and Puga (2004), see also Duranton and Puga (2014). Building on Abdel-Rahman and Fujita (1990), they present a model of a city economy with market imperfections. Migration to the city provides for a bigger city with more talent that interacts with the market imperfections and generate agglomeration benefits. The model also emphasizes costly commuting costs. Commuting costs provides a dispersion force. The size of the city hangs in the balance between agglomeration benefits, user benefits and commuting costs. Transport of people enters the picture through commutes. Transport of goods is limited: The intermediates of the model cannot be transported out of the city, while final goods can be transported at zero cost.

Models of a single city are similar in design to small open economy. By contrast, models of urban and sometimes rural systems are like models of the global economy. Important early contributions include Krugman (1991, Fujita and Krugman (1995) and Helpman (1998). These models exclude transport of individuals, but they include iceberg costs of transporting differentiated goods. Transport of goods gives rise to an agglomeration force. Krugman (1991) combines iceberg costs of differentiated goods with costless transport of homogenous goods, Helpman (1998) assumes that the homogenous good cannot be transported, while Fujita and Krugman (1995) assume positive costs of transporting the homogenous good. The transport or non-transport of homogenous goods gives a dispersion force.

The early models of cities and urban systems have recently been elaborated e.g., by Behrens et al. (2014), Redding and Turner (2015) and Redding and Rossi-Hansberg (2017). These authors solve a general equilibrium system of n locations that each produce differentiated goods. In Redding and Turner (2015) and Redding and Rossi-Hansberg (2017) there are iceberg costs of transporting differentiated goods to other cities. In Behrens et al. differentiated goods cannot be exported, but individuals (the input factor) can migrate at zero cost.

The empirical literature on transport and agglomeration makes heavy use of the concept “effective density” or “market potential” (the two are used interchangeably), see e.g., the survey of Ahlfeldt and Pietrostefani (2019). In the empirical literature effective density refers to the synergies of ideas and human capital along the lines of Marshall (1890) and endogenous growth models (Lucas, 1988; Romer, 1990). Graham (2007) and Graham et al., (2010a) are two examples of empirical work that postulates an index of effective density as a sum of employment in adjacent locations, with distance from “our location” as weights. Instead of geographical distance as weights one may use generalized cost of transport including time and pecuniary cost, as in Graham et al., (2010b).

In the theoretical literature the concept is often attributed to Harris (1954). Harris defines it as “an abstract index of the intensity of possible contacts in markets”. Contemporary models of urban systems have interpreted the concept in the form of market access of goods (Krugman, 1993, Eaton and Kortum, 1993), particularly associated with foreign trade (Donaldson and Hornbeck, 2016). Hence, although the name may be the same the connotations are different in the empirical and theoretical literatures: The theoretical literature emphasizes market access of goods, while the empirical literature emphasizes density of ideas. The theory papers on market potential are not really helpful in explaining the empirical models.

Analyzing the impact of a transport investment on agglomeration is like analyzing a perturbation of the city or urban system. A small number of previous papers have done this. Venables (2007) has a model containing an increasing returns to scale production function, a cost of commuting, and an income tax. He finds that a transport investment that lowers the cost of commuting has a direct impact on the aggregate cost of commuting plus an external agglomeration benefit and cost to the extent that the investment induces migration to the city. Venables also shows how an income tax interacts with the other market imperfections.

Kanemoto (2013) also considers the impact of an investment to lower the cost of commutes. Kanemoto has an explicit microeconomic underpinning of the aggregate production function, and he has several cities. However, like Venables, Kanemoto does not discuss agglomeration benefits in a given population, nor does he discuss different transportation aims and modes.

Our paper makes three contributions to the literature on transport and agglomeration. First, we show how transport investment may generate agglomeration benefits in a given population and that this is the proper channel since agglomeration benefits of immigration are dwarfed by agglomeration costs. Second, we provide a satisfactory theoretical underpinning for the concept of effective density. Third, we discuss agglomeration benefits of all relevant transportation aims and modes, including recreational travel and freight.

3. The model

We present here a model of a city economy that features agglomeration. We use upper case letters for aggregate variables, lower-case letters for individual level variables, and (where necessary) lower-case letters with a bar for average variables. For parameters we use lower case Greek letters.

3.1 Commuting cost and land rent

Our modeling of commuting costs and land rent follows Duranton and Puga (2004) and is by now fairly standard. A short summary is offered. Commuting cost and land rent determine the spatial extent of the city. The individual commuting cost c is a function of distance traveled, x , and a parameter τ that summarizes the quality of infrastructure service:

$$c = c(x, \tau), \frac{\partial c}{\partial \tau} < 0, \frac{\partial c}{\partial x} > 0 \quad (1)$$

A longer distance (high x) increases costs, while improved infrastructure service (high τ) decreases cost. All workplaces are located at the same location in the city, the Central Business District (CBD).

Everybody is equal and therefore, in equilibrium the sum of commuting cost and land rental cost will be the same for all. Land rent at the border is zero and there is no congestion immediately outside the border.

There are N individuals in the city. Everybody lives somewhere on a disk of area N and radius $\sqrt{N/\pi}$ from the CBD. Subsuming the square root into the function $c(x, \tau)$ this gives the following relation between commuting cost and rental cost of land:

$$r(x) + c(x, \tau) = c(N, \tau) + 0 = c(N, \tau) \quad (2)$$

Equation (2) says that the sum of commuting cost and rental cost of land is the same everywhere in the city, including at the border where land rent is zero. In particular, the equation holds for an individual experiencing average commuting costs ($\bar{c}$) and average land rent ($\bar{r}$), which we state as equation (3):

$$\bar{c} = c(N, \tau) - \bar{r} = \bar{c}(N, \tau) \quad (3)$$

3.2 Production technology of the final good

Production of the final good and intermediates again follows the standard model, which is a love of variety production function and fixed costs of making intermediates. The city produces a final good Y by means of a mass m of intermediates $y(s)$:

$$Y = \left\{ \int_0^m y(s)^{\frac{1}{1+\sigma}} ds \right\}^{1+\sigma} \quad (4)$$

The parameter σ determines the curvature of the production function, the elasticity of substitution.

3.3 Production technology of intermediates

Intermediates are produced by increasing returns to scale technologies:

$$y(s) = \beta l(s) - \alpha \quad (5)$$

β indicates variable cost, α indicates fixed cost, and $l(s)$ is input of human capital in production of the intermediate. To begin with we assume that intermediates are not exported. Intermediate producers then face downward sloping demand curves from the local final goods sector, and profit maximization implies:

$$q = \frac{w(1+\sigma)}{\beta} \quad (6)$$

Intermediates use identical production technologies where q is the common price of intermediates and w is the common wage of human capital in the city. A common wage and no other primitive inputs imply that there is one

final goods sector in equilibrium. Free entry into production of intermediates implies zero profits, which determine a common production level of intermediates y by means of equations (5), (6) and (7):

$$qy(s) - wl(s) = 0 \quad (7)$$

$$y = \frac{\alpha}{\pi} \quad (8)$$

Equation (5) determines the common level of human capital l in each intermediate:

$$l = \frac{\alpha(1+\sigma)}{\beta\sigma} \quad (9)$$

With a fixed level of human capital H in the city, the mass of intermediates can be found:

$$m = \frac{H}{l} = \frac{\beta\sigma}{\alpha(1+\sigma)} H \quad (10)$$

3.4 Effective density

We depart from the standard model and assume that each individual is endowed with h units of human capital. We let $g(i, j)$ denote the intellectual influence of individual j on individual i . $g(i, j)$ is a scalar between 0 and 1. The network literature (e.g., Topa and Zenou, 2015) usually assumes that $g(i, j)$ is either 0 if there is no contact between i and j , or 1 if there is unhindered contact. These are extreme outcomes. Most links between people face transaction costs in the form of culture, distance, frequency of interaction etc that suggest that an intermediate value between 0 and 1 is appropriate.

We assume that the links between people can be improved by better communication technologies:

$$g(i, j) = g(i, j; c_1 \dots c_n) \quad \frac{\partial g}{\partial c_k} < 0 \quad \forall k \quad (11)$$

$c_1 \dots c_n$ are the costs of communication technologies between i and j . Individuals in the city may also receive influence from outside the city. Such influence is incorporated into equation (11).

We are concerned with ordinary physical transportation, whether business travel where people meet professionally in meetings and seminars and professional dinners, or leisure travel where ideas may be shared on the sidelines of a football field or during a chance meeting at a café, or commutes where people of common interests may end up talking at the subway station. Suppress other explanatory variables and let τ be an indicator of infrastructure quality that decreases the cost of transportation in the manner of equation (1).

Adding over all influencers gives aggregate influence on individual i :

$$g(i) = \int_0^N g(i, j; \tau) h(j) dj \quad (12)$$

Equation (12) is our expression for effective density. It is an index, or weighted sum of human capital elsewhere in the urban area that one considers a city. The index allows significant flexibility. If the influence from employees, say, to entrepreneurs is a priori zero, the relevant $g(i, j)$ are always zero and g is lower than it would have been otherwise. If $g(i, j)$ of some j are equal, e.g., because these j share the same location, equation (12) will cluster the relevant $h(j)$ into groups. Such a clustering is common in empirical formulations.

In equation (13), $\frac{\int_0^N g(i, j; \tau) h(j) dj}{N}$ is average influence on individual i . In general, the average influence depends on the cost of communication vis-à-vis everybody else, and this cost will differ depending on one's location in the city. We suppress this locational difference and assume that the average influence on all individuals is the same and denoted g . Total influence on each individual is gH :

$$g(i) = g = \int_0^N g(i, j; \tau) h(j) dj = Nh \frac{\int_0^N g(i, j; \tau) h(j) dj}{N} = g(\tau)H, \quad \frac{\partial g}{\partial \tau} > 0 \quad (13)$$

In equation (13) we ignore any influence of population (N) on effective density (g). The interpretation is that population growth is accompanied by proportional spatial growth.[†]

Stronger intellectual influences increase productivity among intermediate producers. For instance, among the self-employed influence and inspiration from others may spur innovation to develop new processes that reduce cost and improve productivity. Among employees the influence from others may inspire to improve work procedures and product lines, again improving productivity. We propose a formulation for productivity improvement as follows:

$$\alpha = \bar{\alpha}(gH)^{\theta} \quad (14)$$

$$\beta = \bar{\beta}(gH)^{\theta} \quad (15)$$

$\bar{\alpha}$ and $\bar{\beta}$ are benchmark parameters of productivity when there is no influence from others. $\theta > 0$ is the elasticity on productivity when intellectual influence increases (i.e. learning), or better: the externality of effective density.

3.5 Aggregate production

Pulling together equations (4), (8), (10), (14) and (15), we obtain the aggregate production function of the final good:

$$Y = g^{\theta} H^{1+\sigma+\theta} \quad (16)$$

A complicated function of constants have been subsumed into Y by an appropriate choice of units. The price of the final good is the numeraire. We assume that our city is an island in a sea of cities and that the final good sector participates in a large market subject to free entry, and zero profits prevail. Zero profits imply a wage rate equal to Y/N , or

$$w = hg^{\theta} H^{\sigma+\theta} \quad (17)$$

3.6 Utility and welfare

We assume that income from land rent is divided equally between the individuals of the city. Since the price of the final good is the numeraire it is straightforward to calculate indirect utility of each individual in the city (v) as wage income plus the average share of land rents, less rental cost, less commuting cost. In other words, indirect utility equals net income in this economy of one final good.

Inserting equations (3) and (17) we obtain:

$$v = w + \bar{r} - c(N, \tau) = w - \bar{c} = hg(\tau)^{\theta} (Nh)^{\sigma+\theta} - \bar{c}(N, \tau) \quad (18)$$

Equation (18) is a key equation for what follows. It states that a city is a trade-off between positive learning externalities (indicated by the exponent θ) and sharing externalities (the exponent σ) on the one hand, and congestion costs ($\bar{c}$) on the other. The city population generates learning (θ) and sharing (σ) externalities, which reinforce each other ($((Nh)^{\sigma+\theta})$), but city size also influences average congestion costs $\bar{c}$. Infrastructure (τ) influences agglomeration directly in the term $g(\tau)^{\theta}$. Previous models have included this impact only through growth in population (N).

People are free to migrate between our city and the outside world, and equilibrium city size obtains when individual utility inside the city equals individual utility outside. Individual utility outside the city is fixed at $\bar{v}$, hence $v = \bar{v}$ in equilibrium. Viewed as a function of city size N the model admits two equilibria, of which one is stable and the other is unstable (Duranton and Puga (2004, 2014)). A stable equilibrium requires $\frac{dv}{dN} < 0$. This requirement states that the equilibrium city is bigger than what would have been optimal. Intuitively, migration to

[†] Recall that everybody lives on a disk of size N . Here we deviate from a recent paper by Davis and Dingel (2019). Davis and Dingel argue that a larger N encourages learning. There are some other differences between our paper and Davis and Dingel (2019) as well. In particular, learning is optimal in their model, there is no external agglomeration benefit.

the city eats away at the surplus of the city until the point where the congestion cost equals the positive externalities.

4. Cost-benefit test for investment in transport

We use the model to set up a cost-benefit test of an investment in transport infrastructure. The test comprises agglomeration benefits, external costs, and user benefits.

4.1 Preliminaries

There are altogether $\bar{N}$ members of the economy inside and outside the city, and to measure the benefit of a transport project we use a simple welfare function:

$$V = vN + \bar{v}(\bar{N} - N) \quad (19)$$

We submit that an investment to improve transport infrastructure should pass the cost-benefit test

$$\frac{dV}{d\tau} = \frac{dv}{d\tau} N + (v - \bar{v}) \frac{dN}{d\tau} = \frac{dv}{d\tau} N > 0 \quad (20)$$

For simplicity we disregard the investment cost of constructing τ . Adding a non-zero investment cost would only change the hurdle of the cost-benefit test. In (20) $(v - \bar{v}) \frac{dN}{d\tau}$ is the displacement effect, the effect of people migrating between the city and the outside world. To the first order, the displacement effect generates zero utility. What remains as a potential benefit is the impact on individual utility, multiplied by city population.

To indicate the impact on individual utility we make the standard assumption in cost-benefit analysis that the economy is initially in equilibrium and the project under consideration will benefit the economy if $\frac{dv}{d\tau}$ is positive.

The effect on individual utility can generally be written as

$$\frac{dv}{d\tau} = \frac{\partial v}{\partial N} \frac{\partial N}{\partial \tau} + \frac{\partial v}{\partial \tau} \quad (21)$$

It is useful to sign the terms of (21). In equilibrium we know that $\frac{\partial v}{\partial N}$ is negative. Further, τ is optimally arranged prior to any project that is new to the economy. This means $\frac{dv}{d\tau} = 0$ initially. It follows that $\frac{\partial N}{\partial \tau}$ is positive when $\frac{\partial v}{\partial \tau}$ is positive. In plain words: Transport infrastructure that improves individual utility directly ($\frac{\partial v}{\partial \tau} > 0$) will attract migrants to the city ($\frac{\partial N}{\partial \tau} > 0$). This seems a reasonable feature of the model.

