Spare Time Economic Model (STEM)

Technical Documentation and Assessment

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1 Purpose of Report

This report provides a comprehensive overview of the Spare Time Economic Model (STEM), an integrated model of the Australian economy developed to project key demographic and economic outcomes over the medium to long term. The model combines demographic projections with macroeconomic forecasting and industry analysis to create a coherent, internally consistent view of Australia's economic future.

The purpose of this report is to:

- Document the structure and methodological approach of the STEM model
- Explain the functioning of each module and how they interact
- Present key outputs and findings from the model
- Assess the model's projections against comparable forecasts from authoritative sources

This technical documentation serves as a reference for understanding both the mechanics of the model and the insights it provides. The analysis focuses on clarity and practical utility, providing a rigorous yet accessible explanation of the model and its implications for economic planning and policy development.

2 Model Goals and Overall Structure

2.1 Model Goals

The STEM model was developed with several key objectives:

- To create a coherent, internally consistent projection of Australia's economy over a multi-decade horizon
- To capture the interrelationships between demographic change, macroeconomic outcomes, and industry structure
- To provide detailed industry-level projections that account for structural economic changes
- To establish a flexible framework that can be updated and expanded as new data becomes available
- To produce outputs at sufficient granularity to inform policy development and economic planning

2.2 Model Structure

STEM is structured as a modular, sequential system with four primary components that build upon each other:

1. **Time Series Projection Module**: Provides baseline forecasts for key economic variables based on historical trends, using techniques such as ARIMA modeling with adjustment mechanisms to ensure long-term convergence to sustainable values.
2. **Demographic Module**: Projects population by age and gender, incorporating fertility, mortality, and migration dynamics, establishing the foundation for labor force and consumption projections.
3. **Macroeconomic Module**: Forecasts key economic aggregates including GDP, employment, inflation, and major expenditure components, with internal consistency mechanisms that reflect economic theory.

4. **Industry Module**: Distributes economic activity across industries using input-output analysis, generating detailed projections of industry growth, structural change, and interdependencies.

The modular design allows for independent development and validation of each component while ensuring that insights from one module inform projections in the others. Data flows between modules in a structured manner: demographic projections feed into labor force estimates in the macroeconomic module; macroeconomic aggregates provide control totals for the industry module's projections.

Figure 1 below illustrates the overall structure and information flows within the STEM model:

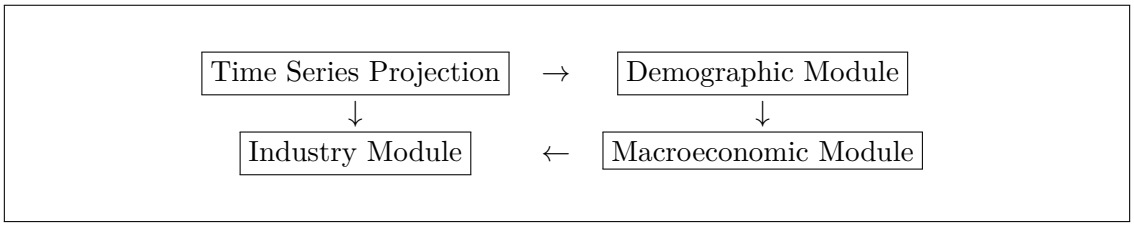

Figure 1: STEM Model Structure and Information Flows

The model's base year is established at 2022, with projections extending over a multi-decade horizon. This timeframe allows for the analysis of long-term structural changes while maintaining reasonable accuracy in the medium term, where policy decisions have their greatest impact.

3 Module Functional Explanation

3.1 Time Series Projection Module

The time series projection module serves as the foundation for forecasting key economic variables based on historical data. This module:

- Uses ARIMA (AutoRegressive Integrated Moving Average) modeling to identify and extrapolate time series patterns
- Applies logit transformations when forecasting share variables (such as industry shares of GDP) to ensure they remain bounded between 0 and 1
- Implements mean reversion mechanisms that gradually adjust forecasts toward historical averages, preventing unrealistic long-term divergence
- Incorporates smoothing techniques to manage transitions between historical data and forecasts, minimizing artificial discontinuities

The module processes historical economic data from the Australian Bureau of Statistics, particularly focusing on GDP components and industry shares. It ensures the mathematical coherence of projections (e.g., ensuring that expenditure shares sum to 100%) while preserving the underlying economic relationships.

3.2 Demographic Module

The demographic module implements a cohort-component model to project Australia's population by single year of age and gender. This approach:

- Projects births using age-specific fertility rates that evolve gradually over time
- Models mortality with age-gender-specific rates that improve at varying paces, reflecting continued advances in healthcare and living standards

- Incorporates net overseas migration with age and gender distribution patterns
- Tracks population aging and dependency ratios, providing insights into economic support requirements

The module is calibrated using ABS demographic data and incorporates features such as:

- Age-specific fertility rates with annual adjustments that reflect changing social and economic factors
- Mortality improvement rates that taper over time to avoid unrealistic life expectancy projections
- Age-specific migration profiles that maintain Australia's position as a destination for skilled workers
- Special handling for the 85+ age group to account for survivor effects and heterogeneity

This detailed demographic modeling provides the labor force foundation for economic projections and captures the economic implications of Australia's aging population, changing household formation patterns, and migration policies.

