POTENTIAL ECONOMY-WIDE EFFECTS OF TECHNOLOGICAL MODERNIZATION AND TRADE-COST REFORMS ON EGYPT'S HORTICULTURAL COMPETITIVENESS: A RECURSIVE DYNAMIC COMPUTABLE GENERAL EQUILIBRIUM ANALYSIS

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Abstract. Egypt's horticultural sector has strong export potential, but productivity constraints and high trade and logistics costs limit competitiveness. This study evaluates the potential economy-wide effects of a coordinated policy package combining technological modernization with trade-cost and market-access reforms. A recursive dynamic computable general equilibrium (CGE) model calibrated to Egypt's 2019 Social Accounting Matrix is simulated over 2026–2035. The scenario applies 1% annual total factor productivity growth, gradual tariff and non-tariff barrier reductions, a 20% export-margin reduction, and a 50% increase in export-demand elasticity. By 2035, real GDP is 0.23% above baseline, while fruit and vegetable exports increase by 18.50% and 19.50%, respectively. Household income and investment also increase, although the Consumer Price Index rises by 0.77%. Effects are heterogeneous, with particularly large responses in the 'other crops' category. The results indicate potential gains from coordinated reforms under the specified assumptions. However, the simulations are counterfactual, do not identify the separate contribution of individual policy components, and have not been subjected to formal sensitivity analysis. The reported magnitudes should therefore be interpreted as conditional on the adopted parameter values and modeling assumptions.

Keywords: Horticultural competitiveness; Technological modernization; Trade costs; Trade facilitation; Dynamic CGE; Egypt.

JEL Classification: Q17; C68; F13; O33; Q18.

ПОТЕНЦИАЛЬНЫЕ ОБЩЕЭКОНОМИЧЕСКИЕ ЭФФЕКТЫ ТЕХНОЛОГИЧЕСКОЙ МОДЕРНИЗАЦИИ И РЕФОРМ ПО СНИЖЕНИЮ ТОРГОВЫХ ИЗДЕРЖЕК ДЛЯ КОНКУРЕНТОСПОСОБНОСТИ ПЛОДООВОЩНОГО СЕКТОРА ЕГИПТА: РЕКУРСИВНЫЙ ДИНАМИЧЕСКИЙ АНАЛИЗ ВЫЧИСЛИМОГО ОБЩЕГО РАВНОВЕСИЯ

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Аннотация. Плодоовощной сектор Египта обладает значительным экспортным потенциалом, однако ограничения производительности, а также высокие торговые и логистические издержки снижают его конкурентоспособность. Целью настоящего исследования является оценка потенциальных общеэкономических эффектов скоординированного комплекса мер, сочетающего технологическую модернизацию с реформами, направленными на снижение торговых издержек и расширение доступа к рынкам. Для анализа используется рекурсивная динамическая модель вычислимого общего равновесия (CGE), откалиброванная на основе Матрицы социальных счетов Египта за 2019 год и применяемая для моделирования периода 2026–2035 гг. Рассматриваемый сценарий предусматривает ежегодный рост совокупной факторной производительности на 1%, постепенное снижение тарифных и нетарифных барьеров, сокращение экспортной маржи на 20%, а также увеличение эластичности экспортного спроса на 50%. Согласно результатам

моделирования, к 2035 году реальный ВВП превышает базовый уровень на 0,23%, тогда как экспорт фруктов и овощей увеличивается соответственно на 18,50% и 19,50%. Доходы домохозяйств и инвестиции также возрастают, при этом индекс потребительских цен превышает базовый уровень на 0,77%. Полученные эффекты неоднородны по секторам экономики, при этом особенно значительные изменения наблюдаются в категории «прочие сельскохозяйственные культуры». Результаты указывают на потенциальные положительные эффекты скоординированных реформ при заданных предпосылках модели. Вместе с тем проведённые расчёты имеют контрфактический характер, не позволяют определить отдельный вклад каждого компонента рассматриваемого комплекса мер и не сопровождались формальным анализом чувствительности. Поэтому количественные результаты следует интерпретировать как условные оценки, зависящие от принятых значений параметров и предпосылок модели.

Ключевые слова: конкурентоспособность плодоовощного сектора; технологическая модернизация; торговые издержки; упрощение процедур торговли; динамическая модель CGE; Египет.

Классификация JEL: Q17; C68; F13; O33; Q18.

1. Introduction

The horticultural sector has become an increasingly important contributor to agricultural transformation, export diversification, and rural economic development in developing countries. Income growth, urbanization, changes in consumer behavior, and rising international demand for high-quality agricultural products have contributed to the rapid expansion of global horticultural trade over the past two decades (Food and Agriculture Organization [FAO], 2023; World Bank, 2020). Horticulture contributes not only to food security and nutrition but also to employment generation, value addition, and the integration of agricultural producers into national and international value chains (FAO & European Bank for Reconstruction and Development [EBRD], 2023; Reardon et al., 2019). However, competitiveness in international markets requires more than simply increasing production. Continued improvements are needed in productivity, product quality, logistics, compliance with sanitary and phytosanitary (SPS) standards, and trade and marketing efficiency (Anderson & van Wincoop, 2004; WTO, 2015).

Egypt provides an important case for examining these issues. The country is one of the major suppliers of horticultural products in the Middle East and North Africa, with fruits and vegetables accounting for a substantial share of agricultural exports. The horticultural sector contributes to export earnings, rural employment, agro-industrial development, and foreign-exchange generation. It also has strong backward and forward linkages with input suppliers, food-processing industries, transport, wholesale and retail trade, and financial services. As a result,

improvements in horticultural competitiveness can generate effects that extend beyond the sector itself and influence the wider economy.

Although Egypt possesses several competitive advantages in horticultural production, the sector continues to face structural constraints that limit its international competitiveness. These include the slow adoption of modern technologies, inadequate post-harvest handling, fragmented value chains, insufficient cold-storage capacity, high logistics costs, and trade-related barriers. Small-scale farmers are particularly constrained by limited access to technology, certification, finance, extension services, and export markets. These constraints can reduce productivity and increase the costs of production and market participation (FAO, 2023).

In recent years, the Egyptian government has introduced a number of reforms aimed at improving trade efficiency and reducing transaction costs. These measures include the National Single Window for Foreign Trade Facilitation (NAFEZA), the Advance Cargo Information (ACI) system, and investments in ports, logistics zones, dry ports, and transport infrastructure. Such reforms are particularly relevant to horticultural products because of their perishability and the importance of timely and efficient transportation.

From an economic perspective, technological modernization and trade-related reforms influence competitiveness through distinct but potentially reinforcing transmission channels. Technological modernization can raise total factor productivity, improve the efficiency of resource use, reduce unit production costs, and enhance product quality and productive capacity. Trade-related reforms can reduce tariff and non-tariff barriers, while trade facilitation can lower administrative, border, and logistics costs, improve market access, and strengthen export incentives (Anderson & van Wincoop, 2004; WTO, 2015). Examining these policy dimensions within a common analytical framework is therefore important for understanding their combined economy-wide effects.

Previous studies have examined determinants of horticultural exports, comparative advantage, market performance, and trade facilitation, but these strands of research have largely developed separately. Commodity-level studies provide valuable insights into export competitiveness but are generally unable to capture resource reallocation across sectors, income distribution, investment responses, and macroeconomic feedbacks. CGE models, by contrast, can evaluate broader economy-wide effects, but relatively limited attention has been given to integrated policy packages combining technological upgrading with trade-cost reductions in the horticultural sector. Consequently, evidence on the economy-wide implications of implementing these measures jointly remains limited.

