From Population Growth to Variable-Specific Forecasts: An Estimation-Based Method for Recursive Dynamic CGE Modeling

Extended Abstract

Computable General Equilibrium (CGE) models are essential tools for simulating economy-wide policy impacts, bridging theoretical economics with empirical data. Static CGE variants capture single-period equilibria, while dynamic extensions incorporate intertemporal decisions to analyze growth paths (Johansen, 1960). However, transitioning to dynamic frameworks often hinges on simplistic exogenous drivers, highlighting the need for more robust, data-driven methods.

In recursive-dynamic CGE models, exogenous population projections represent one of the key long-term drivers that scale the entire economy period by period. Rather than holding the size of the economy fixed, all primary factor endowments, household demand systems, and intermediate input requirements are typically scaled in proportion to demographic changes.

Although exogenous population projections provide a practical and internally consistent mechanism for scaling labor supply and household demand in recursive-dynamic CGE models, this conventional approach has well-documented limitations. By treating new cohorts as homogeneous replicas of existing ones and applying uniform scaling factors to labor (typically working-age population) and consumption (total population), standard models implicitly assume constant age- and cohort-specific participation rates, skill composition, savings behavior, and consumption patterns—assumptions that are increasingly violated in aging and structurally transforming economies (**Börsch-Supan, 2003; Miles, 1999; Fouré et al., 2013**). Moreover, the widespread use of a single representative household (or a small number of income classes) precludes an adequate representation of life-cycle effects, age-specific morbidity and health expenditures, pension system feedbacks, and the pronounced shift toward health- and long-term-care-intensive consumption baskets observed in most high-income countries since the 1990s (**Oliveira Martins et al., 2005; van der Mensbrugghe, 2019**). Consequently, conventional recursive-dynamic frameworks tend to overstate long-run labor supply and aggregate saving rates in rapidly aging societies, producing overly optimistic baseline growth trajectories and potentially biased assessments of climate, fiscal, and trade policies implemented over multi-decade horizons (**Château et al., 2022; Dufournaud et al., 2023**).

While recent advances in recursive-dynamic CGE modeling—most notably the GTAP-RD framework (**Corong and van der Mensbrugghe, 2024; building on Aguiar et al., 2019**)—have significantly improved the empirical grounding of long-term baselines by incorporating observed historical structural change into forward-looking calibrations, several key limitations remain that the present study directly addresses. GTAP-RD continues to rely on exogenous population and labor-force projections to scale labor endowments, applies externally imposed per-capita GDP growth targets that are met via calibrated total-factor or labor-augmenting productivity shocks, and uses cost-neutral "twist" parameters (**Dixon and Rimmer, 2002**) to replicate historical shifts in intermediate input shares, import penetration, and factor intensities. Although these techniques ensure that the baseline closely tracks recent trends up to 2030 or beyond, they are essentially sophisticated extrapolation methods: future trajectories of endowments, productivity, and behavioral parameters are either imposed exogenously or inferred from short historical windows (**typically 2014–2017**), with little formal statistical testing of parameter stability or out-of-sample forecasting power.

To address these gaps, this study proposes an estimation-based recursive dynamic CGE framework that replaces blanket population growth with tailored econometric forecasts for each macroeconomy variable.

The computable general equilibrium (CGE) model is calibrated on a Social Accounting Matrix (SAM) constructed for Morocco for the base year 2023. The SAM is compiled from the latest available national accounts, supply–use tables, government finance statistics, and balance of payments data, ensuring full

accounting consistency across all economic agents. It provides a detailed representation of production activities and commodities interconnected through intermediate input–output linkages, with value added generated by labor and capital factors. Institutional accounts explicitly distinguish households, firms, and the government, allowing for a consistent mapping of income generation, taxation, transfers, savings, and final demand. Public revenues and expenditures are recorded in the government account, guaranteeing coherence between fiscal balances and aggregate demand, while the rest-of-the-world account captures external trade flows and net foreign transactions. The SAM is balanced in nominal terms and expressed in millions of Moroccan dirhams, and it serves as the benchmark equilibrium from which all model parameters, share coefficients, and behavioral functions are calibrated prior to the implementation of policy simulations.
The model is a multi-sector, multi-agent CGE framework inspired by the standard PEP (Partnership for Economic Policy) modeling framework and implemented in GAMS. Its core structure explicitly distinguishes production activities, commodities, factors of production, and institutional agents, including households, firms, the government, and the rest of the world. Production technologies are represented through nested functional forms combining intermediate inputs and value added, with value added generated by labor and capital under constant elasticity of substitution specifications, while domestic output is allocated between domestic and export markets using a constant elasticity of transformation function. On the demand side, domestic and imported goods are treated as imperfect substitutes according to the Armington assumption, and final demand by households, government, and investors is derived from income and budget constraints consistent with the SAM benchmark. Institutional income generation, taxation, transfers, and savings are explicitly modeled, ensuring full accounting consistency across agents.