Armed with these preliminaries we are ready to work out the cost-benefit test of specific, new transportation aims and modes.

4.2 Cost-benefit test for commutes

We find the impact on welfare of an increase in τ that affects the average cost of commutes, $\bar{c}$:

$$\begin{aligned} \frac{dV}{d\tau} = \frac{dv}{d\tau} N &= \left\{ \frac{dg}{d\tau} \theta h g^{\theta-1} H^{\sigma+\theta} + \left[h^2 g^{\theta} (\sigma + \theta) H^{\sigma+\theta-1} - \frac{\partial \bar{c}}{\partial N} \right] \frac{\partial N}{\partial \tau} - \frac{\partial \bar{c}}{\partial \tau} \right\} N \\ &= \theta \frac{dg}{g} Y - \frac{\partial \bar{c}}{\partial \tau} N + \left((\sigma + \theta) h w - \frac{\partial \bar{c}}{\partial N} N \right) \frac{\partial N}{\partial \tau} \end{aligned} \quad (22)$$

We spell out the terms of (22). When τ increases the first term in (22) is the percentage increase in effective density (dg/g) times the elasticity of productivity with respect to effective density (θ), times production. This term is the external agglomeration benefit of much empirical work. In empirical work θ is often found to be around 0.04 (Ahlfeldt and Pietrostefani, 2019).

The second term in (22), $\frac{\partial \bar{c}}{\partial \tau} N$, is the decrease in average transportation and congestion cost for commutes that the improvement brings about, times the number of inhabitants in the city. This term is the user benefit of the investment and the only term of this model that would be included in a traditional cost-benefit appraisal.

The third term in equation (22), $\left((\sigma + \theta)hw - \frac{\partial \bar{\varepsilon}}{\partial N} N \right) \frac{\partial N}{\partial \tau}$, collects the effects of a larger population. Inside the brackets the first term, $(\sigma + \theta)hw$, combines the sharing and learning externalities of a larger population, where the sharing externality implies that more intermediate varieties can be supported, and the learning externality implies that a higher human capital base generates more synergies, more learning. The second impact inside the brackets, $\frac{\partial \bar{\varepsilon}}{\partial N} N$, is the increase in average congestion cost when new inhabitants arrive, multiplied by population.

The bracketed term in the second line of equation (22) equals $\frac{\partial v}{\partial N}$, which we know is negative in an economy that starts out from equilibrium. The cost increase in congestion is more important than the benefit increase through sharing and learning. Hence there is no external benefit of the bracketed terms in total, rather the expression points to an external cost. Still, the previous literature has emphasized the agglomeration benefit inherent in the expression and not the overall sign (Venables, 2007).

4.3 Cost-benefit test for recreational travel

Commutes are carried out in order to generate income and production. Residential travel, by contrast, is done to increase utility. In the model so far, all one does in one's spare time is to consume Y . We now assume there are two goods for citizens to choose from, namely the consumption good Y and time T spent on recreation in the form of contact with friends and family etc. Labor supply stays the same. Individual consumption of recreation is t and $T = tN$.

Y has a price of 1 as before. The unit cost of recreation is p_t . More precisely, p_t is the cost of travelling to gain access to the recreational service (i.e. friends, family). We integrate recreational travel into the analysis by inserting its price into the indirect utility function of households, see equation (23).

$$v = v(p_t, w - \bar{c}) = v(p_t(\tau, N), hg^\theta H^{\sigma+\theta} - \bar{c}(N, \tau)) \quad (23)$$

Similarly to the cost of commutes we assume that improvements in infrastructure τ lower the price of recreational travel, and that a larger population N increases the price of recreational travel (average length of time spent travelling, congestion) hence $\frac{\partial p_t}{\partial \tau} < 0$, $\frac{\partial p_t}{\partial N} > 0$. Let $\frac{\partial N}{\partial \tau} < 0$ as before, and consider a project that increases the indicator τ . In this setup the indicator τ allows for more convenient recreational travel *and* commutes, since both travels occur on the same roads, railways etc. We obtain

$$\frac{dv}{d\tau} = \frac{\partial v}{\partial p_t} \left(\frac{\partial p_t}{\partial \tau} + \frac{\partial p_t}{\partial N} \frac{\partial N}{\partial \tau} \right) N + \frac{\partial v}{\partial (w - \bar{c})} \left[\theta \frac{dg}{g} Y - \frac{\partial \bar{c}}{\partial \tau} N + \frac{\partial (w - \bar{c})}{\partial N} \frac{\partial N}{\partial \tau} \right] \quad (24)$$

From Roy's identity we have $\frac{\partial v}{\partial p_t} = -t$. Hence, equation (24) is positive if and only if:

$$-T \frac{\partial p_t}{\partial \tau} + \theta \frac{dg}{g} Y - \frac{\partial \bar{c}}{\partial \tau} N + \left(\frac{\partial (w - \bar{c})}{\partial N} - T \frac{\partial p_t}{\partial N} \right) \frac{\partial N}{\partial \tau} > 0 \quad (25)$$

From equation (25) a project that promotes recreational travel gives a user benefit that is proportional to recreational transport consumption, $-T \frac{\partial p_t}{\partial \tau}$. Furthermore it increases effective density as an external benefit,

$\theta \frac{dg}{g} Y$. The impact on effective density may be further disentangled using (11), since we now have two items, commutes and recreational travel, that contribute (through a higher τ) to higher effective density. In plain terms recreational contact may transfer knowledge and influence, adding to the impact of commutes. Most empirical analysis does not distinguish travel by purpose when calculating external agglomeration impacts of higher effective density. Implicitly, recreational travel is treated on par with commutes, highlighting the relevance of including recreational travel in the theory model.

The project may also reduce travel costs for commuters, $\frac{\partial \bar{\varepsilon}}{\partial \tau} N$.

These improvements in welfare set in motion migration to the city. Population increases, which gives rise to positive learning and sharing externalities, but also further congestion and impediments to recreational services.

Around a stable equilibrium the congestion and impediments dominate, the net impact of immigration is an external cost.

Compared to commutes the difference when assessing recreational travel is the a) the stronger economic benefit of increased density $\frac{d\mathbf{g}}{d\mathbf{g}}$, b) the user benefit $-T \frac{\partial p_t}{\partial \tau}$ and c) the additional external economic cost associated with population growth, $-T \frac{\partial p_t}{\partial N}$.

4.4 Cost-benefit test for transport of final goods

As noted earlier in the paper, there is a strand in the literature on market access, effective density and agglomeration benefits that is concerned with trade in goods and transport of goods. We now extend our model to trade in goods. First, we consider trade in the final good. We ignore recreation (the previous section).

To model trade in goods we assume that the economy has access to a final good X that can be imported for consumption at price p_x . Consumption of the final good that is domestically produced, is Z . From equation (18) the budget constraint of the economy is

$$p_x X + Z = (w - \bar{c})N \quad (26)$$

For each consumer, equation (26) modifies indirect utility as follows:

$$v = v(p_x, w - \bar{c}) \quad (27)$$

We assume iceberg costs in transporting good X to our city. An investment to reduce iceberg costs will reduce p_x .

Similarly to above, we have that $\frac{\partial N}{\partial p_x} < 0$ in a stable equilibrium.

By means of equation (27) and Roy's identity we obtain

$$\frac{dv}{dp_x} = \frac{\partial v}{\partial p_x} N + \frac{\partial v}{\partial (w - \bar{c})} \frac{\partial (w - \bar{c})}{\partial N} \frac{\partial N}{\partial p_x} \quad (28)$$

Since the investment to reduce iceberg costs will reduce p_x the cost-benefit test is formulated in the negative. Equation (28) is negative if and only if

$$-X + \frac{\partial (w - \bar{c})}{\partial N} \frac{\partial N}{\partial p_x} < 0 \quad (29)$$

The equation tells us that a decrease in iceberg freight cost produces a user benefit in proportion to imports of the final good, plus a net external cost of migration to the city. The net external cost consists of a gross external benefit and a larger gross external cost, like in the other cases we have examined. The reason, of course, is that lower freight costs improve transport lines of goods, lower prices and increase the standard of living in the city. People realize this and move to the city in response. There is a beneficial impact of sharing and learning, but in the neighborhood of equilibrium this benefit is dominated by costs of congestion. In contrast to improvements in commuting costs or recreational costs within the city, lower freight costs do not bring people closer together and has no consequence for effective density of a given population.

4.5 Cost-benefit test for transport of intermediates

To conclude the taxonomy of transport modes and aims we consider transport of intermediate goods. In addition to domestic intermediate goods we assume that it is possible to purchase from other regions n intermediate goods $x_1 \dots x_n$ at fixed prices $q_1 \dots q_n$. The purchase is financed by sales of the final good Y . The production function (4) is modified to.

$$Y = F\left(x_1 \dots x_n, \left\{\int_0^m y(z)^{\frac{1}{1+\sigma}}\right\}^{1+\sigma}\right) = F(x_1 \dots x_n; g^\theta H^{1+\sigma+\theta}) \quad (30)$$

The regional budget constraint is modified to

$$V = Y - \sum_{i=1}^n q_i x_i - \bar{c}N \quad (31)$$

The budget constraint equals city utility. Assume freight costs decrease and q_i goes down. (31) is a money metric utility function and Hotelling's lemma immediately gives $\frac{d(S - q_i x_i)}{dq_i} = -x_i$. The cost-benefit test is again formulated in the negative:

$$\frac{dV}{dq_i} = -x_i + \frac{\partial V}{\partial N} \frac{\partial N}{\partial q_i} < 0 \quad (32)$$

(32) bears similarities to (29). (32) tells us that a decrease in the cost of an intermediate gives a user benefit in proportion to consumption of that intermediate, plus an external economic cost as the primary benefit is eaten away by migration to the city. External economic benefits are absent in the aggregate despite the sharing and learning externalities.

Discussion and conclusion

The previous theoretical literature on costs and benefits of urban transportation has associated agglomeration benefits with immigration. We have developed a simple model that allows agglomeration benefits in a city structure of a given population size. This is the maintained assumption in much empirical work. Along the way we have shown that in the neighborhood of equilibrium the external agglomeration benefit of immigration actually is dominated by an external congestion cost. Further, we have shown that investments to improve transport facilities for people in cities will entail agglomeration benefits to a given population, while investments to improve the transportation of goods influence population size. While these investments bring agglomeration benefits, they entail larger external costs and the net external effect is negative.

External benefits and costs, and traditional user benefits, associated with different transport purposes are summarized in Table 1.

Table 1. Types of transport, types of benefit

Type of transport	External economic benefits and costs		User benefits			
	Benefit (through effective density)	Cost (net effect of congestion, productivity)	Recreation	Transport accessibility	Consumption	Lower cost of production
Recreational travel	X	X	X	X		
Commutes	X	X		X		
Freight, final goods		X			X	
Freight, intermediate goods		X				X

Table 1 reiterates that only transport projects that increase transportation of people produce agglomeration benefits at given population size. The agglomeration benefits at given population size are positive in nature.

All urban transport projects – whether passenger or freight – facilitate a response in terms of immigration. With immigration a number of benefits and costs are set into motion. Learning and sharing externalities are enhanced, commuting costs rise, and environmental amenities may be strained. However, to the first order the costs of immigration are larger than the benefits. The reason is that immigration is a response to the benefit of a transport project. The benefit implies that city life is more attractive and immigration results. Immigration eats away at the surplus until it is eliminated. If it were never eliminated marginal utility would remain higher in cities, and city growth would be a runaway process (unstable equilibrium). Hence, the agglomeration benefits requiring migration are arguably less interesting than those at given population. By implication improving transport of goods is less likely to bring about agglomeration benefits than transport of people, and projects that improve both commutes and recreational travel could be the most fruitful of all.

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AFRICAN PEACEKEEPING OPERATIONS IN RECENT YEARS*

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Abstract. The article aims to present a general outlook of the ongoing peacekeeping operations of the most important international, European and African military and civilian organizations. Peacekeeping has become very important after the independence of African countries because of the continuous conflicts that devastate the war-torn continent. The establishments taking part in this effort include the United Nations, NATO, the European Union and the African Union. After giving a general picture of the nature of the peacekeeping operations, the article goes on one by one each of the organizations to describe their role and participation in the recent peacekeeping activities that characterize the world's landscape now. In the end, the author assesses the situation, gives a comprehensive conclusion and provides some future aspects that he thinks will be probable in the forthcoming years regarding peacekeeping attitudes.

Keywords: Peacekeeping; Africa; United Nations; NATO; European Union; African Union

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1. Introduction

African peacekeeping operations are an essential part of the world of modern security (Agyekum, 2020; Richmond, 2021; Elliott et al. 2021, Fisher & Wilen, 2022; Besenyő, 2023). There are a lot of dangers in the world that must get addressed, and there are a lot of problems and conflicts in the modern era that are to be handled. Terrorism, drug- and arms trade, migration and other security-related issues are widespread across the continent and Sub-Saharan Africa. Water shortage, food security problems, famine throughout the area, and many land debates and ethnic or religiously-based conflicts are present in the territory which the Sahara governs. These problems present a clear risk to the people living there, and they are prone to various dangerous factors that overwhelmingly affect the population on the continent. The disaccords between the different groups, armed militias and civilians often lead to aversive disagreements, which can produce awkward situations in an area full of problems and complex agricultural and industrial interests. The conflict-ridden areas are dangerous because the remnants of wars and regional skirmishes are still present in the politically and socially divided territories. Land

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mines and other appliances from precious conflicts can be found in the desert and elsewhere on the continent, so caution is advised when someone crosses the war zones, even by vehicle. These reasons are only part of why there is a need for peacekeepers in the area where conflicts have devastated the environment and the life of the people. Peacekeepers try to resolve the situations and give hope to the people in the conflict zones as they try to handle delicate situations between warring partners. To understand better the African situation, we must consider the organizations that try to consolidate the conflicts between the different sides opposed to each other. This article will consider the main international military and civilian organizations participating in peacekeeping methods and operations on the continent. The most important organizations in restoring peace in recent years in the area are well known to the public. These peacebuilding and peacekeeping establishments are led first by the United Nations Peacekeeping Operation (UNPKO), followed in importance by the NATO operations mainly conducted in Somalia and Libya. The most crucial organization in the European Union, which is a civilian entity, usually organizes training missions to help to strengthen the military capacity of a given country.

Last but not least is the African Union, a relatively new institution (created in 2002), and it represents the African nation's power that has been neglected for a long time. This way, not only European and international organizations can enter into the country's peacekeeping activity, but also the nations that belong to the area. The African Union is still a young establishment, but it contributes a lot to the peacekeeping operations that try to resolve peace on the continent. After discussing all of the possible and available organizations that have taken part in peacekeeping operations in recent years on the continent, the article would like to assess the situation and give an opinion on what the future lies for the peacekeepers on the continent, if there is an opportunity for them to better the peace resolving activity they try to accomplish in Africa.