This study addresses this gap by employing a recursive dynamic CGE model calibrated to Egypt's 2019 Social Accounting Matrix (SAM). The analysis evaluates a single integrated policy

package comprising four components: annual total factor productivity growth, gradual reductions in tariff and non-tariff barriers, lower export margins, and increased export-demand responsiveness. Unlike studies that examine individual policy measures in isolation, the present analysis focuses on the combined effects of these interventions within one counterfactual scenario. The paper makes three main contributions. First, it integrates productivity-enhancing technological modernization and trade-cost reductions within a recursive dynamic CGE framework. Second, it incorporates dynamic investment and capital accumulation, allowing the analysis to extend beyond short-run equilibrium effects. Third, it provides quantitative estimates of the potential effects of the integrated policy package on horticultural activities and the broader Egyptian economy.

The remainder of the paper is organized as follows. Section 2 reviews the relevant literature and presents the conceptual framework. Section 3 describes the methodology, model specification, data sources, and simulation scenario. Section 4 presents and discusses the simulation results and their economic implications. Section 5 concludes the study and outlines the main policy implications for strengthening Egypt's horticultural competitiveness.

2. Literature Review and Conceptual Framework

2.1. Literature Review

Agricultural competitiveness has received increasing attention because of its contribution to economic development, export diversification, rural employment, and food security. In emerging economies, improving competitiveness generally requires simultaneous efforts to enhance production efficiency and reduce barriers to market access. Accordingly, recent literature has focused particularly on two broad policy areas: technological modernization and trade-related reforms.

2.1.1. Technological Modernization and Agricultural Competitiveness

Technological advancement is widely recognized as an important driver of productivity and competitiveness in agriculture. Investments in improved seed varieties, mechanization, precision agriculture, digital technologies, irrigation systems, and post-harvest technologies can increase total factor productivity, reduce production costs, improve product quality, and help producers comply with international standards (Fuglie, 2018; FAO, 2023). These improvements are particularly important for horticultural products because of their quality requirements, perishability, and sensitivity to post-harvest management.

Empirical evidence suggests that technological innovation can contribute to higher agricultural productivity and improved market performance. Fuglie (2018) identifies productivity growth as an increasingly important source of agricultural output growth worldwide. Reardon et al. (2019) similarly emphasize that modernization of agri-food value chains can improve producers' participation in domestic and international markets through better logistics, quality

management, and supply-chain coordination. However, technological improvements alone may not necessarily translate into stronger export performance when producers continue to face high transportation costs, inefficient customs procedures, and other barriers to market access.

2.1.2. Trade Facilitation and Export Performance

Trade facilitation has become an important policy instrument for improving agricultural competitiveness. Costs and delays associated with international trade can be reduced through more efficient customs administration, streamlined border procedures, improved transport infrastructure, electronic documentation, and advanced logistics services (Anderson & van Wincoop, 2004; WTO, 2015).

Previous research generally indicates that lower trade costs can support export growth and improve the allocation of resources. The implementation of the WTO Trade Facilitation Agreement has further highlighted the importance of institutional and procedural reforms in supporting international trade. Such improvements are particularly important for perishable agricultural products, for which timely delivery, preservation of product quality, and efficient logistics are critical determinants of competitiveness. In the case of horticultural exports, improved logistics and border procedures can reduce spoilage losses, shorten delivery times, and strengthen access to international markets.

2.1.3. Economy-Wide Policy Evaluation Using CGE Models

Partial equilibrium analysis is useful for examining individual commodity markets but generally does not capture interactions among production sectors, factor markets, institutions, and international trade. Computable General Equilibrium (CGE) models address this limitation by representing the interrelationships among households, firms, government, production activities, factor markets, and the external sector (Dervis, de Melo, & Robinson, 1982; Lofgren, Harris, & Robinson, 2002).

Recursive dynamic CGE models extend this analytical framework by incorporating investment, capital accumulation, population growth, and changes in productivity over time. Such models have been applied to the analysis of agricultural policies, trade reforms, climate-change adaptation, and structural transformation because they can capture both sector-specific effects and broader economy-wide adjustments (Burfisher, 2017).

Despite the growing number of CGE applications, relatively few studies have examined technological modernization and trade-cost reductions simultaneously in the context of horticulture. Much of the existing literature evaluates productivity improvements and trade-related reforms separately, providing limited information on the economy-wide effects of implementing these measures as part of a single policy package.

2.1.4. Research Gap

The existing literature provides substantial evidence on the importance of technological modernization, productivity growth, and improved market access for agricultural competitiveness. Nevertheless, several gaps remain.

First, many empirical studies examine individual policy instruments separately and therefore provide limited information on the economy-wide effects of implementing them jointly. Second, commodity-level studies often focus on the export competitiveness of particular products without explicitly accounting for intersectoral resource reallocation, income distribution, investment responses, and macroeconomic feedbacks. Third, relatively limited attention has been given to the economy-wide implications of integrated horticultural competitiveness policies in Egypt, despite the importance of horticultural exports to the country's agricultural development strategy.

This study addresses these gaps by employing a recursive dynamic CGE model calibrated to Egypt's 2019 Social Accounting Matrix (SAM) to evaluate an integrated policy package combining technological modernization and trade-related reforms. Unlike studies that analyze individual interventions separately, the present study examines both the direct sectoral responses and the indirect economy-wide adjustments generated by the combined policy scenario.

2.2. Conceptual Framework

The conceptual framework is based on the premise that horticultural competitiveness depends on both production efficiency and access to markets. Technological modernization can improve competitiveness by increasing total factor productivity, reducing unit production costs, improving product quality, and expanding productive capacity. At the same time, reductions in trade-related barriers and export costs can improve market access, reduce transaction costs, and strengthen incentives for export-oriented production.

The combined policy package affects producer behavior through changes in productivity, relative prices, production costs, and expected returns. These changes can influence output, exports, demand for production factors, household and business income, savings, and investment. Higher income may increase domestic demand, while higher savings and investment contribute to capital accumulation and future productive capacity.

Within the recursive dynamic CGE framework, these effects are transmitted through interconnected commodity, factor, institutional, and international markets. Productivity improvements reduce the amount of resources required to produce a given level of output and can strengthen sectoral competitiveness. Reductions in trade-related costs improve access to foreign markets and may encourage the reallocation of resources toward more competitive activities. Over time, investment and capital accumulation transmit these effects across successive periods,

potentially influencing gross domestic product, employment, household income, investment, and export performance.

Because the empirical analysis evaluates only one integrated policy package, the study does not separately identify the causal contribution of technological modernization, trade-cost reductions, export-margin reductions, or increased export-demand responsiveness. The central research question is therefore:

What are the potential sectoral and economy-wide effects of implementing the proposed integrated policy package in Egypt over the period 2026–2035?

The conceptual framework therefore provides the theoretical basis for the recursive dynamic CGE model and clarifies the principal transmission mechanisms through which the integrated policy scenario may affect horticultural competitiveness and the wider Egyptian economy.

3. Materials and Methods

The study employs a recursive dynamic computable general equilibrium (CGE) model calibrated to Egypt's 2019 Social Accounting Matrix (SAM) to examine the potential sectoral and economy-wide effects of an integrated policy package combining technological modernization and trade-related reforms. The CGE framework represents the interactions among production activities, factors of production, households, firms, government, investment, international trade, and the rest of the world. The sectoral disaggregation includes horticultural activities such as vegetables, fruits, and other crops, as well as input industries, food-processing activities, transport, wholesale and retail trade, business services, and other sectors of the economy.

The 2019 Social Accounting Matrix (SAM) serves as the benchmark equilibrium for calibrating the recursive dynamic CGE model. The baseline is constructed in two stages. First, the 2019 SAM is mapped to the model accounts and used to calibrate the benchmark equilibrium. Parameters identified from the SAM are calibrated so that the model reproduces the 2019 benchmark, while parameters that cannot be identified directly from the SAM are assigned on the basis of empirical evidence and explicit modeling assumptions.