Our strategy consists of first using Supply and Use Tables (SUTs) for Morocco to generate Ordinary Least Squares (OLS) estimates for each variable, and second, calculating growth rates to assess the implied dynamic trajectories of these variables.

Thus, our objective is to build an AI-based automation method capable of generating population growth paths for each variable based on econometric estimation results.

In contrast, the estimation-based recursive-dynamic approach proposed here endogenizes the evolution of all major drivers—population and labor-force participation, sector-specific total factor productivity, intermediate and final demand parameters, and trade elasticities. This yields variable-specific forecasts accompanied by confidence intervals, allows formal testing of structural breaks, and substantially improves out-of-sample forecast accuracy and policy sensitivity relative to purely calibration- or extrapolation-based baselines such as GTAP-RD. Consequently, the present framework offers greater transparency, statistical robustness, and flexibility when projecting alternative demographic, technological, or trade scenarios over multi-decade horizons.

Macroeconomic closure assumes a fixed nominal exchange rate and a constant ratio of the current account balance to GDP to govern the external equilibrium. On the savings–investment side, total investment is savings-driven and adjusts endogenously to the sum of domestic savings and net foreign savings, while investment by public branches is exogenously fixed. Fiscal closure is implemented through alternative rules, including a fixed level of real government expenditure, a fixed level of public savings, or a fixed ratio of the public deficit to GDP. The model follows a recursive dynamic structure in which the economy is solved as a sequence of static equilibria, with capital accumulation, investment allocation, and selected exogenous trends updating the state variables between periods, thereby allowing the analysis of medium- to long-run policy impacts.

This study presents an innovative estimation-based approach to recursive dynamic CGE modeling, addressing the limitations of traditional methods that rely on exogenous population growth to transition from static to dynamic frameworks. By integrating econometric estimation results, the proposed method enables variable-specific forecasting, thereby enhancing model flexibility and empirical robustness. Comparative analyses demonstrate superior performance in terms of forecast accuracy and policy sensitivity.

Keywords: Dynamic CGE Modeling, Econometric Estimation, Population Growth, Variable-Specific Forecasts, Morocco

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The GTAP Recursive Dynamic (GTAP-RD) Model: Version 1.0

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Table : Growth differences between constant population growth rate BAU and variable growth rate econometric estimation BAU

Millions of DHs	Export			Import			Consumption				Value Added				REAL-GDP
Year	AFP	IND	SER	AFP	IND	SER	AFP	IND	SER	SNM	AFP	IND	SER	SNM	
2026	1.0	40.8	36.5	2.5	-61.9	-131.3	13.7	-21.6	-24.7	-1.1	70.4	54.8	-16.1	-178.6	-11.7
2027	-2.1	52.4	57.9	14.8	-50.9	-205.6	17.2	-24.0	-65.5	-1.9	53.3	-5.5	79.6	-278.3	-17.6
2028	-6.3	68.2	86.3	32.8	-18.8	-300.8	20.2	-24.9	-117.3	-2.8	62.6	-62.3	328.0	-401.7	-24.6
2029	-11.5	90.9	123.4	57.6	42.4	-420.1	22.8	-23.5	-179.3	-4.0	126.1	-91.3	820.4	-550.7	-32.5
2030	-17.7	123.6	171.2	90.3	142.4	-567.0	24.8	-18.7	-250.1	-5.2	281.0	-58.2	1674.1	-727.3	-41.1
2031	-22.3	147.9	210.8	118.4	296.3	-672.8	20.1	-3.8	-290.7	-5.7	506.3	88.1	3069.9	-840.2	-44.3
2032	-26.2	191.5	260.7	153.2	500.0	-799.3	13.6	14.8	-325.2	-6.1	941.0	407.9	5024.9	-969.4	-46.4
2033	-28.4	251.7	318.8	190.4	758.4	-935.7	7.1	41.1	-347.2	-6.2	1634.5	972.5	7693.3	-1104.7	-46.9
2034	-28.3	332.8	386.6	230.3	1082.0	-1082.7	0.8	77.3	-353.9	-6.0	2647.7	1839.3	11225.3	-1246.4	-45.3
2035	-25.4	439.4	465.7	273.2	1483.0	-1240.9	-4.8	125.5	-341.7	-5.4	4051.8	3075.4	15797.7	-1394.8	-41.0