INTERNATIONAL MONETARY FUND

# The Israeli Structural Model

Daniel Baksa, Yotam Peterfreund, Nadav Podoler, Ivy Sabuga, Tanya Slobodnitsky, and Luis-Felipe Zanna

**WP/25/213**



**2025**
OCT

WORKING PAPER

 WP/25/213

**IMF Working Paper**
Institute for Capacity Development

**The Israeli Structural Model**
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Authorized for distribution by Natan Epstein
October 2025



**ABSTRACT:** This paper introduces the Israeli Structural Model (ISM), a New-Keynesian Dynamic Stochastic General Equilibrium (DSGE) model tailored to reflect key characteristics of the Israeli economy. The ISM incorporates diverse consumer saving behaviors and labor skills, a dynamic high-tech (HT) sector, international trade and capital integration, and comprehensive fiscal components. As an integral part of the Ministry of Finance's (MOF) Forecasting and Policy Analysis System (FPAS), the ISM serves as a macroeconomic policy scenario analysis tool, aiding in policy discussions and decision-making. This paper illustrates the ISM's policy use by evaluating strategies for utilizing additional government revenue generated from the HT sector boom in 2022 and their macroeconomic impacts. It compares three policy options: accelerated public debt reduction, redistribution through transfers, and increased public investment. The findings indicate that increased public investment is the most beneficial strategy, in the aftermath of the COVID-19 pandemic, accelerating GDP's convergence to its trend, reducing public debt to GDP ratios, and mitigating real appreciation and the impact on the most vulnerable population.



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|---|---|
| JEL Classification Numbers: | E52, E63, F41, F42 |
| Keywords: | Israel; Forecasting and Policy Analysis System; DSGE Model; Fiscal Policy; Monetary Policy |
| Author's E-Mail Address: | DBaksa2@imf.org, YotamPe@mof.gov.il, NadavPo@mof.gov.il, SlTat@mof.gov.il, ISabuga@imf.org, FZanna@imf.org |

WORKING PAPERS

# The Israeli Structural Model

Prepared by Daniel Baksa, Yotam Peterfreund, Nadav Podoler,
Ivy Sabuga, Tanya Slobodnitsky, and Luis-Felipe Zanna[1]

1 The Israeli Structural Model presented in this paper is one of the key outcomes of a technical assistance project on macroeconomic frameworks provided by the IMF's Institute for Capacity Development (ICD) to the modeling team at the Ministry of Finance (MOF) Chief Economist Office. The paper presents the results of applying this model for policy scenario analysis. While IMF staff contributed to the model's technical development, the selection and calibration of policy targets and key parameters-such as the debt anchor and steady-state growth assumptions-and the design of scenarios reflect the choices made by the MOF Chief Economist Office's modeling team at the end of 2022.This paper greatly benefited from discussions with staff of the MOF. We are grateful for comments from Benjamin Carton, Stephanie Eble, Carlos Eduardo Goncalves, and Ezgi Ozgul Ozturk. We also acknowledge the contribution and support of Lev Drucker and Shira Greenberg for this project. The views expressed in this paper are those of the authors and not necessarily those of the International Monetary Fund, or its Executive Board.

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# 1 Introduction

Dynamic Stochastic General Equilibrium (DSGE) models have increasingly become a prominent tool in policy institutions, including central banks and ministries of finance, since they can be used for forecasting and policy scenario analysis.[1] A survey conducted by Yagihashi (2020) indicates a consistent rise in the adoption of DSGE models by these institutions, particularly within Europe, following the 2007-2008 Global Financial Crisis (GFC). DSGE models are widely recognized as essential instruments for conducting policy scenario analysis in a manner that is both open and transparent. For example, Woodford (2011) and Christiano, Eichenbaum and Rebelo (2011) demonstrate that stylized DSGE models have effectively illustrated the benefits of fiscal stimulus measures.

While these state-of-the-art DSGE models offer notable benefits, they also face criticisms from researchers and practitioners. Notably, as emphasized by Linnemann (2014), these critiques include the absence of heterogeneity, given that DSGE models typically operate under the assumption of a representative household; the dependence on the rational expectations hypothesis; the ad-hoc representation of financial markets; and the sensitivity of model dynamics to exogenous shocks.[2] In response to these concerns, Christiano, Eichenbaum and Trabandt (2018), Gali (2017), and Blanchard (2018) offer important insights, asserting that DSGE models are highly improvable and remain crucial to the future of macroeconomics. They underscore the inherent transparency of DSGE models, which allows for the identification of questionable assumptions and inconsistencies. Additionally, DSGE models empower policymakers to assess policy trade-offs through quantitative experiments that are often difficult to conduct in traditional economic analyses of real economies.

The Ministry of Finance (MOF) of Israel is one of the policy institutions that has recently developed its own DSGE model. Prior to the development of this model, the MOF relied on several forecasting models. The primary forecasting tool was a semi-structural autoregressive integrated moving average (ARIMA) model, which monitored key macroeconomic and fiscal variables in the Israeli economy over time and provided

[1] This trend, which was led by central banks, was in part based on the premise that DSGE models can replicate macroeconomic stylized facts associated with monetary policy shocks, as shown by Christiano, Eichenbaum and Evans (2005), and have good medium-term forecasting properties in comparison to Vector Autoregression (VAR) econometric models, as argued by Smets and Wouters (2003).

[2] See also Stiglitz (2011).

short-term projections for one to two years.

Under the auspices of technical assistance (TA) on macroeconomic frameworks provided by the Institute for Capacity Development (ICD) of the International Monetary Fund (IMF), the MOF has strengthened its toolkit for forecasting and policy analysis. This TA facilitated the development of several model-based frameworks, including: (i) a multivariate filter (MVF) designed to assess the state of the economy, initially created in collaboration with the IMF Research Department; (ii) a semi-structural gap model known as the Israeli Forecasting Model (IFM), primarily used for forecasting purposes; and (iii) the ISM, as detailed in this paper, which is employed for policy scenario analysis addressing structural questions.

The ISM captures specific characteristics of the Israeli economy and is generally described as a New-Keynesian small-open economy model, where long-term growth is driven by productivity and population growth. The ISM structure is based on the ICD canonical DSGE model of Remo et al. (2025), which incorporates several standard DSGE features reflected in academic and policy work, including studies by Smets and Wouters (2003), Christiano, Eichenbaum and Evans (2005), and Kumhof et al. (2010).

The model incorporates heterogeneity in household saving behaviors and labor skills, along with real rigidities such as external habit formation and real wage rigidities. It features overlapping generations (OLG) consumers, who possess high labor skills and can smooth consumption over time through asset accumulation (savers). In contrast, liquidity-constrained (LIQ) consumers have low labor skills and must consume their current income in each period (non-savers). The inclusion of both OLG and LIQ households helps break the Ricardian equivalence, providing valuable insights into the distributional consequences and long-term sustainability of fiscal measures. Their presence, together with the nominal price and wage rigidities discussed below, amplifies Keynesian demand effects and enhances the effectiveness of fiscal policy and its associated multipliers. Additionally, the OLG structure introduces Pigouvian wealth effects on demand.

The model features two key production sectors: the high-tech (HT) sector and the non-HT sector. Specifically, the production side comprises physical capital producers, as well as HT and non-HT firms. Capital producers supply sector-specific capital to both HT and non-HT firms and pay investment adjustment costs. They operate under conditions of perfect competition and flexible prices. Firms in the HT sector primarily produce HT goods for export, utilizing sector-specific capital, skilled labor, and public capital. These firms experience monopolistic competition, nominal price rigidities, and real adjustment costs related to labor and imports. Conversely, firms in the non-HT sector (often referred to as the "rest of sectors") produce goods for both domestic and external markets by combining oil imports, sector-specific capital, and both skilled and unskilled labor. The model employs a properly calibrated constant elasticity of substitution (CES) production function that integrates these factors, facilitating capital-skill complementarity. This means that there is substitution between capital and low-skill labor, while capital complements high-skill labor.[3] Similar to their HT counterparts, non-HT firms also face monopolistic competition, nominal price rigidities, and real adjustment costs associated with labor and imports.

The production side of the model also includes importers (both oil and non-oil), exporters, and retailers. Oil importers procure oil from abroad and sell it domestically for use in production, adhering to the law of one price. Non-oil importers source non-oil imports from foreign markets and sell these goods to retailers. In this process, they encounter monopolistic competition and price rigidities, which translates into imperfect exchange rate pass-through. Exporting retailers produce both HT and non-HT outputs for export by combining products from HT and non-HT firms with oil and non-oil imports, all of which are subject to adjustment costs. Additionally, retailers aggregate output for both private and public consumption, as well as for private and public investment, by integrating outputs from the HT and non-HT sectors along with oil and non-oil imports.

The behavior of key macroeconomic variables of the foreign sector is modeled exogenously. For instance, the foreign inflation and interest rate, oil prices, and foreign GDP follow AR(1) processes that feature stochastic shocks. Foreign GDP affects the export demands for HT and non-HT goods, which also depend on the real exchange rate and on relative prices of these goods, respectively. Moreover, the foreign interest rate embeds a country risk premium that increases with the total (both public and private) foreign debt-to-GDP ratio.

The ISM includes a comprehensive fiscal block. The government adheres to a budget constraint, whereby deficits—occurring when public expenditures exceed revenues—can be financed by issuing debt. On the revenue side, the government levies lump-sum taxes

[3] See Krusell et al. (2000).

as well as distortionary taxes on labor income, capital income, and consumption. On the expenditure side, the government incurs current expenditures, targeted transfers, and public investment, which may be subject to inefficiencies. Regarding borrowing, the government has access to both domestic and external commercial debt. Fiscal policy is modeled as a forward-looking reaction function that largely reflects the Israeli fiscal context. In this framework, the primary surplus (the instrument) responds to current and anticipated deviations of total public debt from a specified target. Additionally, there are straightforward rules governing public debt issuance for both domestic and external debt, wherein the overall deficit is financed through exogenously determined fractions of each type of borrowing. Other revenue and expenditure instruments are modeled as exogenous AR(1) processes that incorporate stochastic shocks.

The central bank is committed to an inflation target and follows a forward-looking interest rate rule, which incorporates smoothing and monetary policy shocks. In this framework, the interest rate responds to deviations of the expected future consumer price index (CPI) inflation from a specified inflation target.

To close the model, markets equilibrium conditions are imposed. These conditions ensure that the demand and supply for HT goods, non-HT goods, skilled and unskilled labor, sector-specific capital, bonds, and other goods, services and assets are equalized. Additionally, they incorporate the current account condition, which states that the growth of the country's net foreign debt is equal to the current account deficit.

The ISM incorporates a comprehensive set of exogenous shocks that can be utilized to construct various macroeconomic scenarios. For households, it includes preference shocks, labor supply shocks (which encompass both preferences and endowments), and wage markup shocks. The block for capital producers features investment adjustment shocks. For HT and non-HT firms, the model integrates productivity shocks, cost-push shocks, and balanced-growth-path (BGP) shocks. Importers are affected by foreign price shocks, cost-push shocks, and oil price shocks. The fiscal block encompasses shocks to distortionary tax rates, lump-sum taxes, targeted transfers, government consumption, and government investment—along with shocks to its efficiency—, primary surplus, debt targets, and domestic financing. Monetary policy is also subject to discretionary shocks. Finally, in the foreign sector, the model accounts for shocks to foreign interest rates, inflation, GDP, and the country risk premium.

To illustrate the application of the ISM, this paper discusses its role in developing a baseline scenario that captures the essential features of the 2022 Israeli macroeconomic outlook while exploring alternative policy scenarios. Specifically, the ISM was applied at the end of 2022, utilizing observed macroeconomic and fiscal data up to 2021 for model calibration, along with information derived from input-output (IO) tables.

During the period of 2020-2021, the Israeli economy experienced a contraction in foreign demand for non-HT goods, a decline in foreign inflation, significant easing of interest rates by the US Federal Reserve, a reduction in domestic demand, and some positive developments in the HT sector. Concurrently, fiscal support was withdrawn after several years of mitigating the negative impacts of the COVID-19 pandemic. In 2022, the economy was further challenged by high commodity prices and supply chain disruptions.

Against this backdrop, the ISM-based baseline captures the pandemic's adverse effects on the economy during 2020-2021. This includes a GDP decline of more than 4 percent, an increase in public debt of approximately 9 percentage points of GDP, and a real appreciation of over 9 percent. Additionally, the model simulations indicate a significant contraction in consumption of both savers and non-savers, as well as notable redistributional effects. A shock-decomposition analysis reveals that the positive developments in the HT sector during 2021 played a crucial mitigating role by generating additional government revenue. This helped to push up real GDP by more than 3 percent, relative to its trend, and push down the public debt-to-GDP ratio by about 2 percentage points (pp).

In the policy scenario analysis, this paper explores various alternatives for allocating the government revenue surplus generated by the expansion of the HT sector. Specifically, it compares three policy options: expedited debt reduction, redistribution through transfers, and increased public investment. Each policy targets a different fiscal objective: debt stabilization, fiscal redistribution, and growth. The analysis assumes that, starting in 2022, the government will continue its current expenditure policy while the economy navigates commodity price shocks and supply chain disruptions. Additionally, it is projected that the HT sector will expand by 0.5 pp of GDP in 2022 and 0.7 pp in 2023. This expansion is expected to generate additional government revenues of approximately 2.9 pp of GDP in 2022 and 1.3 pp in 2023.

The model-based analysis indicates that all three policies can contribute to accelerating the convergence of GDP to its pre-pandemic trend, reducing public debt-to-GDP ratios, and providing some positive redistributional effects. As anticipated, the expedited debt reduction policy has the most significant impact on debt levels, with public debt-to-GDP ratios returning to pre-pandemic levels by 2023. Meanwhile, the transfer redistribution approach offers the greatest protection to the most vulnerable population; for instance, consumption among LIQ households increases by nearly 11 percent in 2022 and 4 percent in 2023, relative to its trend. Additionally, the increased public investment policy facilitates a quicker recovery of GDP, closing the gap from its trend within a couple of years. Perhaps less expected is the finding that all policies achieve their objectives at the cost of further real exchange rate appreciation—an additional appreciation of between 8.2 and 10.5 percent in 2022, relative to the trend—, raising concerns about competitiveness, particularly for the non-HT sector.

The findings indicate that, among the three policies, bolstering public investment is the most favorable approach. This strategy accelerates the GDP's return to its long-term trajectory, reduces public debt-to-GDP ratios, mitigates real appreciation, and thereby lessens the impact on the competitiveness of the non-HT sector, while also offering some protection to the most disadvantaged consumers. Beyond this, the comparative analysis illustrates how the ISM captures key intricacies of the Israeli economy and serves as a useful tool for the MOF in conducting scenario-based policy analysis.

The paper is organized as follows. Section 2 provides an overview of the Israeli economy along with key stylized facts and briefly discusses the fiscal policy framework. Section 3 describes the structure of the ISM, while Section 4 discusses the model calibration. Section 5 illustrates the use of the model for policy scenario analysis. Finally, Section 6 presents some concluding remarks.

# 2 Macroeconomic Stylized Facts and Fiscal Policy

This Section provides a review of the macroeconomic landscape and the fundamental structural features of the Israeli economy, with an emphasis on the elements incorporated into the ISM. The first Subsection offers a concise examination of the long-standing macroeconomic trends and structural characteristics of the Israeli economy, which play a critical role in shaping the ISM. Additionally, it presents a historical backdrop, highlighting significant macroeconomic events that have greatly influenced the evolution of the HT sector. Furthermore, it explores recent economic developments, particularly those arising during the COVID-19 pandemic, alongside an analysis of sectors comprising skilled and unskilled labor.

The second Subsection examines the fiscal and monetary policy landscape in Israel, outlining the strategies adopted to achieve medium-term goals. It discusses the fiscal architecture, detailing the various types of debt, deficits, taxation mechanisms, and expenditure patterns, while also providing a concise summary of the monetary policy framework. This comprehensive overview aims to illuminate the intricate policy environment within which the Israeli economy operates. Together, these Subsections provide foundations for the fiscal scenario analysis presented below, using the ISM.

## 2.1 Some Stylized Facts

After gaining independence in 1948, Israel faced significant challenges, including the consequences of the independence war, integrating a large population, and accepting refugees, which resulted in high unemployment and low foreign currency reserves. In response, the government implemented austerity measures, such as rationing food and household goods, lasting until 1959. The economy started to recover in 1952 with a reparations agreement from West Germany, leading to annual growth rates exceeding 10 percent in the following decade, alongside rising expenditure among wage-earning families and increased per capita consumption. However, growth stalled in the 1970s after the *Yom Kippur War* in 1973 and the banking crisis in 1983, resulting in hyperinflation that peaked at nearly 450 percent. The government's successful economic stabilization plan not only revitalized the economy but also served as a model for other nations. In the 1990s, the economy transformed further due to waves of Jewish immigration from the former Soviet Union, bringing over one million educated individuals into the HT sector, and a favorable economic environment created by the peace process initiated in 1991, including the *Oslo Accords* and a peace treaty with Jordan.

In the early 2000s, the Israeli economy experienced a downturn due to two significant events: the burst of the global *dot-com* bubble, which led to the bankruptcy of many startups, and the *Second Intifada*, resulting in increased security costs, decreased investment and tourism, and rising unemployment. However, Israel began to recover in 2002 by tapping into new export markets, particularly in the rapidly growing East Asian region. This recovery was fueled by a resurgence in the HT sector, a gradual rebound from the *dot-com* crash, and a rising demand for computer software. Furthermore, the increased need for security and defense products after the *September 11 attacks* allowed Israel to export its technologies effectively. The financial sector's limited exposure to high-risk foreign assets helped the economy withstand the global financial crisis of 2007-2008. By 2009, Israel achieved positive real GDP growth and concluded the decade with a low unemployment rate. Over the 2010-2019 period, the Israeli economy demonstrated strong growth, stable inflation, low public debt, and a gradual decrease in unemployment compared to OECD averages (Table 1).

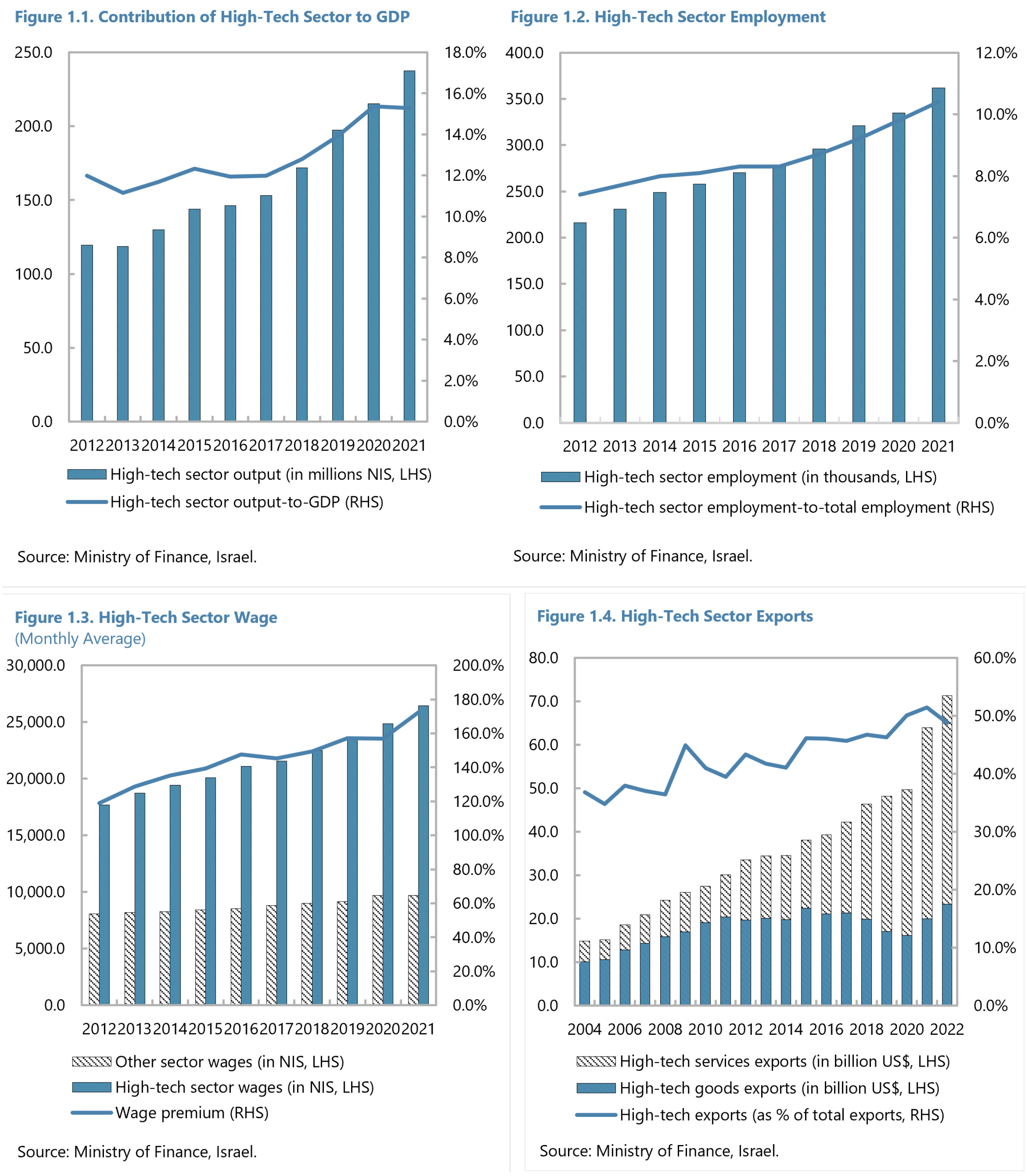
**Table 1: Israel's Macroeconomic Indicators**

| Indicator | Value (in percent) | Remarks |
|---|---|---|
| GDP potential growth | 3.8 | |
| GDP growth (in constant prices) | 4.2 | Average 2010-2019 |
| Inflation target | 2.0 | Between 1-3 percent |
| Inflation rate | 1.1 | Average 2010-2019 |
| Unemployment rate | 5.6 | Average 2010-2019, 2019 level: 3.8 percent |
| Debt-to-GDP target | 60.0 | 58.9 percent in 2019 |
| Private consumption-to-GDP | 53.46 | Average 2010-2019 |
| Export-to-GDP | 31.81 | Average 2010-2019 |
| Import-to-GDP | 30.34 | Average 2010-2019 |
| Government current expenditure-to-GDP | 19.0 | Average 2010-2019 |
| Government capital expenditure-to-GDP | 2.0 | Average 2010-2019 |
| Government financial transfer to household-to-GDP | 9.9 | Average 2010-2019 |
| Government consumption tax-to-GDP | 7.26 | Average 2010-2019 |
| Government labor income tax-to-GDP | 4.58 | Average 2010-2019 |
| Government non-tax revenues-to-GDP | 2.66 | Average 2010-2019 |

Source: Ministry of Finance, Israel.

The robust growth of the Israeli economy from 2010 to 2019 can be largely attributed to the increasingly dominant HT sector (Figure 1). By 2021, this sector represented approximately 15 percent of GDP and employed around 10 percent of the total workforce. The HT sector has experienced significant transformation, shifting its production focus from goods to services. Its transformation has also spurred rapid export growth, with HT exports accounting for over 50 percent of Israel's total exports in 2021. The high demand for HT workers has driven wages upward, creating a wage gap compared to other sectors. This gap has continued to widen in tandem with the HT sector's expanding share of the economy.