2. General peacekeeping tendencies in Africa

African peacekeeping missions are becoming more and more important in recent times. Before we analyze each organization that takes part in the peacekeeping activities of the continent, it would be proper to give an overall view of the operations and processes that are going on in the area. Thus, it would be interesting to look at the activities in general, what efforts these organizations make and how they relate to each other.

The missions started in the wake of the independence of the African countries, namely around the 60s. The number of peacekeeping operations has been abundant since that time, reaching nearly 30 deployments. Recently, the number of peacekeepers on duty exceeded 50.000 personnel (Klobucista, Renwick, 2021). Other sources confirm these operations' magnitude, as they reached high numbers in the 20th century. According to Williams, there have been 90 missions during 1947-2013. He also lists the number of operations started after 1990 and comes to a count of 77, which is a relatively high number (Williams, 2015). These data confirm that there was a considerable effort in the second half of the 20th century from the international military and civilian organizations, such as the UN, NATO, EU and their African counterparts, to increase their efforts to participate in the peacebuilding initiatives on the continent. As Besenyő concludes, due to the consistent problems that threaten Africa, such as kidnappings, terrorism, colonial struggle and corruption that permeates the countries' ruling groups, issues still exist on the continent. That is one reason why international organizations such as NATO, the UN and other powers like China and Brazil took an interest in the area struck by poverty and conflict (Besenyő, 2019). However, some sources point to the fact that peacekeeping in Africa was widespread in the 90s and the reasons for that are twofold: first, it was coincidental that the conflicts that needed handling in Africa increased exponentially in number, and at the same time the main superpowers of the Cold War and with its end ceased to support the sides in the countries which they have done before. Thus the conflicts multiplied (Jackson, 2019, p. 16).

Before entering into a detailed discussion about the organizations and their general work on the continent, it might be helpful to define peacekeeping. To provide a short but thorough explanation for the term, we will turn again to Paul D. Williams, a famous expert in African conflicts. He writes the following:

"Peace operations" are defined as the expeditionary use of uniformed personnel (troops, military observers/experts, and police), with or without a United Nations (UN) mandate but with an explicit mandate to assist in the prevention of armed conflict by supporting a peace process; serve as an instrument to observe or assist in the implementation of ceasefires or peace agreements; or enforce ceasefires, peace agreements or the will of the UN Security Council to build a stable peace." (Williams, 2015, p.40)

After defining the meaning of peacekeeping as a phenomenon, it is interesting to turn to the general organizations that send contingents to the continent to reach order in the conflict-ridden areas. One of the most critical international establishments is the United Nations, the most significant contributor to peacekeeping operations in Africa. To mention some of them, we could cite UNISEA (Abyei), MINUSMA (Mali), UNMISS (South Sudan), MINURSO (Western Sahara), MONUSCO (Democratic Republic of the Congo). Other organizations also take part in the operations; it is enough to mention the name of the European Union, NATO, African Union, ECOWAS or SADC (Southern African Development Community). They are the creators of operations AMISOM (Somalia) or MNJTF (Chad and neighbouring countries) (Klobucista, Renwick, 2021).

To understand why it is necessary to conduct these operations, it is helpful to know the major problems that the continent faces and what these operations are trying to get an answer for. If we got a better grip on the events that happen on the continent and make the situation terrible, we could understand better why the continent is devastated by war and interstate conflict. According to Besenyő, we can conclude the reasons for these hostilities in a few lines, which could be the following causes: racial and ethnic differences, religious radicalism, border disputes, corruption and political inequality, fights for dominion over the countries, the effects of colonization that still lives on (Besenyő, 2019). The peacekeepers thus have a lot to achieve on the continent since the problems and conflicts are widespread in the area, and it will take a lot of effort to at least mend some of the difficulties that make the situation unbearable for the people living there. After understanding the difficulties that the peacekeepers face, let's turn to the role of the officers on the ground, their job and the mandate they are trusted with. These include DDR (disarmament, demobilization and reintegration) processes, landmine controls, keeping up the democratic standards, the defence of human rights and the protection of safe elections in conflict-torn countries where the military forces and the police are unable to keep up the order (Klobucista, Renwick, 2021). The peacekeepers' duties are, therefore, not as easy as it looks because they face a lot of hardships that devastated the countryside. However, it can be said that the military and police officers sent there do their best to improve people's lives and solve the long-standing conflicts that govern the continent. However, one organization itself doesn't seem to be enough sometimes to handle the ongoing problems in the African countries, so – according to some experts – the different peacekeeping organizations started to cooperate; thus, various pairs of hybrid operations came into being. This means that the hardships of the area brought together European, African and other organizations to tackle the situation and make life better for the civilians living there. For example, there are instances for the EU-AU, UN-AU and similar cooperations, and even bilateral relationships became favourable among the different countries interested in the region (like France, the US, Germany, UK) (Williams, 2015). It is interesting to note that African organizations – such as the African Union and the ECOWAS – have also become interested in participating in peacekeeping organizations in the country. Still, they face several challenges in their participation. They need capacity-building, logistics help and management assessment to improve their role in these operations, and they are also lacking enough funding, so they are continuously forced to ask for help from foremost the UN, but also other European or other organizations to make them possible to work in the area (Holt, Shanahan, 2005). Besenyő also corroborates this because, in his opinion, the African organizations aren't ready for the appropriate planning and logistical execution of these missions, because they have to rely on the United Nations and other organizations which have more experience on the continent regarding peacekeeping activities

(Besenyő, 2021). However, the peacekeepers not only face practical problems; according to Paul D. Williams, they have four major problems: they are not appropriately informed all the time, the UN Security Council sometimes gives misleading orders to the soldiers, the warring parties may protest to the presence of the soldiers in the area, and they also counter very harsh environmental circumstances (Williams, 2015). Finally, it is worth mentioning the so-called Brahimi report, which intends to bring closer the United Nations and the African-led forces into better cooperation because it could give a view of what future could lie there for international peacekeeping. The report suggests that the AU and the ECOWAS ought to develop a common strategy and structured draft to improve their effectiveness in the area. The report also advises developing a better understanding of the so-called African Standby Forces, which would help the military capability of the African forces (Holt, Shanahan, 2005). There are two another, huge problems for the peacekeepers in general, first of all, because according to research they are used as an alternative solution for a reasonable goal to achieve in the governmental circles, so when the politics are unable to negotiate a deal, peacekeepers are sent in. Secondly, the governments that lend territory for the peacekeeping missions to operate wouldn't allow them legal concessions in the country, this way the effectiveness of the missions is in question sometimes (Bamidele, 2013, p. 118). Although these problems are existent in the realm of peacekeeping in Africa, the peacekeepers are eager to find solutions to ease the tensions between the aforementioned governments and their organizations, so they are continuously trying to facilitate peaceful solutions between the state and the peacekeepers in order to make operations in the conflict-ridden area more comfortable. According to research, the governments' orders and opinion is taken into consideration by the military officers and their leaders, but sometimes it is hard to maintain a fair relationship with some African governments which hinder the movement of the peacekeeping troops in those countries (Piccolino, 2019, p. 3).

3. The role of the United Nations in the peacekeeping activities

The United Nations is one of the most important – if not the most – contributors to peacekeeping activities in Africa. It has deployed several missions to restore peace in the conflict-torn area with more or less success. To be brief, at least the largest ones should be mentioned along with the countries they operate in MINUSCA (Central African Republic), MINURSO (Western Sahara), UNMISS (South Sudan), MONUSCO (the Democratic Republic of Congo), UNISFA (Abyei) and UNAMID (Darfur). For the time being, it is important only to mention their names and their countries of origin. Peacekeeping operations by the UN also face many difficulties when deployed to African areas because the continent is full of various conflicts. To mention some of them: they must ensure the rights of civilians, who are continuously harassed, and they should prevent the occurrence of mass atrocities. There is always the problem of the governments, who are usually reluctant to help the non-African peacekeepers in their efforts. Another problem is posed by sexual abuse, which is a serious and dangerous crime committed by soldiers and even peacekeepers. Notwithstanding these difficulties, the military observers and police officers serving in the missions have clear mandates to follow, which include: civilian protection, assisting governments in stabilizing the conflict situation, DDR processes, promoting humanitarian goals, keeping up equality in the country's legislation, and finally, they must monitor the compliance of the rules admitted by the parties (Congressional Research Service, 2019).

As we can see, UN peacekeepers make a lot of efforts to try to maintain peace in the conflict-ridden areas in Africa, facing difficult circumstances and the dire environment in which people of the continent live. Even though they have good intentions and want to help the countries in question, they sometimes have to face fierce resistance from governments, locals and civilian organizations who – because of their colonial experiences – wish that the foreign soldiers should rather disappear from their country. This was the case in two specific countries, Mali and the Democratic Republic of the Congo. At the end of October 2022, several protests broke out demanding the departure of these missions (MINUSMA in Mali and MONUSCO in the DRC). Experts say there are two main reasons why these organizations are not welcomed besides the obvious colonial resentment Africans feel toward European peacekeepers. One of them is their ineffectiveness in countering the jihadist threat permeating the two

countries in recent times. The other one is the lack of discipline, which has come to govern the UN operations in the last few years. As mentioned before, the resentment from local governments and their involvement in local politics for which they use anti-Western sentiment has been hindering the effectiveness of the peacekeeping operations, which this way struggles to keep up the excellent work. There is also the question of the civilians, the innocent population threatened by the jihadist forces, and becoming annoyed by the inertia of the peacekeeping forces to control these insurgent radicals (Dessu, Yohannes, 2022).

There is another crucial aspect from which we could assess the effectiveness of UN operations in Africa. There are different approaches to the success of the missions. At the same time, some experts think they are not producing enough results; others believe that they are relatively successful and help improve the situation of the people in the area. Let's begin with one opinion about the failure of such operations and listen to the author's reasons for his thoughts. Isaac Mugabi thinks that one of the main reasons the UN missions are unsuccessful is that they don't belong to the areas at hand and don't know about the local situations. He gives the example of MONUSCO, which in his opinion, has not stopped the raping and looting that has been going on in the eastern district of the country for a long time. He also thinks the intervention speed of the contingent is very slow and ineffective; that way, the insurgents have time to commit atrocities in the Kiwu area of the country (Mugabi, 2021). Another sign that peacekeeping is not going so well in the area is a recent event in the summer of 2022, near August, when UN peacekeepers shot dead two rebels in the DRC. This happened during tense demonstrations against the MONUSCO units to pull out of the country. The eastern part of the country is full of rebel groups that incite violence in the territory, for example, the ADF (Allied Democratic Forces) or the March 23 Movement (M23). It is said that even Rwanda supports these rebels so there were diplomatic crossfires from both sides considering this problem (Wembi, Dahir, 2022). It can be seen that the military confrontations and the diplomatic hostility between the sides produces a harsh and difficult environment for the peacekeepers to work in. It is no different in other African areas, like Mali with the MINUSMA. There have also been difficulties for the European and UN forces concerning the ineffectiveness of handling the radicals' breakthrough in the country. One of the main issues is that while Europeans are reluctant to stay in the country, Russia is interested in moving there, which could create more international debates (Mugabi, 2021). The United Nations is also active in Mali, where it set up an operation which helps the MINUSMA in gathering intelligence information regarding the activities of the enemies of the operations – this operation is called ASIFU –, thus creating another opportunity for the international and national organizations to assess the information regarding the homegrown terrorist networks roaming the country (Karlsrud, Smith, 2015, p. 4). However, there are not always positive aspects of the peacekeeping activities of the United Nations, because according to some experts, the effectiveness of the largest international organization is not always as effective as it seems regarding the countries they try to make peace in. The biggest problem in the eyes of some critics is that some of the operations that the United Nations coordinates answer too late to the ongoing problems, or are not able to prevent them in time, thus it becomes a burden for the problematic area rather than a solution because of its lack of consistency (Phayal, Prins, 2019, p. 5). This problem was so acute, that some experts on the theme came to a conclusion that it is not enough to just prepare for such occasions in which the UN has to get involved in an operation, but rather the organization should establish an office that would provide information on the possibilities of such outbreaks of conflicts to prevent the escalation of problematic episodes better (Benson, 2021, p. 13). Another pending issue that definitely weakens the African community and the chances of the countries to have a peaceful and prosperous life on the continent is the role of the so-called warlords, who represent a serious problem for the United Nations forces who try to do their utmost to prevent these chieftains or rulers from producing more catastrophe than they have already done to the African environment and society as a whole. These warlords are eager to thwart and hinder the ongoing peace negotiations between governments and the United Nations since they have their own political and financial interest in the areas devastated by conflict, thus it is a great challenge for the UN to involve and at the same time handle these military figures to broker peace deals between warring parties (Akpan, Olisah, 2019, p. 88).

There is, however, a more positive opinion on the effectiveness of the troops taking part in peacekeeping operations on the continent. Howard, for example, thinks the missions were relatively successful and useful in restoring peace in the conflict-torn environment. He assesses the missions and concludes that the successful missions superseded the failed ones. He praises the three most essential operations, the MINUSMA, MONUSCO and MINUSCA. He also despises the troops he calls mercenaries who appeared in Mali and the Central African Republic. In his opinion, the peacekeeping operations helped develop the local civilians' human rights. At the same time, he praises the operations for being effective as, according to his sources, there have been fewer fatal incidents regarding the indigenous people. The missions help solve, or at least try to maintain, the stability of civil wars and decrease the aggression permeating the continent for hundreds of years. He mentions 11 successful missions after the Cold War, which is, according to his counts, a 2/3 victory over the forces that would like to push the zone into conflict to exploit it (Howard, 2022).

After enumerating the countless operations that the UN peacekeepers have taken part in, it may be useful to look at one of the essential conflict zones in the region, namely the Central African Republic and what happened there. To be brief, after the Muslim Seleka came to power, Christian forces started to mobilize units called the Anti-Balaka, who started a civil war among each other. Thus UN deployed a peacekeeping force into the area called MINUSCA, which is responsible to handle the delicate situation between the warring parties. It is a typical situation, as there was an African Union-led force before the UN had to step in. Still, they needed the assistance of a more professional organization, although they did quite an excellent job handling the delicate situation between the parties. UN deployed 1800 soldiers and police officers, while 4800 African soldiers remained in the contingent (Smith, 2014).

We cannot disregard as well the case of women in relation with the peacekeeping efforts and how the UN tries to involve the role of the gender-based activities in recent times. According to research, women's role is increasing on the continent, and they are more and more able to receive a leading role in the decisive issues that characterize a country's social and political life. Thanks to the UN and their efforts, women are more included in security related cases, where they were neglected before. They receive more and more protection from harassment and get a larger role altogether in the politics of the governments of the aforementioned countries, and the United Nations also helps them in the gender-based problems that they face in their hardships on the war-torn continent (Sharland, 2021, p. 115). This gender-centered approach was established in 2000 in the document by the UN Security Council Resolution 1325 (2000): this writing establishes the basic rights of women to participate in the peacekeeping operations on a same level as men do. They should – according to the document – take more active part in the governmental, political issues of the countries and the peacekeeping forces that try to equalize the genders in the missions to promote the rights of women as well (Holmes, 2020, p.1).