3.3 Macroeconomic Module

The macroeconomic module generates consistent projections of Australia's economic aggregates, with dynamic feedback mechanisms between key variables. Core features include:

- A production function approach that combines labor inputs, capital accumulation, and total factor productivity (TFP) to determine potential output
- Labor market dynamics that model participation rates and unemployment as functions of economic conditions
- A capital accumulation process driven by investment and subject to depreciation
- Monetary policy modeled with a modified Taylor Rule that responds to inflation and output gaps
- Fiscal dynamics that incorporate debt sustainability and automatic stabilizers
- Expenditure components that are sensitive to interest rates and fiscal impulses

The module is designed to ensure internal consistency across variables. For example:

- GDP growth reflects both supply-side constraints (potential output) and demand-side dynamics
- Labor utilization responds to the output gap, creating cyclical employment patterns
- Inflation is modeled using a Phillips curve approach, responding to labor market conditions and inflation expectations
- Government expenditure adjusts to maintain long-term fiscal sustainability while providing counter-cyclical support

This integrated approach ensures that the model captures both short-term business cycle dynamics and long-term growth trends, with appropriate economic relationships maintained throughout the projection period.

3.4 Industry Module

The industry module disaggregates macroeconomic projections into detailed industry-level forecasts using input-output analysis. This module:

- Distributes final demand across industries based on evolving industry shares

- Captures inter-industry relationships through the input-output framework
- Applies the Leontief inverse matrix to determine total production requirements
- Projects structural change in the economy as industries grow at different rates
- Maintains consistency with macroeconomic control totals while allowing for industry-specific dynamics

The industry module leverages Australia's detailed input-output tables from the ABS and implements:

- RAS methodology (bi-proportional adjustment) to ensure balanced tables in each projection year
- Adjustment mechanisms that align industry shares from time series forecasts with input-output structure
- Calculation of total output requirements from final demand using the Leontief inverse
- Value added calculations that maintain consistency with macroeconomic GDP

This detailed industry-level modeling allows for the analysis of structural change, industry growth disparities, and the implications of changing consumption and investment patterns on Australia's industrial composition.

4 Output Summary

The STEM model generates a comprehensive set of projections covering demographic, macroeconomic, and industry dimensions. Key outputs are summarized below.

4.1 Demographic Projections

The demographic module projects Australia's population to grow steadily over the forecast period, with the following key trends:

- Total population is projected to reach approximately 38 million by 2060, up from about 26 million in the base year
- The population is aging, with the median age increasing from 38.5 years to 42 years by 2060
- The old-age dependency ratio (ratio of people aged 65+ to working-age population) is projected to increase from 25% to nearly 35% by 2060
- Net overseas migration continues to be the primary driver of population growth, contributing approximately 60-65% of total growth
- Fertility rates remain below replacement level, stabilizing around 1.7 children per woman

These demographic trends have significant implications for labor supply, dependency ratios, and the structure of consumption and government spending in the economy.

4.2 Macroeconomic Projections

The macroeconomic module generates projections for key economic indicators that show:

- Real GDP growth averaging 2.4% annually over the long term, with cyclical variations
- Labor productivity growth of approximately 1.2% per annum, below historical averages but consistent with recent trends
- Labor market maintains near-full employment with 3.4% unemployment

- Inflation converging to the RBA target of 2.5% over the medium term, with periodic deviations
- Labor force participation gradually declining as the population ages, partially offset by increased participation among older age groups
- Investment-to-GDP ratio averaging 24%, with higher levels in the near term to support capital deepening
- Government debt-to-GDP ratio stabilizing around 35% over the long term, following a period of gradual fiscal consolidation

The projections reflect a gradual moderation in economic growth compared to historical rates, primarily due to aging demographics and slower productivity growth, consistent with patterns observed in other advanced economies.

4.3 Industry Projections

The industry module provides detailed projections of industry growth and structural change, with the following key findings:

- Service sectors continue to grow as a share of the economy, particularly health care, professional services, and education
- Health care and social assistance is projected to become the largest industry by 2040, driven by demographic aging and income growth
- Manufacturing maintains a stable but reduced share of economic activity, with a shift toward higher-value specialized production
- Mining gradually declines as a share of GDP but remains significant, with continued productivity improvements offsetting resource depletion
- Construction experiences cyclical patterns but maintains a stable long-term share of economic activity
- Information, media and telecommunications shows strong growth, reflecting ongoing digital transformation

These projections highlight the continuing evolution of Australia's economy toward services, knowledge-based activities, and high-value exports, while traditional sectors maintain important but evolving roles.