**Figure 1: High-Tech Sector Developments in Israel**

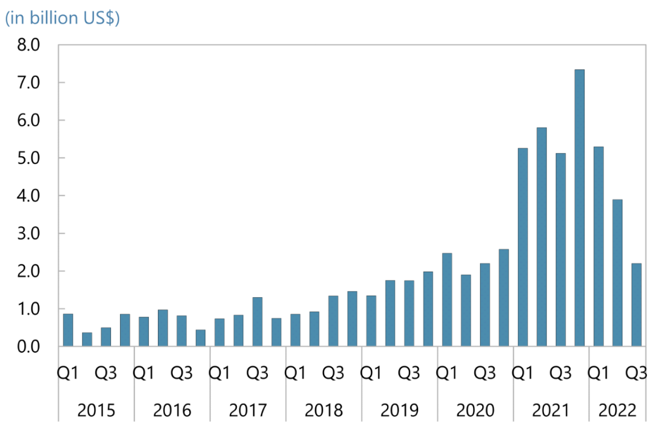



In 2020, the global COVID-19 pandemic severely affected the world economy, causing widespread lockdowns and disruptions in international travel and shipments. Israel responded with two lockdowns, one in 2020 and another in early 2021, which restricted economic activity. The Bank of Israel faced challenges in implementing effective monetary interventions due to the already low interest rate of 0.25 percent, resorting to limited quantitative easing measures. The Israeli government, on the other hand, significantly increased expenditures and introduced an economic aid plan aimed at supporting workers, households, health services, and businesses. Consequently, government debt rose to 70.6 percent of GDP in 2021, up from 58.9 percent in 2020.

While many sectors experienced a significant decline in activity, the HT sector quickly adapted to the changing circumstances and remained at full capacity, increasing both employment and exports. The strong performance of the HT sector played a crucial role in mitigating the devastating economic effects of the COVID-19 restrictions and preventing a recession. In fact, real GDP grew by 8.1 percent year-on-year in 2021. As COVID-19 vaccines became widely available to Israeli households, the government began lifting restrictions, promoting a recovery in the labor market across most non-HT sectors, though some, like tourism, continued to struggle. By 2021, many sectors had approached pre-pandemic employment levels.

Following its resilience during the peak of the pandemic in 2020, the HT sector reached an all-time high in venture capital (VC) investments in 2021, resuming a robust growth trajectory akin to pre-pandemic levels (see Figure 2). This significant increase in VC investments bolstered tax revenues, particularly in direct income taxes.[4] Additionally, consumption (indirect) taxes rebounded to pre-pandemic levels, reflecting the swift recovery of the Israeli economy from the effects of the COVID-19 crisis.

**Figure 2: Increase in Venture Capital Investments**



Source: Ministry of Finance, Israel.

[4]Most venture capital investment flows almost immediately and directly into wages, thereby increasing income tax revenues. By contrast, corporate tax revenues materialize only at much later stages.

## 2.2 The Policy Framework

The recent history of Israeli fiscal policy has been significantly influenced by the hyperinflation crisis of the 1980s, which marked a turning point in the country's transition from a closed and centralized economy to an open and liberalized one. After experiencing years of soaring inflation rates ranging from 100 to 500 percent, primarily due to unchecked growth in public expenditures, the Israeli government implemented an economic stabilization plan in 1985. This plan involved collaboration between various key stakeholders, including the government, central bank, and labor unions, who undertook several measures to address the crisis. These measures included significant reductions in government expenditures and deficit, as well as measures to prevent the central bank from monetizing government debt.

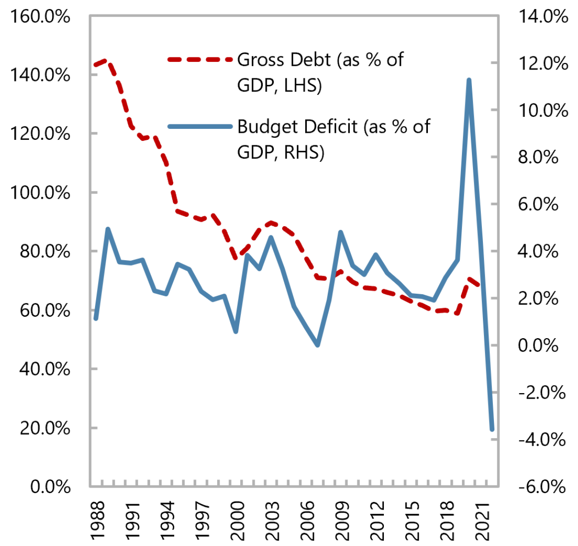
Over the years, a series of fiscal rules has been established to maintain the stability of the Israeli economy. In 1992, the *Target Deficit Rule* was legislated, setting a maximum limit on the fiscal deficit as a percentage of GDP. This was followed in 2004 by the implementation of the *Expenditure Rule*, which imposed restrictions on the growth of government expenditure. Under this rule, the growth of government expenditure is tied to GDP growth and deviations from the debt target, rather than being linked to income.

In 2017, a new fiscal rule called the *Numerator* was introduced, which restricts the accumulation of future liabilities that do not align with the other fiscal rules. The *Numerator* mandates the government to publish a planned budget for the next three years, including government expenditures, twice a year. The primary objective of this rule is to ensure fiscal responsibility. When the government intends to pass a new law that carries fiscal liabilities for future years, it must fit within the planned budget for the upcoming three years. If it exceeds the anticipated budget, the government is required to reduce other expenditures to ensure compliance with the planned budget.

The *Target Deficit Rule*, *Expenditure Rule*, and *Numerator* were implemented to help the economy achieve its debt target of 60 percent of GDP, a key objective of the 1985 economic stabilization plan. Figure 3 provides a historical perspective on fiscal sector developments in Israel. From the 1990s to 2020, the deficit fluctuated between 0 and 5 percent of GDP. Despite occasional breaches of the *Target Deficit Rule*, debt levels consistently declined during this period, falling from 143 percent of GDP in 1988 to 58.9 percent in 2019.

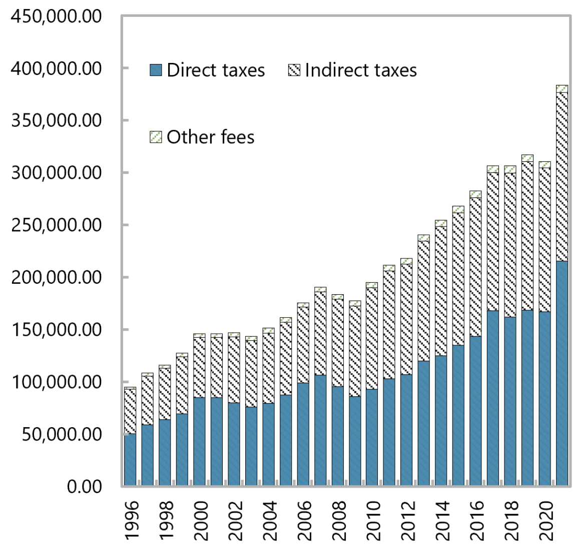
## Figure 3: Fiscal Sector Developments in Israel

**Figure 3.1. Government Debt and Deficit**
(as percent of GDP)



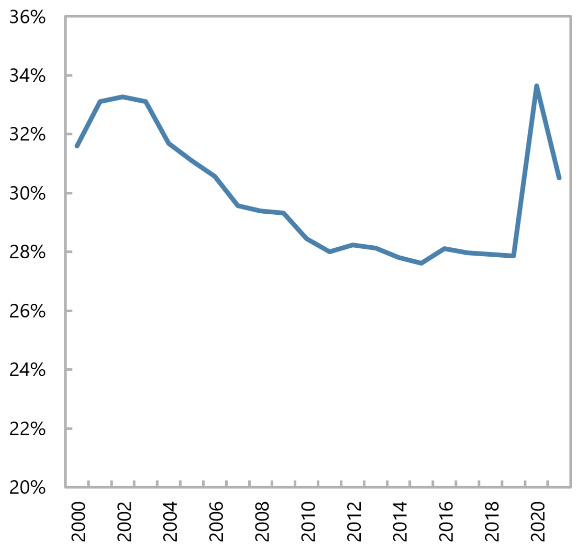

Source: Ministry of Finance, Israel.

**Figure 3.2. Total Revenue**
(in million NIS)



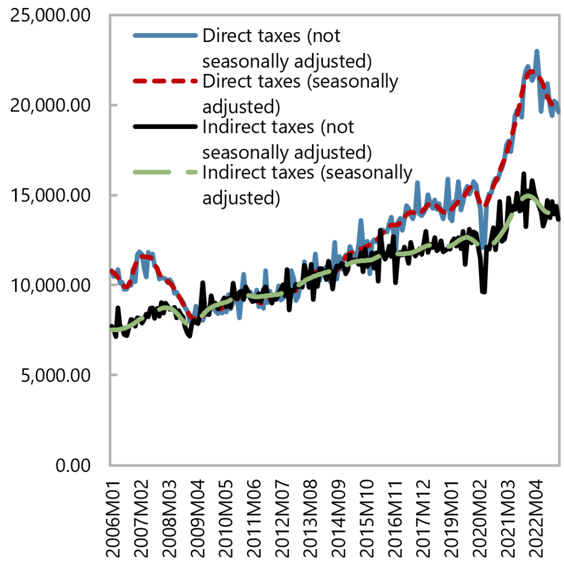

Source: Ministry of Finance, Israel.

**Figure 3.3. Government Expenditure**
(as percent of GDP)




Source: Ministry of Finance, Israel.

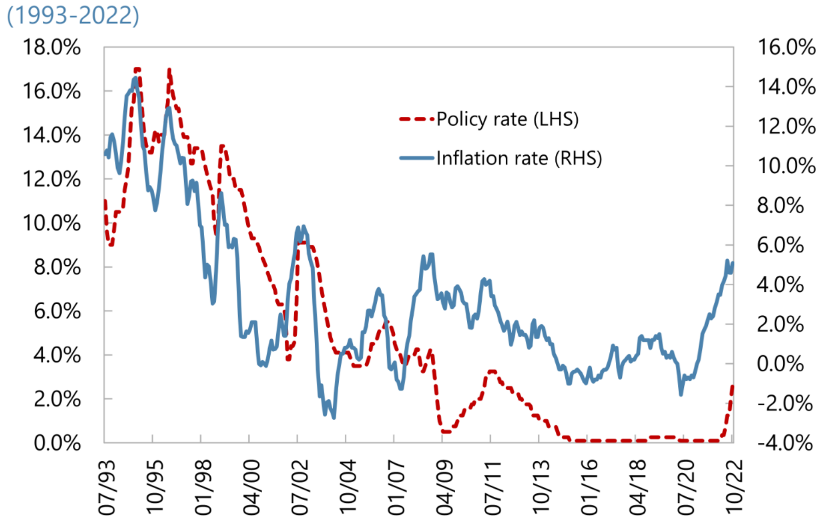
**Figure 3.4. Tax Revenue**
(in million NIS)




Source: Ministry of Finance, Israel.

In 2020, Israel, like many countries, experienced a significant rise in deficit and debt levels due to the COVID-19 pandemic. However, through the implementation of restrained fiscal policies and unexpected revenues from the thriving HT sector, both the deficit and debt levels declined. The deficit fell from 11.3 percent of GDP in 2020 to 4.4 percent in 2021, while gross debt decreased from 70.6 percent of GDP to 68 percent.

**Figure 4: Inflation and Monetary Policy in Israel**

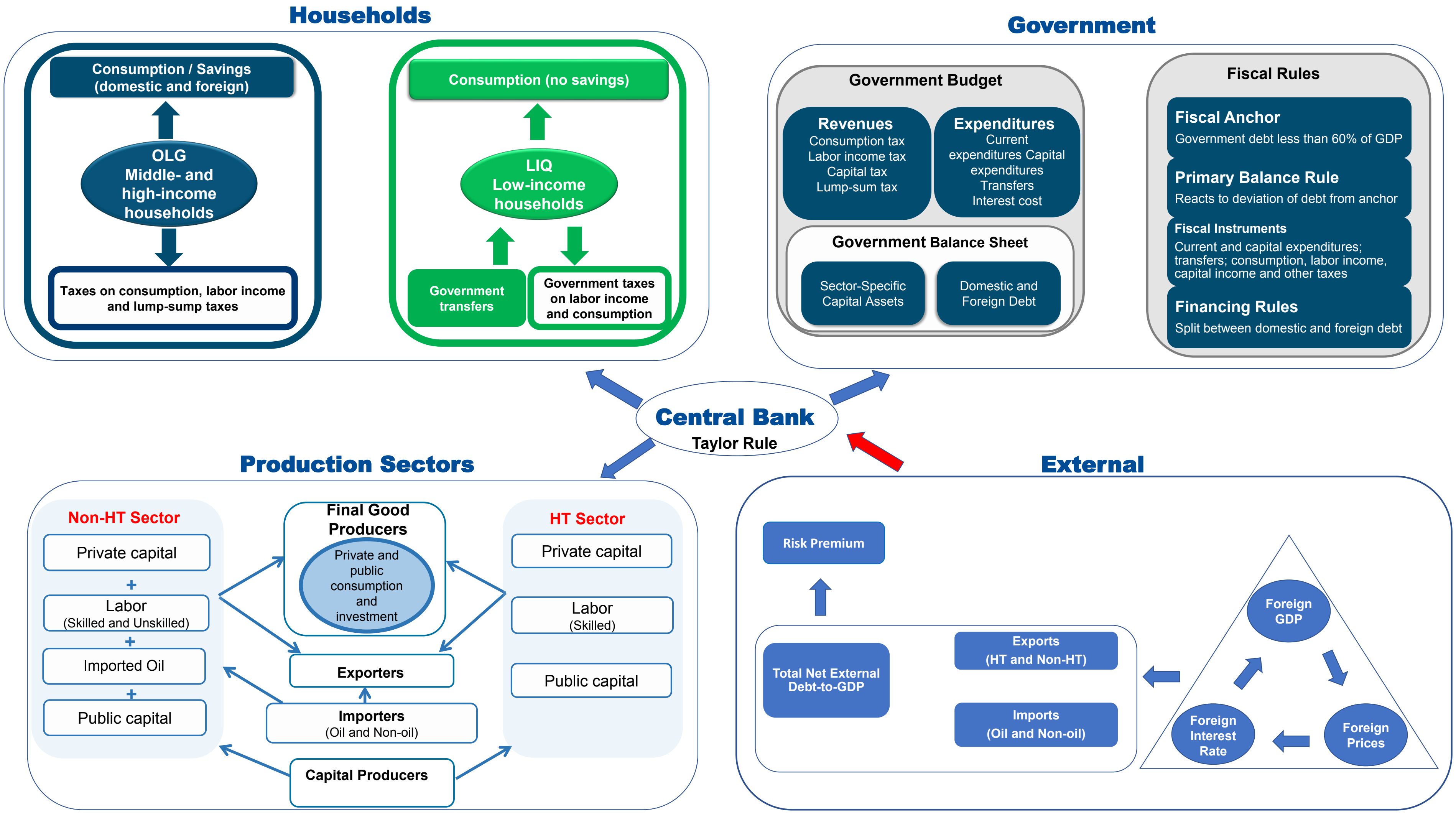



Source: Bank of Israel

Focusing on the components of the deficit, total tax revenues in Israel reached 24.3 percent of GDP in 2021, up from 21.9 percent in 2020. Direct taxes comprised 56.2 percent of total revenues, while indirect taxes accounted for 42.0 percent, with the remaining revenue generated from fees. From 1996 to 2019, tax revenues grew by an average of 3.3 percent in real terms. Although revenues experienced a modest decline of 1.5 percent in 2020, there was an impressive rebound in 2021, with a growth rate of 21.7 percent, coinciding with a GDP growth rate of 8.6 percent. In the first half of 2022, tax revenues remained high, exceeding projections and significantly surpassing the trend line, primarily due to strong growth in the HT sector.

Turning to expenditures, Israeli GDP was negatively impacted by the *Second Intifada* and the *dot-com* crisis, leading to increased spending in 2001. However, from 2004 to 2019, government expenditure gradually declined, stabilizing around 28 percent of GDP. In 2020, government spending surged due to the COVID-19 pandemic but declined in 2021 following a reduction in pandemic-related expenditures. This trend is expected to continue in the near future. In the 2022 budget, allocations included 43.1 percent for social services, 20.1 percent for security, and 13.1 percent for debt payments, with 4.1 percent for principal and 9.1 percent for interest.

Figure 5: The ISM Structure




Source: Authors

In terms of monetary policy, the Bank of Israel (BOI) has practiced inflation targeting since the early 1990s. During this period, inflation rates began to decline, reaching approximately 10 percent by 1996 (Figure 4). In response, the BOI gradually reduced interest rates to stimulate economic growth and investment. However, the early 2000s brought challenges, including the *Second Intifada* and the burst of the *dot-com* bubble, which created inflationary pressures. The BOI successfully contained these pressures, and by 2003, inflation was reduced to below 1 percent. Consequently, interest rates were significantly lowered, with the BOI decreasing the benchmark rate from around 8 percent in the early 2000s to as low as 0.25 percent by 2015. This policy aimed to support economic recovery while maintaining inflation within the target range of 1-3 percent. The COVID-19 pandemic in 2020 triggered new inflationary pressures in Israel. By January 2022, inflation had surpassed the BOI's inflation target range, prompting an increase in the interest rate to 0.35 percent during the April policy meeting. As inflation continued to escalate, reaching 5.1 percent in October 2022, the BOI adopted a tightening policy, raising the policy rate to 3.25 percent through six separate monetary policy decisions.

# 3 The Structure of the ISM

The ISM is an open-economy DSGE model that captures selected heterogeneous characteristics of the Israeli economy and is specifically designed for policy scenario analysis. It can be characterized as a New Keynesian small-open economy model, featuring two types of households—OLG and LIQ consumers—each with distinct saving patterns and labor skills, as well as two productive sectors: the HT sector and the non-HT sector.

More specifically, the ISM consists of four high-level blocks: (i) the household block, (ii) the production block, which includes non-HT firms, HT firms, physical capital producers, importers, exporters, and retailers (final good producers), (iii) the policy block, encompassing the MOF and the BOI, and (iv) the rest of the world block. Exogenous long-term growth in the model is driven by increases in productivity and population. Figure 5 provides a graphical description of the main blocks of the model.

## 3.1 Growth Trend

In the ISM, balanced growth has two components: productivity growth, denoted by $g_t^A$, and population growth, represented as $g_t^N$. Both components are exogenous and together determine the trend growth $g_t$:

$$1 + g_t = (1 + g_t^N)(1 + g_t^A). \tag{1}$$

For simplicity, we assume that $g_t^N = g^N$ and $g_t^A = g^A$. To ensure stationarity, variables in the model will be rescaled by the factor $(1 + g)^t$.

Next, we will describe the behavior of all the agents in each of the blocks of the ISM.

## 3.2 Household Sector

The ISM includes two types of households: a mass of $\psi$ of OLG consumers and a mass $1-\psi$ of LIQ consumers. Both types of households face a constant probability of dying $\omega$. OLG households represent middle and higher-income groups, while LIQ households consist of lower-income individuals. These households exhibit different saving patterns and labor skills, reflecting existing income disparities in Israel. OLG households provide skilled labor to HT and non-HT firms, whereas LIQ households supply unskilled labor exclusively to non-HT firms. This structure facilitates the analysis of income redistribution policies and their effects on the economy.

### 3.2.1 OLG Households

The OLG households have a finite planning horizon, creating a distinction between individual and aggregate variables. To solve the households' optimization problems, we draw on the works of Blanchard (1985) and Yaari (1965). First, we derive the first-order conditions (FOCs) for an individual household along with its consumption function. Following this, we compute the aggregate consumption function.

In the model, each household faces a constant probability of surviving of $(1 - \omega)$ in each period, which can be calibrated to align with the average length of productive life in Israel. For an individual who is "$a$" years old, the objective is to maximize the following expected discounted lifetime utility, choosing both consumption and leisure:

$$\mathbb{E}_t \sum_{n=0}^{\infty} (1-\omega)^n \beta^n \left\{ \frac{e^{u_{t+n}^C}}{1-\gamma} \left[ \left( \frac{C_{a+n,t+n}^{OLG}}{\left(C_{t+n-1}^{OLG}\right)^h} \right)^{\sigma_{OLG}} \left(\mathcal{S}_{t+n}^{OLG} - L_{a+n,t+n}^{OLG}\right)^{1-\sigma_{OLG}} \right]^{1-\gamma} \right\}, \tag{2}$$

where $\beta$ is the discount rate, $h$ is external habit formation parameter, $e^{u_t^C}$ is a demand shock, $C_{a,t}^{OLG}$ denotes individual consumption, $C_t^{OLG}$ is average consumption for OLG households, $\mathcal{S}_t^{OLG}$ is the total time endowment of the household, $L_{a,t}^{OLG}$ is skilled labor supply, $\gamma$ is the risk aversion parameter, and $\sigma_{OLG}$ is the weight of consumption in the utility function.

OLG households face the following budget constraint in period $t$, which ensures that their total expenditure on goods and the net accumulation of financial assets are equal to their disposable income:

$$\begin{aligned}(1+\tau_t^C)P_t^C C_{a,t}^{OLG} + (1-\omega)(B_{a,t} + S_t B_{a,t}^*) + T_{a,t} = (1-\tau_t^{L,OLG})W_t^{OLG,r}L_{a,t}^{OLG} + \mathfrak{pr}_{a,t} \\ + (1+i_{t-1})B_{a-1,t-1} \\ + (1+i_{t-1}^*)(1+Prem_{t-1})S_t B_{a-1,t-1}^*. \quad (3)\end{aligned}$$

They allocate their income towards consumption paying the price $P_t^C$ along with a value-added tax at a rate of $\tau_t^C$. Furthermore, OLG households save in risk-free government domestic bonds $B_{a,t}$ and foreign currency-denominated bonds $B_{a,t}^*$, and pay lump-sum taxes $T_{a,t}$. They earn labor income, receiving a nominal reservation wage $W_t^{OLG,r}$, after deducting personal income tax at a rate of $\tau_t^{L,OLG}$. Additionally, they earn profits $\mathfrak{pr}_{a,t} = \int_0^1 Profit_{a,t}(j)dj$, as owners of all firms. OLG households also receive interest income from domestic savings $(1+i_{t-1})B_{a-1,t-1}$ at the domestic interest rate $i_{t-1}$, and from foreign savings $(1+i_{t-1}^*)(1+Prem_{t-1})S_t B_{a-1,t-1}^*$ at the foreign interest rate $i_{t-1}^*$, where $S_t$ denotes the nominal exchange rate and $Prem_{t-1}$ represents the country-risk premium.

After deriving the first-order conditions of the optimization problem and aggregating across cohorts, OLG housholds' consumption can be represented as a Modigliani-type consumption function of permanent income $Inc_t$ and initial wealth:

$$(1+\tau_t^C)C_t^{OLG} = MPC_t\left(Inc_t + (1+r_{t-1})B_{t-1} + (1+r_{t-1}^*)REER_t B_{t-1}^*\right), \quad (4)$$

where $MPC_t$ is the marginal propensity to consume which is time variant and depends on deep parameters, the domestic real interest rate $r_t$, and other macro variables (Appendix A). $REER_t = \frac{S_t P_t^{C*}}{P_t^C}$ corresponds to the consumption-based real exchange rate and $r_t^*$ represents the foreign real interest rate.

The solution and cohort aggregation also yields the optimal intra-temporal condition:

$$\frac{C_t^{OLG}}{\psi \mathcal{S}_t - L_t^{OLG}} = \left(\frac{\sigma_{OLG}}{1-\sigma_{OLG}}\right)\left(\frac{1-\tau_t^{L,OLG}}{1+\tau_t^C}\right)w_t^{OLG,r}, \quad (5)$$

which equalizes the marginal rate of substitution between consumption and labor to the households real reservation wage $w_t^{OLG,r} = \frac{W_t^{OLG,r}}{P_t^C}$, accounting for tax distortions—this is an implicit representation of the OLG's labor supply.

Furthermore, by combining the first-order conditions, we can derive the uncovered interest parity (UIP) condition, which can be approximated—suppressing the expectations operator—as follows:

$$1 + i_t = (1 + i_t^*)(1 + Prem_t)\frac{S_{t+1}}{S_t}. \tag{6}$$

This condition precludes arbitrage opportunities by equalizing the return on domestic bonds to the return on foreign-currency denominated bonds adjusted for expectations of depreciation and the country-risk premium.