It is perhaps interesting to note the role of China in the UN peacekeeping missions. In spite of what the international media and people usually think about Chinese influence, the large Asian country's intentions are not exclusively hostile to the goals of the UN, instead, they are the believers in diplomatic efforts and want to contribute to the UN peacekeeping efforts. In cooperation, the two forces could achieve something beneficial for both sides and also for the world power sharing (Coleman, Job, 2021, p. 1451).

Concluding the activities of the UN-led forces in the region, perhaps it is to summarize what the operations of the UN peacekeeping missions were mandated for. First, they had the duty to protect the civilian populace to ensure the safety of African citizens. Then they must have stepped up against mass atrocities, which created a fearful environmental atmosphere in the region. One of the biggest challenges was for the peacekeepers to work out a diplomatically appropriate cooperation with the governments, who were very sensitive to European troops because of their colonization experiences. Perhaps the most crucial task was to hinder the jihadist threat spreading across the Sahara and which causes people to fear for their lives and makes their living sometimes unbearable. The sexual abuses also had to be stopped, and with more or less success, the peacekeepers managed to get the

situation in hand, so these atrocities might start to diminish. It was also essential to strengthen their ties to the African-led operations, so they could work together on restoring peace to the continent with their African counterparts (Congressional Research Service, 2019).

4. NATO operations in recent times

First, before we conclude NATO's participation in operations in Africa, we should conclude the organization's basic rules during missions. It has three primary rules: it wants to uphold the equality between the participants of the world order; second, it coordinates its efforts with parallel institutions like the United Nations and the European Union; and third, it would like to improve the humanitarian situation that is devastated by conflict on the continent (Segell, 2011). From these guidelines, we can assess that the organization's primary goals are to protect the fragile peace in Africa or to balance the ongoing conflicts that threaten civilians' safety. NATO is an organization designed mainly to preserve world peace and ensure the safety of the citizens of its countries. It helps where it can in the world elsewhere as well. If we visit the homepage of the organization, it gives a detailed account on its mission mandate and goals that it wants to achieve in the world:

“NATO is an active and leading contributor to peace and security on the international stage. It promotes democratic values and is committed to the peaceful resolution of disputes. However, if diplomatic efforts fail, it has the military capacity to undertake crisis management operations alone or in cooperation with other countries and international organizations.” (North Atlantic Treaty Organization, 2022)

From this, we can understand the values the organization proposes and tries to follow in the international world of conflicts and troublesome events. However, NATO doesn't participate as much in the continent's problematic conflicts as for example the UN. Its first incursion into Africa's security issues occurred during the Darfur conflict that erupted in 2003 between the black African farmers and the Sudanese Arabic government forces called the Janjaweed. At that time, an African Union mission was already underway at the scene and tried to resolve the situation. Still, sooner or later, they had to realize that they alone were not enough to put things in their place, so first, they called for NATO's assistance to help stabilize the conflict. The humanitarian situation was so dire that foreign intervention was required from the international organization, which didn't refuse it due to the human rights abuse cases in the area.

Nevertheless, this became the first mission that NATO helped another country out of its jurisdiction, and they cooperated with the African Union force AMIS in the second half of 2005. NATO decided to deploy non-combatant units to the ground, and at the end of the year, it started work in the area. NATO's main tasks were airlift support which it provided to African Union troops, and the organization also took part in capacity-building measures that helped strengthen the armies of the African forces (Segell, 2011). Not soon after, however, this proved insufficient, so the United Nations had to enter the scene with its hybrid force called UNAMID in 2008. However, NATO – for the first time in its history – proved that its intentions are not only selfish, and it wants to promote world peace and restore international order wherever there is a conflict-ridden area which requires its help to get secure again.

Nevertheless, NATO participated not only in this mission in Africa but had another episode worth mentioning because it had a severe effect on the continent's history and political life. The African Union began another mission after Darfur in Africa. Still, this time it aimed at restoring the peace in Somalia, which became a base for terrorists and pirates in the Eastern African area. NATO's main goals involved getting rid of piracy in the waters close to the country, and the presence of terrorism was so threatening that the organization had to deploy its troops to ensure that the dangerous elements were either eliminated or neutralized. The security situation was also precarious in Somalia; thus, NATO's presence was unavoidable to give at least a minimal feeling of security to the Somali citizens who suffered a lot from the jihadist attacks and never felt safe because of the continuous activity of the terrorists organizations in the area. NATO also took responsibility for training the soldiers of the

African Union's units, so capacity-building here also became an issue. As the African organization was establishing so-called African Standby Forces – which would have served as rapid reaction commandos against the dangerous elements and situations – NATO also undertook their improvement and training, thus developing the capacity of the African forces in the frame of international cooperation. NATO, however, faced other problems mentioned previously in this article concerning the UN forces: they were not always welcome by local troops, as they reminded them of the past when colonizers invaded their country, so they required the utmost diligence in their diplomatic efforts to relieve the tensions accumulated by past experiences (Kaim, 2013).

After taking part in the fight against piracy and terrorism in Somalia, NATO took part in another operation when the Arabic Spring broke out. The organization participated in Operation Unified Protector in Libya in 2011 to make an order to the revolution-torn country. After assessing the facts from this mission, some conclusions can be summarized: NATO was authorized by the UN, and it used only air force instead of combat troops, and the main reason why it interfered was the care for the well-being of the population, namely humanitarian reasons (Segell, 2011).

The organization had controversial issues concerning Turkey and Mali as well. For example, Turkey and France were part of Operation Sea Guardian's mission, which aimed at reducing the maritime terrorism threat near Libya and the Mediterranean. Turkey, however, was pushing its limits in 2020 when it allegedly attacked a French battleship – which was not acknowledged by Turkish forces. This shows the flaws that appear in the cooperation between the countries in the organization, and it presents the danger that inside NATO there can be debates about important issues which can be determinant in the security issues the organization is concerned with (bbc.com, 2020). The other case was with Mali when the Spanish foreign minister Jose Manuel Albares didn't deny the possibility of the country entering the ongoing Mali conflict in the 2022 Madrid summit if there was an urgent need. This came at a time when the migrant flow was unbearable towards the southern borders of Europe, and the country was one of the areas in the Sub-Saharan region that caused massive flow towards the European countries. This remark has caused unwanted tension between the African country and the Spanish government because the conflict has been ongoing for several years (france24.com, 2022).

5. The activity of the European Union in Africa

The European Union is mainly a civilian organization with no real army or military force to intervene in conflicts of other countries. However, the establishment is eager to participate at least in helping the countries above with security safety and capacity-building measures along with logistical help. That said, it can be expected that the European Union doesn't take part in the affairs of the African continent as seriously as, for example, the United Nations and NATO, but it would like to offer its assistance to the African countries who need training and humanitarian aid so that it could contribute to the peaceful solution of the continent which suffers from endless conflicts. The European Union was always the upkeep and propagator of human rights and equality between nations. It would like to uphold its standards in parts of the world where assistance is needed.

Nevertheless, the European Union is looking forward to cooperating with regional African organizations such as the African Union, which became reality in February 2022, when a summit was held between the two organizations. These talks discussed the main issues at hand, stemming from the COVID-19 disease that devastated the world and took millions of lives. They agreed on improving their cooperation to rebuild the former stability that characterized the relationship between the two entities. They couldn't evade the current problems that have threatened the peace of the regions between the two areas, for example, terrorism, migration, sexual violence, assassinations, attacks by jihadist forces, etc. They agreed that these problems caused a lot of people to lose their homes, becoming internally displaced people (IDPs), which reached the number of 2.2 million persons. They also agreed to further their goals of cooperation: humanitarian assistance, cooperation on migration and restoring the healthy situation because of the end of the COVID-19 illness (Désir, 2022). The European Union

bases its directives on these basic instructions and suitable measures. It tries to grow up to the standards that the world requires to restore the direct conversion between the two organizations and continents. In the further sections, we will consider the operations and the situations the EU launched in recent years on the black continent.

It is perhaps well known that the European Union has had a training mission in Mali for several years (EUTM Mali), which is responsible mainly for capacity-building measures in the Malian army. However, recent events in world politics – and this goes for other operations the Europeans have started on the continent – have entirely changed the effectiveness of the European forces on the ground. We are talking about the so-called Wagner Group, which –although denied by the Kremlin – is led by a close associate of Putin called Yevgeniy Prigozhin. These Russian mercenaries appear everywhere in Africa and chase away European forces ruthlessly. Let's consider first the Malian training mission, where the Malian government tied itself to the Russians, and supports – not officially – the Wagner group, so even Joseph Borell (EU foreign policy chief) said the mission couldn't work in the area further along the Russian mercenaries, who allegedly killed 200 civilians in the village of Moura. Also, according to the news, Paris is withdrawing from the country because of the incidents (africanews.com, 2022). Besides the French troops, there was an additional contingent of Germans also in the country. However, they are only present in a small number. Although they are deployed there to fight the jihadist forces, their enthusiasm is questioned after they see what Wagner Group is capable of. Thus foreign minister Annalena Baerbock visited the area to inspect the situation and is on the verge of withdrawing the German contingent entirely from the area because she doesn't want to get confronted with the Russian mercenaries and their activities on the ground (france24.com, 2022). Later, in November, the German government decided that due to unbearable security circumstances in the area, they gradually pulled out their troops from Mali, because they couldn't guarantee the safety of their soldiers in the country, especially with Mali supporting Russians in the area. The withdrawal mentioned above will take place in 2023 and finish by May 2024. The decision came after remarks from the Malian government concerning their excellent relationship with the Kremlin. In light of this development, the German government thought it wiser to pull out from the war-torn and dangerous country to protect their soldiers from Russian influence (dw.com, 2022).

The European Union is not only active in Mali, but has other operations going on on the continent. Its policies usually don't let it intrude very much into the life of African people since its traditions include respecting other cultures and religions, and it only enters into other countries' sovereign territory with good intentions to help strengthen their military or train their forces, to give military or financial support. However, the situation in the Central African Republic became so dire that the European Union devised a technical assistance mission to train CAR soldiers to restore order in the country. Nevertheless, with the rise of Russian imperial politics, it was expected that Wagner Group would appear at the scene and intrude on the life of the training mission, which comprised only 70 experts. Because of this, the European Union decided to pull back these soldiers so that the training mission couldn't continue because of the presence of the Russian mercenaries (euractiv.com, 2013). The other country that the European Union was interested in is non-other than Mozambique, which has substantial oil reserves (LNG). Since the Russian-Ukrainian war affects European gas distribution, Europe is looking for the possible energy resources it can find globally that can replace the Russian gas they are willing to sanction. The problem is that in Mozambique, jihadist networks also carry out attacks against these targets. This makes it challenging to harvest abundant energy in the country and would help the European community survive Russia's blackmailing politics relating to gas reserves. To achieve a more peaceful situation by getting a share of these resources, to European Union supports the SADC with financial aid to help them in their peacekeeping mission against these radicals in the country (Guarascio, 2022). Besides Mali, the Central African Republic and Mozambique, the European Union also takes part in confidence building measures in the Democratic Republic of the Congo. Its main politics are to help ensure the safety and financial capability and capacity building of the Congolese country and military. The peace-building activity in the state by the European organization has been

overwhelming and it gives a great opportunity for the African nation to become more stable than it has been in the past decades (Froitzheim, Söderbaum, Taylor, 2011, p. 46).

6. The African Union and its politics in Africa

The African Union was established in 2002, reaching its 20th year. It has also significantly emphasized the continent's role in international politics and peacekeeping. The organization started with 55 members, which comprised almost all African countries. Its predecessor was the Organization of African Unity (OAU), and it tried every means in its possession to improve the effectiveness of the cooperation of the African countries in the peacekeeping methods (Eyssen, 2022). Africa has had a lot of tricky situations in the past 20 years; it is enough to enumerate some of them: terrorism in the Sahel region, conflict in Ethiopia, Somalia and the Democratic Republic of the Congo, along with coup d'états in Sudan, Mali and Guinea. There have been two agendas that came to hit the headlines in African countries: first, in 2015 the African Union devised a common plan called Agenda 2063, which aims at development in every way possible for the continent, and the other one was 2016 reform designed by Paul Kagame (Rwanda). This points to the plan of the African Union to strive for economic integration, which could bring the African countries closer together and make them easier to cooperate (Pinto, 2022).

After describing the main objectives the organization undertook in these 20 years, it is likely to enumerate some of the missions they took part in and evaluate with what effect they have participated in the peacekeeping operations they have started. The African Union first undertook the operation in Burundi from 2003 to 2004. The name of the mission was AMIB, or AU Mission in Burundi. The African Union mission had almost the same mandate as the European organizations usually have: the DDR methods, ceasefire agreement oversight and the like. However, as mentioned before, there was always a problem with AU operations: they needed more funding to run a smooth mission where they could arrange their issues the way they wanted without foreign interference. After the Burundi mission, the African Union embarked on a much bigger adventure. They entered Sudan, Darfur region, which was torn by conflict since 2003.

The mission started in 2004 and lasted until 2007. Their tasks were similar to what they had been before: humanitarian assistance to the people suffering in the area and checking the ceasefire violations by the parties at war. They monitored the movements of the conflicting groups and the civilians to intervene when necessary and supervise police officers during their duty to see if they were making the correct decisions and had acted reasonably. However, the same problem occurred as before. The organization alone could not take matters into its hand, and it had finally to rely on the help of the United Nations. They took over the operation at the end of 2007. The African Union had another critical mission in the area, namely in Somalia, where they created the mission AMISOM, which was established to thwart the terrorist and piracy acts in the region. The operation started in 2007 and has been designed to support the anti-terrorist efforts of the country to make it a safer place for its citizens. Their main problem was the notorious Al-Shabaab terrorist organization, which carried out regular attacks against installations in the country. After 2009, not many things changed, so the operation was missing the key instruments to implement peace in Somalia. Summarizing its most valuable effects on the world of peacekeeping could be the handling of the international media, it could be enhanced with the cooperation of the local tribesmen and community, and even the psychological maintenance of the locals is considered to be a very important part of the preparation for the peacekeeping operations regarding the indigenous population (Mohamud, 2019, p. 1353). Another important aspect of the contribution to the African Union mission is the issue of the Brexit regarding Great Britain, which has been among the main suppliers of trade in the area along with other greater European States, thus the Somalians now have to negotiate with the British separately from the EU which will complicate things for the African Union mission (Tor, 2017, p. 3). To summarize the main characteristics of the African Union missions, one could conclude the following: there were not enough soldiers given from the participating states, the AU had to ask for foreign intervention and financial aid to continue its work, they had problems with the host country as how far they can go with their mandate, and all of the missions had to be

undertaken sooner or later by the UN. Paul D. Williams, an expert on this theme, concludes that the African Union should design its operations better to achieve better results because they need more planning, logistic and financial capabilities (Williams, 2009). One of the main characteristics of the African Union's missions was that it not only went to conflict-ridden areas to create peace and to negotiate between warring parties, which needed international or domestic powers to intervene in their problematic issues, but the organization's other feature is that it also gets involved in handling terrorist-related incidents and areas where there radical organizations show up. The operations which the African Union organized were mostly against the Boko Haram, a Nigeria-based terrorist organization and the previously mentioned Al-Shabaab in Somalia. Thus the AU is not only taking care of simple conflict issues, but also tries to intervene when its necessary to prevent terrorist activities from taking place (Botha, 2021, p. 40.). It is may be of interest that in the previous paragraphs the peacekeeping organizations were described as being late from entering into a conflict, and they only get involved when its already too late to intervene. However, according to some, there is for example an interim force in the African Union called Continental Early Warning System (CEWS). Its job is to maintain a constant attention to all nearby elements of conflict to be ready to prevent them from happening, so the African Union may have found some kind of solution to the huge problem of the other organizations of being late in a conflict zone (Lawson, 2018, p. 3).