5 Output Assessment

The STEM model projections have been assessed against comparable forecasts from several authoritative sources, including the Australian Treasury, Reserve Bank of Australia (RBA), NSW Treasury, and Infrastructure Australia. This comparison provides context and validation for the model's outputs.

5.1 Demographic Comparison

The demographic projections from STEM show broad alignment with official population projections:

- The total population trajectory is closely aligned with the ABS's Series B projections through 2040, with STEM projecting slightly higher growth in later decades due to more optimistic migration assumptions
- STEM's aging profile is consistent with Treasury's Intergenerational Report (IGR), which similarly forecasts an increase in the median age and old-age dependency ratio

- The model's projected fertility rate of 1.7 aligns with the central assumptions in both ABS projections and the IGR
- Net overseas migration assumptions in STEM (235,000 annually with modest growth) are slightly above the Treasury IGR long-term assumption (235,000 fixed) but within the range considered by the Centre for Population

The demographic projections provide a reasonable central case that aligns with official forecasts while acknowledging the inherent uncertainty in long-term population modeling.

5.2 Macroeconomic Comparison

The macroeconomic projections from STEM have been compared with forecasts from the Treasury, RBA, and major economic research organizations:

- STEM's long-term GDP growth projection (2.4% annually) is slightly below Treasury's IGR projection (2.6%) but above some private forecasts (2.0-2.3%)
- The labor productivity growth assumption (1.2%) is aligned with the RBA's recent medium-term assessments but below Treasury's long-term assumption (1.5%)
- STEM's projected unemployment rate (3.4% long run) is lower than Treasury's NAIRU assumption (4.75%).
- The model's inflation projections align with RBA targets, as do most long-term forecasts
- STEM's government debt projections are more optimistic than recent Treasury updates, reflecting slightly different assumptions about fiscal consolidation paths

Overall, the macroeconomic projections represent a moderately conservative view of Australia's growth prospects, balancing recent productivity challenges against potential demographic and technological tailwinds.

5.3 Industry Comparison

The industry projections have been compared with industry forecasts from sources including Infrastructure Australia, NSW Treasury, and industry-specific studies:

- The projected dominance of healthcare aligns with NSW Treasury's industry projections, which similarly highlight demographic and income effects
- The measured decline in mining's share of GDP is consistent with Infrastructure Australia's outlook, though STEM projects a more gradual transition
- STEM's manufacturing outlook is more stable than some projections that forecast continued rapid decline, reflecting the module's incorporation of recent reshoring and security trends
- The growth in professional services and digital sectors aligns with Jobs and Skills Australia forecasts
- Construction projections show cyclical patterns similar to those in RBA sectoral analyses, though with slightly lower amplitude

The industry projections offer a balanced view of structural change, capturing the major trends identified by specialized sectoral studies while maintaining consistency with macroeconomic aggregates.

5.4 Model Strengths and Limitations

The STEM model demonstrates several notable strengths:

- Integration of demographic, macroeconomic, and industry dimensions provides a coherent, internally consistent projection framework

- Detailed age-gender modeling captures the economic implications of population aging more comprehensively than many macroeconomic models
- The input-output approach allows for detailed industry analysis that accounts for supply chain relationships
- Adjustment mechanisms prevent unrealistic long-term divergence from historical patterns while allowing for structural change

However, the model also has limitations that should be acknowledged:

- The sequential structure may not fully capture feedback effects between industry composition and macroeconomic outcomes
- Technology changes and disruptions are difficult to model and may alter industry relationships in ways not captured by historical patterns
- Global economic and geopolitical shocks are not explicitly modeled, though they could significantly impact Australia's economic trajectory
- Climate change impacts and the energy transition could create structural breaks that are challenging to incorporate in the current framework

These limitations suggest areas for future model development, including the incorporation of scenario analysis, climate transition modeling, and enhanced international linkages.

6 Conclusion

The Spare Time Economic Model (STEM) provides a comprehensive, integrated framework for projecting Australia's economic future. By combining demographic dynamics, macroeconomic relationships, and input-output analysis, the model generates detailed and internally consistent projections across multiple dimensions of the economy.

The model's outputs broadly align with forecasts from authoritative sources such as the Treasury, RBA, and specialized research organizations, providing confidence in its baseline projections. At the same time, the model offers unique insights through its integrated structure, particularly in linking demographic change to industry-level outcomes.

STEM's projections point to an Australian economy that continues to grow but at a moderating pace, with significant structural change toward service sectors, particularly health care and professional services. The aging population creates both challenges and opportunities, while productivity growth remains a critical factor in determining long-term prosperity.

There is an ambitious development plan which will significantly enhance STEM's capabilities, particularly in spatial disaggregation and specialized applications like freight and housing analysis. These enhancements will transform STEM into an even more powerful tool for policy development, infrastructure planning, and economic strategy across multiple levels of government and the private sector.

As with any long-term projection model, STEM's outputs should be interpreted as a coherent central case rather than precise predictions. The model's value lies not just in its specific numerical projections but in the insights it provides about relationships between different aspects of the economy and the implications of current trends for Australia's economic future.