### 3.2.2 LIQ Households

The main characteristic of LIQ households is their inability to save or obtain credit. They make decisions regarding labor supply and consume all their disposable income in each period. They maximize the following expected lifetime utility derived from consumption and leisure:

$$\mathbb{E}_t \sum_{n=0}^{\infty} (1-\omega)^n \beta^n \left\{ \frac{e^{u_{t+n}^C}}{1-\gamma} \left[ \left( \frac{C_{a+n,t+n}^{LIQ}}{\left(C_{t+n-1}^{LIQ}\right)^h} \right)^{\sigma_{LIQ}} \left( \mathcal{S}_{t+n}^{LIQ} - L_{a+n,t+n}^{LIQ} \right)^{1-\sigma_{LIQ}} \right]^{1-\gamma} \right\}, \tag{7}$$

subject to the budget constraint:

$$(1 + \tau_t^C) C_{a,t}^{LIQ} = (1 - \tau_t^{L,LIQ}) w_t^{LIQ,r} L_{a,t}^{LIQ} + TR_{a,t}. \tag{8}$$

LIQ households earn their real disposable income from two sources: their after-tax earnings from wage income $(1 - \tau_t^{L,LIQ}) w_t^{LIQ,r} L_{a,t}^{LIQ}$—where $w_t^{LIQ,r}$ is their reservation wage—, and transfers from the government, $TR_{a,t}$. All of their income is allocated towards consumption $C_{a,t}^{LIQ}$.

For LIQ households, the budget constraint (8) can be used to aggregate across cohorts and derive their aggregate LIQ consumption. Moreover, the solution of the optimization problem yields the following intra-temporal optimal condition, after aggregation, which implicitly defines their labor supply:

$$\frac{C_t^{LIQ}}{(1-\psi)\mathcal{S}_t - L_t^{LIQ}} = \left(\frac{\sigma_{LIQ}}{1-\sigma_{LIQ}}\right)\left(\frac{1-\tau_t^{L,LIQ}}{1+\tau_t^C}\right) w_t^{LIQ,r}. \tag{9}$$

Note that for both types of households, the implicit labor supply curves establish a positive relationship between the labor supplied and their respective real reservation wages, while demonstrating a negative relationship with respect to their respective consumptions, thereby capturing wealth effects.

### 3.2.3 Real Wage Rigidity

The ISM also incorporates simple real wage rigidity dynamics by differentiating between wages paid by firms ($w^j$)—market wages—and reservation wages ($w^{j,r}$) set by households, where $j \in \{OLG; LIQ\}$. In each period, market wages adjust according to the following process:

$$\log\left(w_t^j\right) = \rho^{w,j} \log\left[w_{t-1}^j(1+g_t^A)\right] + (1-\rho^{w,j}) \log\left(w_t^{j,r}\right), \tag{10}$$

where lagged log wages are adjusted for productivity growth ($g_t^A$) and $\rho^{w,j}$ represents the degree of persistence in wage dynamics.

## 3.3 Production Sector

The production side consists of physical capital producers, HT firms, non-HT firms, importers (oil and non-oil), exporters, and retailers.

### 3.3.1 Physical Capital Producers

Firms producing physical capital are owned by OLG households and supply sector-specific capital to both HT and non-HT firms. They create capital $K_{t-1}^j$ by investing the amount $Inv_t^j$ according to the following technology:

$$K_t^j = (1-\delta)K_{t-1}^j + Inv_t^j[1 - S_j(\cdot)], \tag{11}$$

where $j \in \{H; N\}$, $\delta$ is the depreciation rate, and $S(\cdot)$ corresponds to investment adjustment costs:

$$S_j(\cdot) = S\left(\frac{Inv_t^j}{Inv_{t-1}^j}\right) = \frac{\phi_{Inv^j}}{2}\left[(1+\xi_t^{Inv^j})\frac{Inv_t^j}{Inv_{t-1}^j} - 1\right]^2, \tag{12}$$

with the parameter $\phi_{Inv^j}$ affecting the degree of these costs, which are also subject to stochastic shocks $\xi_t^{Inv^j}$.

Capital producers operate in a perfect competition environment with flexible prices. Their objective is to maximize their profits subject to the technology constraint (11). They derive profits from revenues of renting capital $R_t^{K,j} K_{t-1}^j$, at the rate $R_t^{K,j}$, subtracting the cost of investment goods $P_t^{Inv,j} Inv_t^j \left[1 + S_j(\cdot)\right]$, priced at $P_t^{Inv,j}$.

Solving the capital producers' optimization problem yields the following investment functions for $j \in \{H; N\}$:

$$\frac{Q_t^j}{(1-\tau_t^K)P_t^{Inv,j}} = 1 + S_j\left(\frac{Inv_t^j}{Inv_{t-1}^j}\right) + S_j'\left(\frac{Inv_t^j}{Inv_{t-1}^j}\right)\frac{Inv_t^j}{Inv_{t-1}^j} - \frac{1-\omega}{1+i_t}\mathbb{E}_t\left(\frac{1-\tau_{t+1}^K}{1-\tau_t^K}\right)\left(\frac{P_{t+1}^{Inv,}}{P_t^{Inv,j}}\right) S_j'\left(\frac{Inv_{t+1}^j}{Inv_t^j}\right)\left(\frac{Inv_{t+1}^j}{Inv_t^j}\right)^2, \quad (13)$$

where $Q_t^j$ corresponds to Tobin's $Q$, $S_j'(\cdot)$ denotes the derivative of the adjustment costs function, and $\tau_t^K$ is the capital gains tax. The solution also provides the following non-arbitrage condition:

$$1 + i_t = \mathbb{E}_t \frac{1-\omega}{Q_t^j}\left[(1-\tau_{t+1}^K)R_{t+1}^{K,j} + Q_{t+1}^j(1-\delta)\right], \quad (14)$$

which equalizes the return on domestic bonds to the return on investing in capital.

### 3.3.2 Non-High-Tech (non-HT) Intermediate Firms

The representative non-HT firm produces goods for both domestic and external markets, working in a monopolistically competitive environment. As a result, the firm has pricing power and can charge prices above marginal cost, generating positive profits in the short run. In this environment, the representative firm faces a downward-sloping Dixit-Stiglitz demand for their output $Y_t^N(i)$, capturing the fact that the firm produces differentiated products that are imperfect substitutes:

$$Y_t^N(i) = \left(\frac{P_t^N(i)}{P_t^N}\right)^{-\varphi_N} Y_t^N, \quad (15)$$

where $Y_t^N$ is the aggregate demand for the intermediate good $i$, $P_t^N(i)$ is the price the firm sets, and $P_t^N$ is the aggregate price level. Additionally, $\varphi_N$ is the price demand elasticity where a higher value indicates a higher degree of substitutability between products.

Non-HT firms also face nominal price rigidities following Rotemberg (1982):

$$R_N(\cdot) = R\left(\frac{P_t^N(i)}{P_{t-1}^N(i)}\right) = \frac{\phi_{P^N}}{2}\left[\frac{P_t^N(i)}{P_{t-1}^N(i)(1+\pi_t^{tar})\left(1+\hat{\pi}_{t-1}^N\right)^{\vartheta_N}} - 1\right]^2 \tag{16}$$

where $\phi_{P^N}$ represents the adjustment cost parameter, $\vartheta_N$ indicates the degree of inflation indexation, $\pi_t^{tar}$ denotes the inflation target, and $1+\hat{\pi}_t^N = \frac{1+\pi_t^N}{1+\pi_t^{tar}}$. When $\vartheta_N = 0$, there is no inflation indexation. On the other hand, when $\vartheta_N = 1$, there is full indexation.

Furthermore, we assume real adjustment costs for labor[5] and oil imports. These adjustment costs ensure that firms cannot easily change or substitute labor and imported oil inputs. For instance, for skilled labor these costs can be described as:

$$H_{OLG,N}(\cdot) = H\left(\frac{L_t(i)^{OLG,N}}{L_{t-1}(i)^{OLG,N}}\right) = \frac{\phi_{L^{OLG,N}}}{2}\left((1+g_t^N)\frac{L_t^{OLG,N}(i)}{L_{t-1}^{OLG,N}(i)} - 1\right)^2, \tag{17}$$

where $\phi_{L^{OLG,N}}$ represents the adjustment cost parameter. There are similar adjustment costs for unskilled labor, $H_{LN}(\cdot)$. Likewise for oil imports:

$$G(\cdot) = G\left(\frac{M_t^{Oil,N}(i)}{M_{t-1}^{Oil}(i)}\right) = \frac{\phi_{M^{Oil,N}}}{2}\left((1+g_t)\frac{M_t^{Oil,N}(i)}{M_{t-1}^{Oil,N}(i)} - 1\right)^2, \tag{18}$$

where $\phi_{M^{N,Oil}}$ corresponds to the adjustment cost parameter.

The production process of non-HT firms involves a CES production function with multiple levels. At the first level, the non-oil component of production, $Y_t^{Noil}(i)$, is combined with imports of oil, $M_t^{N,Oil}(i)$, with public capital, $K_{t-1}^{Gov}$, acting as a shifter:[6]

$$Y_t^N(i) = \left(\frac{K_{t-1}^{Gov}}{\bar{K}_{t-1}^{Gov}}\right)^{\alpha_{G,N}}\left[\mu_N^{\frac{1}{\xi}} Y_t^{Noil}(i)^{\frac{\xi-1}{\xi}} + (1-\mu_N)^{\frac{1}{\xi}} M_t^{N,Oil}(i)^{\frac{\xi-1}{\xi}}\right]^{\frac{\xi}{\xi-1}}, \tag{19}$$

where $\bar{K}_{t-1}^{Gov}$ represents the average level of public capital, $\alpha_{G,N}$ is the output elasticity of non-HT firms with respect public capital, $\xi$ is the elasticity of substitution between

[5]The purpose of introducing labor adjustment costs is not related to labor market participation or the hiring and recruitment process, which would require a more detailed labor market structure, such as a labor-search model. Instead, this cost is intended to limit rapid sectoral reallocation as in reality.

[6]Public capital is added as a shifter in the production function of DSGE models because it enhances the productivity of private capital, influences overall economic performance, and allows for effective policy analysis regarding fiscal interventions. By considering public capital as a shifter, DSGE models can better reflect the complexities of real-world economies and the role of government in influencing economic activity.

domestic non-oil and imported oil inputs, and $\mu_Y$ is the share of the domestic non-oil production input.[7]

At the second level, unskilled labor, $L_t^{LIQ,N}(i)$, is combined with an aggregate input, $Z_t(i)$, to produce the non-oil component. At the third level, this aggregate input is produced by mixing sector-specific capital, $K_{t-1}^N(i)$, and skilled labor, $L_t^{OLG,N}(i)$. This production structure is calibrated to capture capital-skill complementarity, indicating substitutability between capital and low-skill labor and complementarity between capital and high-skill labor.[8] Formally:

$$Y_t^{Noil}(i) = \left[\theta^{\frac{1}{\varrho}} Z_t(i)^{\frac{(\varrho-1)}{\varrho}} + (1-\theta)^{\frac{1}{\varrho}} \left(A_t^{LIQ} L_t^{LIQ}(i)\right)^{\frac{\varrho-1}{\varrho}}\right]^{\frac{\varrho}{\varrho-1}}, \tag{20}$$

with

$$Z_t(i) = \left[\alpha_N{}^{\frac{1}{\kappa_N}} K_{t-1}^N(i)^{\frac{\kappa_N-1}{\kappa_N}} + (1-\alpha_N)^{\frac{1}{\kappa_N}} \left(A_t^{OLG,N} L_t^{OLG,N}(i)\right)^{\frac{\kappa_N-1}{\kappa_N}}\right]^{\frac{\kappa_N}{\kappa_N-1}}, \tag{21}$$

where $\alpha_N$ represents the share of private capital in the non-oil component of production input, $\theta$ denotes the share of skilled labor and private capital in the non-oil domestic input, and $A^j$ represents the labor-augmenting technology, where $j \in \{OLG, N; LIQ\}$. Meanwhile, $\kappa_N$ is the elasticity of substitution between private capital and skilled labor, and $\varrho$ indicates the elasticity of substitution between non-skilled labor and the combined share of private capital and skilled labor in the non-oil production inputs. These two elasticities are used to calibrate the wage-premium following Krusell et al. (2000).

The representative non-HT firm is a profit maximizer. The solution to her problem, suppressing the reference to each variety $i$, yields optimal conditions that can be combined to derive the following equilibrium conditions. The marginal costs:

$$mc_t^N = \left(\frac{K_{t-1}^G}{\bar{K}_{t-1}^G}\right)^{-\alpha_{G,N}} \left[\mu_N \left(mc_t^{Noil}\right)^{1-\xi} + (1-\mu_N)\left(p_t^{Oil}\right)^{1-\xi}\right]^{\frac{1}{1-\xi}}, \tag{22}$$

[7]Note also that although the ISM is not specifically designed to capture Dutch disease effects, it can reflect real appreciation pressures stemming from booms in the high-tech (HT) sector, which may adversely impact the non-HT sector. Dutch disease dynamics could be incorporated by following the approach of Melina, Yang and Zanna (2016) in the IMF's DIGNAR model, as applied to Israel in Mineshima and Nguyen (2018).

[8]Krusell et al. (2000) explains that high-skilled labor is complementary to capital due to its ability to effectively utilize advanced technologies, while low-skilled labor is more substitutable with capital, as low-skilled tasks can often be automated.

with

$$mc_t^{Noil} = \left[\theta\left(p_t^Z\right)^{1-\varrho} + (1-\theta)\left(\frac{\hat{w}_t^{LIQ}}{A_t^{LIQ}}\right)^{1-\varrho}\right]^{\frac{1}{1-\varrho}}, \tag{23}$$

and

$$p_t^Z = \left[\alpha_N\left(r_t^{K,N}\right)^{1-\kappa_N} + (1-\alpha_N)\left(\frac{\hat{w}_t^{OLG,N}}{A_t^{OLG,N}}\right)^{1-\kappa_N}\right]^{\frac{1}{1-\kappa_N}}, \tag{24}$$

where $mc_t^N = \frac{MC_t^N}{P_t^C}$ represents the marginal cost of non-HT production relative to the consumption goods price, and $\hat{w}_t^j$ is the effective labor cost described by

$$\hat{w}_t^j = w_t^{OLG}\left[1 + H_j\left(\frac{L_t^j}{L_{t-1}^j}\right) + H_j'\left(\frac{L_t^j}{L_{t-1}^j}\right)\frac{L_t^j}{L_{t-1}^j}\right] - \mathbb{E}_t\frac{w_{t+1}^{OLG}}{1+r_t}H_j'\left(\frac{L_{t+1}^j}{L_t^j}\right)\left(\frac{L_{t+1}^j}{L_t^j}\right)^2, \tag{25}$$

for $j \in \{OLG, N; LIQ\}$. The demand functions for sector-specific capital, skilled labor, the aggregate input ($Z_t$), unskilled labor, the non-oil component, and oil imports:

$$K_{t-1}^N = \alpha_N\left(\frac{p_t^Z}{r_t^{K,N}}\right)^{\kappa_N} Z_t, \tag{26}$$

$$L_t^{OLG,N} = (1-\alpha_N)\left(\frac{p_t^Z}{\hat{w}_t^{OLG,N}}\right)^{\kappa_N}\left(A_t^{OLG,N}\right)^{\kappa_N-1} Z_t, \tag{27}$$

$$Z_t = \theta\left(\frac{mc_t^{Noil}}{p_t^Z}\right)^{\varrho} Y_t^{Noil}, \tag{28}$$

$$L_t^{LIQ} = (1-\theta)\left(\frac{mc_t^{Noil}}{\hat{w}_t^{LIQ}}\right)^{\varrho}\left(A_t^{LIQ}\right)^{\varrho-1} Y_t^{Noil}, \tag{29}$$

$$Y_t^{Noil} = \mu_N\left(\frac{mc_t^N}{mc_t^{Noil}}\right)^{\xi}\left(\frac{K_{t-1}^G}{\bar{K}_{t-1}^G}\right)^{\alpha_{G,N}(\xi-1)} Y_t^N, \tag{30}$$

$$M_t^{Oil,N} = (1-\mu_N)\left(\frac{mc_t^N}{\hat{p}_t^{Oil,N}}\right)^{\xi}\left(\frac{K_{t-1}^G}{\bar{K}_{t-1}^G}\right)^{\alpha_{G,N}(\xi-1)} Y_t^N, \tag{31}$$

where

$$\hat{p}_t^{Oil,N} = p_t^{Oil}\left[G\left(\frac{M_t^{Oil,N}}{M_{t-1}^{Oil,N}}\right) + G'\left(\frac{M_t^{Oil,N}}{M_{t-1}^{Oil,N}}\right)\frac{M_t^{Oil,N}}{M_{t-1}^{Oil,N}}\right] - \mathbb{E}_t\frac{p_{t+1}^{Oil}}{1+r_t}G'\left(\frac{M_{t+1}^{Oil,N}}{M_t^{Oil,N}}\right)\left(\frac{M_{t+1}^{Oil,N}}{M_t^{Oil,N}}\right)^2, \tag{32}$$

and $p_t^{Oil}$ represents the relative domestic oil price. And the New-Keynesian Phillips curve for the non-HT sector's inflation:

$$\left[\frac{1+\hat{\pi}_t^N}{(1+\hat{\pi}_{t-1}^N)^{\vartheta_N}}\right] R'\left(\frac{1+\hat{\pi}_t^N}{(1+\hat{\pi}_{t-1}^N)^{\vartheta_N}}\right) = \left(\frac{1-\omega}{1+r_t}\right)\mathbb{E}_t\Delta_{t+1}^N\left[\frac{1+\hat{\pi}_{t+1}^N}{(1+\hat{\pi}_t^N)^{\vartheta_N}}\right] R'\left(\frac{1+\hat{\pi}_{t+1}^N}{(1+\hat{\pi}_t^N)^{\vartheta_N}}\right)$$
$$+\varphi_N\left(\frac{mc_t^N}{p_t^N}-\frac{\varphi_N-1}{\varphi_N}\right), \tag{33}$$

where $\Delta_{t+1}^N = \left(\frac{p_{t+1}^N}{p_t^N}\right)\left(\frac{Y_{t+1}^N}{Y_t^N}\right)$ and $p_t^N = \frac{P_t^N}{P_t^C}$ represents the price of non-HT goods relative to the consumption goods price.

### 3.3.3 High-Tech (HT) Intermediate Firms

Unlike non-HT firms, the firms in the HT intermediate sector produce HT goods primarily for export and use only skilled labor, $L_t^{OLG,H}$, sector-specific capital, $K_{t-1}^H$, and public capital as production inputs. The production function for HT firms, suppressing the reference to each variety $i$, is described as follows:[9]

$$Y_t^H = \left(\frac{K_{t-1}^{Gov}}{\bar{K}_{t-1}^{Gov}}\right)^{\alpha_{G,H}}\left[\alpha_H^{\frac{1}{\kappa_H}} K_{t-1}^{H\,\frac{\kappa_H-1}{\kappa_H}} + (1-\alpha_H)^{\frac{1}{\kappa_H}}\left(A_t^{OLG,H}L_t^{OLG,H}\right)^{\frac{\kappa_H-1}{\kappa_H}}\right]^{\frac{\kappa_H}{\kappa_H-1}}, \tag{34}$$

where $\alpha_{G,H}$ represents the elasticity of production of HT firms with respect to public capital, $\alpha_H$ is the share of private capital in the HT production input, $\kappa_H$ denotes the elasticity of substitution between sector-specific private capital and skilled labor, and $A_t^{OLG,H}$ denotes labor productivity in the HT sector.

These firms operate under monopolistic competition and face nominal price rigidities, incurring similar quadratic costs, $R_H(\cdot)$, as described in equation (16). They also experience real adjustment costs for labor, $H_{OH}(\cdot)$, akin to those outlined in equation (17). The solution to the representative HT firm's problem yields optimal conditions that can be combined to derive the following equilibrium conditions. These conditions represent, respectively, the marginal cost function, the HT firms' demands for sector-specific capital and skilled labor, and the New-Keynesian Phillips curve for the HT sector's inflation:

$$mc_t^H = \left(\frac{K_{t-1}^{Gov}}{\bar{K}_{t-1}^{Gov}}\right)^{-\alpha_{G,H}}\left[\alpha_H\left(r_t^{K,H}\right)^{1-\kappa_H} + (1-\alpha_H)\left(\frac{\hat{w}_t^{OLG,H}}{A_t^{OLG,H}}\right)^{1-\kappa_H}\right]^{\frac{1}{1-\kappa_H}}, \tag{35}$$

$$K_{t-1}^H = \alpha_H\left(\frac{mc_t^H}{r_t^{K,H}}\right)^{\kappa_H}\left(\frac{K_{t-1}^{Gov}}{\bar{K}_{t-1}^{Gov}}\right)^{\alpha_{G,H}(\kappa_H-1)} Y_t^H, \tag{36}$$

[9]The HT sector in the model refers to all technology companies, including both manufacturing and services. See Figure 1.4 for the HT sector's contribution to Israel's total exports.

$$L_t^{OLG,H} = (1-\alpha_H)\left(\frac{mc_t^H}{\hat{w}_t^{OLG,H}}\right)^{\kappa_H}\left(\frac{K_{t-1}^{Gov}}{\bar{K}_{t-1}^{Gov}}\right)^{\alpha_{G,H}(\kappa_H-1)}\left(A_t^{OLG,H}\right)^{\kappa_H-1}Y_t^H, \tag{37}$$

and

$$\left[\frac{1+\hat{\pi}_t^H}{(1+\hat{\pi}_{t-1}^H)^{\vartheta_H}}\right]R'\left(\frac{1+\hat{\pi}_t^H}{(1+\hat{\pi}_{t-1}^H)^{\vartheta_H}}\right) = \left(\frac{1-\omega}{1+r_t}\right)\mathbb{E}_t\Delta_{t+1}^H\left[\frac{1+\hat{\pi}_{t+1}^H}{(1+\hat{\pi}_t^H)^{\vartheta_H}}\right]R'\left(\frac{1+\hat{\pi}_{t+1}^H}{(1+\hat{\pi}_t^H)^{\vartheta_H}}\right) + \varphi_H\left(\frac{mc_t^H}{p_t^H}-\frac{\varphi_H-1}{\varphi_H}\right), \tag{38}$$

where $\hat{w}_t^{OLG,H}$ is the effective labor cost, which has a similar representation to the one described by equation (25), $\Delta_{t+1}^H = \left(\frac{p_{t+1}^H}{p_t^H}\right)\left(\frac{Y_{t+1}^H}{Y_t^H}\right)$, $p_t^H = \frac{P_t^H}{P_t^C}$ represents the price of HT goods relative to the consumption goods price, $mc_t^H = \frac{MC_t^H}{P_t^C}$ represents the marginal cost of HT production relative to the consumption goods price, and $1+\hat{\pi}_t^H = \frac{1+\pi_t^H}{1+\pi_t^{tar}}$.

### 3.3.4 Oil Importers

Oil importers purchase oil from abroad and sell it domestically for production, while respecting the law of one price. For simplicity, we assume that the oil importers have no market power, and they transit the oil from the foreign economy to the domestic economy without any markup. The international oil price $P_t^{Oil,*}$ is given exogenously, and the importers convert it to the domestic currency price according to:

$$P_t^{Oil} = P_t^{Oil,*}S_t, \tag{39}$$

or in real (relative) terms:

$$p_t^{Oil} = p_t^{Oil,*}REER_t, \tag{40}$$

where $p_t^{Oil,*}$ represents the relative foreign oil price.

### 3.3.5 Non-Oil Importers

Non-oil importers engage in the purchase of non-oil imports from foreign countries, subsequently selling these goods to retailers. However, during this process, they encounter monopolistic competition and price rigidities, resulting in imperfect exchange rate pass-through. To model the behavior of these non-oil importers, we assume they operate within a monopolistic competition framework, where pricing decisions incorporate a quadratic cost function based on the work of Rotemberg (1982).