Conclusion

When we summarize the operations the main organizations undertook in recent years, these missions all started to solve the widespread conflicts on the continent. With more or less success, they tried their best to ensure that the rights of the civilians who were the victims of these aggressions get treated right. However, in an environment like this, it isn't easy to reach a common solution where every party gets what it wants and the rights of every side are satisfied. All UN, NATO, EU and the AU tried their best to ensure that the conflicts that devastated the continent get resolved, and people could live a peaceful life again. However, the civilians living in the area are still very far from acquiring that status. There are a lot of consequences that could be deduced from this research, but there needs to be more space to write them all down. However, some basic remarks could be stated according to the assessed data. For example, there should be greater cooperation between the European, international and African organizations to ensure closer participation between these establishments to find a common solution that would benefit all African people and help to get them the respectful life they deserve. The missions should be better planned logistically and better coordinated by their leaders, and the soldiers' training should be more thorough in enduring extreme circumstances to reach results that can help improve the lives of ordinary citizens and civilians living on the war-torn continent. To conclude everything, it is essential to cooperate at every level possible so that the prospects for reducing conflicts could improve and the effectiveness of the peacekeeping operations could improve. If we were to achieve this by every method at our disposal, the life of the African people would be able to be improved by far in the following decades.

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Open Access



INDUSTRIAL CONTROL SYSTEMS (ICS) CYBER PREDICTION MODEL***Joana Katina¹, Tomas Plėta², Romualdas Petkevičius³, Lina Lelešienė⁴**¹ Vilnius University, Institute of Computer Science, Department of Computational and Data Modeling, Didlaukio st. 47, LT-08303 Vilnius, Lithuania² Vilnius Gediminas Technical University, Saulėtekio Ave. 11, LT-10223 Vilnius^{3,4} Mykolas Romeris University, Ateities St. 20, LT-08303 Vilnius, LithuaniaE-mails: ¹Joana.Katina@mif.vu.lt; ²Tomas.Plėta@gmail.com; ³Romualdasp@gmail.com; ⁴Lelesiene.Lina@gmail.com

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Abstract. Acceleration of scientific and technical progress, speeding up of technological changes, IT process globalisation and integration of OT processes invoked new challenges in preparing cyber strategies. Issues with adapting strategy for a particular specificity, region and specific cyber-attacks are not applicable. Therefore, a natural need arises to adjust the process for future cyber-attacks. It should be noted that the vast majority of organisations still need to possess a strategy that has been developed in correlation with future cyber-attacks. A part of organisations, irrespective of the lack of methodology and necessary infrastructure at the initial stage, commenced applying strategic management methods as a more dynamic environment demanded adequate changes in the cyber security within the organisation itself. The organisation started to plan such changes because, at the initial stage of the strategic management theory development, the strategy was understood as a plan drawn up to achieve the set objectives, regardless of the future need. Implementing such strategic procedures is grounded on something other than scientific calculations and is often associated with excessive use of funds. Therefore, the main goal of this article is to determine how much the r-Interdiction Median Problem with Fortification (RIMF) module can be used as a model for deciding methods for protecting critical infrastructure systems.

Keywords: cyber security; fortification; critical infrastructure; r-Interdiction Median Problem with Fortification

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1. Introduction

Critical energy infrastructure often includes smart grids, which are used either for remote control or industrial automation contingent on electronic computers. These systems use two-way communication with a focus on the computational processing of information. It is a technology that has been widely used for several years. Well-established in energy production and management plants, a smart grid invokes the available resources by utilising

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a variety of operating tools and energy measures such as power control and energy production. A smart grid integrates the capabilities of information technology and networks with those of smart management. The exchange of information takes place in real-time with the help of various devices that need to be operated within a critical infrastructure by applying new algorithms. Smart grids can detect faults and problems in a system, such as energy automation, production and management systems. The available resources of the system in critical infrastructure are utilised due to their ability to analyse in real time, thus, meeting the requirements (Tvaronavičienė, Plėta, Beretas, & Lelešienė, 2022). It is easily scalable and can be connected to other energy plants supporting common technologies (Bitirgen & Filik, 2023). Smart grids offer two-way communication; these are crucially important security issues, or else the reverse flow of electricity can cause security problems and reliability increases simultaneously in the critical industrial infrastructure.

A smart grid in critical infrastructure must be adequately protected against external factors. Despite its convenience and reliability, it poses security challenges (Somogyi & Nagy, 2022). Smart grids feature a significant pathogen; precisely, they integrate information into the network that will entail the ci issues as this network uses industrial equipment communications and all digital devices, making it vulnerable to cyber-attacks and malware infection. A targeted attack on a smart grid is aimed at intercepting sensitive information, taking over personal data and, finally, taking control of automated industrial operations. As mentioned above, smart grids are always a part of critical infrastructure and are adequately protected for their ability to interact with other intelligent devices such as IIoT. Inadequate configuration on smart devices that interact with the smart grid can be a gateway for intruders to the smart grid. Finally, innovative/supervisory operational teams involved in critical industrial infrastructure are an essential advantage as they can significantly improve communication within the infrastructure and avoid possible decisions that eventually lead to vulnerable systems in the future.

Smart grids offer significant benefits to later rendered critical infrastructure and industrial infrastructure in general; therefore, the citizens then receive these benefits as an organised critical infrastructure can provide high-quality benefits mainly to citizens with lower costs, including the security of energy production. In conclusion, the success of smart grids lies in the modern management techniques, their use, and the operation of all the teams involved in a critical industrial infrastructure, which provides an enhanced ability to solve many issues that may occur.

Some countries are facing problems related to the application of new technologies, including smart grids, due to the complexity of the state's legal system implementing the necessary cultivation permits and regulations, resulting in the inefficiency of critical infrastructure and services rendered. The energy plants that are also classified as critical infrastructure were created years ago; some of their functions at the time of their initial operation had low priorities, or these functions were not intended for upgrades that may be expected in the future. Only efficiency production was a priority, neglecting cyber-security. These systems were designed for another era when the needs for energy production were less demanding. Later, the necessary improvements had to be gradually made to meet the increasing demand for energy production. Cyber-security concerns in making these upgrades were only sometimes the priority.

Studies on cyber-security strategies and improvement of existing systems are based on a theory called "Game theory", in which blockchain models are integrated into multiple levels of programs also known as "Leader - follower". This hierarchical optimisation process presents the problem, where both the leader and the follower want to optimise their position at the same time, while the follower's solution is the reaction to the leader's solution. Optimal protection in critical infrastructure must be applied in such a way as to significantly reduce the rate of information loss and process failure (Parvasi et al. 2020). At this point, it is worth mentioning that, nowadays-critical infrastructure is significantly less vulnerable than in the past (Almaleh, & Tipper, 2022).

The goal of the research. Cyber strategy is a long-term planning tool, and it needs to have future insight to develop. Developing cyber strategies is mandatory for planning technical capabilities to protect organisations from cyber threats. It is a necessary forecast for future cyber-attacks, which should be integrated into cyber security strategy.

Methodology. The article analyses scientific research on the description and practical application of the r-Interdiction Median Problem with Fortification (RIMF) method. The paper describes the theory of the method's origin and analyses its use. One example of the practical application of the method was selected to achieve this goal, which was carefully analysed and described. At the end of the article, a conclusion was drawn on how realistic it is to use this method for integration into a cybersecurity strategy.

RIMF model intended to identify cyber threat recognition practices for protecting critical infrastructure can be applied. The RIMF model is an extension of the RIM model, as a tracking model for identifying protection practices of essential infrastructure systems. For the implementation, the RIMF model is divided into **two categories**: the external category, which models the decisions of the defenders, and the internal category, which detects cyber-attack scenarios based on a given protection strategy. The choice of the optimal model for forecasting and evaluating critical infrastructure is the most important arm for the smooth and uninterrupted operation of the infrastructure. Using general models of future predictions and troubleshooting offers analysis and calculations of various ways and procedures using data collected in different methods. It presents results that are only sometimes accurate by failing to draw correct conclusions. The use of multiple models of predictions provides several outcomes and more ways for a comprehensive understanding of the issues. The RIMF model may improve identifying security practices connected to malicious attacks, systems, and multiple targets. Using models that are not ideal or insufficient to capture the problem may lead to inadequate application of security strategies and fail cyber-attack and system breaches.

The central part of this article consists of two sections. Section 2 describes the algorithm and how it can be used to identify vulnerabilities in the systems and implement cyber-security by applying best practices. In Section 3, critical infrastructure objects will be analysed to verify the algorithm's operation described in the second section.

2. Review of literature

The issue of security is one of the important moments of the modern world, which has been discussed more than once and will be discussed in the future since not only the economic or political state of the country but also the people depend on it. There are many articles, guides and methods you need to do to protect yourself, your property and your finances. Nevertheless, only a few ways can determine a particular system's safety. Much attention is paid to methods that, through data analysis and specific calculations, can determine the probability of attacks and the level of protection of systems. In their publications and articles, scientists describe the use of various models to establish a particular object's security level or to determine the likelihood of an attack on it. Recently, scientists have been actively studying and describing in their works the possibilities of using one of these methods in different areas, called the r-Interdiction Median Problem with Fortification method (Zhang, Li & Jin, 2022).

For a very long time, sources of risk, due to which you can lose not only the object but also the supply of goods and services, due to natural causes, such as floods and fires, and man-made causes, such as terrorism and military operations (Church, Scaparra & Middlenton, 2004), have attracted attention. In 689 BC, the king of Sennacherib built a dam on the Euphrates River to deliberately create a manufactured disaster by flooding the city of Babylon (Church & Scaparra, 2005). In turn, the military tried to identify critical points in the supply chain, the defeat of which would lead to delays or reduction in supplies to conflict zones (Church & Scaparra, 2005).

Critical infrastructure may be defined as those elements that, when lost, significantly disrupt the system's ability to perform its function. These elements can include transportation linkages (e.g. bridges, tunnels, rail, etc.), facilities (e.g. port terminals, production facilities, warehouses, operations centers, emergency response facilities, hospitals, etc.), critical stockpiles (e.g. smallpox vaccine, drugs, food, etc.), key personnel (e.g. water system operators) and landmarks that may contribute to loss of well-being. Grubescic et al. (2008) studied network survivability by calculating network connectivity given a specific node or link failure. These studies aim to study and identify critical components, not the reliability and safety of the entire system. For example, if one of the power supply facilities covering a large area fails, the remaining facilities will not have enough resources to provide electricity, which will disrupt the entire system (Azaiez & Bier, 2007; Su, Gao, & Zhang, 2022). Therefore, one of the research priorities is the development of methods for protecting critical infrastructure (Church, Scaparra, & Middlenton, 2004, Soto et al., 2015; Zhang et al., 2023).

Previously used mathematical models for identifying network vulnerabilities have focused on determining how the loss of one or more objects will affect the operation of the infrastructure. For early models of prohibitions, see a publication by Church, Scaparra and Middlenton (2004), "Identifying critical infrastructure: The median and covering facility interdiction problems". They provide a short list of previously developed models, systematized according their goals, types, special constraints and the main network model.

Deny models help to identify potential weaknesses in the system without optimising security. For example, how to understand which facilities should be strengthened or secured? All objects, if the security process is relatively inexpensive. However, what if resources are limited and security costs are high? It is not sure, then, that an object's security, defined as critical, can provide the most excellent protection against an intelligent antagonist (Scaparra & Middlenton, 2008). Therefore, the optimal interdiction depends on what needs to be strengthened to prevent the consequences as much as possible. For this, the assumption was introduced that resources are limited and only a part of objects can be protected. The fortification was necessary to expand the possibilities of applying the median r-prohibition model to things that should be protected and to minimise the impact of prohibitions on other objects (Church & Scaparra, 2005).

The r-Interdiction Median Problem with the Fortification method is based on the p-median system structure. The main task of which is to find the optimal solution by placing p objects in the network in such a way as to reduce the cost of their maintenance and delivery. Most studies use a game theoretic approach and formulate protection problems as bi-level defender-attacker models (Scaparra & Church, 2008; Xiao et al., 2019). Researchers studying two-level and three-level tasks have extended the prohibition models to include protection decisions.

They developed a maximum-minimum budget allocation model, which makes critical infrastructure more resistant to physical attacks. The researchers consider problems within budget constraints, maximising the minimum cost of a possible attack.

Analysing scientific articles describing the r-Interdiction Median Problem with the Fortification method, one can notice that the theory described in the publication by Church, Scaparra and Middlenton (2004) is taken as the basis for all calculations. Therefore, from all the studied articles (Higle, 2005; Berman, Krass, & Menezes, 2007; Liu, Fan, & Ordonez, 2009; Aksen, Piyade, & Aras, 2010; Jenelius, Westin & Holmgren, 2010; Akbari-Jafarabadi et al., 2017; Li, X., Kizito, & Paula, 2018; Roboredo, Pessoa, & Aizemberg, 2019) one was chosen for further research, which deals with attacks on critical objects. Only some scientific articles consider the possibility of using the method to integrate it into cyber strategy. Therefore, this article will analyse the methods of calculation and the results obtained, described in the article by Scaparra Liberation and Daskin (2011). According to the authors, this example can be used when creating a cybersecurity strategy.

3. The RIMF model

When forecasting infrastructure problems, it should be emphasised that a probability assessment should be carried out. The use of a highly reliable problem-solving model and the use of the best cyber-security practices must be implemented to design strategies against multiple numbers and vectors of attack, even when the probability distribution and intruders' behaviour are unknown.

Therefore, the information from conducting forecast studies and proposed solutions will not only focus on high-probability scenarios but will be more general in predicting all possible future scenarios.

Forecasting will focus on comparing parts of the infrastructure by invoking stochastic optimisation methods. This will be achieved by making the best use of security resources or energy management information systems, significantly limiting the extent of the damage. Creating proprietary security algorithms that leverage the capabilities of the infrastructure in this way could motivate the design and creation of more secure equipment, the result of innovative applications, and a significant reduction, if not elimination, of the risk of system breaches within critical infrastructure.