Second, the calibrated 2019 economy is projected recursively from 2020 through 2026 without introducing the policy shocks associated with the integrated horticultural competitiveness package. In each annual solution, population and labor supply evolve exogenously, while capital stocks are updated according to investment undertaken in the preceding period and the assumed depreciation rate. Other exogenous variables and policy parameters follow their prescribed baseline paths. The equilibrium solution for each year determines the relevant state variables carried forward into the subsequent period.

Accordingly, the 2026 baseline is not obtained by directly applying a single growth adjustment to the 2019 SAM. Instead, it represents the cumulative outcome of sequential annual equilibrium solutions for 2020–2026. No additional 1% annual TFP shock, tariff or non-tariff barrier reduction, export-margin reduction, or increase in export-demand elasticity is introduced during this baseline projection.

From 2026 onward, the policy scenario is simulated using the same recursive dynamic structure and is compared with the corresponding baseline equilibrium for each year through 2035. The same behavioral equations, macroeconomic closure rules, and structural parameters are maintained in both the baseline and policy simulations. Consequently, all reported results represent percentage deviations of the policy scenario from the corresponding baseline rather than unconditional forecasts of Egypt's future economic performance.

3.1. Production Structure

Production in each sector is represented using a nested Constant Elasticity of Substitution (CES) structure. At the upper level, total sectoral output is determined by a combination of value added and intermediate inputs. Value added is further decomposed into labor and capital through a CES function, allowing producers to substitute between production factors in response to changes in their relative costs.

The upper-level production function is specified as follows:

$$X_i = A_i \left[\delta_i \, VA_i^{\rho_i} + (1 - \delta_i) \, INT_i^{\rho_i}\right]^{(1/\rho_i)} \quad (1)$$

where X_i is the total output of industry i; A_i is the productivity parameter; δ_i is the distribution parameter related to value added; VA_i is the value added; INT_i is the sum of intermediate inputs; and ρ_i is the substitution parameter between value added and intermediate inputs.

Value added is generated from labor and capital, which are also combined using a CES specification. Technological progress is introduced through changes in the productivity parameter $\mathbf{A_i}$. An increase in total factor productivity enables producers to generate a greater level of output from a given quantity of inputs and may reduce unit production costs.

The nested production structure allows the model to capture both the direct effects of productivity changes on sectoral output and the indirect effects arising from changes in the demand for labor, capital, and intermediate inputs. The corresponding substitution elasticities are treated as exogenous calibration parameters. Their values are informed by previous CGE applications to Egypt and by the broader CGE parameterization literature, rather than being directly identified from the 2019 SAM.

3.2. International Trade Structure

International trade is modeled according to the Armington assumption, under which domestically produced and imported goods are treated as imperfect substitutes (Armington, 1969). Accordingly, the composite commodity is represented as a CES aggregation of domestically supplied and imported goods:

$$Q_i = [\alpha_i D_i^{\rho_i} + (1 - \alpha_i) M_i^{\rho_i}]^{(1/\rho_i)} \quad (2)$$

where Q_i is the composite quantity; D_i is the quantity of domestically supplied goods; M_i is the quantity of imports; α_i is the CES share parameter; and ρ_i is the CES substitution parameter.

On the supply side, producers allocate total sectoral output between domestic and export markets using a Constant Elasticity of Transformation (CET) function:

$$X_i = [\beta_i E_i^{\theta_i} + (1 - \beta_i) D_i^{\theta_i}]^{(1/\theta_i)} \quad (3)$$

where X_i is total output of sector i; E_i is the quantity exported; D_i is the quantity supplied to the domestic market; β_i is the CET share parameter; and θ_i is the CET transformation parameter.

The Armington and CET specifications are particularly relevant to the present analysis because changes in trade-related costs and export margins alter relative prices and returns, thereby affecting import demand, export supply, and the allocation of domestic production between domestic and foreign markets.

3.3. Household Consumption

Household consumption is represented using a Linear Expenditure System (LES), which distinguishes between subsistence consumption and discretionary expenditure. Household demand for each commodity depends on total household income, commodity prices, minimum consumption requirements, and the marginal allocation of the remaining budget across commodities.

The household demand function is specified as follows:

$$C_i = \gamma_i + \mu_i [Y - \Sigma_j P_j \gamma_j] / P_i \quad (4)$$

where C_i denotes household consumption of commodity *i*; γ_i is the minimum or subsistence consumption requirement for commodity *i*; **Y** is total household income; P_i is the price of commodity *i*; P_j is the price of commodity *j*; and μ_i is the marginal budget share allocated to commodity *i* after subsistence consumption requirements have been satisfied.

The LES specification allows household consumption patterns to respond to changes in income and relative prices while maintaining minimum consumption requirements. In the present study, household income and consumption are interpreted as indicators of household economic conditions rather than as direct measures of welfare.

3.4. Macroeconomic Closure and Recursive Dynamic Adjustment

The macroeconomic closure specifies how the model balances trade flows, income, savings, and investment. The nominal exchange rate is used as the numeraire. The current account

balance is treated as exogenous and fixed, while government expenditure is also exogenous. Investment is savings-driven, so total investment adjusts to the level of available savings. Because macroeconomic closure rules determine how policy shocks are transmitted through the economy, alternative closure assumptions may produce different quantitative results.

The recursive dynamic component of the model operates through capital accumulation, population growth, and productivity growth. Capital available to each sector in period *t* depends on the capital stock inherited from the previous period, new investment, and depreciation. Conceptually, the capital accumulation equation is specified as follows:

$$\mathbf{K_{j,t} = (1 - \delta_j)K_{j,t-1} + \Sigma_k IND_{k,j,t}} \quad (5)$$

where $\mathbf{K_{j,t}}$ denotes the capital stock available to sector *j* in period *t*; $\mathbf{K_{j,t-1}}$ is the capital stock inherited from the previous period; $\mathbf{IND_{k,j,t}}$ represents new type-*k* capital investment allocated to sector *j* in period *t*; and $\mathbf{\delta_j}$ is the depreciation rate of capital in sector *j*.

Population grows exogenously at an annual rate of 1.5%. The recursive structure allows policy effects to accumulate over time because changes in income and savings influence investment, which in turn affects the future capital stock and productive capacity. Productivity improvements also influence sectoral production capacity throughout the simulation period.

The recursive simulation proceeds sequentially as follows. The model is first calibrated to the 2019 SAM and solved annually from 2020 through 2026 to construct the no-policy baseline. Beginning in 2026, the integrated policy scenario is simulated relative to this baseline. For each subsequent year, the model is solved for a new equilibrium, savings and investment are determined, the capital stock is updated, and the resulting state variables are carried forward to the next period. This recursive procedure continues through 2035.

3.5. Data and Parameterization

The benchmark economy is represented using Egypt's 2019 Social Accounting Matrix (SAM), prepared by the Central Agency for Public Mobilization and Statistics (CAPMAS) and the International Food Policy Research Institute (IFPRI). The SAM records transactions among production activities, commodities, factors of production, households, firms, government, investment, stock changes, and the rest of the world, and provides the benchmark structure used to calibrate the CGE model.

According to the 2019 SAM, total output amounts to EGP 8,472.86 billion, household consumption to EGP 4,019.16 billion, exports to EGP 948.38 billion, and imports to EGP 1,369.17 billion (Table 1). Import tariffs recorded in the SAM amount to approximately EGP 39.19 billion, while indirect taxes amount to EGP 104.71 billion. Table 2 presents selected sectors relevant to horticulture and related activities rather than the complete sectoral structure of the SAM.