Non-oil importers maximize their profits and face the following non-oil imports demand function:

$$M_t(i) = \left(\frac{P_t^M(i)}{P_t^M}\right)^{-\varphi_M} M_t, \tag{41}$$

where $\varphi^M$ is the price elasticity of substitution.

The price adjustment cost for non-oil imports is given by:

$$R_M(\cdot) = R\left(\frac{P_t^M(i)}{P_{t-1}^M(i)}\right) = \frac{\phi_{P,M}}{2}\left[\frac{P_t^M(i)}{P_{t-1}^M(i)(1+\pi_t^{tar})\left(1+\hat{\pi}_{t-1}^M\right)^{\vartheta_M}} - 1\right]^2 \tag{42}$$

where $\phi_{P,M}$ represents the adjustment cost parameter, $P_t^M$ is the price of non-oil imports and $1+\hat{\pi}_{t-1}^M = \frac{1+\pi_{t-1}^M}{1+\pi_{t-1}^{tar}}$ represents the lagged deviation of non-oil import inflation from target. Additionally, $\vartheta_M$ corresponds to the inflation indexation parameter for non-oil imports inflation $\pi_t^M$.

The solution to the non-oil importers' problem yields the following equation, which captures imperfect exchange rate pass-through:

$$\begin{aligned}\left[\frac{1+\hat{\pi}_t^M}{(1+\hat{\pi}_{t-1}^H)^{\vartheta_M}}\right] R'\left(\frac{1+\hat{\pi}_t^M}{(1+\hat{\pi}_{t-1}^M)^{\vartheta_M}}\right) = \left(\frac{1-\omega}{1+r_t}\right)\mathbb{E}_t\Delta_{t+1}^M\left[\frac{1+\hat{\pi}_{t+1}^M}{(1+\hat{\pi}_t^M)^{\vartheta_M}}\right] R'\left(\frac{1+\hat{\pi}_{t+1}^M}{(1+\hat{\pi}_t^M)^{\vartheta_M}}\right) \\ + \varphi_M\left(\frac{REER_t}{p_t^M} - \frac{\varphi_M - 1}{\varphi_M}\right),\end{aligned} \tag{43}$$

where $\Delta_{t+1}^M = \left(\frac{p_{t+1}^M}{p_t^M}\right)\left(\frac{M_{t+1}}{M_t}\right)$ and $p_t^M = \frac{P_t^M}{P_t^C}$ is the relative price of non-oil imports.

### 3.3.6 Exporters

Export retailers produce goods $X_t^j$ for exporting by combining sector-specific inputs $Y_t^j$, $j \in \{H; N\}$, and imports (oil and non-oil), which are subject to adjustment costs, $G_{Oil,X,j}(\cdot)$ and $G_{M,X,j}(\cdot)$, similar to the ones described in equation (18). They use a CES technology of the following type:

$$X_t^j = \left[\mu_{Y,j}^{\frac{1}{\kappa_{x,j}}}\left(Y_t^j\right)^{\frac{\kappa_{x,j}-1}{\kappa_{x,j}}} + \mu_{M,j}^{\frac{1}{\kappa_{x,j}}}\left(M_t^{Oil,X,j}\right)^{\frac{\kappa_{x,j}-1}{\kappa_{x,j}}} + (1-\mu_{Y,j}-\mu_{M,j})^{\frac{1}{\kappa_{x,j}}}\left(M_t^{X,j}\right)^{\frac{\kappa_{x,j}-1}{\kappa_{x,j}}}\right]^{\frac{\kappa_{x,j}}{\kappa_{x,j}-1}}. \tag{44}$$

The solution to the exporter's problem yields the following set of demand functions:

$$Y_t^j = \mu_{Y,j}\left(\frac{p_t^j}{p_t^{X,j}}\right)^{-\kappa_{x,j}} X_t^j, \tag{45}$$

$$M_t^{Oil,X,j} = \mu_{M,j} \left( \frac{\hat{p}_t^{Oil,X,j}}{p_t^{X,j}} \right)^{-\kappa_{x,j}} X_t^j, \tag{46}$$

$$M_t^{X,j} = (1 - \mu_{Y,j} - \mu_{M,j}) \left( \frac{\hat{p}_t^{M,X,j}}{p_t^{X,j}} \right)^{-\kappa_{x,j}} X_t^j, \tag{47}$$

where the final prices, for $j \in \{H; N\}$, are given by

$$p_t^{X,j} = \left[ \mu_{Y,j} \left( p_t^j \right)^{1-\kappa_{x,j}} + \mu_{M,j} \left( \hat{p}_t^{Oil,X,j} \right)^{1-\kappa_{x,j}} + (1 - \mu_{Y,j} - \mu_{M,j}) \left( \hat{p}_t^{M,X,j} \right)^{1-\kappa_{x,j}} \right]^{\frac{1}{1-\kappa_{x,j}}}, \tag{48}$$

satisfying $1 + \pi_t^{X,j} = \left(1 + \pi_t^C\right) \frac{p_t^{X,j}}{p_{t-1}^{X,j}}$, and where the effective costs for imports correspond to

$$\hat{p}_t^s = \mathfrak{p}_t \left[ 1 + G\left( \frac{M_t^s}{M_{t-1}^s} \right) + G'\left( \frac{M_t^s}{M_{t-1}^s} \right) \frac{M_t^s}{M_{t-1}^s} \right] - \mathbb{E}_t \frac{\mathfrak{p}_{t+1}}{1 + r_t} G'\left( \frac{M_{t+1}^s}{M_t^s} \right) \left( \frac{M_{t+1}^s}{M_t^s} \right)^2, \tag{49}$$

where $\mathfrak{p}_t = p_t^{Oil}$ if $s = Oil, X, j$ and $\mathfrak{p}_t = p_t^M$ if $s = M, X, j$.

### 3.3.7 Retailers

Retailers produce aggregate output $Z_t^j$ for consumption (private and public), and investment (private and public) by combining intermediate goods from the HT sector, $Y_t^{H,j}$, and non-HT sector, $Y_t^{N,j}$, with oil imports, $M_t^{Oil,j}$, and non-oil imports $M_t^{Noil,j}$. The representative retailer's production function is also a CES technology:

$$Z_t^j = \left[ (\mu_{N,j})^{\frac{1}{\kappa_j}} \left( Y_t^{N,j} \right)^{\frac{\kappa_j - 1}{\kappa_j}} + (\mu_{H,j})^{\frac{1}{\kappa_j}} \left( Y_t^{H,j} \right)^{\frac{\kappa_j - 1}{\kappa_j}} + (\mu_{Oil,j})^{\frac{1}{\kappa_j}} \left( M_t^{Oil,Z,j} \right)^{\frac{\kappa_j - 1}{\kappa_j}} \right.$$
$$\left. + (1 - \mu_{N,j} - \mu_{H,j} - \mu_{Oil,j})^{\frac{1}{\kappa_j}} \left( M_t^{Z,j} \right)^{\frac{\kappa_j - 1}{\kappa_j}} \right]^{\frac{\kappa_j}{\kappa_j - 1}}, \tag{50}$$

for $j \in \{C; Inv^N; Inv^{Gov}; Inv^H; Gov; Inv^N S_N(\cdot); Inv^H S_H(\cdot)\}$, where both imports, as before, are subject to adjustment costs, $G_{Oil,Z,j}(\cdot)$ and $G_{M,Z,j}(\cdot)$, of the type described in equation (18). Note that the retailers also produce goods to satisfy the demand from the adjustment costs associated with private investment. That is, $Inv^N S_N(\cdot)$ and $Inv^H S_H(\cdot)$.

From the maximization problem of the retailers, we can derive the following set of demand functions:

$$Y_t^{N,j} = \mu_{N,j} \left( \frac{p_t^N}{p_t^j} \right)^{-\kappa_j} Z_t^j \tag{51}$$

,

$$Y_t^{H,j} = \mu_{H,j} \left( \frac{p_t^H}{p_t^j} \right)^{-\kappa_j} Z_t^j, \tag{52}$$

$$M_t^{Oil,Z,j} = (1 - \mu_{N,j} - \mu_{H,j} - \mu_{Oil,j}) \left( \frac{\hat{p}_t^{M,Z,j}}{p_t^j} \right)^{-\kappa_j} Z_t^j \tag{53}$$

$$M_t^{Z,j} = \mu_{Oil,j} \left( \frac{\hat{p}_t^{Oil,Z,j}}{p_t^j} \right)^{-\kappa_j} Z_t^j, \tag{54}$$

where the final prices, $j \in \{C; Inv^N; Inv^{Gov}; Inv^H; Gov; Inv^N S_N(\cdot); Inv^H S_H(\cdot)\}$, are given by

$$p_t^j = \Bigg[ \mu_{N,j} \left(p_t^N\right)^{1-\kappa_j} + \mu_{H,j} \left(p_t^H\right)^{1-\kappa_j} + \mu_{Oil,J} \left(\hat{p}_t^{Oil,Z,j}\right)^{1-\kappa_j} + (1 - \mu_{N,j} - \mu_{H,j} - \mu_{Oil,j}) \left(\hat{p}_t^{M,Z,j}\right)^{1-\kappa_j} \Bigg]^{\frac{1}{1-\kappa_j}} \tag{55}$$

satisfying $1 + \pi_t^j = \left(1 + \pi_t^C\right) \frac{p_t^j}{p_{t-1}^j}$, and where the effective costs for imports correspond to

$$\hat{p}_t^s = \mathfrak{p}_t \left[ 1 + G\left( \frac{M_t^s}{M_{t-1}^s} \right) + G'\left( \frac{M_t^s}{M_{t-1}^s} \right) \frac{M_t^s}{M_{t-1}^s} \right] - \mathbb{E}_t \frac{\mathfrak{p}_{t+1}}{1 + r_t} G'\left( \frac{M_{t+1}^s}{M_t^s} \right) \left( \frac{M_{t+1}^s}{M_t^s} \right)^2, \tag{56}$$

where $\mathfrak{p}_t = p_t^{Oil}$ if $s = Oil, Z, j$ and $\mathfrak{p}_t = p_t^M$ if $s = M, Z, j$.

## 3.4 The Government Sector

The government sector consists of the Central Bank (CB), which conducts monetary policy, and the Fiscal Authority, which is responsible for the revenue, expenditure, and debt policies of the country.

### 3.4.1 The Central Bank (CB)

The CB is committed to an inflation target and follows a Taylor rule, with the interest rate serving as the instrument. The Taylor rule is forward-looking, whereby the interest rate responds to deviations of the expected future Consumer Price Index (CPI) inflation, $\mathbb{E}_t \pi_{t+1}^C$, from the inflation target, $\pi_t^{tar}$, as follows:

$$1 + i_t = (1 + i_{t-1})^{\rho_i} \left[ (1 + i) \mathbb{E}_t \left( \frac{1 + \pi_{t+1}^C}{1 + \pi_t^{tar}} \right)^{\phi_\pi} \right]^{1-\rho_i} e^{\epsilon_t^i}, \tag{57}$$

where $\rho_i$ is the parameter capturing the degree of interest rate smoothing, $i$ is the steady-state nominal interest rate, $\phi_\pi$ corresponds to the interest rate response coefficient to inflation, and $\epsilon_t^i$ represents a monetary policy shock that follows a stochastic process. Additionally the Fisher equation holds, $1 + i_t = (1 + r_t) \mathbb{E}_t \left(1 + \pi_{t+1}^C\right)$, where $r_t$ corresponds to the real interest rate.

### 3.4.2 The Fiscal Authority (FA)

The model incorporates a comprehensive fiscal block. The FA adheres to a budget constraint, which allows deficits to be financed through debt issuance when public expenditures ($Exp_t$) exceed revenues ($Rev_t$). The FA can borrow through issuing both domestic commercial debt ($Debt_t^{Dom}$) and external commercial debt ($Debt_t^*$), with the respective interest rates being $i_{t-1}$ and $i_{t-1}^*$. The government budget constraint can then be written as:

$$Debt_t^{Dom}+S_tDebt_t^*+Rev_t=(1+i_{t-1})Debt_{t-1}^{Dom}+(1+i_{t-1}^*)(1+Prem_{t-1})S_tDebt_{t-1}^*+Exp_t. \quad (58)$$

Fiscal policy is represented by a rule, expressed in ratios to GDP, where the primary surplus ($\frac{PS_t}{GDP_t}$), acting as the policy instrument, responds to the primary balance target ($\frac{\bar{PS}_t}{GDP_t}$), as well as the current and future deviations of total public debt from its target level ($Debt_t^{Dev}$). Formally:

$$\frac{PS_t}{GDP_t}=\rho_1\frac{PS_{t-1}}{GDP_{t-1}}+(1-\rho_1)\left(\frac{\bar{PS}_t}{GDP_t}+\vartheta^D Debt_t^{Dev}\right), \quad (59)$$

where

$$Debt_t^{Dev}=\rho_2\left(\frac{Debt_t}{GDP_t}-\frac{\bar{Debt}_t}{GDP_t}\right)+(1-\rho_2)\mathbb{E}_tDebt_{t+1}^{Dev} \quad (60)$$

and the primary balance is defined as $PS_t = Rev_t - Exp_t$. The coefficient $\rho_1$ captures the persistence of the primary surplus-to-GDP ratio, while the parameter $\vartheta^D$ determines the sensitivity of the primary surplus to deviations in government debt. The fiscal rule establishes a fixed path for the primary balance, with policymakers determining the appropriate instruments to achieve the targeted balance.[10] This framework captures key aspects of the Israeli fiscal system and serves as a mechanism to close the model.

Interest payments are defined as:

$$IntCost_t=i_{t-1}Debt_{t-1}^{Dom}+[(1+i_{t-1}^*)(1+prem_{t-1})-1]S_tDebt_{t-1}^*. \quad (61)$$

We define the total government debt as the sum of domestic and foreign debt: $Debt_t = Debt_t^{Dom}+S_tDebt_t^*$.

The accumulation of government domestic and foreign debt provides financing according to the following equations:

$$Fin_t=Debt_t^{Dom}-Debt_{t-1}^{Dom} \quad (62)$$

[10]The government consumption acts as a fiscal variable that serves as the residual in the primary balance, facilitating the adjustment of the primary balance towards a rule-based target value while considering other components.

and

$$Fin_t^* = S_t Debt_t^* - S_t Debt_{t-1}^* \tag{63}$$

To finance the government balance, $GS_t = PS_t - IntCost_t$, we assume simple financing rules that govern the issuance of domestic and external debt, respectively.[11] That is,

$$Fin_t = \mathcal{K}_t \cdot GS_t \tag{64}$$

and

$$Fin_t^* = (1 - \mathcal{K}_t) \cdot GS_t. \tag{65}$$

where $\mathcal{K}_t$ is exogenously given.

On the revenue side, the government levies distortionary taxes on labor income ($Tax_t^L$), capital income ($Tax_t^K$), and consumption ($Tax_t^C$), as well as lump-sum taxes ($T_t$), represented by the equation:

$$Rev_t = Tax_t^C + Tax_t^L + Tax_t^K + T_t. \tag{66}$$

Tax revenues are specified as follows, where $\tau_t^j$, for $j \in \{C; L, OLG; L, LIQ; K\}$, are modeled as exogenous AR(1) processes that incorporate stochastic shocks:

$$Tax_t^C = \tau_t^C P_t^C C_t, \tag{67}$$

$$Tax_t^L = \tau_t^{L,OLG} W_t^{OLG} L_t^{OLG} + \tau_t^{L,LIQ} W_t^{LIQ} L_t^{LIQ}, \tag{68}$$

$$\begin{aligned} Tax_t^K = \tau_t^K \Bigg[ &(R_t^{K,N} K_{t-1}^N + R_t^{K,H} K_{t-1}^H - P_t^{Inv,N} Inv_t^N - P_t^{Inv,H} Inv_t^H \\ &- P_t^{Inv,N} Inv_t^N S\left(\frac{Inv_t^N}{Inv_{t-1}^N}\right) - P_t^{Inv,H} Inv_t^H S\left(\frac{Inv_t^H}{Inv_{t-1}^H}\right)\Bigg] \end{aligned} \tag{69}$$

On the expenditure side, the government incurs current expenditures ($P_t^{Gov} Gov_t$), targeted transfers ($TR_t$), and public investment ($P_t^{Inv,Gov} Inv_t^{Gov}$):

$$Exp_t = TR_t + P_t^{Gov} Gov_t + P_t^{Inv,Gov} Inv_t^{Gov}. \tag{70}$$

The sector-specific public investment for $j \in \{N; H\}$ helps increase public capital according to:

$$K_t^{Gov,j} = e_t Inv_t^{Gov,j} + (1 - \delta_{Gov}) K_{t-1}^{G,j}, \tag{71}$$

[11]Note that the government budget constraint (58) can be written as: $Debt_t^{Dom} + S_t Debt_t^* = Debt_{t-1}^{Dom} + S_t Debt_{t-1}^* - GS_t$.

where

$$e_t = e_{t-1} + \varepsilon_t^e. \tag{72}$$

Note that public investment may be subject to inefficiencies, potentially adding less than one-to-one real value to public capital, as discussed in Berg et al. (2012). This inefficiency is captured by the parameter $e_t$, which can be shocked to reflect the insights of Berg et al. (2019)—what matters for growth is not the level of efficiency but changes in efficiency.

## 3.5 External Sector

In this model, Israel is treated as a small open economy with no capacity to influence global markets. Consequently, key macroeconomic variables related to the foreign sector are modeled exogenously. These variables include foreign inflation, foreign interest rates, oil prices, and foreign GDP. Their behavior is assumed to follow either a simple structural equation or an AR(1) process. The foreign interest rate, $i_t^*$, in particular, is determined by a forward-looking Taylor rule:

$$1 + i_t^* = (1 + i_{t-1}^*)^{\rho_{i^*}} \mathbb{E}_t \left[ (1 + \bar{r}*)(1 + \bar{\pi}^{tar*}) \mathbb{E}_t \left( \frac{1 + \pi_{t+1}^*}{1 + \bar{\pi}^{tar*}} \right)^{\phi_{i^*}} \right]^{1-\rho_{i^*}} e^{\epsilon_t^{i*}}, \tag{73}$$

where $\rho_{i^*}$ represents the coefficient capturing the persistence of the foreign interest rate, $\bar{r}^*$ denotes the steady-state level of the foreign real interest rate, $\phi_{i^*}$ indicates the response of the foreign interest rate to deviations of the expected foreign inflation rate $\pi_{t+1}^*$ from its target $\bar{\pi}^{tar*}$, and $\epsilon_t^{i^*}$ represents a stochastic shock to the foreign interest rate.

The foreign inflation rate follows a persistent process that can be affected by world oil prices, $P_t^{Oil*}$:

$$1 + \pi_t^* = (1 + \pi_{t-1}^*)^{\rho_{\pi^*}} \left[ (1 + \bar{\pi}^{tar*}) \left( \frac{P_t^{Oil,*}}{\bar{P}^{Oil,*}} \right)^{\phi_{\pi^*}} \right]^{1-\rho_{\pi^*}} e^{\epsilon_t^{\pi*}}, \tag{74}$$

where $\rho_{\pi^*}$ is the persistence parameter, $\phi_{\pi*}$ is the response coefficient of foreign inflation to the deviation of world oil prices with respect to their steady-state level, $\bar{P}^{Oil*}$, and $\epsilon_t^{\pi^*}$ represents a stochastic shock to foreign inflation.

World oil prices, in turn, follow the following process:

$$P_t^{Oil,*} = (P_{t-1}^{Oil,*})^{\rho_{Oil,*}} (\bar{P}^{Oil,*})^{1-\rho_{Oil,*}} e^{\epsilon_t^{Oil,*}}, \tag{75}$$

where $\rho_{Oil,*}$ is the coefficient capturing the persistence of the process, and $\epsilon_t^{Oil,*}$ represents a stochastic shock.

We also assume that export demands for non-HT goods or HT goods–i.e., $X_t^j$ for $j \in \{N; H\}$– depend on their respective effective foreign demand, $GDP_t^{*,j}$, their respective relative price of exports for non-HT goods, $p_t^{X,j}$, and the real exchange rate $REER_t$, as represented by the following equation:

$$X_t^j = \left( \frac{p_t^{X,j}}{REER_t} \right)^{-\theta_N} GDP_t^{*,j}, \tag{76}$$

where $\theta_j$ is the sensitivity parameter of exports demand for j goods–$j \in \{N; H\}$–with respect to the real exchange rate.

The effective foreign demand for $j \in \{N; H\}$ exports is characterized as follows:

$$GDP_t^{*,j} = (GDP_{t-1}^{*,j})^{\rho_{GDP^{*,j}}} \left[ GDP_{SS}^{*,j} (r_t^* - \bar{r}^*)^{-\phi_{r,*}} \right]^{(1-\rho_{GDP^{*,j}})} e^{\epsilon_t^{GDP^{*,j}}}, \tag{77}$$

where $\rho_{GDP^{*,j}}$ is the coefficient capturing the persistence of the effective foreign demand, $GDP_{SS}^{*,j}$ denotes the steady-state level of this demand, $\phi_{r^*}$ is the response coefficient measuring the sensitivity of this demand to deviations of the foreign interest rate $r_t^*$ from its steady-state level $\bar{r}^*$, and $\epsilon_t^{GDP^{*,j}}$ represents a stochastic shock.

Foreign creditors charge a premium over the risk-free interest rate. This premium increases with the total net foreign debt-to-GDP ratio of the country, $\frac{\mathbb{D}_t^*}{GDP_t}$, where $\mathbb{D}_t^* = Debt_t^* - B_t^*$.[12] This relationship is reflected in the following equation:

$$1 + prem_t = e^{\chi \left( REER_t \frac{\mathbb{D}_t^*}{GDP_t} - \bar{REER} \frac{\bar{\mathbb{D}}^*}{\bar{GDP}} e^{\epsilon_t^{\mathbb{D},*}} \right)} e^{\epsilon_t^{Prem}}, \tag{78}$$

where $\frac{\bar{\mathbb{D}}^*}{\bar{GDP}}$ can be interpreted as the sustainable long-term external debt-to-GDP ratio that includes the government foreign debt. The parameter $\chi$ measures the sensitivity of the premium to total foreign debt.[13] The premium as well as the sustainable long-term external debt-to-GDP ratio can be subject to shocks $\epsilon_t^{Prem}$ and $\epsilon_t^{\mathbb{D},*}$, respectively.

## 3.6 Equilibrium Conditions

To close the model, market equilibrium conditions are imposed. These conditions equalize the demand and supply of skilled and unskilled labor, sector-specific capital, and bonds

[12] In many economies, foreign debt significantly affects capital flows, interest rates, and exchange rate volatility due to its link with sovereign risk and investors' perceptions of a country's ability to meet obligations, influencing the UIP and exchange rates.

[13] This parameter can also reflect the degree of openness of the capital account.

($Debt_t^{Dom} = B_t$). They also involve the following market equilibrium conditions for non-HT goods and HT goods:

$$Y_t^N = Y_t^{N,C} + Y_t^{N,Inv^N} + Y_t^{N,Inv^H} + Y_t^{N,Inv^{Gov}} + Y_t^{N,Gov} + Y^{N,X} + Y_t^N R_N(\cdot)$$
$$+ Y_t^{N,Inv^N} S_N(\cdot) + \frac{w_t^{OLG}}{p_t^N} L_t^{OLG,N} H_{ON}(\cdot) + \tag{79}$$

and

$$Y_t^H = Y_t^{H,C} + Y_t^{H,Inv^H} + Y_t^{H,Inv^N} + Y_t^{H,Inv^{Gov}} + Y_t^{H,Gov} + Y_t^{H,X} + Y_t^N R_H(\cdot)$$
$$+ Y_t^{H,Inv^N} S_H(\cdot) + \frac{w_t^{OLG}}{p_t^H} L_t^{OLG,H} H_{OH}(\cdot). \tag{80}$$

Using these goods market equilibrium and the budget constraints of the agents in the model, we can demonstrate that total supply equals the aggregate demand from households, investors, governments, and exporters, and define GDP as:

$$GDP_t = C_t + \sum_j p_t^{Inv,j} Inv_t^j [1 + S_j(\cdot)] + \sum_j p_t^j Y_t^j R_j(\cdot) + \sum_j w_t^{OLG} L_t^{OLG,j} H_{OLG,j}(\cdot)$$
$$+ \frac{w_t^{LIQ}}{p_t^N} L_t^{LIQ,N} H_{LIQ}(\cdot) + p_t^M M_t R_M(\cdot) + p_t^{Inv,Gov} Inv_t^{Gov} + p_t^{Gov} Gov_t$$
$$+ \sum_j p_t^{X,j} X_t^j - p_t^M M_t - p_t^{Oil} M_t^{Oil}, \tag{81}$$

for $j \in \{N; H\}$.