Vulnerability assessment and risk analysis models for cyber-attacks that are either human-induced are used to design plans for security policy upgrades or critical infrastructure upgrades, as well as an understanding of vulnerable systems that need upgrades. The study considers a range of data, including infrastructure users, how they access the equipment, the communication networks, the way of communication and the processes performed. The main concern is optimising the entire infrastructure to make it more efficient and secure. A well-known model for capturing vulnerabilities in systems that are a part of critical infrastructure is the r-Interdiction Median Problem with Fortification (RIMF) model. The model is used to identify vulnerabilities in the systems and to implement security practices by applying optimal solutions provided that managers of the model know in advance and try to evaluate the vulnerabilities of the model. Both analysing and capturing problems is a process that distorts reality, as it captures malicious actions, cyber-attacks, and physical attacks on infrastructure, which without the use of predictive models would be uncertain thoughts about the future, which with time would lead to uncertainty and might repeat in the future without a clear understanding of events that would follow.

Over time, the use of the RIMF model has been expanded and upgraded as a stochastic component has been added, which can examine system problems against a range of cyber-attacks, which vary between one and a maximum number of R . In this way, every resulting output is associated with some probability, while for the minimisation of false or incomplete result which has a large exclusion from the actual data of the problem, so to minimise the loss of the worst case means to treat, through protection, all interference that further damages the systems so that only the least harmful ones can occur. A prediction model like RIMF is not infallible, it is likely to produce data that does not exactly address the problems and weaknesses, which is directly related to future cyber-security and physical protection strategies that need to be implemented in critical infrastructure. Nevertheless, the model tends to identify with a high degree of precision future cyber-attacks and physical disasters. The model identifies optimal protection strategies that are considered satisfactory by correlating them with the number of problems. The design of the cyber and physical security analysis of critical infrastructure should take into account to a large extent the results of such studies, which often do not significantly deviate from their predictions, thinking that not all data may always be relevant, but something which is not related to problematic use or the lack of usefulness of the prediction model, but is often due to limited input such as critical historical data that may have been omitted.

Fortifying application is considered necessary to minimise the result's loss of accuracy and address the difficulties affecting the system under consideration. This phenomenon is called S-RIMF. RIMF can list all the interference in critical infrastructure and capture level by level the problems with the characteristic repressions of possible

obstructions (r) and installations (P). The model works as follows: Define with H_r where H is the obstruction points in the premises (r). Each obstruction point H is equivalent to a cyber-attack or a general threat, while I_h denotes all obstructions to critical infrastructure. C_h captures correlations with interference standards, (h) represents the cost of systems when facilities (L_h) are inactive. Standard (h) is presented as covered if on the premises I_h is enhanced.

The barrier model relates exclusively to unprotected critical infrastructure. The worst-case scenario and the loss of information should always be considered to take the necessary measures to protect critical infrastructure in such a way as to include disruptive attack patterns in the forecast analysis. The S-RIMF standards are as follows:

$$z_j = \begin{cases} 1, & \text{If the location is enhanced} \\ 0, & \text{For any other case} \end{cases} \quad (3.1)$$

$$y_h = \begin{cases} 1, & \text{If the obstruction pattern } h \text{ is covered} \\ 0, & \text{For any other case} \end{cases} \quad (3.2)$$

The worst cost scenario is decoded by W_r , which (r) captures critical infrastructure. Therefore, the modelling will be as follows:

$$\min Z^* = \sum_{r=1}^R p_r W_r, \text{ where} \quad (3.3)$$

$$W_r \geq c_h(1 - y_h) \forall h \in H_r, \forall r = 1, \dots, R \quad (3.4)$$

$$\sum_{j \in I_h} z_j \geq y_h \forall h \in H_r, \forall r = 1, \dots, R \quad (3.5)$$

$$\sum_{j \in F} z_j \leq Q \quad (3.6)$$

$$z_j \in \{0,1\} \forall j \in F \quad (3.7)$$

$$0 \leq y_h \leq 1 \forall h \in H_r, \forall r = 1, \dots, R \quad (3.8)$$

Objectives of the above equation are the following:

- The notation with (W_r) identifies the sum of costs in combination with operating costs.
- $r =$ with the number of cyber-attacks compared to the loss value denoted by (W_r) .
- $H =$ number of critical infrastructures covered in combination with prohibition methods denoted by I_n .
- $Q =$ symbolises the number of critical infrastructures, which shows increased protection.
- Confirmation of the variables that have been used.

It is worth noting at this point that S-RIMF is complex and sometimes difficult to understand. Its complexity is directly related to the number of interference patterns combined with the number of critical infrastructures denoted by (P). As it is understood, the number of constraints and variables is related to the number of constraint patterns, then the prediction model is impractical and exceeds its implementation objectives; it is concluded that there is an improvement in uncertainty, which satisfactorily addresses the S-RIMF, which is a significant breakthrough in the field of protection modelling. If someone compares the RIMF and the S-RIMF will notice a considerable improvement in the prediction of cyber-attacks and general damages.

4. Practical application of the RIMF algorithm for critical infrastructure

The method described in Chapter 2 is widely used to solve problems of finding the optimal solution in many areas of activity. Numerous articles describe this method and are used to develop service systems, determine security methods, establish how much infrastructure can be subject to terrorist attacks, and optimally allocate funds and other resources to solve security issues.

In this article, we are discussing predicting cyber-attacks on critical infrastructure, the main focus was kept on research related to the study of strategies for protecting critical infrastructure from possible attacks, analysing probable failures and studying the design of reliable systems. A very good practical application of the RIMF model, with possible adjustments, additions and calculations, is described in the article by Scaparra Liberation and Daskin (2011) "Analysis of Facility Protection Strategies Against Uncertain Number of Attacks: The Stochastic R-Interdiction Median Problem with Fortification", which will be analysed in this Chapter.

The authors of the article "Analysis of Facility Protection Strategies against Uncertain Number of Attacks: The Stochastic R-Interdiction Median Problem with Fortification" use some geographical data in their research. More precisely, objects are located in the UK (150 objects) and USA (263 objects). Thus, to compare the results and test the method, 250 random evenly spaced objects were generated. All calculations were performed on a computer using the C++ program. For optimisation, a special CPLEX 9.1 module allows to selection and set of the necessary parameters corresponding to the task. Using computer equipment and a particular program made it possible to reduce the calculation time and avoid errors associated with the human factor.

The study uses a large data set, so they were optimally divided into groups with a specific number of objects using the P-median method. The number of attacks (R) is not large, in the range from 2 to 5, and the value of objects that can be protected (Q) is proportional to the number of objects tested (P): 10%, 15% and 20%. As a result, the combination of parameters after the optimisation process looks like this (Table 1):

P	40	50	60
Q	4 6 8	5 8 10	6 9 12
R	2-5		

Table 1. Combination of parameters

The model identifies optimal protection strategies that are considered satisfactory by correlating them with the number of problems. To minimise costs (Wr), for each value of r , the program calculates a probability (p_r), which helps to model the average value of attacks directed at a small number of objects. For these purposes, one of the formulas is used:

$$p_r = 2 * \frac{r}{R(R+1)} \quad \text{or} \quad p_r = 2 * \frac{R-r+1}{R(R+1)} \quad (4.1)$$

The results of the calculations are shown in Figures 1, 2 and 3 (Appendix I). As you can see, the first, second and third columns indicate the parameters P, Q and R. Further, the value of the optimal solution (Z^*) for each data set and the average execution time of the algorithms. An asterisk marks those solutions that are not optimal for this data set. The last row shows the average running time of the algorithms for the entire data set.

Having analysed the studies described in the article "Analysis of Facility Protection Strategies Against Uncertain Number of Attacks: The Stochastic R-Interdiction Median Problem with Fortification" and the data obtained above, we can conclude that this method can also be used to find out the optimal solution for predicting cyber-attacks on critical infrastructure. As the data of the algorithm demonstrates, the number of objects and, of course, the number of analysed attacks influence the determination of the optimal solution. This method can be applied to

a specified number of attacks and an indefinite one, as in the example above. To achieve this, it is necessary to supplement the method with the definition of the upper and lower bounds. The exact number of attacks used in the calculations requires a long and detailed work of collecting data.

Using the results of the study described in the article “Analysis of Facility Protection Strategies Against Uncertain Number of Attacks: The Stochastic R-Interdiction Median Problem with Fortification”, it is possible to improve the cyber prediction model for critical infrastructure, depending on what results have to be obtained. For example, by entering the maximum and minimum attack values for an indefinite number of threats, it is determined, in percentage terms, how far sub-optimal solutions are from optimal ones.

Conclusion

Unfortunately, the prediction models used to forecast future threats to critical infrastructure do not provide 100% accuracy, but they give essentially good forecasting for countering future attacks. More than just predicting threats from a single model is required, so more than one combination of prediction models is used, choosing a single threat prediction model can lead to ineffective future security strategies and result in sufficient security measures. Security control scenarios in critical infrastructure play an important role as for each scenario, an optimal security strategy has to be identified as determined by the prediction model. It should be noted that it might only be effective if there is a large number of interferences, and it may not be optimal if the foreseeable losses are small. The result will only be partially valid if the model identifies a low probability in combination with many failures. In implementing the model, the design of future security policies and critical protective infrastructure against multiple types of threats and cyber-attacks should be used, including those linked between multiple critical infrastructures and the elements should be considered. In addition, as mentioned above, the prediction models present an analysis that is approximately in line with the scenarios and data that were analysed. Based on the data that was evaluated, the potential threats, the extent of the damages and their costs are calculated. Finally, the prediction models and related tools are perfect for drafting the cyber-security strategy.

Cyber strategy is a long-term planning tool, and it needs to have future insight to develop. Developing cyber strategies is mandatory for planning technical capabilities to protect organisations from cyber threats. It is a necessary forecast for future cyber-attacks, which should be integrated into cyber security strategy.

Therefore, a method was analysed, using which it is possible to calculate not only the probability of a potential threat but also the amount of damage. Based on the data, their quantity and quality, it is possible to calculate for one separate object and several connected objects. Basically, the r-Interdiction Median Problem with Fortification (RIMF) method is used in logistics, economics, game development, the military, and more, but not in cybersecurity. Of course, there are many directions for future research related to the method and its application to ensure the safety of critical facilities. But, after analysing the application of the r-Interdiction Median Problem with Fortification (RIMF) method, the main task of this article is to decide whether it is possible to use it in practice, integrating it into a security strategy. Of course, using this method is possible and even necessary to properly plan the possibilities for protecting organisations from cyber threats. The practical application of this method will help improve the cyber strategy of critical infrastructure. By collecting and analysing information received about critical objects, their protection and attacks on them, in the future, improving the method, and using additional calculation formulas, will only enhance and strengthen cybersecurity.

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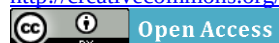
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CIRCULAR BIOECONOMY IN EGYPT: THE CURRENT STATE, CHALLENGES, AND FUTURE DIRECTIONS***Leonardo Piccinetti ¹, Mohamed Ramadan A. Rezk ², Tarek Y. S. Kapiel ³, Nahed Salem ⁴,
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Abstract. The concept of circular bioeconomy or bio-based circular economy is an integrated concept of circular economy and bioeconomy. In other words, it alludes to a systematic approach to economic growth that makes use of cascading biomass production from biological resources. In order to fulfil the objectives of sustainable development and the circular bioeconomy in Egypt, it is recommended that the bioeconomy be focused on as an economy of societal value in this article. It also discusses future directions and actions that can be used in this regard. This paper presents the current situation of the development of circular bioeconomy in Egypt and discuss future directions and measures that can be exploited and recommends focusing on the bioeconomy as an economy of societal value, enabling the achievement of the goals of sustainable development and the circular bioeconomy. Although there is no specific strategy for the bioeconomy, there are numerous government initiatives aiming to benefit from it in the future.

Keywords: circular economy; bioeconomy; circular bioeconomy; bio strategy; Egypt

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1. Introduction and literature review

The concept of circular bioeconomy refers to the systemic method for economic development that incorporates the cascading use of biomass from biological resources (Leong et al., 2021). A circular economy seeks to reduce reliance on (new) natural resource extraction while extending the amount of time resources spend via alternate

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usage cycles. The bioeconomy, a concept that can include economic activities connected to the creation, development, production, and use of biological products and processes for energy, materials, and chemicals, can supplement the circular economy (Biofuture Platform, 2018).

The bio economy encompasses all fundamental modes of production, including industrial and economic sectors that use biological resources and techniques to create bio-based products and services while also establishing new businesses and jobs. (Aworunse et al., 2023). Bioeconomy is an emerging field that focuses on the sustainable use of biological resources to create economic value. It is a rapidly growing sector, driven by advances in technology, policy changes, and consumer demand for sustainable products. In recent years, there has been a surge in interest in bioeconomy as a way to create economic growth while preserving the environment.

The term bio economy in the 1980's, was used to depict a solar energy-driven sustainable economy, which fits within the confines of ecology without the permanent constraint to grow. In the 1990s, a redefinition of the bio economy was advanced. It was described as an "economic sector that makes use of new biological knowledge for industrial and commercial purposes". This definition, alongside the corresponding establishment of the 2002 Strategy on Biotechnology sets the stage for the "Knowledge-based Bio economy" (KBBE) in 2005 (Gawel et al., 2019).

According to a European Commission (EC) conference report, the KBBE is a sustainable economy based on renewable resources that will not only contribute to the development of more environmentally safe production systems and the expansion of scientific frontiers. (Birner, 2018). The European Commission (2018) recently defined the bio economy as an economy that uses renewable biological resources from land and sea (for example, animals, crops, fish, forests, and microorganisms) to produce energy, food, and materials. (D'Adamo et al., 2022). Modern bio economy should not focus only on biomass and substitution of fossil fuels with sustainable and renewable alternatives but should be targeted towards "biologisation" of the economy via disruptive innovations that convert bio resources into food, feed, products, and services that integrate sustainability (Global Bioeconomy Summit, 2020).

The bioeconomy is an essential component for connecting and organising people to achieve the SDGs (Reim et al. 2019; Ranjbari et al., 2022). Sustainable development is defined as development that meets the needs of the current generation without risking future generations' ability to meet their own needs. (Brundtland Report, 1987). The three primary aspects of sustainable development are well articulated in the SDGs global framework, launched by the United Nations in 2015, and have become important indicators in the pursuit of sustainable development. (Kardung et al., 2021). The work of Heimann (2019) identified SDGs 1 to 3, 6 to 9, and 12 to 15 to be affected by bioeconomy activities.

Circular bioeconomy is a rapidly growing field that has been gaining traction in recent years. It is an interdisciplinary field that combines biology, economics, and technology to create sustainable solutions to produce food, energy, and materials.

The goal of bioeconomy is to create a more efficient and sustainable way of producing goods and services while minimizing environmental impacts. One of the most significant trends in bioeconomy is the shift towards using renewable resources such as plant-based materials and bioplastics instead of traditional petroleum-based materials. This shift has been driven by consumer demand for more sustainable products and by government policies that incentivize the use of renewable resources. Companies are increasingly investing in research and development to develop new bioproducts and bioprocesses that can replace traditional petroleum-based materials. Another trend in circular bioeconomy is the increasing use of digital technologies to improve efficiency and reduce costs. Digital technologies such as artificial intelligence (AI) and machine learning (ML) are being used to optimize production processes, reduce waste, and improve product quality. Additionally, digital technologies are

being used to track raw materials from source to end product, allowing companies to better manage their supply chains and ensure sustainability throughout their operations.