The horticultural sectors identified in the SAM include vegetables, fruits, and other crops. In 2019, vegetable output amounted to EGP 101.34 billion, fruit output to EGP 94.34 billion, and output of other crops, including flowers, herbs, and spices, to EGP 3.11 billion. Fruit exports amounted to EGP 15.35 billion, vegetable exports to EGP 4.53 billion, and exports of other crops to EGP 1.61 billion, while imports of other crops amounted to EGP 12.74 billion (Table 2).

Additional parameters required for the model include production and trade elasticities, export-demand elasticity, household-demand parameters, population growth, the interest rate, and the capital depreciation rate. These parameters cannot be identified directly from the 2019 SAM and are therefore introduced as external calibration parameters. Where Egypt-specific evidence is available, the parameterization is anchored to previous CGE applications and empirical studies for Egypt; otherwise, values are selected as transparent modeling assumptions within ranges commonly used in the CGE literature. Table 3 reports both the values used and their calibration basis.

No formal sensitivity analysis is conducted in the present study. Consequently, the quantitative results should be interpreted as conditional on the adopted parameter values, behavioral elasticities, policy-shock magnitudes, and macroeconomic closure assumptions. In particular, the assumed 13% ad valorem equivalent of non-tariff barriers, the export-demand elasticity, the annual productivity-growth assumption, and the magnitude of the trade-cost reductions represent important sources of uncertainty. Alternative values for these parameters could generate different quantitative outcomes.

Table 1. Social Accounting Matrix for Egypt, 2019 (EGP billion)

		L	K	K	AG	AG	AG	AG	AG	AG	AG	J	J	J	I	I	I	X	X	X	OTH	OTH	OTH
		LAB	CAP	LAND	HH	FIRM	GVT	TD	TM	TI	ROW	AGR	IND	SER	AGR	IND	SER	AGR	IND	SER	INV	VSTK	TOT
L	LAB											201.88	183.07	1176.69									1561.64
K	CAP											312.44	1109.14	1772.68									3194.27
K	LAND											64.48											64.48
AG	HH	1561.64		64.48		2520.99	79.94				444.36												4671.41
AG	FIRM		2973.37				584.81				20.20												3578.38
AG	GVT		4.66		1.43	187.71		277.04	39.19	104.71	2.34							4.80	49.17	50.25			721.30
AG	TD				84.27	192.77																	277.04
AG	TM														0.88	38.31							39.19
AG	TI														6.06	49.99	48.65						104.71
AG	ROW		216.24		8.35	0.02	39.33								116.64	922.37	330.16						1633.10
J	AGR														771.47			30.78					802.25
J	IND															2801.62			389.12				3190.74
J	SER																4106.70			373.16			4479.87
I	AGR				580.25							100.45	312.02	9.34							20.80	6.27	1029.13
I	IND				1678.63							77.20	1359.07	780.85							351.14	16.34	4263.22
I	SER				1760.28		456.59					45.80	227.44	740.30	134.08	450.92		10.02	41.07		589.65	29.37	4485.52
X	AGR										45.61												45.61

X	**IND**										**479.36**												**479.36**
X	**SER**										**423.41**												**423.41**
OTH	**INV**				**558.20**	**676.90**	**-439.36**				**217.82**												**1013.56**
OTH	**VSTK**																				**51.98**		**51.98**
OTH	**TOT**	**1561.64**	**3194.27**	**64.48**	**4671.41**	**3578.38**	**721.30**	**277.04**	**39.19**	**104.71**	**1633.10**	**802.25**	**3190.74**	**4479.87**	**1029.13**	**4263.22**	**4485.52**	**45.61**	**479.36**	**423.41**	**1013.56**	**51.98**	

Notes: L = labor factor income; K = capital factor income; LAND = agricultural land income; HH = households; FIRM = firms; GVT = government; TD = direct taxes; TM = import tariffs; TI = indirect taxes; ROW = rest of the world; AGR = agriculture; IND = industry; SER = services; INV = investment (capital formation); VSTK = change in inventories; TOT (OTH) = total balancing/adjustment account.

Source: Central Agency for Public Mobilization and Statistics (CAPMAS) & International Food Policy Research Institute (IFPRI). (2021). *2019 Social Accounting Matrix for Egypt*. IFPRI. https://doi.org/10.7910/DVN/FSCI03

Table 2. Selected Sectoral Output, Household Consumption, Trade, Tariffs, and Non-Tariff Equivalents in Egypt, 2019 (EGP billion)

Sector	Output Value	Output Share (%)	Household Consumption Value	Household Consumption Share (%)	Exports Value	Exports Share (%)	Imports Value	Imports Share (%)	Import Tariff Value	Import Tariff Share (%)
Vegetables	101.34	1.20	80.25	2.00	4.53	0.48	0.06	0.00	—	—
Fruits	94.34	1.11	63.95	1.59	15.35	1.62	8.29	0.61	0.64	1.63
Other crops (flowers, herbs, and spices)	3.11	0.04	—	—	1.61	0.17	12.74	0.93	0.03	0.08
Fertilizers	59.35	0.70	—	—	18.90	1.99	2.80	0.20	—	—
Chemicals (pesticides and agrochemicals)	529.83	6.25	316.86	7.88	60.67	6.40	166.53	12.16	1.69	4.31
Machinery	79.22	0.93	0.10	0.00	1.24	0.13	80.62	5.89	2.94	7.50
Equipment	62.02	0.73	45.48	1.13	30.08	3.17	115.12	8.41	2.33	5.95
Water supply	55.55	0.66	35.65	0.89	—	—	—	—	—	—
Electricity	242.75	2.87	137.00	3.41	0.80	0.08	0.00	0.00	—	—
Transport services	486.08	5.74	322.13	8.01	140.99	14.87	154.20	11.26	—	—
Wholesale and retail trade	688.40	8.12	66.38	1.65	—	—	—	—	—	—
Fruit and vegetable processing	33.79	0.40	8.11	0.20	9.31	0.98	1.65	0.12	0.16	0.41
Animal feed manufacturing	16.77	0.20	—	—	0.21	0.02	1.69	0.12	0.02	0.05
Beverage industry	17.51	0.21	9.18	0.23	0.45	0.05	1.15	0.08	0.02	0.05
Textiles	73.89	0.87	20.30	0.51	24.98	2.63	50.36	3.68	5.08	12.96
Financial services	132.71	1.57	55.41	1.38	8.17	0.86	31.59	2.31	—	—
Business services	350.92	4.14	60.46	1.50	24.44	2.58	106.64	7.79	—	—
Hotels	184.34	2.18	—	—	173.99	18.35	13.97	1.02	—	—
Restaurants	217.70	2.57	217.45	5.41	—	—	—	—	—	—

Note: Monetary values are expressed in EGP billion. The table reports selected sectors relevant to horticulture and related economic activities rather than the complete sectoral structure of the 2019 Social Accounting Matrix. Percentage shares for output, household consumption, exports, imports, and import tariffs are calculated relative to the corresponding economy-wide aggregates. A dash (—) indicates that no value is reported for the corresponding sector and variable.

Source: Authors' calculations based on the 2019 Social Accounting Matrix for Egypt (CAPMAS & IFPRI, 2021). https://doi.org/10.7910/DVN/FSCI03

Non-tariff barriers are not directly reported in the 2019 SAM. For the policy simulations, NTBs affecting horticultural exports are represented by an ad valorem tariff-equivalent rate of 13% of export value. This rate is adopted as a simplifying modeling assumption based on Fugazza and Maur (2008), who report a regional non-tariff measure ad

valorem equivalent of approximately 13.3% for the Middle East and North Africa, drawing on estimates by Kee et al. (2006). Accordingly, the 13% rate used in the model should not be interpreted as a sector-specific empirical estimate of non-tariff barriers affecting Egyptian horticultural exports.