The equilibrium conditions also include the resource constraint for the economy, which helps pin down the dynamics of the current account ($CAB_t$). Under this constraint, the current account balance is equal to the accumulation of net foreign assets:

$$CAB_t = S_t P_t^{C,*}(B_t^* - Debt_t^*) - S_t P_{t-1}^{C,*}(B_{t-1}^* - Debt_{t-1}^*). \tag{82}$$

The current account is the sum of the trade balance ($TB_t$) plus net income from abroad (including interest rate payments):

$$CAB_t = TB_t + i_{t-1}^* S_t P_{t-1}^{C,*}(B_{t-1}^* - Debt_{t-1}^*), \tag{83}$$

where

$$TB_t = P_t^{X,N} X_t^N + P_t^{X,H} X_t^H - S_t P_t^* M_t - S_t P_t^{Oil,*} M_t^{Oil}, \tag{84}$$

and $M_t$ and $M_t^{Oil}$ are represented by the following equations, respectively:

$$M_t = \sum_j M_t^{Z,j}[1 + G_{M,Z,j}(\cdot)] + M_t^{X,N} + M_t^{X,H} + M_t R_M(\cdot) \tag{85}$$

and

$$M_t^{Oil} = \sum_j M_t^{Oil,Z,j}[1 + G_{Oil,Z,j}(\cdot)] + M_t^{Oil,X,N} + M_t^{Oil,X,H}, \tag{86}$$

for $j \in \{C; Inv^N; Inv^{Gov}; Inv^H; Gov; Inv^N S_N(\cdot); Inv^H S_H(\cdot)\}$.

### 3.7 Exogenous Shocks

The model incorporates a comprehensive array of exogenous shocks, enabling the construction of various macroeconomic policy scenarios. For households, these include preference shocks, labor supply shocks, and wage markup shocks. The capital producers' block features investment adjustment shocks. HT and non-HT firms experience productivity shocks, cost-push shocks, and balanced growth path (BGP) shocks. Importers face foreign price shocks, cost-push shocks, and oil price shocks.

In terms of fiscal policy, the model includes shocks to distortionary tax rates, lump-sum taxes, targeted transfers, government consumption, government investment (including efficiency shocks), primary surplus, debt targets, and domestic financing. Monetary policy, on the other hand, is affected by discretionary shocks. Finally, the foreign sector is subject to shocks in foreign interest rates, inflation, GDP, and the country risk premium.

## 4 Model Calibration

This section describes the calibration of the model to the Israeli annual data. The calibration process involves assigning numerical values to the parameters based on a strategy outlined below. The sample period for calibration is mostly based on the decade after the global financial crisis and prior to the COVID-19 crisis, 2010-2019. The parameters and their assigned values are listed in tables 2-7.

Table 2 provides calibration of key (deep) structural parameters. These values are determined through a combination of expert judgment, input-output table analysis, and empirical estimates to capture the dynamics of the model. The calibration process ensures that the model aligns with key economic indicators and features of the Israeli economy, allowing for accurate analysis and policy simulations. Table 3 displays steady-state ratios concerning public financing and monetary policy in Israel, derived from the national accounts and steady-state values of the country over the last decade. Additionally, Table 4 displays the steady-state ratios that describe the components of the national accounts of Israel. The remaining calibrated parameters, depicted in Tables 5, 6, and 7 in Appendix B, are determined through expert judgment to effectively capture the dynamics observed in the data.

## 4.1 Steady-State Paramaters

Table 2 provides a summary of the model calibration for key structural parameters. The steady-state technology growth rate is fixed at 1 percent per year ($g^A = 1.01$), and the population growth rate is set at 1.9 percent per year ($g^N = 1.019$), which roughly match these growth rates for the period 2010-2019. The combination of these growth rates yields a steady-state growth rate of 2.9 percent per year.

**Table 2: Structural Steady State Parameters**

| Parameter | Value | Definition |
|---|---|---|
| $g$ | 0.029 | Balanced growth path |
| $g^N$ | 0.019 | Population growth |
| $g^A$ | 0.01 | Productivity growth rate |
| $\omega$ | 0.05 | Implied by 20 year long planning horizon of OLG households |
| $\gamma$ | 1 | Relative risk aversion parameter |
| $\sigma_{OLG}$ | 0.65 | Share of consumption in OLG households' utility |
| $\sigma_{LIQ}$ | 0.5 | Share of consumption in LIQ households' utility |
| $\delta$ | 0.1 | Depreciation rate of private capital in non-HT and HT sector |
| $\psi$ | 0.65 | OLG HH share of normalized time endowment |
| $\tilde{S}$ | 1 | Level of time endowment |
| $\bar{A}_{OLG_N}$ | 1 | Normalized steady state production technology of skilled labor for N sector |
| $\bar{A}_{OLG_H}$ | 1 | Normalized steady state production technology of skilled labor for HT sector |
| $\bar{A}_{LIQ}$ | 1 | Normalized steady state production technology of unskilled labor |
| $h$ | 0.35 | Consumption habit formation parameter |
| $\alpha_H$ | 0.5872 | HT capital share in production function |
| $\alpha_N$ | 0.3792 | Non-HT capital share in production function |
| $\alpha_{G_H}$ | 0.01 | Share of public capital investment in HT production function |
| $\alpha_{G_N}$ | 0.02 | Share of public capital investment in Non-HT production function |
| $\phi_t^{Inv^j}$ | 0.10 | Investment adjustment cost parameter |
| $\phi_{L^{OLG,j}}$ | 0.5 | Real adjustment cost parameter for OLG HH labor |
| $\phi_{L^{LIQ}}$ | 5 | Real adjustment cost parameter for LIQ HH labor |
| $\varphi_N$ | 6 | Price elasticity of demand parameter of intermediate non-HT goods |
| $\kappa_N$ | 1.01 | Elasticity of substitution between private capital and skilled labor |
| $\varrho$ | 1.67 | Elasticity of substitution between unskilled and the combined private capital and skilled labor in $Y^{Noil}$ |

Source: Data averages for the period 2010-2019 for Israel, literature, expert judgment, and empirical estimates.

OLG households are assumed to have a 20-year planning horizon on average, based on Kumhof et al. (2010). The degree of myopia can be calculated by $\frac{1}{\omega}$, implying $\omega = 0.05$. To align with Israeli data for the same period, we assume that the share of OLG or skilled households is

$\psi = 0.65$.[14] This ratio reflects the medium- and high-income households, while the remaining 35 percent are LIQ households, defining the dependent population and the low-income labor force with limited access to the financial market. Following the business cycle literature, parameters for the share of consumption in the OLG households' utility function ($\sigma_{OLG} = 0.65$) and in the LIQ households' utility function ($\sigma_{LIQ} = 0.5$) are selected to align with an OLG labor supply elasticity of 0.5, also adopted from Kumhof et al. (2010). The relative risk aversion coefficient is calibrated at $\gamma = 1$, ensuring quantitative alignment with fiscal multipliers. The consumption habit formation parameter is set to $h = 0.35$, which is typically within the standard values in the literature, to match the economic narrative.

Steady-state productivity for parameters $\bar{A}_{OLG_N}$, $\bar{A}_{OLG_H}$, $\bar{A}_{LIQ}$, and time endowment $\tilde{S}$ are normalized to unity. The 10 percent annual depreciation rate for physical private capital is a typical value in the literature ($\delta = 0.1$). To capture a 20 percent markup, $\varphi_N$ is calibrated at 6, following the literature. The calibrated elasticity of substitution between private capital and skilled labor is denoted by $\kappa_N = 1.01$, while the elasticity of substitution between non-skilled labor and the combined share of private capital and skilled labor in non-oil production inputs is represented by $\varrho = 1.67$. These two elasticities are utilized to match the wage premium in data for the period 2010-2019. The capital shares in the high-tech ($\alpha_H$) and non-high tech ($\alpha_N$) production functions are calibrated to capture the sectoral and aggregate investment to GDP ratios consistent with Israeli data.

## 4.2 Fiscal and Monetary Policy Paramaters

Our calibration for fiscal and monetary parameters and ratios is presented in Table 3. The public capital efficiency parameter is set at $\bar{e} = 0.75$, which is positioned mid-range between the calibration values of 0.5 for an average low-income country and 1 for a high-income country, as discussed by Berg (2012). The depreciation rate of public investment is established at $\delta_{Gov} = 0.10$.

The public debt target assumption reflects the government's medium-term preferences and is consistent with the historical average from 2010 to 2019, targeting a total government debt of 62 percent of GDP. This includes domestic debt set at 53 percent of GDP and foreign debt at 9 percent of GDP. Additionally, we computed the servicing costs in accordance with these ratios and the prevailing rates during the period to accurately reflect the servicing costs for both domestic and foreign debt.

[14] The 65 percent share of skilled workers is calculated to approximately correspond to workforce data indicating individuals holding a high school diploma or higher.

Tax ratios are aligned with the fiscal account statistics of Israel. Long-run effective tax rates ($\tau^C, \tau^{L,OLG}, \tau^{L,LIQ}, \tau^K$) are calibrated to harmonize with the value-added, labor income, and profit tax ratios to GDP for the period 2010-2019. The consumption tax rate is calibrated based on the computed average rate of 17 percent. Similarly, the labor income tax rate for LIQ households is approximated to be half that of the OLG households, with respective rates calibrated at 12 percent and 24 percent. Meanwhile, the capital income tax rate is calibrated to capture the revenues from the capital gain income to GDP ratio.

Similarly, ratios for current expenditure to GDP, capital expenditure to GDP, and financial transfers to GDP are computed based on the annual averages from 2010 to 2019. The sum of these ratios accounts for the total expenditure to GDP, calibrated at 30 percent, consistent with the calibration used by Argov et al. (2012) for a DSGE model for the Bank of Israel. The primary deficit should align with the debt target and the medium-term revenue and expenditure ratios.

Other (lump-sum) taxes cover the difference between the two approaches for the primary deficit, rebalancing the government budget. The lump-sum tax to GDP ratio is set at 8.05 percent, which also includes non-modeled revenues of the government, such as privatization and other foreign aids or contributions to the Israeli budget. The total revenue to GDP ratio is 30.05 percent. This adjustment captures an overall deficit of around 3 percent of GDP, consistent with the 2010-2019 annual average.

Turning to monetary policy parameters, the headline inflation target $\bar{\pi}^{tar}$ is set at 2 percent per year, in line with the Bank of Israel's target (see Argov et al. (2012)). Similarly, the steady-state real interest rate $\bar{r}$ is calibrated at 3.0 percent per year to align with the trend in Israeli real interest rates. The monetary policy rule parameters, such as the response to inflation and interest rate smoothing, are set at $\phi_\pi = 2.5$ and $\rho_i = 0.4$, which are also broadly in line with the estimated parameters of Argov et al. (2012).

## 4.3 National Accounts

Our calibration of national accounts ratios relies heavily on the decade-long averages derived from Israeli data for the period 2010-2019, as illustrated in Table 4.

Private investment constitutes about 23 percent of GDP, with the non-HT sector and HT sector representing 17 percent and 6 percent of GDP, respectively. Private investment in the HT sector is captured using data on venture capital investment in that sector for the period 2010-2019. Meanwhile, average government current spending for the period accounts for around 19 percent of GDP.

## Table 3: Selected Fiscal and Monetary Statistics

| Parameter | Value | Definition |
|---|---|---|
| | | **Public Finance:** |
| $\frac{\tilde{Rev}}{\tilde{GDP}}$ | 31.05 | **Total tax revenue-to-GDP ratio** |
| $\frac{\tilde{Tax}^C}{\tilde{GDP}}$ | 10.0 | Consumption tax-to-GDP ratio |
| $\frac{\tilde{Tax}^L}{\tilde{GDP}}$ | 12.0 | Labor income tax-to-GDP ratio |
| $\frac{\tilde{Tax}^K}{\tilde{GDP}}$ | 1.0 | Capital income tax-to-GDP ratio |
| $\frac{\tilde{T}}{\tilde{GDP}}$ | 8.05 | Lump-sum tax-to-GDP ratio |
| $\frac{\tilde{Exp}}{\tilde{GDP}}$ | 31.0 | **Total expenditures-to-GDP ratio** |
| $\frac{p^{Gov}\tilde{Gov}}{\tilde{GDP}}$ | 19.0 | Current expenditure-to-GDP ratio |
| $\frac{\tilde{p}^{Gov}Inv^{Gov}}{\tilde{GDP}}$ | 2.0 | Capital expenditure-to-GDP |
| $\frac{\tilde{TR}}{\tilde{GDP}}$ | 10.0 | Financial transfers-to-GDP ratio |
| $\frac{\tilde{GS}}{\tilde{GDP}}$ | 2.84 | **Overall deficit-to-GDP ratio** |
| $\frac{\tilde{PS}}{\tilde{GDP}}$ | -0.31 | ***Primary deficit-to-GDP ratio*** |
| $\frac{\tilde{IntCost}}{\tilde{GDP}}$ | 3.15 | ***Servicing cost-to-GDP ratio*** |
| $\frac{(1+r^*)\frac{1+\pi^C-1}{1+\pi^C}(1+g)\tilde{Debt}^{Dom}}{\tilde{GDP}}$ | 2.42 | Domestic debt servicing cost-to-GDP ratio |
| $\frac{(1+r)\frac{1+\pi^*-1}{1+\pi^*}(1+g)REER\tilde{Debt}^*}{\tilde{GDP}}$ | 0.73 | Foreign debt servicing cost-to-GDP ratio |
| $\frac{\tilde{Debt}}{\tilde{GDP}}$ | 62.0 | **Total public debt-to-GDP ratio** |
| $\frac{\tilde{Debt}^{Dom}}{\tilde{GDP}}$ | 53.0 | Domestic public debt-to-GDP ratio |
| $\frac{\tilde{Debt}^*}{\tilde{GDP}}$ | 9.0 | Foreign public debt-to-GDP ratio |
| $\bar{e}$ | 0.75 | Steady-state public capital inefficiency cost parameter |
| $\delta_{Gov}$ | 0.1 | Depreciation rate parameter of public capital |
| $\tau^C$ | 0.17 | Steady-state consumption tax rate |
| $\tau^{L,OLG}$ | 0.24 | Steady-state OLG HH personal income tax rate |
| $\tau^{L,LIQ}$ | 0.12 | Steady-state LIQ HH personal income tax rate |
| $\tau^K$ | 0.10 | Steady-state capital tax rate |
| | | **Monetary policy:** |
| $\bar{r}$ | 0.03 | Steady-state real interest rate |
| $\bar{\pi}^{tar}$ | 0.02 | Steady-state inflation target |
| $\phi_\pi$ | 2.5 | Response to inflation parameter in Taylor rule |
| $\rho_i$ | 0.4 | Interest rate smoothing parameter in Taylor rule |
| $\rho_{r,trend}$ | 0.95 | Persistence parameter of the real interest rate trend |

Source: Data averages for the period 2010-2019 for Israel, literature, expert judgment, and empirical estimates.

In terms of external trade, exports of goods and services are calibrated at 30 percent of GDP, with a balanced share of HT and non-HT exports, each accounting for 15 percent of GDP based on average data from 2010 to 2019. Imports of goods and services amount to approximately 31 percent of GDP, with non-oil imports forming the majority at around 27 percent of GDP, while oil imports account for approximately 4 percent of GDP, based on the period average.

The private total consumption-to-GDP ratio is approximately 58.68 percent, derived as the remainder of the other components on the expenditure side of GDP. The distribution of consumption aligns with household-level data: skilled or OLG households contribute about 47 percent of total consumption, compared to the 11 percent contributed by unskilled or LIQ households.

**Table 4: National Accounts Steady-State Ratios (percent of GDP)**

| Parameter | Value | Definition |
|---|---|---|
| | | **National Accounts (Demand)** |
| $\frac{\tilde{C}}{G\tilde{D}P}$ | 58.68 | Private consumption |
| $\frac{\tilde{C}^{OLG}}{G\tilde{D}P}$ | 47.46 | Private consumption of OLG HH |
| $\frac{\tilde{C}^{LIQ}}{G\tilde{D}P}$ | 10.61 | Private consumption of LIQ HH |
| $\frac{\tilde{p}^{Inv} Inv^H}{GDP}$ | 6.0 | HT sector private investment |
| $\frac{\tilde{p}^{Inv} Inv^N}{GDP}$ | 17.0 | Non-HT sector private investment |
| $\frac{p^{Gov}\tilde{Gov}}{G\tilde{D}P}$ | 19.0 | Government expenditures |
| $\frac{p^{X,H}\tilde{X}^H + p^{X,N}\tilde{X}^N}{G\tilde{D}P}$ | 30.0 | Exports of goods and services |
| $\frac{p^{X,H}\tilde{X}^H}{G\tilde{D}P}$ | 15.0 | Exports of HT goods and services |
| $\frac{p^{X,N}\tilde{X}^N}{G\tilde{D}P}$ | 15.0 | Exports of non-HT goods and services |
| $\frac{p^M\tilde{M} + p^{Oil}\tilde{M}^{Oil}}{G\tilde{D}P}$ | 31.07 | Imports of goods and services |
| $\frac{p^M\tilde{M}}{G\tilde{D}P}$ | 26.71 | Non-oil imports goods and services |
| $\frac{p^{Oil}\tilde{M}^{Oil}}{G\tilde{D}P}$ | 4.37 | Oil imports |
| | | **National Accounts (Supply)** |
| $\frac{p^N\tilde{Y}^N - p^{Oil}\tilde{M}^{Oil}}{G\tilde{D}P}$ | 83.59 | Intermediate production |
| $\frac{p^H\tilde{Y}^H}{G\tilde{D}P}$ | 16.41 | HT sector |
| | | **National Accounts (Income)** |
| $\frac{W^{OLG}\tilde{L}^{OLG} + W^{LIQ}\tilde{L}^{LIQ}}{G\tilde{D}P}$ | 51.64 | Labor wage income |
| $\frac{W^{OLG}\tilde{L}^{OLG}}{G\tilde{D}P}$ | 47.34 | Skilled labor wage income |
| $\frac{W^{LIQ}\tilde{L}^{LIQ}}{G\tilde{D}P}$ | 4.3 | Unskilled labor wage income |
| $\frac{R^{K,N}\tilde{K}^N\frac{1}{1+g} + R^{K,H}\tilde{K}^H\frac{1}{1+g}}{G\tilde{D}P}$ | 32.8 | Capital income |
| $\frac{Pr\tilde{o}fit^N + Pr\tilde{o}fit^H}{G\tilde{D}P}$ | 15.56 | Profit |
| | | **Balance of Payment** |
| $\frac{REER\tilde{\mathbb{D}}^*}{G\tilde{D}P}$ | -75.0 | Net foreign assets |
| $\frac{REER\tilde{B}^*}{G\tilde{D}P}$ | -66.0 | Private net foreign assets |
| $\frac{REERD\tilde{e}bt^*}{G\tilde{D}P}$ | -9.0 | Public net foreign assets |
| $\frac{REER\tilde{B}^*}{G\tilde{D}P}(1 - \frac{1}{1+g})$ | -1.87 | Current account balance |
| $\frac{p^{X,H}\tilde{X}^H + p^{X,N}\tilde{X}^N - p^M\tilde{M} - p^{Oil}\tilde{M}^{Oil}}{G\tilde{D}P}$ | -2.68 | Net export |

Source: Data averages for the period 2010-2019 for Israel, literature, expert judgment, and empirical estimates.

The supply side of the national account is calibrated to match the HT sector ratio in terms of GDP, which is 16 percent for the period average. The remaining sector then corresponds to 84 percent. On the income side of the national accounts, profit-to-GDP income is captured based on the period average.

The calibration of productivity for skilled and unskilled labor, wage premiums, and the shares of OLG and LIQ households results in skilled wage income accounting for 47.34 percent of GDP and unskilled wage income accounting for 4.3 percent of GDP. The remaining income captures capital income from investments, collectively accounting for 100 percent of GDP. The balance of payment calibrations aim to match the external resource constraint of real and financial cross-border exchanges between residents and non-residents.

# 5 Using the ISM for Policy Scenario Analysis

This section illustrates the application of the model for policy scenario analysis, comprising two main components: the construction of a baseline scenario and the evaluation of alternative scenarios. Developing a robust baseline is critical for accurately representing the initial conditions of the Israeli economy, particularly in light of the significant disruptions caused by the COVID-19 shock in 2020, which destabilized the economy's equilibrium. Furthermore, the HT sector played a pivotal role in mitigating the adverse effects of the crisis, thereby providing a strong rationale for exploring alternative scenarios that emphasize its influence.

In 2021, the Israeli economy began its recovery, marked by a sustained boom in the HT sector. This expansion contributed to increased fiscal revenues, a trend that continued into 2022. Against this backdrop, the ISM is utilized to examine alternative allocations of these additional fiscal resources. Specifically, we consider three policy options: debt reduction, redistribution measures, and increased public investment. Through these policy simulations, the ISM offers valuable insights into the potential economic outcomes and trade-offs associated with each alternative. This approach enables policymakers to evaluate the projected impacts on key macroeconomic variables and supports more informed decision-making.

## 5.1 Setting the Baseline Scenario to Capture the Impact of COVID-19

Like many other countries, Israel experienced a significant economic downturn during the COVID-19 pandemic, with GDP contracting by 1.9 percent on an annualized basis. This decline was primarily driven by sharp reductions in private consumption and gross fixed capital formation—two of the most severely affected components of aggregate demand. However, in contrast to the prolonged recoveries observed in many other advanced economies, Israel exhibited a rapid rebound, posting strong growth rates of 8.6 percent in 2021 and 6.5 percent in 2022. The recovery was largely supported by increases in public consumption and gross fixed investment, bolstered by the continued strength of the HT sector.