There has been an increase in public-private partnerships (PPPs) between governments, businesses, universities, and other stakeholders to promote research and development into bioeconomy solutions. These PPPs have enabled companies to access funding for research projects that would otherwise be difficult or impossible to finance on their own. Additionally, these PPPs have enabled governments to provide incentives for companies that invest in circular bioeconomy solutions such as tax credits or grants. Generally, there has been a significant increase in interest in circular bioeconomy over the past few years due to advances in technology, policy changes, consumer demand for sustainable products, and increased public-private partnerships. As this trend continues, it is likely that more companies will invest in developing new bioproducts and bioprocesses while governments continue to provide incentives for those who invest in bioeconomy solutions.

The national waste plan in Egypt has set aside 20% of the country's 26 million tonnes of garbage annually to produce energy, 60% for the production of fertilizers and alternative fuels, and 20% for burial. The entire amount of investment potential for implementing waste-to-electricity projects is around \$974 million, and the total amount for implementing fertilizer and alternative fuel production projects is approximately \$319 million (Ashour, Sally, 2021).

This article provides a critical overview of current policies that determine and influence the development of a circular bioeconomy in Egypt. It also discusses the current state of the circular bioeconomy in Egypt, the role of local players in the adoption of the circular bioeconomy, the future directions, opportunities and challenges of the circular bioeconomy, measures that can be leveraged, and discusses how to focus on the bioeconomy in Egypt as an economy with social value and capable of achieving the Sustainable Development Goals.

2. Methodology

The methodology depends on reviewing the existing literature on circular bioeconomy in Egypt, including studies on the current state of circular bioeconomy in Egypt, challenges faced by stakeholders, and potential future directions. In the current paper, the data have collected from relevant stakeholders, including government officials, industry experts, and academics. These data included information on the current state of circular bioeconomy in Egypt, challenges faced by stakeholders, and potential future directions. The findings were used to draw conclusions about the current state of circular bioeconomy in Egypt, challenges faced by stakeholders, and potential future directions for research and policymaking. Finally, based on our findings from the analysis of the collected data and literature review, we provided recommendations for research and policymaking related to circular bioeconomy in Egypt. These recommendations were tailored to address specific challenges faced by stakeholders as well as provide guidance for future research directions related to this topic.

The paper is limited to the Egyptian context, and thus the findings may not be applicable to other countries. It does not consider the potential economic and environmental impacts of implementing a circular bioeconomy in Egypt, which could provide further insight into the feasibility of such an approach. The paper also does not address potential policy interventions that could be implemented to facilitate the transition to a circular bioeconomy in Egypt as it does not consider the potential social implications of implementing a circular bioeconomy, such as changes in employment patterns or access to resources for certain populations.

3. Status of circular bioeconomy in Egypt

The service sector makes up around 56% of Egypt's GDP, followed by industry (32.6%) and then agriculture, forestry, and fisheries (11.8%). The Sustainable Development Strategy (SDS) 2030, the Sustainable and Green

Growth Strategy, the National Action Plan for Sustainable Consumption and Production (SCP), and the National Solid Waste Management Program (NSWMP). all indirectly support the concept of the Circular bioeconomy. Additionally, the Egypt 2030 plan, which is built on three pillars—economic, environmental, and social—defines objectives that specifically address circular economy in fields including solid waste management, agriculture, and business. The economic pillar of the Egypt 2030 also encourages Circular Economy activities in the industrial sector by promoting the idea of a "green economy," which aims to preserve the environment and use energy more effectively and cleanly. The environmental pillar seeks to protect and utilize natural resources effectively (Nada Maamoun, 2021).

Several international bodies have developed comprehensive blueprints and adopted the circular bioeconomy as a viable approach for enabling new opportunities for economic development and innovation, as well as achieving the SDGs (FAO, 2018; Pandey, 2021). As a well more than 50 countries now developing bioeconomy action plan (Aguilar et al., 2019). While some African countries have a well-defined bioeconomy strategy. When compared to countries in Asia, Europe, and America, a number of African countries have abundant biomass resources but are poorly to implement the bioeconomy. Gambia is the country with the highest biomass production. Rwanda, Sierra Leone, Malawi, the Democratic Republic of the Congo, and Tanzania round out the top ten. Algeria, Mauritania, Egypt, and Chad are the poorest performers in this category (Oguntuase & Adu, 2021), Egypt is still lagging, despite abundant biomass resources (see Figure 1 below)..

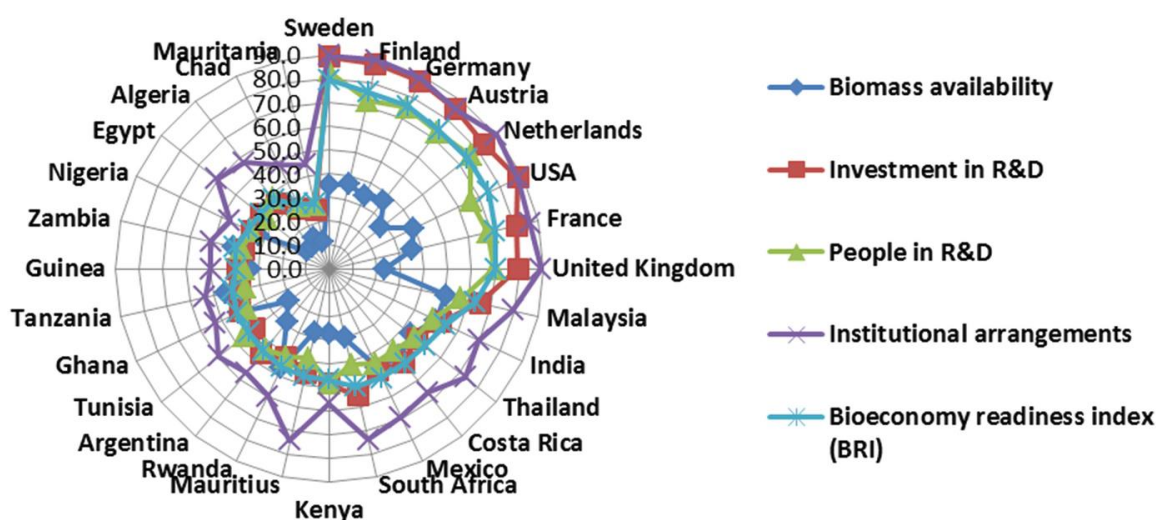


Fig. 1. State of bioeconomy production determinants in selected countries

Source: Oguntuase & Adu, 2021

Egypt has a long history of using natural resources to produce food, energy, and other goods, despite the many challenges that Egypt's bioeconomy faces, including water scarcity, land degradation, and climate change. The bioeconomy in Egypt is a rapidly growing sector that is becoming increasingly important to the country's economic development. In recent years, the Egyptian government has taken steps to promote the development of the bioeconomy to create jobs and spur economic growth.

Agriculture is one of the most important sectors of the Egyptian economy and is a major contributor to its GDP. The country has a long history of agricultural production and has been able to maintain its position as one of the world's leading producers of wheat, cotton, rice, corn, vegetables, fruits, and other crops. In recent years, Egypt

has seen an increase in investment in agricultural research and development (R&D) to improve yields and reduce costs. This has resulted in increased productivity and efficiency in crop production.

Biomass, a major emerging alternative to fossil resources, can provide a variety of products and energy. As a result, biofuel is critical to sustaining a knowledge-driven and environmentally safe bioeconomy that reduces global warming and climate change (Antar et al., 2021). Egypt could harness agricultural, crop residues and municipal wastes as a possible feedstock for the sustainable production of bioenergy (Abdelhady et al., 2014, Wafiq & Hanafy, 2015, Abdulrahman & Huisinigh, 2018).

According to a recent analysis of bioenergy in Egypt that were analyzed include crop and livestock residues to produce heat, power or combined heat and power (CHP) (FAO and EBRD 2017), In terms of crop residues, maize stalks, rice straw, sugarcane bagasse and cotton stalk are the most readily available. Maize stalk, rice straw and cotton stalk are most present in the Middle Delta region, while sugarcane bagasse is most present in the Upper Egypt region, in terms of livestock residues, the availability is very limited due to the reported availability shares (0 percent for chicken manure, 25 percent for cattle manure).

CHP (both from direct combustion and anaerobic digestion) can contribute approximately 7 percent to Egypt's overall renewable energy. If all biomass from agricultural crops, sewage sludge, municipal solids, and animal waste is available, the maximum theoretical potential energy will be 416.9 potential energy. Table 1, representing 92.6% of the total production in all installed power plants in Egypt nowadays (Said et al., 2013)

Table 1. Theoretical potential energy from biomass residues in Egypt

Biomass type	Theoretical potential energy (PJ)	Percentage of total energy (%)
Agricultural crop residues	185.75	44.6
Animal wastes (cows and buffalo)	40.61	9.7
Sewage waste (sewage sludge)	16.74	4.0
Municipal solid waste	173.80	41.7
Total	416.9	100

Source: Said et al., 2013

Biotechnology is another key component of Egypt's circular bioeconomy, which has seen significant growth over recent years. Biotechnology is considered as the foundation of the bio economy where bio economy involves the large-scale usage of biotechnology (Aguilar et al., 2019). Innovations including DNA sequencing, high-throughput molecular operations, modify genomes and metabolic pathways to improve organisms with wholly synthetic genomes, and nanotechnology have significantly increased the probability of biotechnology to drive the bio economy (Frisvold et al., 2021).

The government identified biotechnology as deserving of special support in the early 1980s, but it was not until a decade later that concrete steps to initiate such support were taken. The Academy of Scientific Research and Technology established a focal point for genetic engineering and biotechnology in 1991. Concerned about over-reliance on the advanced industrial countries for the development of this sector, senior policymakers turned to local experts and skilled expatriates from around the world to develop a national agenda. The 'National Strategy for Genetic Engineering and Biotechnology' resulted from these efforts.

The government allocated long-term funding as part of the strategy to introduce biotechnology to universities and public research institutes, as well as to establish new centers of research excellence, including three pilot plants for scaling up technology. In addition, the government funds training and fellowships in advanced industrial countries and has led several technical and trade missions around the world to promote exports (Abdelgafar et al., 2004). The country has established several research centers dedicated to biotechnology research, which focus on areas such as genetic engineering, tissue culture techniques, plant breeding techniques, food processing technologies, pharmaceuticals production processes etc. These centers have helped Egypt become a leader in biotechnology research and development (R&D) in Africa with several successful projects being completed over recent years.

4. Egypt's national initiatives supporting circular bioeconomy

Egypt is a country that has been actively investing in the development of its circular bioeconomy. The country has implemented a number of national initiatives to support the growth of this sector, which is expected to play an important role in the country's economic development. These include the Bio-Economy Strategy, which was launched in 2018 and aims to create an enabling environment for innovation and investment in the sector. The strategy focuses on four main areas: research and development, technology transfer, market access, and policy implementation. It also seeks to strengthen collaboration between public and private sectors, as well as promote public-private partnerships (MIIC, 2018).

In addition, the government has launched several programs to support bio-based industries. These include the Bio-Industry Development Program (BIDP), which provides financial support for research and development activities related to bio-based products and services; the Bio-Innovation Program (BIP), which provides funding for innovative projects related to biotechnology; and the Bio-Energy Program (BEP), which supports renewable energy projects using biomass resources.

Egypt plans to implement 3 projects in circular bioeconomy, with a total value of \$1.250 billion. The first one is a project to extract algae oil for use in biofuel production, with a production capacity of 350,000 tons annually, with investments amounting to \$600 million, to reduce 1.2 million tons of carbon dioxide annually. The second project is the production of biodegradable plastic with a production capacity of 75,000 tons, and with investments amounting to 600 million dollars, to reduce 45,000 tons of carbon dioxide annually, while the third project, is a project to convert plastic waste into oil to be used as a raw material for the manufacture of polyethylene, with a production capacity of 30 thousand tons annually, and investments amounting to 50 million dollars, to reduce 63 thousand tons annually of carbon dioxide (Ministry of petroleum, 2022).

In 2022, Praj Industries, an Indian industrial biotech company, signed an agreement with Egyptian Sugar and Integrated Industries Company (ESIIC) to accelerate bioeconomy in Egypt. The agreement aimed to develop infrastructure, help formulate policy framework, and create awareness for bioeconomy. Sugarcane bagasse and rice straw were envisaged to be feedstock for ethanol production (ETEnergyworld.com, 2022).

Here are some examples of Egypt's national initiatives supporting circular bioeconomy: One initiative is a plastic recovery scheme that rewards informal recyclers through digital credits. Egypt's government and several multinational companies back the scheme, and it helps reduce plastic pollution, create income opportunities, and improve waste management. Another initiative is a project that converts rice straw into biogas and organic fertilizer. Egypt's Ministry of Agriculture and Land Reclamation support the project and it helps reduce greenhouse gas emissions, enhance soil quality, and provide renewable energy. A third initiative is a program that promotes sustainable agriculture practices such as organic farming, integrated pest management and water conservation. The program is implemented by Egypt's Ministry of Environment and several NGOs, and it helps improve food security, biodiversity, and climate resilience (Iskandar, 2021).

The Ministry of Environment-affiliated Bioenergy Foundation for Sustainable Development expanded its efforts in utilizing agricultural waste in 2022 by setting up biogas units, developing hybrid solar-electric power systems to lower the cost of electricity produced, and developing systems for producing biogas from biological waste other than human and animal waste. In the governorates of Gharbia and Beni Suef, 154 units were installed, making a total of 1843 units that treat 49,000 tonnes of biological waste and produce 1.9 million cubic meters of biogas yearly, or the equivalent of 65,000 gas cylinders. Out of which 9,000 are residents, 31 startups were founded, creating 72 direct jobs and 93 indirect jobs (Ministry of Environment, 2022).

Finally, Egypt is actively promoting international cooperation in this field through its participation in various international organizations such as G20's Global Bioeconomy Initiative (GBI) and African Union's African Bioeconomy Alliance (ABA) (Chavarria et al., 2020). Egypt is making significant efforts to develop its bioeconomy sector by implementing various national initiatives that provide financial support as well as promote collaboration between public and private sectors. This will help create new jobs while also contributing towards sustainable economic growth in Egypt.

5. The role of local actors in the deployment of circular bioeconomy

The deployment of circular bioeconomy is an important step in the transition to a more sustainable future. The role of local actors in this process is essential, as they are the ones who can bring about the necessary changes on the ground. Local actors can play a variety of roles in promoting the circular bioeconomy and contributing to its success.

First, local actors can provide valuable insights into the needs and preferences of their communities. They are often well-informed about local resources and potential opportunities for bioeconomy development. This knowledge can be used to identify suitable locations for circular bioeconomy projects and to develop strategies for their implementation. Local actors also have a better understanding of the social, economic, and environmental context in which these projects will take place, which is essential for successful deployment. (Egea González and Torrente, 2022)

Second, local actors can be instrumental in mobilizing support for circular bioeconomy projects from other stakeholders such as governments, businesses, and civil society organizations. They can help create awareness about the benefits of circular bioeconomy and build consensus among different stakeholders on how best to deploy it. Local actors may also be able to provide access to financing or other resources needed for project implementation.