Table 3. Behavioral and Dynamic Parameters Used in the CGE Model and Their Calibration Basis

Parameter	Value	Source / Calibration Basis
CES elasticity for composite capital	1.20	Authors' calibration assumption informed by standard CGE parameterization practice (Annabi et al., 2006; Burfisher, 2017)
CES elasticity for value added	0.80	Calibration value consistent with Egypt-specific CGE applications; labour–capital substitution elasticities of 0.2–0.9 are reported by Eldeep and Zaki (2023)
CET elasticity for total output	1.50	Authors' calibration assumption informed by CGE parameterization literature (Annabi et al., 2006; Eldeep & Zaki, 2023)
Armington CES elasticity for the composite good	1.58	Calibration value within the 0.9–2.4 range reported for substitution between domestic and imported goods in an Egypt-specific CGE model (Eldeep & Zaki, 2023)
CET elasticity between exports and domestic sales	1.58	Calibration value within the 1.5–3.0 range reported for transformation between domestic and export supply in an Egypt-specific CGE model (Eldeep & Zaki, 2023)
Export-demand elasticity	2.00	Authors' benchmark calibration assumption used to represent foreign-demand responsiveness. The parameter is not estimated from the 2019 SAM and is treated as an exogenous behavioral elasticity in the simulations.
Frisch parameter for the Linear Expenditure System (LES)	−1.50	Authors' LES calibration assumption informed by CGE household-demand parameterization literature (Annabi et al., 2006)
Income elasticity of household consumption	0.89	Authors' calibration assumption informed by empirical household-demand studies for Egypt (Rady & Kandil, 2017)
Population growth rate	1.50%	Baseline demographic assumption consistent with recent population-growth rates reported for Egypt in World Development Indicators
Interest rate	12.00%	Rounded benchmark assumption; Eldeep and Zaki (2023) use a nominal interest rate of 11.8% based on Central Bank of Egypt data
Capital depreciation rate	3.00%	Authors' recursive-dynamic calibration assumption governing annual capital-stock depreciation

Note: Parameters that are not directly observed in the 2019 SAM are treated as exogenous calibration parameters. They are not interpreted as econometrically estimated coefficients for Egypt. Where possible, parameter values are informed by Egypt-specific CGE applications, empirical studies, and established CGE parameterization literature; otherwise, they are specified as explicit modeling assumptions.

Source: Authors' parameterization based on Annabi et al. (2006), Eldeep and Zaki (2023), Burfisher (2017), Rady and Kandil (2017), and the World Bank World Development Indicators.

The parameters reported in Table 3 govern the principal behavioral and dynamic relationships in the model. The CES elasticities determine substitution possibilities within the production and commodity-aggregation structures, while the CET elasticities govern the ability of producers to reallocate output between domestic and export markets. The export-demand elasticity represents the responsiveness of foreign demand to changes in export prices. Household consumption is modeled through the Linear Expenditure System (LES), in which the Frisch parameter and income elasticity affect the response of household demand to changes in income and relative prices. Population growth and capital depreciation enter the recursive dynamic structure and influence the evolution of demand, investment, capital accumulation, and productive capacity over time.

Because these behavioral and dynamic parameters are not jointly estimated from the 2019 SAM, the quantitative simulation results are conditional on the adopted parameterization. In particular, the magnitude of sectoral responses may depend on assumptions concerning substitution and transformation elasticities, export-demand responsiveness, productivity growth, trade-cost reductions, and other dynamic parameters. This consideration is especially relevant for sectors displaying relatively large percentage deviations from the baseline.

No formal sensitivity analysis is conducted in the present study. Accordingly, the stability of the quantitative results under alternative parameter values has not been systematically assessed. The reported results should therefore be interpreted as conditional counterfactual outcomes under the specified parameter values and modeling assumptions rather than as estimates that are invariant to alternative parameterizations. The implications of this limitation are discussed further in Section 4.8.

3.6. Integrated Policy Scenario

The study evaluates one integrated counterfactual policy scenario combining technological modernization and trade-related reforms over the period 2026–2035. The scenario consists of four components implemented simultaneously:

- **Productivity improvement:** Total factor productivity increases by 1% annually.

- **Tariff and non-tariff barrier reduction:** Tariff and non-tariff barrier equivalents are reduced by 10% per year relative to their level in the preceding period. The reduction is therefore applied gradually and multiplicatively throughout the simulation horizon.

- **Export-margin reduction:** Export margins are reduced by 20%, representing lower logistics and trade-related costs.

- **Improved export-market responsiveness:** Export-demand elasticities are increased by 50%, representing a hypothetical increase in the responsiveness of foreign demand to changes in export prices.

The four components are implemented simultaneously as a single integrated policy package. Consequently, the model identifies the equilibrium response to the package as a whole rather than the marginal contribution of any individual policy component.

The assumed policy magnitudes are treated as counterfactual simulation parameters rather than forecasts of actual policy implementation. In particular, the 50% increase in export-demand elasticity represents a behavioral-parameter experiment designed to capture stronger export-market responsiveness; it should not be interpreted as a direct trade-facilitation policy instrument.

All simulation results are reported as percentage deviations from the corresponding baseline values. They should therefore be interpreted as conditional counterfactual outcomes under the specified policy shocks, behavioral parameters, benchmark data, and macroeconomic closure assumptions rather than as unconditional forecasts of Egypt's future economic performance.

Because all policy components are implemented jointly, the simulation cannot determine whether their combined effects are complementary, additive, or substitutive. A formal assessment of complementarity would require separate simulations of technological modernization alone, trade-cost reductions alone, and the combined policy package.

Table 4. Components and Assumptions of the Integrated Policy Scenario

Policy Component	Model Representation	Assumed Scenario Value	Interpretation
Technological modernization	Total factor productivity (TFP) growth	**+1% annually**	Represents a gradual improvement in production efficiency and technological performance
Tariff and non-tariff barrier reduction	Reduction in tariff rates and the assumed ad valorem equivalent of non-tariff barriers	**−10% annually from the remaining level; initial NTB equivalent = 13% of horticultural export value**	Tariffs are based on the benchmark trade structure, while NTBs affecting horticultural exports are represented by an assumed 13% ad valorem equivalent. Both are reduced gradually and multiplicatively over the simulation horizon
Export-margin reduction	Reduction in export-related transaction and logistics costs	**−20%**	Represents lower export-related transaction and logistics costs
Improved export-market responsiveness	Increase in export-demand elasticity	**+50%**	Represents a hypothetical increase in the responsiveness of foreign demand to changes in export prices

Note: The reported values are counterfactual policy-simulation assumptions rather than forecasts of actual policy implementation. The 1% TFP shock is applied annually. Tariff rates and the assumed non-tariff barrier equivalent are reduced by 10% annually relative to their remaining level in the preceding period. For horticultural exports, the initial non-tariff barrier equivalent is represented by an assumed ad valorem rate of 13% of export value. This rate is adopted as a simplifying modeling assumption based on Fugazza and Maur (2008), drawing on Kee et al. (2006), and should not be interpreted as a sector-specific empirical estimate for Egypt. The 20% export-margin reduction represents lower export-related transaction and logistics costs, while the 50% increase in export-demand elasticity is treated as a behavioral market-access assumption rather than as a direct trade-facilitation instrument. Because all four components are implemented simultaneously, the simulation identifies the effect of the integrated policy package as a whole and does not isolate the marginal contribution of each component.

Source: Authors' assumptions informed by the literature on productivity growth, trade costs, non-tariff measures, trade facilitation, and international demand responses (Solow, 1957; Anderson & van Wincoop, 2004; Fugazza & Maur, 2008; Kee et al., 2006; Hummels, 2007; WTO, 2012; UNCTAD, 2013).