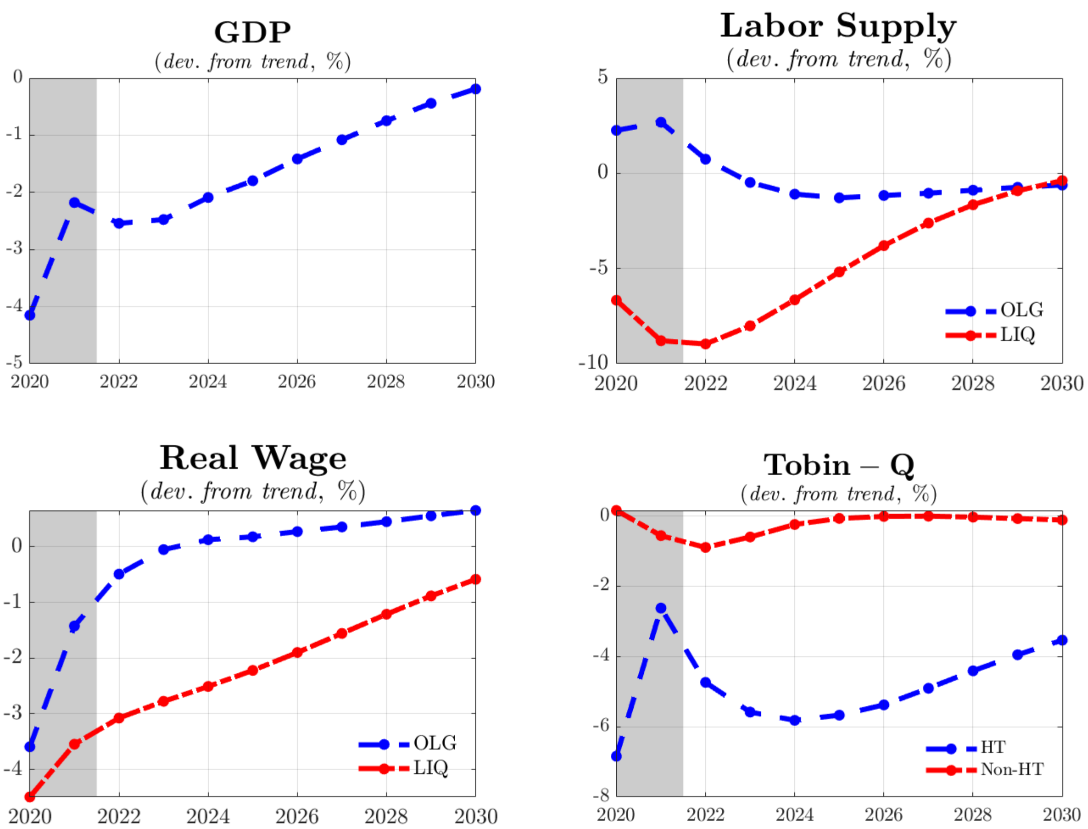
To examine these macroeconomic dynamics, the ISM was used to simulate a baseline scenario that captures the key developments during the crisis and subsequent recovery. The construction of the baseline scenario relies on the model's structure and a calibrated sequence of shocks to replicate the behavior of key economic variables in 2020 and 2021. The simulation spans a three-year horizon beginning in 2020, with Figures 6–10 illustrating the resulting trajectories.

In 2020, we considered a combination of domestic and foreign shocks. External shocks encompassed fluctuations in foreign demand, global inflation, and shifts in the U.S. Federal Reserve's monetary policy. On the domestic front, the economic impact of COVID-19 was modeled through a series of structural disturbances, including shocks to household time preferences, time endowments, labor demand, and sector-specific demand for HT goods and services.

The foreign shock led to a 10 percent decline in effective foreign demand, primarily driven by a recession among major trading partners and a sharp drop in tourism following the global lockdown. This exerted downward pressure on Israeli non-HT exports and contributed to a deterioration in the external balance. Concurrently, the U.S. Federal Reserve (Fed) reduced its policy rate by 120 basis points and signaled its intention to maintain rates at the zero lower bound for the foreseeable future, in response to weakening inflation and an unprecedented economic contraction. As a result, effective foreign inflation declined by 1 percent in 2020, falling below target. Despite the global downturn, Israel's HT sector demonstrated notable resilience, benefiting from increased international demand for digital services and technological products. To reflect this trend, we incorporated a positive 30 percent shock to HT-related foreign demand in 2020, which partially offset the overall decline in external demand. The foreign shocks related to monetary policy and inflation were extended into 2021, in line with prevailing global conditions during the pandemic.

The COVID-19 shock affected domestic supply of goods, with the baseline scenario incorporating negative productivity shocks ($\epsilon_{A,OLG_t}$ and $\epsilon_{A,LIQ_t}$) that impacted the permanent income of LIQ and OLG households (see Figure 6). This reduced household permanent income, hindered the potential growth of the Israeli economy, and increased inequality between skilled and unskilled labor forces. Lower productivity shocks led, in both sectors, to a decline in the marginal product of labor, resulting in lower real wages for households, a decrease in the market value of capital (Tobin-Q) for domestic investors, and a postponement of private investment.[15] Furthermore, the negative productivity shock in the HT sector prevented the excess reallocation of skilled labor from the non-HT sector to the HT sector, limiting the economy's capacity to adapt efficiently during the crisis.[16]

**Figure 6: The Severe Impact of the COVID-19 Pandemic**




Source: Authors' calculations.

Beyond its negative impact on production, the lockdown also adversely affected household demand and labor supply decisions. OLG households increased their precautionary savings in response to heightened uncertainty, which is reflected in negative preference shocks ($\epsilon_t^{u^C}$). Simultaneously, restrictions on mobility and workplace access limited workers' ability to

[15]The non-monotonic path of the Tobin-Q for the HT sector as well as its more pronounced dynamics relative to the non-HT sector are explained by the productivity shock to the HT sector in 2020 that helped match the short-term GDP model dynamics with the data.

[16]The skilled labor force remains relatively stable in both sectors. During the COVID recession, the decline in the non-HT sector is modest compared to that of the unskilled labor force. Meanwhile, the boom in the HT sector drives additional demand for skilled labor.

participate in the labor market, reducing their income, as captured by the time endowment shock ($\epsilon_t^S$). Together, these shocks contributed to a sharper decline in domestic consumption in 2020 (Figure 7).[17]

In addition, a negative labor demand shock for LIQ workers ($\epsilon_t^\theta$) further reduced demand for this group and weakened their income positions. This effect was compounded by a temporary negative wage shock ($\epsilon_t^{w^{LIQ}}$), which amplified the adverse impact of the supply-side disruption on LIQ households.[18]

The combination of these shocks led to a pronounced deterioration in consumption, wages, and labor income in 2020, significantly deepening the recession—broadly in line with observed data. In addition, heightened uncertainty and weakening investor sentiment were captured by an investment adjustment cost shock ($\epsilon_t^{\phi_{Inv}}$), which further curtailed investment activity (Figure 7). Despite the broader economic downturn, global demand for HT services remained resilient, as reflected by a positive shock to foreign demand for HT exports.

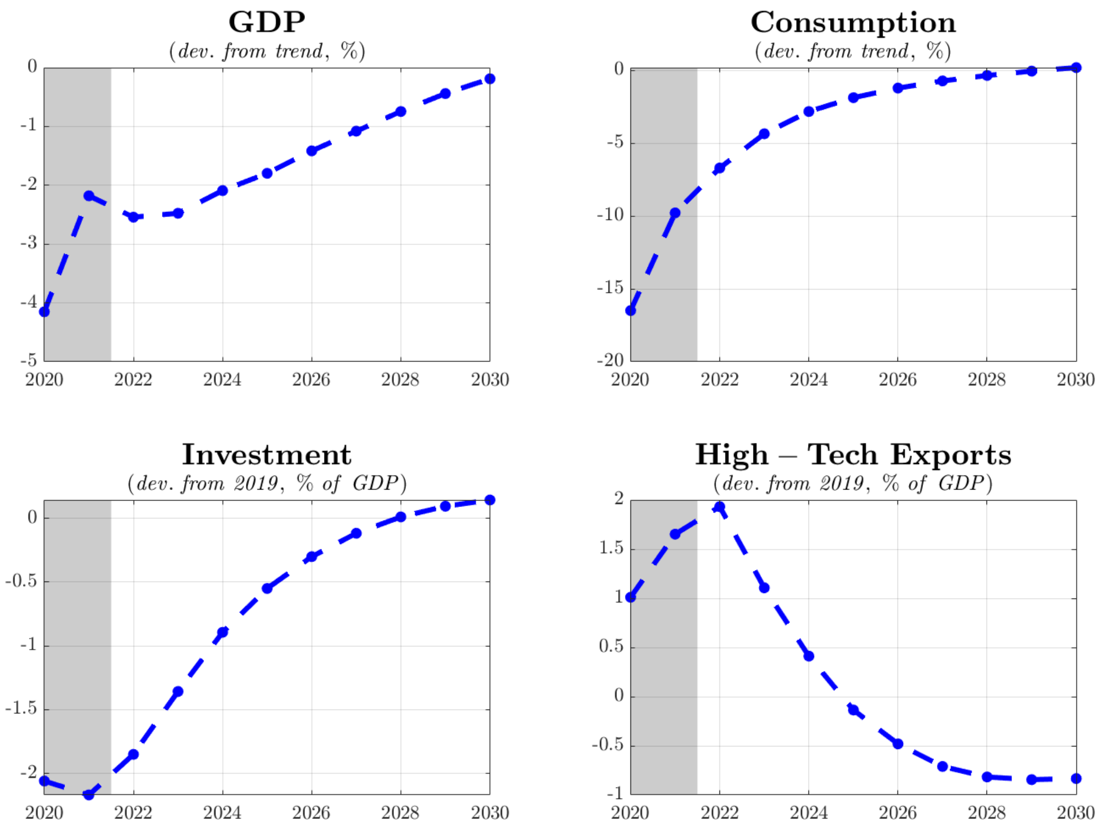
Monetary policy responded to the declining inflationary pressures in 2020 by gradually lowering the interest rate, consistent with the systematic response prescribed by the Taylor rule, rather than through an exogenous policy shock (Figure 8). At the same time, fiscal policy acted decisively to counter the adverse effects of weakening foreign and domestic demand. The government raised the debt target to accommodate a higher level of public indebtedness ($\epsilon_t^{\bar{Debt}}$) and temporarily suspended the fiscal rule—represented by setting $\rho_1 = 0$ in equation (59)—thereby enabling a discretionary expansion in government consumption ($\epsilon_t^{Gov}$) to support aggregate demand. Additionally, the resilient performance of the HT sector continued to generate substantial tax revenues during the crisis. This unmodeled fiscal windfall is captured through an additional lump-sum tax shock ($\epsilon_t^T$), reflecting the sector's robustness and its contribution to public finances amid the broader economic downturn.

In 2021, the economic recovery began, supported by sustained momentum in the HT sector. This momentum, combined with rising inflation, contributed to real exchange rate appreciation. As both domestic and global economies gradually stabilized in the aftermath of the COVID-19 shock, the government began to unwind emergency support measures and initiated a phased reduction in public debt. In this context, the fiscal rule was reinstated—setting $\rho_1 = 1$ in equation (59)—thereby facilitating a systematic convergence of the debt-to-GDP ratio toward

[17] The COVID-19 pandemic triggered a negative demand shock, resulting in a negative wealth effect, while simultaneously constraining labor supply. Accordingly, both shocks were incorporated into this judgment-based experiment.

[18] This is in line with the view that LIQ labor was heavily impacted by lockdowns and the lower demand from the declining non-HT sector.

**Figure 7: The COVID-19 Impact on Domestic Demand**




Source: Authors' calculations.

its target level (Figure 8). To more closely align the model with observed fiscal developments, we also introduce a positive shock to the primary surplus ($\epsilon_t^{PS}$), modestly accelerating the pace of fiscal consolidation.

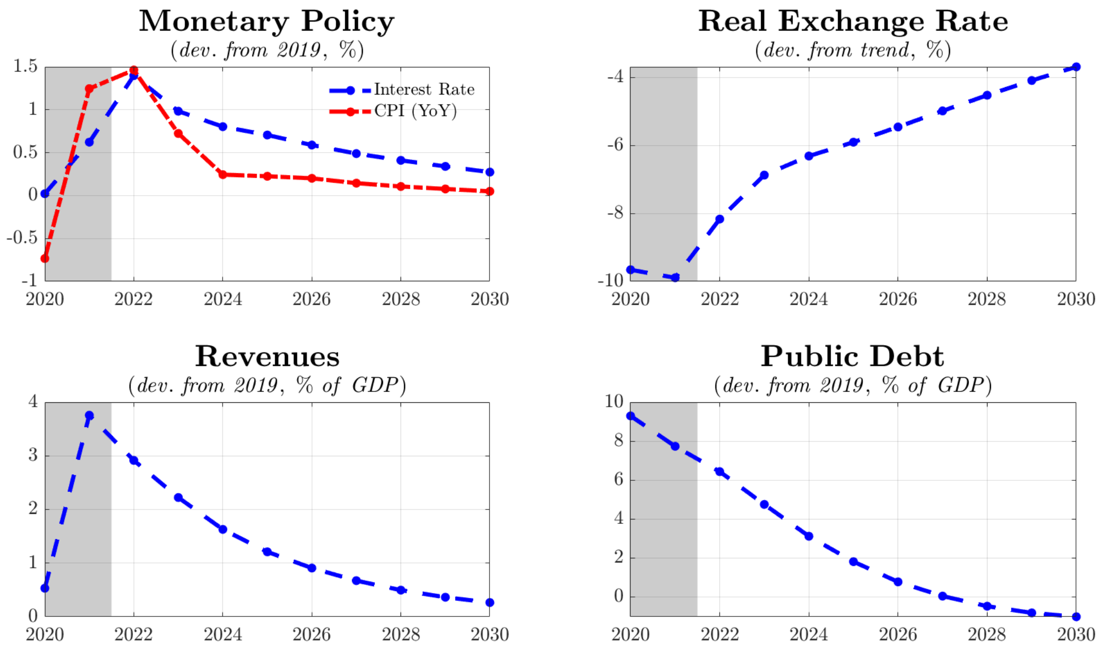
In sum, the ISM-based baseline captures the adverse economic effects of the pandemic on key economic variables, during 2020–2021. These include a decline in GDP of over 4 percent, an increase in public debt of approximately 10 percentage points of GDP, and a real exchange rate appreciation exceeding 10 percent.[19]

By 2022, the economic recovery was nearly complete. However, global inflationary pressures intensified, driven by the closing of the foreign output gap and rising global commodity prices ($\epsilon_t^{Oil,*}$), alongside foreign inflationary shocks ($\epsilon_t^{\pi}$) that affected both the global and Israeli

[19]The appreciation of the real exchange rate in the baseline scenario is primarily driven by a strong external demand shock in the high-tech sector. The expansion of this sector boosts export revenues, which in turn appreciates the currency.

economies. Despite these headwinds, fiscal policy remained on a consolidation path, maintaining its commitment to reducing public debt toward the target level (Figure 8).

**Figure 8: Policy Responses to the COVID-19 Pandemic**



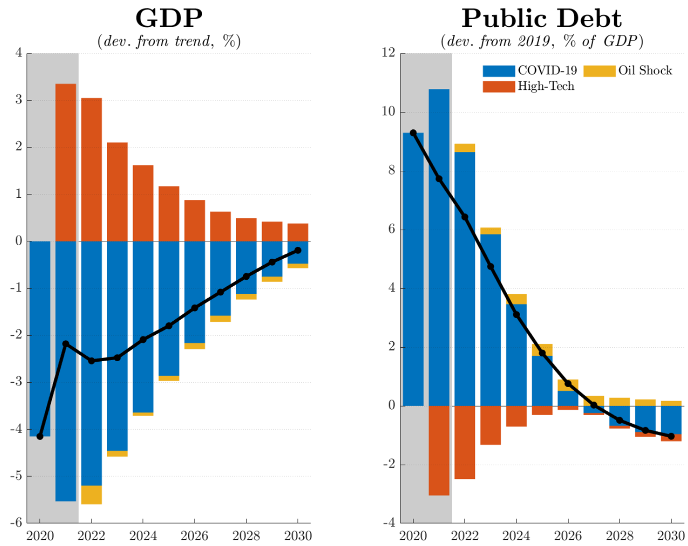

Note: A negative value in the real exchange rate figure indicates an appreciation of the domestic currency.
Source: Authors' calculations.

A shock-decomposition analysis reveals that the positive developments in the HT sector during 2021 played a crucial mitigating role by generating additional government revenue.[20] Although the COVID-19 shock was the main driving force, the dynamics of the HT sector helped to push up real GDP by more than 3 percent, relative to its trend, and push down the public debt-to-GDP ratio by 3 percentage points (pp), as seen in Figure 9.

The baseline scenario also highlights the significant redistributive effects of the pandemic across different household types. LIQ households experienced substantial reductions in labor hours, primarily due to their lower skill levels, which limited their adaptability and made them more easily substitutable in the labor market. In contrast, OLG households with higher skill levels—excluding those employed in the HT sector—faced a more moderate decline in labor hours. Notably, OLG households working in the HT sector were relatively insulated from the labor market impact, benefiting from the sector's expansion, as illustrated in Figure 10.

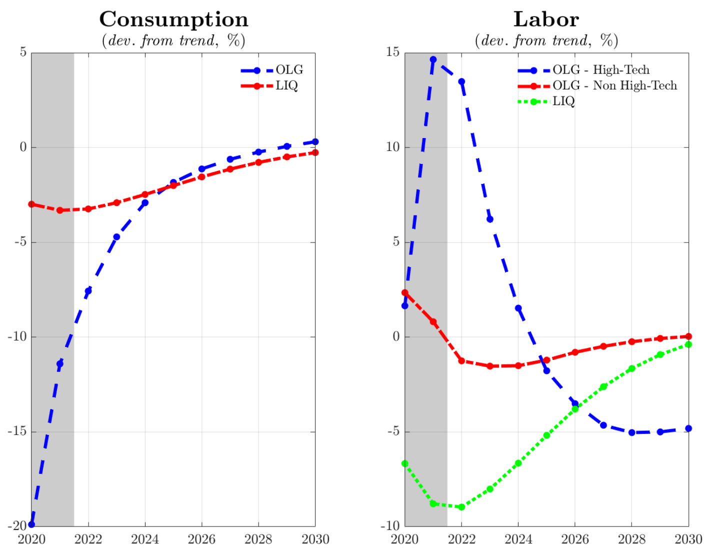
[20]The shock-decomposition analysis relies on a judgmental mapping of observed macroeconomic episodes to the model's structural shocks. This method was selected due to insufficient time series data for formal model inversion, but the decomposition remains guided by the model's transmission channels.

## Figure 9: The Mitigating Role of the HT Sector




Source: Authors' calculations.

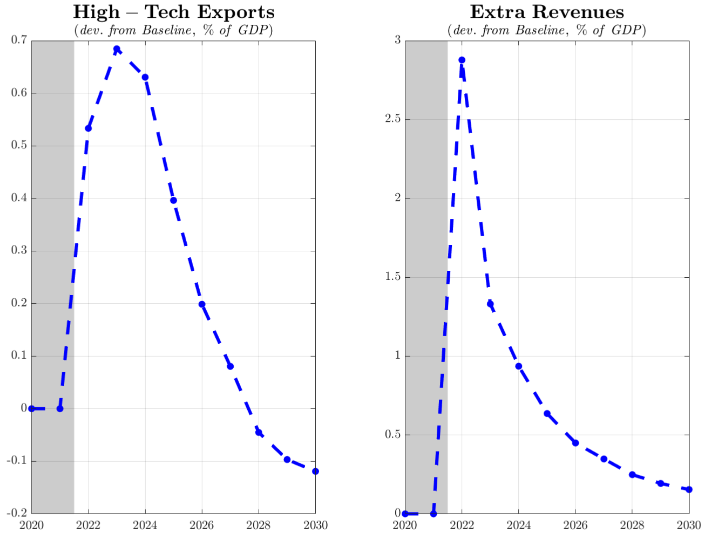
## Figure 10: The Re-distributional Effects of the COVID-19 Pandemic




Source: Authors' calculations.

In terms of consumption, OLG households experienced a larger—though temporary—decline, reflecting their higher steady-state consumption levels. Meanwhile, LIQ households suffered a more persistent reduction in consumption, largely driven by the lasting adverse effects on their employment prospects.

**Figure 11: Higher Fiscal Revenues Due to the Expansion of the HT Sector**




Source: Authors' calculations.

## 5.2 Alternative Scenarios

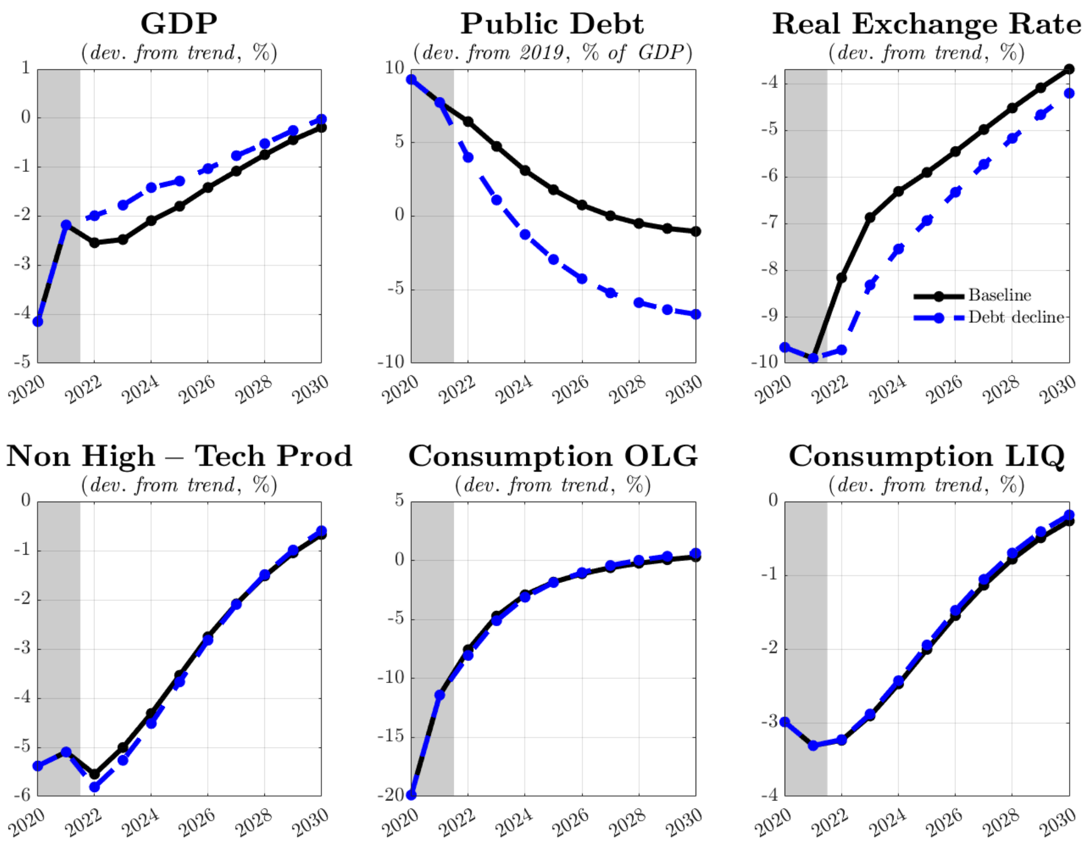
After establishing the baseline scenario, we demonstrate how the ISM can be applied to policy scenario analysis. Beginning in 2021, the strong and sustained recovery of the HT sector, coupled with an unexpected boom in 2022, generated additional fiscal revenues for the Israeli Ministry of Finance (MOF). The ISM-based analysis aims to quantify the macroeconomic effects of various policy responses using these revenues, along with the associated trade-offs. We present this analysis as it was conceptualized at the end of 2022, before the actual macroeconomic and fiscal outcomes for that year were known.

All scenarios begin in 2022 and assume that, compared to the baseline, the HT sector performs significantly better—driven by higher foreign demand for HT goods and increased labor demand within the sector due to higher production. As a result, the government receives additional tax revenues, including both higher income taxes and increased lump-sum taxes, reflecting other HT sector-related revenues that cannot be explicitly modeled. The key assumptions regarding the HT sector and the additional fiscal revenues are illustrated in Figure 11.

Given the baseline and fiscal rule, the key question is how to allocate the extra revenue without automatically increasing government consumption. The scenarios we explore are as follows: (1) fixing government consumption and using the additional revenue to reduce public debt more than in the baseline; (2) fixing government consumption and allocating the extra revenue to transfers, with two-thirds directed to LIQ households and one-third to OLG households; and (3) fixing government consumption and using the extra revenue for public investment, which is subject to inefficiencies. These three scenarios reflect different fiscal policy objectives, ranging from debt sustainability considerations, to distributional goals, to growth-oriented strategies.

These alternative scenarios highlight various economic trade-offs and the consequences of different policy choices. Policymakers can use the insights from the model-based analysis to assess the potential impacts on key economic variables. By considering alternative uses of additional fiscal revenues, policymakers can make informed decisions that align with their priorities. Figures (12)-(14) provide quantitative results for each scenario, offering visual representations of their respective impacts.