Third, local actors can act as facilitators between different stakeholders involved in circular bioeconomy projects. They can help ensure that all parties are working towards a common goal and that any conflicts or disagreements are addressed quickly and effectively. This is especially important when it comes to projects involving multiple stakeholders with different interests or objectives (Calvert et al., 2017).

A bioeconomy is an economy where renewable biological resources are used to produce food, energy, and industrial goods. Local actors are non-state actors that operate at a sub-national level, such as communities, families, or individuals (Lemard-Marlow and Wilt, 2019).

Local actors can play a role in improving the circular bioeconomy by reducing waste, promoting sustainability, and creating value from biological resources and serve as ambassadors for circular bioeconomy initiatives by promoting them within their communities and encouraging others to get involved (Wiebke et al.,

2019). This could include activities such as organizing public events or providing information about available resources or opportunities related to circular bioeconomy development.

The Sustainable Consumption and Production Strategy aims to foster sustainable communities and cities in Egypt by encouraging sustainable consumption and production. It prioritizes sectors such as energy, water, solid waste, and agriculture. Furthermore, the new waste law, which was adopted by Egypt's parliament in 2020, aims to directly address the activities of the circular bioeconomy, as well as to regulate and promote waste management-related operations and to encourage waste management investments.

The circular bioeconomy is an emerging sector of the global economy that is based on the sustainable use of renewable biological resources. It is a rapidly growing field that has the potential to revolutionize the way we produce and consume goods and services. As such, it is essential for countries to ensure that they are adequately prepared to take advantage of this new economic opportunity (Kumar & Kumar, 2020). Technology readiness is essential for any country looking to capitalize on the opportunities presented by the circular bioeconomy. This includes having access to advanced technologies such as biotechnology, nanotechnology, and artificial intelligence (AI). These technologies can be used to develop new products and services, improve existing ones, or create entirely new markets. Additionally, they can help countries reduce their reliance on non-renewable resources and increase their efficiency in producing goods and services (Kumar & Sharma, 2020).

In order to ensure that a country is ready for the circular bioeconomy, it must have access to these advanced technologies as well as a skilled workforce capable of utilizing them effectively. This means investing in research and development (R&D) in order to stay ahead of the curve when it comes to technological advancements. Additionally, countries should focus on creating an environment conducive to innovation by providing incentives for businesses looking to invest in R&D or create new products or services related to the circular bioeconomy.

Countries should also look into developing public-private partnerships (PPPs) in order to facilitate collaboration between government agencies, private companies, universities, and other stakeholders in order to maximize the potential of their circular bioeconomy initiatives. PPPs can help ensure that all parties involved have access to necessary resources while also allowing them to share knowledge and expertise with one another (Kumar & Sharma, 2020).

6. Future opportunities and challenges

Circular bioeconomy is an emerging field that focuses on the sustainable use of biological resources to create economic value. It is a rapidly growing sector, driven by advances in technology, policy changes, and consumer demand for sustainable products. In recent years, there has been a surge in interest in bioeconomy as a way to create economic growth while preserving the environment.

One of the most significant trends in circular bioeconomy is the shift towards using renewable resources such as plant-based materials and bioplastics instead of traditional petroleum-based materials. This shift has been driven by consumer demand for more sustainable products and by government policies that incentivize the use of renewable resources. Companies are increasingly investing in research and development to develop new bioproducts and bioprocesses that can replace traditional petroleum-based materials.

Another trend in circular bioeconomy is the increasing use of digital technologies to improve efficiency and reduce costs. Digital technologies such as artificial intelligence (AI) and machine learning (ML) are being used to optimize production processes, reduce waste, and improve product quality. Additionally, digital technologies are being used to track raw materials from source to end product, allowing companies to better manage their supply chains and ensure sustainability throughout their operations.

There has been an increase in public-private partnerships (PPPs) between governments, businesses, universities, and other stakeholders to promote research and development into circular bioeconomy solutions. These PPPs have enabled companies to access funding for research projects that would otherwise be difficult or impossible to finance on their own. Additionally, these PPPs have enabled governments to provide incentives for companies that invest in circular bioeconomy solutions such as tax credits or grants.

Generally, there has been a significant increase in interest in circular bioeconomy over the past few years due to advances in technology, policy changes, consumer demand for sustainable products, and increased public-private partnerships. As this trend continues into the future it is likely that more companies will invest in developing new bioproducts and bioprocesses while governments continue to provide incentives for those who invest in circular bioeconomy solutions.

The global bioeconomy market is expected to grow at a compound annual growth rate (CAGR) of 8.2% from 2020 to 2027, reaching \$1.7 trillion by 2027. This growth is driven by increasing demand for renewable energy sources, such as biomass and biogas, as well as advances in biotechnology that are allowing for more efficient production processes. Additionally, the increasing focus on sustainability has led to increased investment in bio-based products and services (IEA, 2021).

One of the most significant trends in the circular bioeconomy is the rise of bioplastics. Bioplastics are plastics that are either made from renewable resources ('bio-based'), are biodegradable, are made through biological processes or a combination of these. Bioplastics are made from renewable resources such as corn starch or sugar cane instead of petroleum-based plastics. They are becoming increasingly popular due to their lower environmental impact compared to traditional plastics and their ability to be recycled or composted (Renee Cho, 2017). In addition, bioplastics have a wide range of applications including packaging materials, medical devices, automotive parts, and consumer products. Some examples of bioplastics are polylactic acid (PLA), polyhydroxyalkanoates (PHA), starch-based plastics, cellulose-based plastics, and bio-polyethylene (bio-PE). Bioplastics have some advantages over conventional plastics such as reducing greenhouse gas emissions, saving fossil resources, enhancing composting and recycling options, and improving biocompatibility. However, they also face some challenges such as higher production costs, lower performance and durability, limited availability and scalability, and potential competition with food crops (Rosenboom, et al., 2022).

Another trend in the circular bioeconomy is the development of new technologies for producing renewable energy sources such as biomass and biogas. These technologies are becoming increasingly efficient and cost-effective which makes them attractive alternatives to traditional fossil fuels. Biomass is organic matter that can be converted into energy through various processes such as combustion, gasification, pyrolysis, fermentation, etc. Biogas is a mixture of gases (mainly methane and carbon dioxide) that is produced by anaerobic digestion of organic waste such as manure, sewage, food waste, etc. These technologies are becoming increasingly efficient and cost-effective because they can use various types of biomass feedstock (including waste), reduce greenhouse gas emissions, enhance energy security and diversity, create jobs and income for rural areas, and support circular bioeconomy principles. However, they also face some challenges such as technical barriers, environmental impacts, social acceptance, policy support, market development, etc. (Antar et al., 2021; Qureshi et al., 2022; Adil, et al., 2022).

Additionally, advances in genetic engineering are a powerful tool that can enhance the performance and diversity of biological resources. It can also enable the development of new products that are not possible with conventional methods and are allowing for more production for efficient processes that reduce waste while still providing high-quality products. Genetic engineering can modify living organisms for various purposes, such as producing biofuels, or creating new materials and can play a key role in developing non-food applications of

biological resources, such as nanocellulose from wood, but it is also controversial due to ethical and regulatory issues (Maximilian et al., 2021). Finally, there has been an increase in investment in bio-based products and services due to their potential for reducing environmental impacts while still providing economic benefits.

Companies are investing heavily in research and development related to bio-based products such as biodegradable packaging materials or plant-based meat substitutes. This trend is expected to continue as companies look for ways to reduce their environmental footprint while still meeting customer demands. Circular bioeconomy is a rapidly growing field that has the potential to revolutionize the way we produce and use resources. It is an economic system based on the sustainable use of biological resources, such as plants, animals, and microorganisms, to create goods and services. The circular bioeconomy has been gaining traction in recent years due to its potential to reduce environmental impacts while providing economic benefits.

The circular bioeconomy is an emerging sector of the global economy that is focused on the sustainable production and use of renewable biological resources. There is an increase in investment in bio-based products and services due to their potential for reducing environmental impacts while still providing economic benefits. Bio-based products can help tackle issues such as climate change, dependence on fossil fuels, employment and rural development. The circular bioeconomy is a rapidly growing sector has the potential to create new jobs, reduce environmental impacts, and provide economic opportunities for communities around the world. (Contreras, 2023).

One of the most promising opportunities for circular bioeconomy is the development of new products and services that are more sustainable than traditional methods. For example, bioplastics are made from renewable sources such as corn starch or sugar cane, rather than petroleum-based plastics. These bioplastics can be used in a variety of applications, from packaging to medical devices. Additionally, biofuels are being developed from plant-based sources such as algae or switchgrass, which can be used as an alternative to gasoline or diesel fuel. These new products have the potential to reduce our dependence on fossil fuels and create more sustainable energy sources.

Another opportunity for circular bioeconomy is the development of new technologies that can improve efficiency and reduce waste. For example, advances in genetic engineering have enabled scientists to create crops with higher yields and improved nutritional value. Additionally, biorefineries are being developed that can convert biomass into valuable products such as fuels or chemicals. These technologies have the potential to reduce our reliance on finite resources while creating economic opportunities for farmers and other stakeholders in the circular bioeconomy.

Despite these opportunities, there are also some challenges associated with circular bioeconomy that must be addressed for it to reach its full potential. One challenge is ensuring that new technologies are developed responsibly so that they do not cause unintended environmental or social harms. Additionally, there is a need for better regulations around intellectual property rights so that companies can protect their investments in research and development without stifling innovation or competition. Finally, there must be adequate funding available for research into new technologies so that they can reach commercialization faster and at a lower cost.

Social measures must be implemented to make sure that the poor are not burdened for Egypt to successfully transition to a circular bioeconomy. So that workers employed in areas affected by the shift towards circularity do not become unemployed, new job possibilities as well as potentially training would be required.

7. Direction for future Circular bioeconomy research in Egypt

Circular bioeconomy is an emerging field of research that focuses on the sustainable use of biological resources to create economic value. It has become increasingly important in recent years as the world faces a growing demand for food, energy, and other resources. As such, there is a need for further research into the potential of circular bioeconomy to provide solutions to global challenges. This article will discuss some of the key areas of future research in circular bioeconomy and how they can be used to address current and future issues.

One area of future research in circular bioeconomy is the development of new technologies and processes that can be used to increase efficiency and reduce waste. This includes technologies such as bioprocessing, which uses biological materials such as enzymes or microorganisms to produce products or services. Other technologies include biorefining, which uses biomass as a feedstock for producing fuels, chemicals, and other materials; bioplastics, which are made from renewable sources; and bioremediation, which uses microorganisms or plants to clean up contaminated sites. Research into these technologies can help reduce environmental impacts while providing economic benefits.

Another area of future research in circular bioeconomy is the development of new business models that can be used to increase sustainability while creating economic value. This includes models such as circular economy, which focuses on reducing waste by reusing materials; collaborative economy, which encourages collaboration between businesses; and sharing economy, which enables people to share resources with each other. Research into these models can help create more efficient production systems while reducing environmental impacts.

A third area of future research in circular bioeconomy is the development of policies that promote sustainable use of biological resources while creating economic value which is a complex and challenging task. It requires balancing the intrinsic value of biodiversity, as well as the ecological, genetic, social, economic, scientific, educational, cultural, recreational and aesthetic values of biological diversity and its components, with the human rights and economic development of peoples and nations (United Nations, 2022, December).

This includes policies such as carbon pricing schemes that incentivize businesses to reduce their emissions; subsidies for renewable energy sources; and regulations that promote sustainable land management practices. Research into these policies can help ensure that biological resources are used responsibly while providing economic benefits for businesses and communities alike. (Bansard & Schröder, 2021, April 15).

A circular bioeconomy is expected to help the Egyptian economy improve. A 1.0% increase in GDP (estimated at €5.2 billion) compared to normal is expected, strongly driven by the increase in investments; In addition to improving the current balance by reducing imports by 685 million euros and increasing exports by 212 million euros, it is also expected to reduce food losses. Also, more than 100,000 additional jobs will be created, which is equivalent to an increase of 0.3%. The increases in employment are concentrated in the agriculture and services sector, largely driven by waste management, construction, and communications, along with distribution, retail, and manufacturing (Ashour, Sally, 2021).

Finally, research into public engagement strategies is needed to ensure that circular bioeconomy initiatives are successful in achieving their goals. It is an emerging and important field of study, and it includes strategies such as public education campaigns about the importance of sustainability; community-based initiatives that involve local stakeholders; and incentives for businesses to adopt sustainable practices. Research into these strategies can help ensure that circular bioeconomy initiatives are successful in achieving their goals while also engaging citizens in meaningful dialogue about sustainability issues. Some of the public engagement strategies that have been proposed or implemented by researchers and practitioners include Supporting bio-based research and

development, innovation, and competitiveness through various mechanisms such as subsidies, tax incentives, regulations, standards, labels, etc. (Brandão et al., 2021).

Implementing awareness-raising campaigns to increase societal participation in bio-based transformation, including more responsible and sustainable consumption. Measuring the degree of circularity of the bioeconomy as well as its contribution to the Sustainable Development Goals using a set of indicators. Studying the transition towards a circular bioeconomy using a systematic literature review on transition studies and existing barriers (Maximilian et al., 2021).

Conclusion

Circular bioeconomy is an emerging field that focuses on the sustainable use of biological resources to create economic value. It is a rapidly growing sector, driven by advances in technology, policy changes, and consumer demand for sustainable products. Egypt is a country that has been actively investing in the development of its circular bioeconomy and the economic pillar of the Egypt 2030 encourages Circular Economy activities in the industrial sector by promoting the idea of a 'green economy'. This work is providing a novel insights about the current situation of circular bioeconomy and its future in Egypt. Egypt has implemented several national initiatives to support the growth of this sector, which is expected to play an important role in the country's economic development. The strategy focuses on four main areas: research and development, technology transfer, market access, and policy implementation. Because of the rising need for renewable energy sources and advancements in biotechnology, the worldwide circular bioeconomy market is anticipated to keep expanding. Due to their potential to have less of an adverse effect on the environment while yet having positive economic effects, investments in bio-based goods and services are anticipated to rise in Egypt. The role of local actors in this process is essential, as they are the ones who can bring about the necessary changes on the ground and can play a variety of roles in promoting the circular bioeconomy and contributing to its success. Circular bioeconomy research in Egypt is expected to help the Egyptian economy improve. Research into public engagement strategies is needed to ensure that circular bioeconomy initiatives are successful in achieving their goals. Public-private partnerships should be created to encourage cooperation between stakeholders as local actors play a crucial role in the deployment of these programmes. To achieve long-term success, the Egyptian government should concentrate on funding R&D and informing customers about the advantages of adopting goods made from biological resources. To ensure that circular bioeconomy efforts achieve their objectives while generating financial value for all stakeholders, research is required.

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