4. Results and Discussion

4.1. Recent Developments in Egypt's Horticultural Sector

The empirical context demonstrates the growing importance of horticulture in Egypt. Total horticultural production increased from approximately 32.93 million tons in 2020/2021 to 41.50 million tons in 2023/2024 (Table 5). Vegetable production increased from 21.30 million tons to 27.80 million tons, while fruit production increased from 11.63 million tons to 13.70 million tons over the same period.

Per capita availability of vegetables increased from 74.0 kg per year in 2020/2021 to 94.7 kg in 2023/2024, while per capita availability of fruits increased from 58.7 kg to 69.0 kg over the same period.

Table 5 summarizes selected horticultural production and per-capita availability indicators reported by CAPMAS in its World Food Day statistical releases. The 2020/2021 figures are taken from the 2022 release, while the 2022/2023 and 2023/2024 figures are reported in the 2025 release.

Table 5. Selected Horticultural Production and Per Capita Availability Indicators in Egypt, 2020/2021, 2022/2023, and 2023/2024

Year	Vegetable Production (million tons)	Fruit Production (million tons)	Total Horticultural Production (million tons)	Vegetable Availability per Capita (kg/year)	Fruit Availability per Capita (kg/year)
2020/2021	21.30	11.63	32.93	74.0	58.7
2022/2023	24.90	13.79	38.69	84.9	69.3
2023/2024	27.80	13.70	41.50	94.7	69.0

Source: Authors' compilation based on Central Agency for Public Mobilization and Statistics (CAPMAS), World Food Day statistical releases, 2022 and 2025.

Egypt's agricultural export performance also improved substantially during this period. According to Egypt's State Information Service, citing the Ministry of Agriculture and Land Reclamation, fresh agricultural exports reached approximately 7.5 million tons in 2023, with a value of about USD 3.7 billion. Exports of processed agricultural products amounted to approximately USD 5.1 billion, bringing the combined value of fresh and processed agricultural exports to nearly USD 9 billion (State Information Service, 2024). Egypt's agricultural exports include a wide range of horticultural commodities, such as citrus fruits, strawberries, grapes, onions, mangoes, pomegranates, peppers, and guavas.

These developments underline the increasing importance of horticulture in Egypt's agricultural production and international trade and provide relevant context for assessing policy measures aimed at improving productive capacity and market competitiveness.

4.2. Macroeconomic Effects of the Integrated Policy Package

The simulation results indicate that the integrated policy scenario generates positive macroeconomic effects over the 2026–2035 period. GDP at market prices is 0.19% above baseline in 2026 and 1.01% above baseline in 2035, while real GDP is 0.08% and 0.23% above baseline in the corresponding years (Table 6).

Table 6. Macroeconomic Effects of the Integrated Policy Package under the Dynamic CGE Simulation for Egypt

Indicator	2026	2035	Average Deviation from Baseline
GDP at market prices	0.19	1.01	0.56
Real GDP at market prices	0.08	0.23	0.15
Total investment expenditure	0.24	0.89	0.54
Real gross fixed capital formation	0.12	0.28	0.20
Household income	0.18	1.07	0.59
Real household consumption	0.07	0.30	0.17
Business income	0.19	1.06	0.59
Government revenue	0.12	0.17	0.15
Government savings	−0.03	0.90	0.39

Indicator	2026	2035	Average Deviation from Baseline
Business savings	0.19	1.05	0.59
Household savings	0.18	1.07	0.59
Consumer Price Index (CPI)	0.11	0.77	0.42
Interest rate	0.02	0.43	0.20

Note: Average values represent the mean percentage deviation from the baseline over the 2026–2035 simulation period.

Source: Dynamic CGE model results.

The increasing magnitude of several effects over time reflects the recursive dynamic structure of the model. Initial changes in productivity, trade conditions, income, and savings influence investment and capital formation, which subsequently affect productive capacity in later periods.

Household income is 0.18% above baseline in 2026 and 1.07% above baseline in 2035, with an average deviation of 0.59% over the simulation period. Business income follows a similar pattern, increasing from 0.19% above baseline in 2026 to 1.06% in 2035. Real household consumption is 0.07% above baseline in 2026 and 0.30% above baseline in 2035.

Total investment expenditure increases from 0.24% above baseline in 2026 to 0.89% in 2035, while real gross fixed capital formation rises from 0.12% to 0.28%. Under the savings-driven investment closure, higher household and business savings contribute to greater investment and capital accumulation. By 2035, household savings are 1.07% above baseline and business savings are 1.05% above baseline.

Government revenue shows a more moderate response, reaching 0.17% above baseline in 2035. This result may reflect higher levels of economic activity and the associated expansion of the tax base. However, the fiscal outcome depends on the macroeconomic closure assumptions and should not be interpreted as evidence that trade-related reforms necessarily improve the fiscal balance.

The Consumer Price Index (CPI) is 0.11% above baseline in 2026 and 0.77% above baseline in 2035. Thus, the integrated policy scenario is associated with higher output, income, and investment, while the general price level also remains moderately above the baseline. The CPI result should therefore be interpreted as part of the overall general-equilibrium adjustment rather than as evidence that the policy package eliminates inflationary pressures.

4.3. Sectoral Effects and Horticultural Competitiveness

The sectoral results reveal substantial differences in the magnitude and direction of the simulated effects across economic activities. The strongest positive responses are concentrated in horticultural activities, particularly fruits, vegetables, and other crops (Table 7).

Vegetables

Vegetable output is 0.30% above baseline in 2026 and 1.24% above baseline in 2035, with an average deviation of 0.74% over the simulation period. Vegetable exports show a considerably stronger response, increasing from 4.04% above baseline in 2026 to 19.50% in 2035, with an average deviation of 11.57%.

The substantially larger response of exports relative to total output indicates a reallocation of vegetable production toward export markets under the integrated policy scenario. This result is consistent with the CET structure of the model, under which producers adjust the allocation of output between domestic and foreign markets in response to changes in relative returns.

Vegetable employment is 0.79% below baseline in 2026 but rises to 0.70% above baseline by 2035. The domestic price of vegetables moves from 0.28% below baseline in 2026 to 0.53% above baseline in 2035. Overall, the results indicate an expansion of vegetable output and exports over the simulation horizon, accompanied by relatively modest changes in domestic prices.

Fruits

Fruit output increases from 1.06% above baseline in 2026 to 3.31% in 2035, with an average deviation of 2.07%. Fruit exports increase more strongly, from 4.13% above baseline in 2026 to 18.50% in 2035, with an average deviation of 11.05%.

Employment in the fruit sector rises from 0.27% above baseline in 2026 to 3.74% in 2035, indicating higher labor demand as the sector expands under the integrated scenario. Household consumption of fruits is 0.52% above baseline in 2026 and 1.06% above baseline in 2035. The domestic price of fruits moves from 0.60% below baseline in 2026 to 0.19% above baseline in 2035.

Taken together, the simulated increases in output, exports, employment, and household consumption indicate that the fruit sector is among the main beneficiaries of the integrated policy scenario.

Other Crops

The largest simulated response occurs in the “other crops” category, which includes flowers, herbs, and spices. Output is 3.52% above baseline in 2026 and 40.44% above baseline in 2035, with an average deviation of 17.94%. Exports increase from 6.48% above baseline in 2026 to 72.23% in 2035, while employment rises to 62.19% above baseline by 2035.

These large percentage changes require particularly cautious interpretation. The other-crops sector is relatively small in the benchmark SAM, with an output value of only EGP 3.11 billion in 2019. Consequently, relatively modest absolute changes can translate into large percentage deviations from the baseline. In addition, the magnitude of the simulated response may

be particularly sensitive to the assumed export-demand elasticity, productivity growth, trade-cost reductions, and other behavioral parameters of the model.