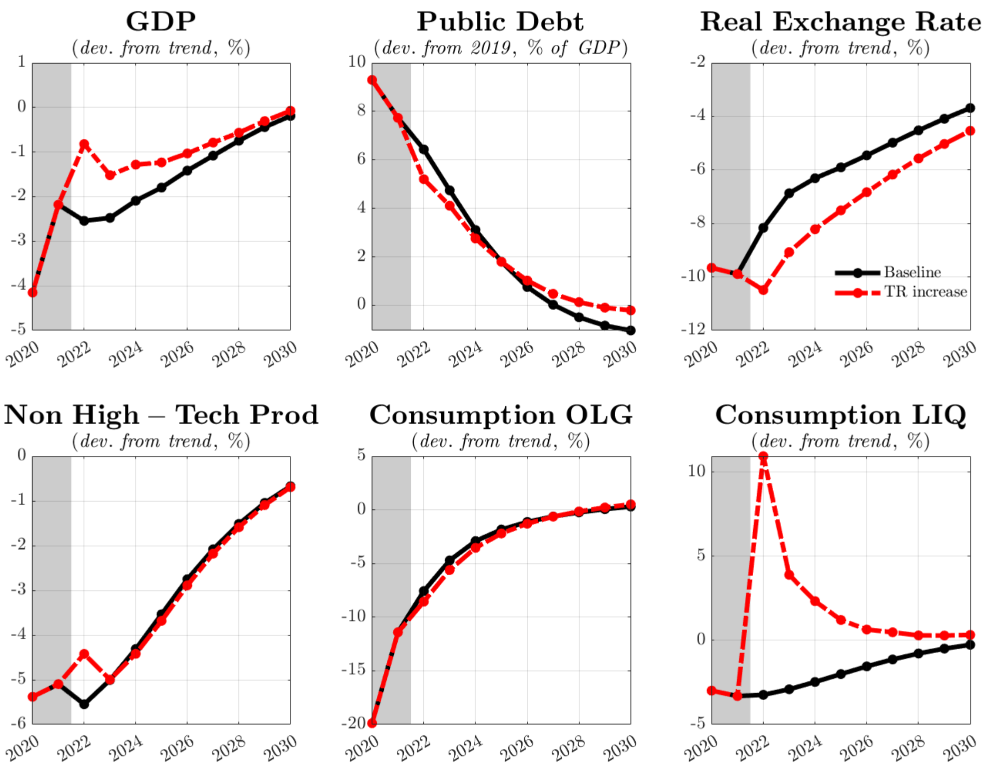
**Figure 12: The Macroeconomic Effects on Selected Variables of Reducing Public Debt Faster**




Note: A negative value in the real exchange rate figure indicates an appreciation of the domestic currency.
Source: Authors' calculations.

**Faster Reduction of Public Debt.** This scenario examines the impact of accelerating public debt reduction. It assumes that surplus revenues from the high-tech sector are used to service public debt rather than being allocated to transfers or public investment. The blue-dashed line illustrates the projected trajectory of various economic indicators in Figure 12. Model projections indicate that the public debt-to-GDP ratio is expected to decrease to 5 percent by 2022, down from its 2019 level, and is anticipated to return to pre-pandemic levels by 2024. Accelerating debt repayment could potentially boost growth rates by approximately one percent above those observed in the baseline scenario without debt consolidation, with a return to pre-pandemic growth rates expected by 2028. Furthermore, this rapid debt reduction might result in higher real appreciation, potentially delaying the recovery of the non-HT sector, while having similar redistribution effects compared to the baseline scenario.[21]

**Figure 13: The Macroeconomic Effects on Selected Variables of the Transfer Policy**

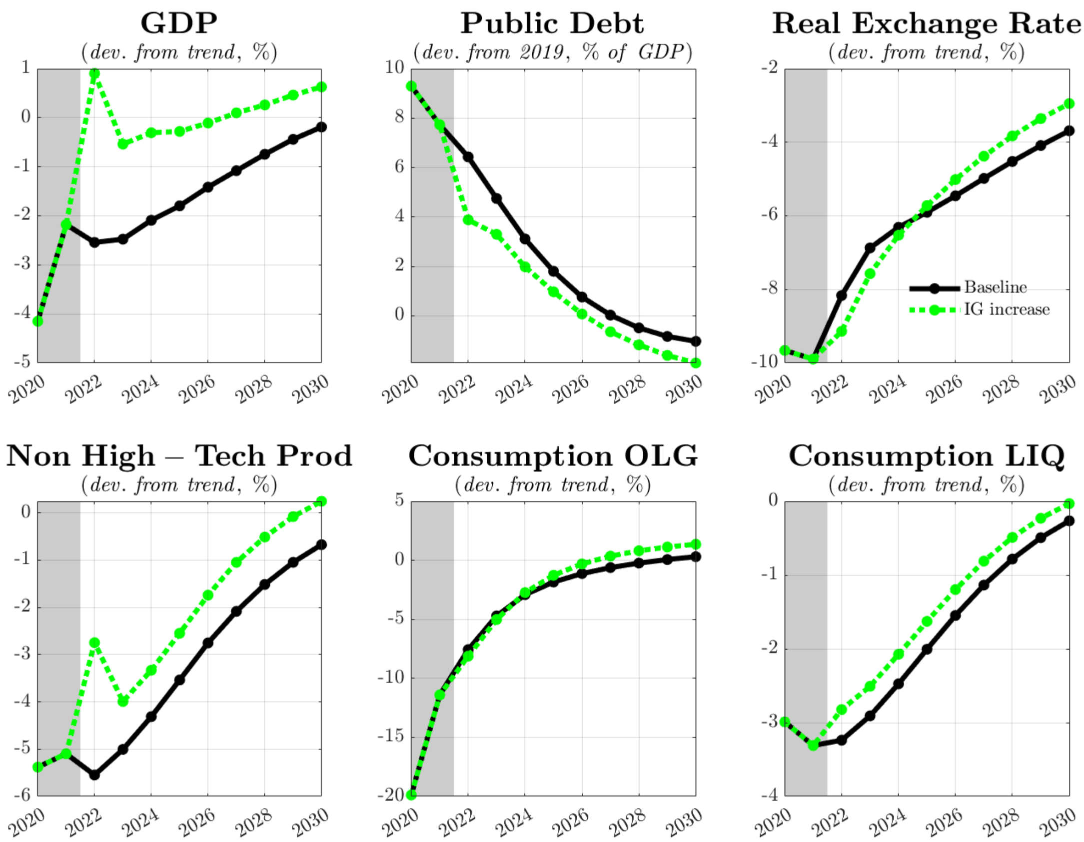



Note: A negative value in the real exchange rate figure indicates an appreciation of the domestic currency.
Source: Authors' calculations.

[21]Although real exchange rate appreciation can be seen as a necessary relative price adjustment resulting from shocks, policymakers commonly view it as a factor that may undermine the competitiveness of tradable sectors and, consequently, economic growth.

**Transfers Redistribution Policy.** The second scenario examines a transfer policy aimed at bolstering support for vulnerable households. Instead of using the surplus revenue from the HT sector boom to accelerate public debt repayment, this scenario proposes reallocating these additional funds to enhance social transfers for low-income LIQ consumers. This approach is represented by the red-dashed lines in Figure 13.[22]

**Figure 14: The Macroeconomic Effects on Selected Variables of Increasing Public Investment**




Note: A negative value in the real exchange rate figure indicates an appreciation of the domestic currency.
Source: Authors' calculations.

Unlike the trajectory of faster debt reduction, this redistributional policy is projected to

[22]The model assumes that labor supply decisions depend on the reservation wage but does not allow the reservation wage itself to be influenced by the level of social transfers. As a result, the model captures redistribution mainly through the savings/consumption channel, but not its potential effects on labor force participation. Given the importance of this issue in the Israeli economy, future work could extend the framework to endogenize the reservation wage. For the present analysis, we note this limitation at the outset.

have a more substantial impact on GDP. The rationale is that such transfers could stimulate consumption, particularly among LIQ consumers, thereby amplifying GDP growth through typical Keynesian effects. Consequently, the analysis suggests that adopting this policy would not only aid in the recovery of consumption levels among vulnerable populations but also contribute to the overall rebound of real GDP. However, under this redistributional policy, the pace of public debt reduction would be slower, particularly on the medium term, and real exchange rate appreciation would be more pronounced. Despite this, the effect of real appreciation on the non-HT sector is mitigated by the previously mentioned demand-driven growth effect.

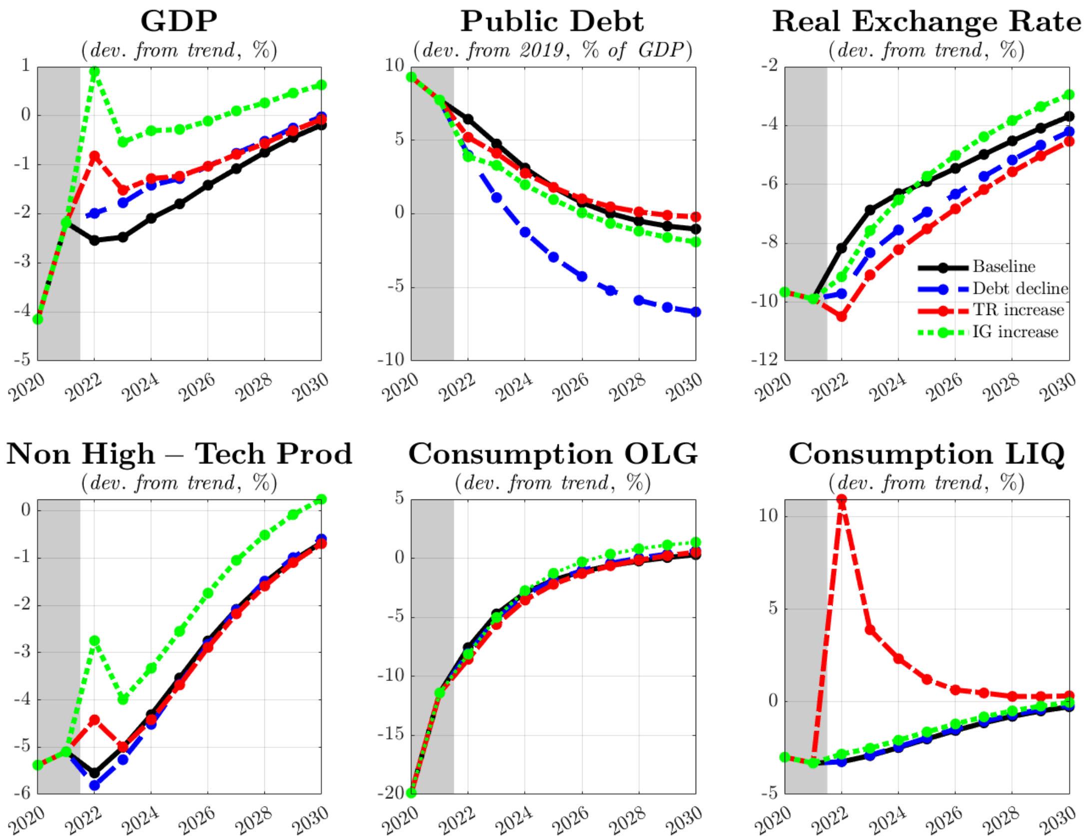
**Increase in Public Investment.** The third scenario explores the potential effects of boosting public investment to expedite the convergence of GDP back to its pre-pandemic trend. Instead of using the additional government revenue from the HT sector boom to accelerate debt repayments or enhance social transfers for the vulnerable population, the government chooses to invest these funds in increasing public investment. The macroeconomic effects of this policy on selected variables are presented by the green-dashed lines in Figure 14. This policy initiative is expected to enhance sectoral productivity and directly impact GDP, surpassing the baseline and other policy scenarios. Through growth effects, this policy also results in a faster consolidation of public debt relative to the baseline. Additionally, although it accentuates real appreciation in the short term, it helps counteract such appreciation in the medium term. This, together with enhancing factor productivity and its direct effect on output, helps mitigate the impact on non-HT production. Relative to the baseline, and through boosting growth, the investment policy also provides some small protection to low-income LIQ consumers.[23]

A comparison of the three policies reveals that all three policy interventions contribute meaningfully to accelerating the return of GDP to its pre-pandemic trend, lowering public debt-to-GDP ratios, and yielding some favorable redistributive outcomes (Figure 15). As expected, the policy prioritizing accelerated debt consolidation exhibits the most pronounced effect on fiscal sustainability, with debt ratios reverting to their pre-crisis levels by 2023. In contrast, the redistributive transfer policy proves most effective in shielding vulnerable populations, evidenced by substantial increases in consumption among LIQ households—approximately 11 percent in 2022 and 4 percent in 2023 above their respective trends. Meanwhile, the policy emphasizing increased public investment enhances the pace of output recovery, effectively narrowing the deviation from trend GDP within a relatively short horizon.

[23]The model can be used to conduct sensitivity analyses of various parameters, such as the efficiency of capital spending.

A noteworthy and somewhat unanticipated result is that all three policy interventions contribute to additional real exchange rate appreciation—ranging between 8.2 and 10.5 percent above trend in 2022—which raises concerns about deteriorating external competitiveness, particularly for the non-HT tradable sector.[24] However, in the case of increased public investment, this adverse effect is partially mitigated, as the policy directly stimulates output in the non-HT sector and enhances its productive capacity, thereby offsetting some of the competitiveness losses associated with the real appreciation.

**Figure 15: Comparison of Alternative Policy Scenarios**




Note: A negative value in the real exchange rate figure indicates an appreciation of the domestic currency.
Source: Authors' calculations.

When evaluated against the criteria of debt stabilization, fiscal redistribution, and output

[24]Each alternative policy scenario reinforces this appreciation through different channels. Faster public debt reduction lowers the sovereign risk premium, creating appreciation pressures. Although one might expect debt reduction to ease appreciation pressures, in this model the decline in premia dominates, resulting in a stronger real exchange rate. The other two scenarios involve expansionary fiscal policies that may also cause appreciation through different channels, such as inflationary pressures.

growth, increased public investment emerges as the most favorable policy option. It facilitates a more rapid macroeconomic recovery, strengthens debt indicators, and tempers the magnitude of real exchange rate appreciation—thus mitigating its negative repercussions for the non-HT tradable sector. Furthermore, it offers some targeted support to lower-income LIQ households, contributing to more equitable distributional outcomes. These results highlight the robustness of the ISM framework in capturing key structural features of the Israeli economy and affirm its value as an effective tool for policy scenario-based analysis by the Ministry of Finance.

# 6 Concluding Remarks

The Israeli Structural Model (ISM) represents a significant milestone of a multi-year IMF technical assistance (TA) with the Israeli Ministry of Finance (MOF). This initiative, aimed at strengthening institutional capacity, focused on the development and implementation of a model-based analytical framework to inform fiscal policy design and evaluation. The ISM is positioned to contribute meaningfully to policy discussions and decision-making processes within the MOF by offering rigorous, model-consistent macroeconomic insights.

The active engagement and endorsement of senior officials within the MOF, particularly managerial-level staff, proved essential for ensuring the initiative's effectiveness and long-term institutional impact. The TA project adopted a "coaching" approach, which prioritized ownership of the modeling framework by MOF staff. This approach involved sustained collaboration and guidance from IMF experts during and in-between missions, fostering gradual transfer of knowledge and skills to country authorities.

A critical dimension of the project involved addressing both technical and institutional aspects of model adoption. Targeted presentations and discussions with senior management played a central role in fostering understanding and institutional buy-in. The overarching objective was to empower MOF staff to independently utilize the ISM for scenario-based analysis, thereby enhancing the analytical foundation for fiscal policy formulation.

This paper provides a detailed exposition of the ISM, an open-economy DSGE model specifically tailored and calibrated to capture the structural features of the Israeli economy. The ISM is intended to serve as a central component of the MOF's forward-looking policy analysis system, offering a coherent and internally consistent framework for macroeconomic risk assessment and scenario-based policy evaluation. By enabling systematic analysis of alternative policy interventions, the ISM strengthens the Ministry's capacity to support evidence-based decision-making.

To illustrate the policy analysis use of the ISM, this paper employs the model to assess alternative fiscal strategies for managing a temporary revenue windfall arising from a surge in high-tech sector activity. The analysis focuses on three distinct policy options: accelerated public debt reduction, targeted fiscal transfers, and increased public investment. Simulation results suggest that enhanced public investment yields the most advantageous macroeconomic and distributional outcomes, promoting a more rapid convergence of GDP to its pre-pandemic trajectory and fostering sustained long-term growth.

Following the conclusion of the IMF TA project, MOF staff have demonstrated institutional ownership of the ISM by independently employing the model to evaluate the medium- to long-term macroeconomic effects of two significant policy developments: the proposed 2023 judicial reform and a prospective permanent increase in defense spending beginning in 2024. Through scenario-based simulations, they quantified the projected impacts of these measures on key macroeconomic variables, underscoring the ISM's relevance for real-time policy analysis and reaffirming its position as a cornerstone of the Ministry's analytical capacity.

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# Appendices

## Appendix A Summary of Normalized Model Equations

All variables must be divided by $A_t N_t$, because there is technology and population growth in the model; except interest rates, relative prices, $L_t$ and $w_t$. $L_t$ must be normalized by $N_t$, while $w_t$ must be normalized by $A_t$ only. The normalized $x_t$ is denoted by $\tilde{x_t}$. Also, we know growth rates of population and technology:

$$N_t = N_{t-1}(1 + g_t^N) \tag{87}$$

$$\bar{A}_t = \bar{A}_{t-1}(1 + g_t^A) \tag{88}$$

Households:

$$(1 + \tau_t^C)\tilde{C}_t^{OLG} = MPC_t \left( \tilde{Inc}_t + \frac{1 + r_{t-1}}{1 + g_t}\tilde{B}_{t-1} + \frac{1 + r_{t-1}^*}{1 + g_t} REER_t \tilde{B}_{t-1}^* \right) \tag{89}$$

$$\tilde{Inc}_t = (1 - \tau_t^{L,OLG})\tilde{w}_t^{OLG,r}\psi\tilde{\mathcal{S}}_t + \tilde{\mathfrak{pr}}_t - \tilde{T}_t + (1 - \omega)\mathbb{E}_t\,(1 + g_{t+1})\,\frac{\tilde{Inc}_{t+1}}{1 + r_t} \tag{90}$$

$$\tilde{\mathfrak{pr}}_t = \tilde{\mathfrak{pr}}_t^N + \tilde{\mathfrak{pr}}_t^{Inv} + \tilde{\mathfrak{pr}}_t^W + \tilde{\mathfrak{pr}}_t^M + \tilde{\mathfrak{pr}}_t^H \tag{91}$$

$$1 = \beta\mathbb{E}_t \left( MPC_{t+1}\frac{1 + r_t}{1 - \omega}\left[\frac{1}{MPC_t} - \frac{1}{\sigma_{OLG}}\right] \right)^{-\gamma} \Lambda_{t+1}(1 + r_t) \tag{92}$$

$$\Lambda_{t+1} = \mathbb{E}_t \left( \frac{\tilde{C}_{t-1}^{OLG}}{(1 + g_t)\tilde{C}_t^{OLG}} \right)^{h\sigma_{OLG}(1-\gamma)} \left( \frac{(1 - \tau_t^{L,OLG})\tilde{w}_t^{OLG,r}}{(1 + g_{t+1}^A)(1 - \tau_t^{L,OLG})\tilde{w}_{t+1}^{OLG,r}} \right)^{(1-\sigma_{OLG})(1-\gamma)} \left( \frac{1 + \tau_{t+1}^C}{1 + \tau_t^C} \right)^{-\sigma_{OLG}(1-\gamma)} \frac{e^{u_{t+1}^C}}{e^{u_t^C}} \tag{93}$$

$$\frac{\tilde{C}_t^{OLG}}{\psi\tilde{\mathcal{S}}_t - \tilde{L}_t^{OLG}} = \frac{\sigma_{OLG}}{1 - \sigma_{OLG}}\frac{1 - \tau_t^{L,OLG}}{1 + \tau_t^C}\tilde{w}_t^{OLG,r} \tag{94}$$

$$\frac{\tilde{C}_t^{LIQ}}{(1 - \psi)\tilde{\mathcal{S}}_t - \tilde{L}_t^{LIQ}} = \frac{\sigma_{LIQ}}{1 - \sigma_{LIQ}}\frac{1 - \tau_t^{L,LIQ}}{1 + \tau_t^C}\tilde{w}_t^{LIQ,r} \tag{95}$$

$$\begin{aligned} (1 + \tau_t^C)\tilde{C}_t^{LIQ} &= (1 - \tau_t^{L,LIQ})\tilde{w}_t^{LIQ,r}\tilde{L}_t^{LIQ} + \tilde{TR}_t \\ \tilde{C}_t &= \tilde{C}_t^{OLG} + \tilde{C}_t^{LIQ} \end{aligned} \tag{96}$$

The real effective wages are

$$\log\left(\tilde{w}_t^{OLG}\right) = \rho^{w,OLG}\log\left(\tilde{w}_{t-1}^{OLG}\right) + (1 - \rho^{w,OLG})\log\left(\tilde{w}_t^{OLG,r}\right) \tag{97}$$

$$\log\left(\tilde{w}_t^{LIQ}\right) = \rho^{w,LIQ}\log\left(\tilde{w}_{t-1}^{LIQ}\right) + (1-\rho^{w,LIQ})\log\left(\tilde{w}_t^{LIQ,r}\right) \tag{98}$$

$$\tilde{\mathfrak{pr}}_t^W = (1-\tau_t^{L,OLG})(\tilde{w}_t^{OLG}\tilde{L}_t^{OLG} - \tilde{w}_t^{OLG,r}\tilde{L}_t^{OLG}) + (1-\tau_t^{L,OLG})(\tilde{w}_t^{LIQ}\tilde{L}_t^{LIQ} - \tilde{w}_t^{LIQ,r}\tilde{L}_t^{LIQ}) \tag{99}$$

Capital producers $j = \{N; H\}$:

$$\tilde{K}_t^j = \tilde{Inv}_t^j[1 - S(\cdot)] + \frac{1-\delta}{1+g_t}\tilde{K}_{t-1}^j \tag{100}$$

$$S\left(\frac{\tilde{Inv}_t^j}{\tilde{Inv}_{t-1}^j}\right) = \frac{\phi_{Inv^j}}{2}\left[(1+\xi_t^{Inv,j})\frac{\tilde{Inv}_t^j}{\tilde{Inv}_{t-1}^j} - 1\right]^2 \tag{101}$$

$$S'\left(\frac{\tilde{Inv}_t^j}{\tilde{Inv}_{t-1}^j}\right) = \phi_{Inv^j}\left[(1+\xi_t^{Inv,j})\frac{\tilde{Inv}_t^j}{\tilde{Inv}_{t-1}^j} - 1\right] \tag{102}$$

$$\begin{aligned}\frac{q_t^j}{(1-\tau_t^K)p_t^{Inv,j}} &= 1 + S\left(\frac{\tilde{Inv}_t^j}{\tilde{Inv}_{t-1}^j}\right) + S'\left(\frac{\tilde{Inv}_t^j}{\tilde{Inv}_{t-1}^j}\right)\frac{\tilde{Inv}_t^j}{\tilde{Inv}_{t-1}^j} - \\ &-\frac{1-\omega}{1+r_t}\mathbb{E}_t(1+g_{t+1})\frac{(1-\tau_{t+1}^K)}{(1-\tau_t^K)}\frac{p_{t+1}^{Inv,j}}{p_t^{Inv,j}}S'\left(\frac{\tilde{Inv}_{t+1}^j}{\tilde{Inv}_t^j}\right)\left(\frac{\tilde{Inv}_{t+1}^j}{\tilde{Inv}_t^j}\right)^2\end{aligned} \tag{103}$$

$$\begin{aligned}q_t^j &= \mathbb{E}_t\frac{1-\omega}{1+r_t}\left\{(1-\tau_{t+1}^K)r_{t+1}^{K,j} + q_{t+1}^j(1-\delta)\right\} \\ \tilde{\mathfrak{pr}}_t^{Inv,j} &= (1-\tau_t^K)\left(r_t^{K,j}\tilde{K}_{t-1}^j\frac{1}{1+g_t} - p_t^{Inv,j}\tilde{Inv}_t^j(1+S(\cdot))\right)\end{aligned} \tag{104}$$