Given the small benchmark size of the sector and the absence of formal sensitivity testing, the magnitude of the simulated response should be interpreted with particular caution. The results indicate the direction of the model response under the specified assumptions, but they should not be interpreted as robust point estimates or unconditional forecasts.

The results also do not imply that trade facilitation or technological modernization considered separately would generate an export increase of 72.23%. Because the policy components are implemented simultaneously, the model identifies only the response to the integrated package and does not isolate the contribution of individual measures. Formal sensitivity testing using alternative parameter values would be required to establish the quantitative robustness of these unusually large sectoral responses.

Table 7. Sectoral Effects of Trade Facilitation and Technological Modernization on Output, Household Consumption, Exports, Employment, and Domestic Producer Prices in Egypt

Sector	Output 2026	Output 2035	Output Average	Household Consumption 2026	Household Consumption 2035	Household Consumption Average	Exports 2026	Exports 2035	Exports Average	Employment 2026	Employment 2035	Employment Average	Domestic Producer Price 2026	Domestic Producer Price 2035	Domestic Producer Price Summary*
Vegetables	0.30	1.24	0.74	0.10	0.14	0.11	4.04	19.50	11.57	−0.79	0.70	−0.03	−0.28	0.53	0.12
Fruits	1.06	3.31	2.07	0.52	1.06	0.75	4.13	18.50	11.05	0.27	3.74	1.92	−0.60	0.19	−0.18
Other crops (flowers, herbs, and spices)	3.52	40.44	17.94	—	—	—	6.48	72.23	33.70	4.61	62.19	28.00	−0.04	0.25	**0.58**
Fertilizers	0.04	0.12	0.07	—	—	—	−0.06	−0.37	−0.20	0.04	0.09	0.07	0.19	1.06	0.59
Chemicals (pesticides and agrochemicals)	0.02	0.05	0.03	0.08	0.46	0.25	−0.06	−0.32	−0.18	0.02	−0.02	0.00	0.15	0.83	0.46
Machinery	−0.06	−0.66	−0.31	0.12	0.66	0.37	−0.17	−1.22	−0.62	−0.17	−1.23	−0.66	0.09	0.57	0.30
Equipment	0.04	0.06	0.05	0.13	0.75	0.42	−0.04	−0.23	−0.12	0.05	−0.02	0.02	0.14	0.75	0.42
Water supply	0.10	0.36	0.22	0.03	0.13	0.07	—	—	—	0.13	0.44	0.27	0.18	1.05	0.58
Electricity	0.03	0.13	0.08	0.04	0.21	0.12	−0.18	−1.02	−0.56	0.05	0.13	0.09	0.17	0.95	0.53
Transport services	0.01	−0.03	−0.01	0.07	0.39	0.22	−0.06	−0.39	−0.21	0.00	−0.08	−0.04	0.18	1.05	0.57
Wholesale and retail trade	0.08	0.30	0.18	−0.02	0.01	−0.01	—	—	—	0.13	0.40	0.27	0.24	1.22	0.70
Fruit and vegetable processing	0.13	−0.23	−0.03	0.07	0.14	0.11	0.26	−0.73	−0.19	0.26	−0.73	−0.19	−0.16	0.57	0.17
Animal feed manufacturing	0.01	−0.04	−0.01	—	—	—	−0.17	−1.05	−0.57	−0.03	−0.18	−0.10	0.15	0.95	0.52
Beverage industry	0.10	0.22	0.15	0.15	0.42	0.27	0.10	−0.24	−0.07	0.10	−0.24	−0.07	−0.09	0.43	0.16
Textiles	−0.02	−0.12	−0.06	0.11	0.61	0.34	−0.06	−0.33	−0.18	−0.06	−0.33	−0.18	0.14	0.83	0.46
Financial services	−0.03	−0.27	−0.13	0.09	0.43	0.25	−0.06	−0.39	−0.20	−0.06	−0.39	−0.20	0.13	0.84	0.45
Business services	0.01	−0.07	−0.02	0.08	0.46	0.26	−0.05	−0.34	−0.18	−0.05	−0.34	−0.18	0.14	0.83	0.46
Hotels	−0.04	−0.34	−0.18	—	—	—	−0.04	−0.35	−0.18	−0.04	−0.35	−0.18	0.10	0.77	0.40
Restaurants	0.07	0.30	0.17	0.07	0.30	0.17	—	—	—	—	—	—	0.12	0.84	0.45

Note: All values represent percentage deviations from the corresponding baseline. Average values for output, household consumption, exports, and employment represent the arithmetic mean percentage deviation over the 2026–2035 simulation

period. For domestic producer prices, the summary statistic represents the arithmetic mean for all sectors except “other crops.” For the “other crops” sector, the reported value of 0.58% represents the median annual percentage deviation over 2026–2035 rather than the arithmetic mean, because the annual series contains extreme values that could disproportionately affect the mean. A dash (—) indicates that the corresponding variable is not reported or not applicable for that sector. Domestic producer prices exclude all product taxes.

Source: Dynamic CGE model results.

For the “other crops” sector, the domestic producer price is 0.04% below baseline in 2026 and 0.25% above baseline in 2035. The reported summary value of 0.58% is the median annual deviation over 2026–2035 rather than the arithmetic mean and should therefore not be interpreted as the average of the two endpoint values.

4.4. Effects on Upstream and Related Sectors

The integrated policy package generates relatively modest and heterogeneous effects across upstream and related sectors. Fertilizer output is 0.12% above baseline in 2035, while chemical output is 0.05% above baseline. These relatively small responses indicate that the expansion of horticultural activities does not necessarily translate into proportional growth in the domestic production of all agricultural inputs.

Machinery output is 0.66% below baseline in 2035, whereas equipment output is 0.06% above baseline. Because import responses are not reported in Table 7, the decline in domestic machinery output should not be attributed directly to increased machinery imports. Rather, it should be interpreted as a general-equilibrium response that may reflect changes in relative prices, factor allocation, and sectoral competitiveness under the integrated policy scenario.

Water-supply output is 0.36% above baseline in 2035, while electricity output is 0.13% above baseline. Overall, the heterogeneous responses of upstream sectors illustrate the general-equilibrium nature of the model: expansion in horticultural production does not imply uniform expansion across all supplying industries because relative-price changes and resource reallocation affect sectors differently.

4.5. Services and Structural Reallocation

The service sectors also exhibit heterogeneous responses under the integrated policy scenario. Output in wholesale and retail trade is 0.30% above baseline in 2035, while employment in the sector is 0.40% above baseline. Transport-services output is 0.03% below baseline, although household consumption of transport services is 0.39% above baseline.

Financial-services output is 0.27% below baseline in 2035, business-services output is 0.07% below baseline, and hotel output is 0.34% below baseline. By contrast, restaurant output is 0.30% above baseline.

These results indicate that the integrated policy package does not generate uniform gains across the economy. Instead, changes in relative prices and returns lead to structural reallocation of labor and capital across activities. Some sectors expand as resources move toward relatively more competitive uses, while others experience modest contractions. This pattern highlights the potential importance of complementary labor-market, training, and investment policies in facilitating structural adjustment.

4.6. Transmission Mechanisms

The simulated results can be interpreted through four interrelated transmission mechanisms.

First, the productivity component of the integrated policy package increases productive efficiency. A 1% annual increase in total factor productivity enables producers to generate more output from a given quantity of inputs and may reduce unit production costs.

Second, the trade-related components alter the costs and incentives associated with participation in international markets. Reductions in tariff and non-tariff barriers and lower export margins reduce assumed trade-related costs, while the increase in export-demand elasticity represents greater responsiveness of foreign demand to changes in export prices.

Third, changes in relative prices and expected returns induce a reallocation of labor and capital across sectors. Activities experiencing stronger improvements in competitiveness may attract additional productive resources, while other activities may contract relative to the baseline.

Fourth, changes in household and business income affect savings and investment. Within the recursive dynamic framework, investment influences the capital stock and productive capacity in subsequent periods, allowing the effects of the policy scenario to accumulate over time.

Together, these mechanisms help explain the increasing magnitude of several simulated effects over the 2026–2035 period. However, because all policy components are implemented simultaneously, the model does not identify the separate quantitative contribution of each transmission mechanism.

4.7. Discussion in Relation to Previous Research

The results are broadly consistent with previous studies emphasizing the importance of productivity and market access for horticultural competitiveness. The strong simulated export responses for fruits and vegetables are consistent with commodity-level studies identifying productivity, market conditions, prices, product quality, and access to international markets as important determinants of Egypt's horticultural export performance (Assad et al., 2024; El-Soliman et al., 2024; Kassem & Hassan, 2021; Kassem et al., 2024; Shehata et al., 2020).

The macroeconomic results are also generally consistent with previous CGE studies of Egypt that have identified positive economy-wide effects associated with trade facilitation and trade reform (Hosny, 2013; Zaki, 2009, 2013). The present study extends this literature by evaluating an integrated policy package that combines productivity improvements with reductions in trade-related costs within a recursive dynamic CGE framework.

The heterogeneous sectoral responses observed in the simulations are consistent with the general equilibrium literature. Trade and productivity policies may affect sectors differently because of variations in factor intensity, trade orientation, production technology, import competition, and the ability of producers to reallocate resources in response to changes in relative prices and returns.

The results provide simulation-based support for considering productivity improvements and trade-related reforms within a common analytical framework. However, the model does not identify the marginal contribution of each individual policy component. In particular, the analysis does not establish whether technological modernization and trade-cost reductions are complementary, additive, or substitutive. Such an assessment would require separate simulations of technological upgrading alone, trade-cost reduction alone, and the combined policy package. Therefore, the findings of the present study should be interpreted as model-based evidence of the potential effects of the integrated policy package as a whole on horticultural competitiveness and the broader Egyptian economy.

4.8. Limitations

Several limitations should be considered when interpreting the results of this study.

First, the model is calibrated to Egypt's 2019 Social Accounting Matrix (SAM). Consequently, the benchmark reflects the structural characteristics of the Egyptian economy in 2019 and may not fully capture subsequent changes in production patterns, trade relationships, prices, institutions, or other economic conditions.

Second, the magnitude of the simulated effects depends on behavioral elasticities and other model parameters that are not directly observed in the SAM. Alternative parameter values may therefore generate different quantitative outcomes.

Third, the policy shocks considered in the analysis are hypothetical counterfactual assumptions rather than forecasts of actual policy implementation. The results should consequently be interpreted as conditional model-based outcomes under the specified assumptions.

Fourth, the study evaluates only one integrated policy scenario. As a result, the model cannot identify the separate effects of technological modernization, tariff and non-tariff barrier reductions, export-margin reductions, or increased export-demand responsiveness. Nor can it determine whether these policy components are complementary, additive, or substitutive.

Fifth, the model does not explicitly capture all institutional, environmental, climatic, regional, and distributional factors that may influence horticultural competitiveness and the transmission of policy effects across the economy.

Finally, the study does not conduct a formal sensitivity or robustness analysis. Therefore, the stability of the quantitative results under alternative parameter values and modeling assumptions has not been systematically assessed. This limitation is particularly important for the relatively large simulated responses observed in the "other crops" sector. The assumed 13% ad valorem equivalent of non-tariff barriers, export-demand elasticities, productivity-growth assumptions, trade-cost reductions, and macroeconomic closure rules constitute important sources

of uncertainty. Future research should systematically vary these assumptions and compare the resulting sectoral and macroeconomic outcomes in order to assess the robustness of the findings.

5. Conclusions and Policy Implications

This study assessed the potential economy-wide effects of an integrated policy package combining technological modernization and trade-related reforms on Egypt's horticultural competitiveness. Using a recursive dynamic Computable General Equilibrium (CGE) model calibrated to the 2019 Egyptian Social Accounting Matrix (SAM), the analysis simulated a policy package incorporating a 1% annual increase in total factor productivity, gradual reductions in tariff and non-tariff barriers, lower export margins, and increased export-market responsiveness over the period 2026–2035.

The simulation results indicate that the integrated policy package has the potential to strengthen Egypt's horticultural production and export performance while generating positive effects across the broader economy. By 2035, fruit output is 3.31% above baseline and fruit exports are 18.50% above baseline, while vegetable exports increase by 19.50%. The results also indicate positive effects on household income, investment, and real economic activity. At the same time, the effects vary considerably across sectors, reflecting differences in factor intensity, trade orientation, production technology, import competition, and the ability of producers to respond to changes in relative prices and market conditions.

The findings provide model-based support for considering productivity improvements and trade-related reforms within an integrated policy framework. However, because the study evaluates only one combined policy scenario, the model does not identify the independent contribution of each policy component. Nor does it establish whether technological modernization and trade-cost reductions are complementary, additive, or substitutive. Such conclusions would require separate simulations of technological upgrading, trade-cost reduction, and the combined policy package. Therefore, the results should be interpreted as conditional counterfactual outcomes of the integrated scenario as a whole.

Several policy implications follow from the analysis.

First, technological modernization should remain an important component of Egypt's strategy for strengthening the horticultural sector. Policies supporting improved irrigation systems, precision agriculture, mechanization, improved crop varieties, digital technologies, and post-harvest management may enhance productivity, reduce production losses, and improve product quality.

Second, technological modernization should be accompanied by continued improvements in trade facilitation. Further development of electronic customs procedures, single-window

systems, port infrastructure, refrigerated transport, logistics services, and cold-chain facilities may reduce transaction costs and improve the competitiveness of perishable horticultural products in international markets.

Third, greater investment is needed in quality assurance and food safety infrastructure. Strengthening laboratories, certification services, traceability systems, sanitary and phytosanitary compliance, and technical support can help Egyptian producers meet international standards and improve access to export markets.

Fourth, policy measures should facilitate greater participation of smallholders in expanding horticultural value chains. Improved extension services, access to finance and technology, producer aggregation, market information systems, and contractual arrangements linking farmers with exporters and processors may strengthen the ability of small-scale producers to benefit from improvements in productivity and market access.

Fifth, structural adjustment should be actively managed. Because the simulated effects are heterogeneous across sectors, some activities may expand while others may contract. Policies that support labor mobility, vocational training, skill development, and efficient allocation of investment can help reduce adjustment costs and facilitate the movement of resources toward more competitive activities.

The study also provides an important methodological implication. Since only one integrated policy scenario is evaluated, the analysis cannot quantify the separate effects of technological modernization, trade-cost reduction, or improved export-market responsiveness. Future research should therefore compare technology-only, trade-reform-only, and combined scenarios in order to identify the contribution of individual policy components and to assess whether their joint effects are complementary.

The main contribution of this study lies in quantifying the potential economy-wide effects of a combined productivity and market-access policy package within a recursive dynamic CGE framework. Future research would benefit from the use of an updated Social Accounting Matrix, alternative macroeconomic closure assumptions, more detailed measures of non-tariff and logistics costs, and systematic sensitivity analysis of key behavioral parameters. Such extensions would strengthen the robustness of the results and provide a more detailed assessment of alternative policy pathways for improving Egypt’s horticultural competitiveness.

Because no formal sensitivity analysis is conducted, the reported magnitudes should be interpreted as conditional simulation results rather than robust estimates that are invariant to alternative parameter values or modeling assumptions.

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