Total investment, profit and skilled worker:

$$\tilde{\mathfrak{pr}}_t^{Inv} = \tilde{\mathfrak{pr}}_t^{Inv,N} + \tilde{\mathfrak{pr}}_t^{Inv,H} \tag{105}$$

$$\tilde{L}_t^{OLG} = \tilde{L}_t^{OLG,N} + \tilde{L}_t^{OLG,H} \tag{106}$$

Non-HT firms:

$$\begin{aligned}\left[\frac{1+\hat{\pi}_t^N}{(1+\hat{\pi}_{t-1}^N)^{\vartheta_N}}\right]R'\left(\frac{1+\hat{\pi}_t^N}{(1+\hat{\pi}_{t-1}^N)^{\vartheta_N}}\right) &= \left(\frac{1-\omega}{1+r_t}\right)\mathbb{E}_t\Delta_{t+1}^N\left[\frac{1+\hat{\pi}_{t+1}^N}{(1+\hat{\pi}_t^N)^{\vartheta_N}}\right]R'\left(\frac{1+\hat{\pi}_{t+1}^N}{(1+\hat{\pi}_t^N)^{\vartheta_N}}\right) \\ &+\varphi_N\left(\frac{mc_t^N}{p_t^N} - \frac{\varphi_N - 1}{\varphi_N}\right)\end{aligned} \tag{107}$$

$$mc_t = \left(\frac{\tilde{K}_{t-1}^{Gov}}{\tilde{K}^{Gov}}\right)^{-\alpha_{G,N}}\left\{\mu_N mc_t^{Noil\,1-\xi} + (1-\mu_N)(\hat{p}_t^{Oil,N})^{1-\xi}\right\}^{\frac{1}{1-\xi}} \tag{108}$$

$$mc_t^{Noil} = \left\{\theta\left[p_t^Z\right]^{1-\varrho} + (1-\theta)\left[\frac{\tilde{w}_t^{LIQ}}{\tilde{A}_t^{LIQ}}\right]^{1-\varrho}\right\}^{\frac{1}{1-\varrho}} \tag{109}$$

$$p_t^Z = \left(\alpha_N \left(r_t^{K,N}\right)^{1-\kappa_N} + (1-\alpha_N)\left(\frac{\tilde{\hat{w}}_t^{OLG,N}}{\tilde{A}_t^{OLG,N}}\right)^{1-\kappa_N}\right)^{\frac{1}{1-\kappa_N}} \tag{110}$$

$$\frac{1}{1+g_t}\tilde{K}_{t-1}^N = \alpha_N \left(\frac{p_t^Z}{r_t^{K,N}}\right)^{\kappa_N} \tilde{Z}_t \tag{111}$$

$$\tilde{L}_t^{OLG,N} = (1-\alpha_N)\left(\frac{p_t^Z}{\tilde{\hat{w}}_t^{OLG,N}}\right)^{\kappa_N} (\tilde{A}_t^{OLG,N})^{\kappa_N - 1} Z_t \tag{112}$$

$$\tilde{Z}_t = \theta \left(\frac{mc_t^{Noil}}{p_t^Z}\right)^{\varrho} \tilde{Y}_t^{Noil} \tag{113}$$

$$\tilde{L}_t^{LIQ} = (1-\theta)\left(\frac{mc_t^{Noil}}{\tilde{\hat{w}}_t^{LIQ}}\right)^{\varrho} (\tilde{A}_t^{LIQ})^{\varrho-1}\tilde{Y}_t^{Noil} \tag{114}$$

$$\tilde{Y}_t^{Noil} = \mu_N \left(\frac{\tilde{K}_{t-1}^G}{\tilde{K}^G}\right)^{\alpha_{G,N}(\xi-1)} \left(\frac{mc_t}{mc_t^{Noil}}\right)^{\xi} \tilde{Y}_t^N \tag{115}$$

$$\tilde{M}_t^{Oil,N} = (1-\mu_N)\left(\frac{\tilde{K}_{t-1}^G}{\tilde{K}^G}\right)^{\alpha_{G,N}(\xi-1)} \left(\frac{mc_t}{\hat{p}_t^{Oil,N}}\right)^{\xi} \tilde{Y}_t^N \tag{116}$$

$$\begin{aligned} \tilde{\mathfrak{pr}}_t^N &= p_t^N \tilde{Y}_t^N - r_t^{K,N}\tilde{K}_{t-1}^N \frac{1}{1+g_t} - \tilde{w}_t^{OLG}\tilde{L}_t^{OLG,N}(1+H(\cdot)) \\ &-\tilde{w}_t^{LIQ}\tilde{L}_t^{LIQ}(1+H(\cdot)) - p_t^{Oil}\tilde{M}_t^{Oil,N}(1+G(\cdot)) - p_t^Y R(\cdot)\tilde{Y}_t^N \end{aligned} \tag{117}$$

$$1+\hat{\pi}_t^N = \frac{1+\pi_t^N}{1+\pi_t^{tar}} \tag{118}$$

$$1+\pi_t^N = (1+\pi_t^C)\frac{p_t^N}{p_{t-1}^N} \tag{119}$$

$$\begin{aligned} \tilde{\hat{w}}_t^{OLG,N} &= \tilde{w}_t^{OLG} + \tilde{w}_t^{OLG} H_{OLG,N}\left(\frac{\tilde{L}_t^{OLG,N}}{\tilde{L}_{t-1}^{OLG,N}}\right) + \tilde{w}_t^{OLG} H'_{OLG,N}\left(\frac{\tilde{L}_t^{OLG,N}}{\tilde{L}_{t-1}^{OLG,Y}}\right)\frac{\tilde{L}_t^{OLG,N}}{\tilde{L}_{t-1}^{OLG,N}} \\ &-\mathbb{E}_t(1+g_{t+1}^A)\frac{\tilde{w}_{t+1}^{OLG}}{1+r_t}H'_{OLG,N}\left(\frac{\tilde{L}_{t+1}^{OLG,N}}{\tilde{L}_t^{OLG,N}}\right)\left(\frac{\tilde{L}_{t+1}^{OLG,N}}{\tilde{L}_t^{OLG,N}}\right)^2 \end{aligned} \tag{120}$$

$$\begin{aligned} \tilde{\hat{w}}_t^{LIQ} &= \tilde{w}_t^{LIQ} + \tilde{w}_t^{LIQ} H_{LIQ}\left(\frac{\tilde{L}_t^{LIQ}}{\tilde{L}_{t-1}^{LIQ}}\right) + \tilde{w}_t^{LIQ} H'_{LIQ}\left(\frac{\tilde{L}_t^{LIQ}}{\tilde{L}_{t-1}^{LIQ}}\right)\frac{\tilde{L}_t^{LIQ}}{\tilde{L}_{t-1}^{LIQ}} \\ &-\mathbb{E}_t(1+g_{t+1}^A)\frac{\tilde{w}_{t+1}^{LIQ}}{1+r_t}H'_{LIQ}\left(\frac{\tilde{L}_{t+1}^{LIQ}}{\tilde{L}_t^{LIQ}}\right)\left(\frac{\tilde{L}_{t+1}^{LIQ}}{\tilde{L}_t^{LIQ}}\right)^2 \end{aligned} \tag{121}$$

$$\begin{aligned} \hat{p}_t^{Oil,N} &= p_t^{Oil} + p_t^{Oil} G\left(\frac{\tilde{M}_t^{Oil,N}}{\tilde{M}_{t-1}^{Oil,N}}\right) + p_t^{Oil} G'\left(\frac{\tilde{M}_t^{Oil,N}}{\tilde{M}_{t-1}^{Oil,N}}\right)\frac{\tilde{M}_t^{Oil,N}}{\tilde{M}_{t-1}^{Oil,N}} \\ &-\mathbb{E}_t(1+g_{t+1})\frac{p_{t+1}^{Oil}}{1+r_t}G'\left(\frac{\tilde{M}_{t+1}^{Oil,N}}{\tilde{M}_t^{Oil,N}}\right)\left(\frac{\tilde{M}_{t+1}^{Oil,N}}{\tilde{M}_t^{Oil,N}}\right)^2 \end{aligned} \tag{122}$$

$$R\left(1+\hat{\pi}_t^N\right) = \frac{\phi_{P^N}}{2}\left[\frac{1+\hat{\pi}_t^N}{(1+\hat{\pi}_{t-1}^N)^{\vartheta}} - 1\right]^2 \tag{123}$$

$$R'\left(1+\hat{\pi}_t^N\right) = \phi_{P^N}\left[\frac{1+\hat{\pi}_t^N}{(1+\hat{\pi}_{t-1}^N)^{\vartheta}} - 1\right] \tag{124}$$

$$H_{OLG,N}\left(\frac{\tilde{L}_t^{OLG,N}}{\tilde{L}_{t-1}^{OLG,N}}\right) = \frac{\phi_{L,OLG,N}}{2}\left[\frac{\tilde{L}_t^{OLG,N}}{\tilde{L}_{t-1}^{OLG,N}} - 1\right]^2 \tag{125}$$

$$H'_{OLG,N}\left(\frac{\tilde{L}_t^{OLG,N}}{\tilde{L}_{t-1}^{OLG,N}}\right) = \phi_{L,OLG,N}\left[\frac{\tilde{L}_t^{OLG,N}}{\tilde{L}_{t-1}^{OLG,N}} - 1\right] \tag{126}$$

$$H_{LIQ}\left(\frac{\tilde{L}_t^{LIQ}}{\tilde{L}_{t-1}^{LIQ}}\right) = \frac{\phi_{L,LIQ}}{2}\left[\frac{\tilde{L}_t^{LIQ}}{\tilde{L}_{t-1}^{LIQ}} - 1\right]^2 \tag{127}$$

$$H'_{LIQ}\left(\frac{\tilde{L}_t^{LIQ}}{\tilde{L}_{t-1}^{LIQ}}\right) = \phi_{L,LIQ}\left[\frac{\tilde{L}_t^{LIQ}}{\tilde{L}_{t-1}^{LIQ}} - 1\right] \tag{128}$$

$$G\left(\frac{\tilde{M}_t^{Oil,N}}{\tilde{M}_{t-1}^{Oil,N}}\right) = \frac{\phi_{M,Oil,N}}{2}\left[\frac{\tilde{M}_t^{Oil,N}}{\tilde{M}_{t-1}^{Oil,N}} - 1\right]^2 \tag{129}$$

$$G'\left(\frac{\tilde{M}_t^{Oil,N}}{\tilde{M}_{t-1}^{Oil,N}}\right) = \phi_{M,Oil,N}\left[\frac{\tilde{M}_t^{Oil,N}}{\tilde{M}_{t-1}^{Oil,N}} - 1\right] \tag{130}$$

HT firms:

$$\begin{aligned}\left[\frac{1+\hat{\pi}_t^H}{(1+\hat{\pi}_{t-1}^H)^{\vartheta_H}}\right] R'\left(\frac{1+\hat{\pi}_t^H}{(1+\hat{\pi}_{t-1}^H)^{\vartheta_H}}\right) = \left(\frac{1-\omega}{1+r_t}\right)\mathbb{E}_t\Delta_{t+1}^H\left[\frac{1+\hat{\pi}_{t+1}^H}{(1+\hat{\pi}_t^H)^{\vartheta_H}}\right] R'\left(\frac{1+\hat{\pi}_{t+1}^H}{(1+\hat{\pi}_t^H)^{\vartheta_H}}\right)\\ +\varphi_H\left(\frac{mc_t^H}{p_t^H} - \frac{\varphi_H - 1}{\varphi_H}\right)\end{aligned} \tag{131}$$

$$mc_t^H = \left(\frac{\tilde{K}_{t-1}^G}{\tilde{K}^G}\right)^{-\alpha_{G,H}}\left(\alpha_H\left(r_t^{K,H}\right)^{1-\kappa_H} + (1-\alpha_H)\left(\frac{\tilde{\tilde{w}}_t^{OLG,H}}{\tilde{A}_t^{OLG,H}}\right)^{1-\kappa_H}\right)^{\frac{1}{1-\kappa_H}} \tag{132}$$

$$\frac{1}{1+g_t}\tilde{K}_{t-1}^H = \alpha_H\left(\frac{\tilde{K}_{t-1}^G}{\tilde{K}^G}\right)^{\alpha_{G,H}(\kappa_H-1)}\left(\frac{mc_t^H}{r_t^{K,H}}\right)^{\kappa_H}\tilde{Y}_t^H \tag{133}$$

$$\tilde{L}_t^{OLG,H} = (1-\alpha_H)\left(\frac{\tilde{K}_{t-1}^G}{\tilde{K}^G}\right)^{\alpha_{G,H}(\kappa_H-1)}\left(\frac{mc_t^H}{\tilde{\tilde{w}}_t^{OLG,H}}\right)^{\kappa_H}(\tilde{A}_t^{OLG,H})^{\kappa_H-1}\tilde{Y}_t^H \tag{134}$$

$$\tilde{\mathfrak{pr}}_t^H = p_t^H\tilde{Y}_t^H - r_t^{K,H}\tilde{K}_{t-1}^H\frac{1}{1+g_t} - \tilde{w}_t^{OLG}\tilde{L}_t^{OLG,H}(1+H_{OLG,H}(\cdot)) \tag{135}$$

$$1+\hat{\pi}_t^H = \frac{1+\pi_t^H}{1+\pi_t^{tar}} \tag{136}$$

$$1+\pi_t^H = (1+\pi_t^C)\frac{p_t^H}{p_{t-1}^H} \tag{137}$$

$$1+\tilde{gr}_t^{OLG,H} = \left((1+\tilde{gr}_{t-1}^{OLG,H})\frac{1+gr_{t-1}^A}{1+gr_t^A}\right)^{\rho}\exp\{\varepsilon_t^{gr^{A,H}}\} \tag{138}$$

$$1+\tilde{gr}_t^{OLG,H} = \frac{\tilde{\bar{A}}_t^{OLG,H}}{\tilde{\bar{A}}_{t-1}^{OLG,H}} \tag{139}$$

$$\tilde{A}_t^{OLG,H} = \tilde{\bar{A}}_t^{OLG,H}\exp\{\varepsilon_t^{\tilde{A}^{OLG,H}}\} \tag{140}$$

$$\begin{aligned}\tilde{\bar{w}}_t^{OLG,H} &= \tilde{w}_t^{OLG} + \tilde{w}_t^{OLG}H_{OLG,H}\left(\frac{\tilde{L}_t^{OLG,H}}{\tilde{L}_{t-1}^{OLG,H}}\right) + \tilde{w}_t^{OLG}H'_{OLG,H}\left(\frac{\tilde{L}_t^{OLG,H}}{\tilde{L}_{t-1}^{OLG,H}}\right)\frac{\tilde{L}_t^{OLG,H}}{\tilde{L}_{t-1}^{OLG,H}}\\ &-\mathbb{E}_t(1+g_{t+1}^A)\frac{\tilde{w}_{t+1}^{OLG}}{1+r_t}H'_{OLG,H}\left(\frac{\tilde{L}_{t+1}^{OLG,H}}{\tilde{L}_t^{OLG,H}}\right)\left(\frac{\tilde{L}_{t+1}^{OLG,H}}{\tilde{L}_t^{OLG,H}}\right)^2\end{aligned} \tag{141}$$

$$H_{OLG,H}\left(\frac{\tilde{L}_t^{OLG,H}}{\tilde{L}_{t-1}^{OLG,H}}\right) = \frac{\phi_{L,OLG,H}}{2}\left[\frac{\tilde{L}_t^{OLG,H}}{\tilde{L}_{t-1}^{OLG,H}}-1\right]^2 \tag{142}$$

$$H'_{OLG,H}\left(\frac{\tilde{L}_t^{OLG,H}}{\tilde{L}_{t-1}^{OLG,H}}\right) = \phi_{L,OLG,H}\left[\frac{\tilde{L}_t^{OLG,H}}{\tilde{L}_{t-1}^{OLG,H}}-1\right] \tag{143}$$

$$R\left(1+\hat{\pi}_t^H\right) = \frac{\phi_{P^H}}{2}\left[\frac{1+\hat{\pi}_t^H}{(1+\hat{\pi}_{t-1}^H)^{\vartheta}}-1\right]^2 \tag{144}$$

$$R'\left(1+\hat{\pi}_t^H\right) = \phi_{P^H}\left[\frac{1+\hat{\pi}_t^H}{(1+\hat{\pi}_{t-1}^H)^{\vartheta}}-1\right] \tag{145}$$

Oil Importers:

$$1+\pi_t^{Oil,*} = (1+\pi_t^*)\frac{p_t^{Oil,*}}{p_{t-1}^{Oil,*}} \tag{146}$$

$$p_t^{Oil} = p_t^{Oil,*}REER_t \tag{147}$$

$$1+\pi_t^{Oil,*} = (1+\pi_{t-1}^{Oil,*})^{\rho}(1+\pi^{Oil,*,ss})^{1-\rho}e^{\varepsilon_t^{Oil,*}} \tag{148}$$

$$\begin{aligned}\tilde{M}_t^{Oil} &= \tilde{M}_t^{Oil,N}+\tilde{M}_t^{Oil,C}+\tilde{M}_t^{Oil,Inv^N}+\tilde{M}_t^{Oil,Inv^H}+\tilde{M}_t^{Oil,Gov}+\\ &+\tilde{M}_t^{Oil,Inv^{Gov}}+\tilde{M}_t^{Oil,X,N}+\tilde{M}_t^{Oil,X,H}+\tilde{M}_t^{Oil,Inv,N}S\left(\cdot\right)+\tilde{M}_t^{Oil,Inv,H}S\left(\cdot\right)\end{aligned} \tag{149}$$

Importers:

$$\left[\frac{1+\hat{\pi}_t^M}{(1+\hat{\pi}_{t-1}^H)^{\vartheta_M}}\right] R'\left(\frac{1+\hat{\pi}_t^M}{(1+\hat{\pi}_{t-1}^M)^{\vartheta_M}}\right) = \left(\frac{1-\omega}{1+r_t}\right)\mathbb{E}_t\Delta_{t+1}^M\left[\frac{1+\hat{\pi}_{t+1}^M}{(1+\hat{\pi}_t^M)^{\vartheta_M}}\right] R'\left(\frac{1+\hat{\pi}_{t+1}^M}{(1+\hat{\pi}_t^M)^{\vartheta_M}}\right) + \varphi_M\left(\frac{REER_t}{p_t^M} - \frac{\varphi_M - 1}{\varphi_M}\right) \tag{150}$$

$$1+\hat{\pi}_t^M = \frac{1+\pi_t^M}{1+\pi_t^{tar}} \tag{151}$$

$$1+\pi_t^M = \left(1+\pi_t^C\right)\frac{p_t^M}{p_{t-1}^M} \tag{152}$$

$$R\left(1+\hat{\pi}_t^M\right) = \frac{\phi_{P^M}}{2}\left[\frac{1+\hat{\pi}_t^M}{(1+\hat{\pi}_{t-1}^M)^{\vartheta}} - 1\right]^2 \tag{153}$$

$$R'\left(1+\hat{\pi}_t^M\right) = \phi_{P^M}\left[\frac{1+\hat{\pi}_t^M}{(1+\hat{\pi}_{t-1}^M)^{\vartheta}} - 1\right] \tag{154}$$

$$\tilde{\mathfrak{pr}}_t^M = p_t^M\tilde{M}_t - REER_t\tilde{M}_t - p_t^M\tilde{M}_tR(\cdot) \tag{155}$$

$$\tilde{M}_t = \tilde{M}_t^C + \tilde{M}_t^{Inv^N} + \tilde{M}_t^{Inv^{Gov},Noil} + \tilde{M}_t^{Inv^H} + \tilde{M}_t^{Gov} + \tilde{M}_t^{X,N} + \\ + \tilde{M}_t^{X,H} + \tilde{M}_tR(\cdot) + \tilde{M}_t^{Inv,N}S(\cdot) + \tilde{M}_t^{Inv,H}S(\cdot) \tag{156}$$

Export Retailer firms $j \in \{H; N\}$:

$$p_t^{X,j} = \left[\mu_{Y,j}\left(p_t^{X,j}\right)^{1-\kappa_{x,j}} + \mu_{M,j}\left(\hat{p}_t^{Oil,X,j}\right)^{1-\kappa_{x,j}} + (1-\mu_{Y,j}-\mu_{M,j})\left(\hat{p}_t^{M,X,j}\right)^{1-\kappa_{x,j}}\right]^{\frac{1}{1-\kappa_{x,j}}} \tag{157}$$

$$\tilde{Y}_t^{X,j} = \mu_{Y,j}\left(\frac{p_t^N}{p_t^j}\right)^{-\kappa_{x,j}}\tilde{X}_t^j \tag{158}$$

$$\tilde{M}_t^{Oil,X,j} = \mu_{M,j}\left(\frac{\hat{p}_t^{Oil,X,j}}{p_t^j}\right)^{-\kappa_{x,j}}\tilde{X}_t^j \tag{159}$$

$$\tilde{M}_t^{X,j} = (1-\mu_{Y,j}-\mu_{M,j})\left(\frac{\hat{p}_t^{M,X,j}}{p_t^j}\right)^{-\kappa_{x,j}}\tilde{X}_t^j \tag{160}$$

$$1+\hat{\pi}_t^j = \frac{1+\pi_t^j}{1+\pi^{tar}} \tag{161}$$

$$1+\pi_t^j = \left(1+\pi_t^C\right)\frac{p_t^j}{p_{t-1}^j} \tag{162}$$

$$\hat{p}_t^{Oil,X,j} = p_t^{Oil} + p_t^{Oil} G\left(\frac{\tilde{M}_t^{Oil,X,j}}{\tilde{M}_{t-1}^{Oil,X,j}}\right) + p_t^{Oil} G'\left(\frac{\tilde{M}_t^{Oil,X,j}}{\tilde{M}_{t-1}^{Oil,X,j}}\right)\frac{\tilde{M}_t^{Oil,X,j}}{\tilde{M}_{t-1}^{Oil,X,j}} \\ -\mathbb{E}_t(1+g_{t+1})\frac{p_{t+1}^{Oil}}{1+r_t} G'\left(\frac{\tilde{M}_{t+1}^{Oil,X,j}}{\tilde{M}_t^{Oil,X,j}}\right)\left(\frac{\tilde{M}_{t+1}^{Oil,X,j}}{\tilde{M}_t^{Oil,X,j}}\right)^2 \tag{163}$$

$$\hat{p}_t^{M,X,j} = p_t^{M} + p_t^{M} G\left(\frac{\tilde{M}_t^{X,j}}{\tilde{M}_{t-1}^{X,j}}\right) + p_t^{M} G'\left(\frac{\tilde{M}_t^{X,j}}{\tilde{M}_{t-1}^{X,j}}\right)\frac{\tilde{M}_t^{X,j}}{\tilde{M}_{t-1}^{X,j}} \\ -\mathbb{E}_t(1+g_{t+1})\frac{p_{t+1}^{M}}{1+r_t} G'\left(\frac{\tilde{M}_{t+1}^{X,j}}{\tilde{M}_t^{X,j}}\right)\left(\frac{\tilde{M}_{t+1}^{X,j}}{\tilde{M}_t^{X,j}}\right)^2 \tag{164}$$

$$G\left(\frac{\tilde{M}_t^{Oil,X,j}}{\tilde{M}_{t-1}^{Oil,X,j}}\right) = \frac{\phi_{M,Oil,X,j}}{2}\left[\frac{\tilde{M}_t^{Oil,X,j}}{\tilde{M}_{t-1}^{Oil,X,j}} - 1\right]^2 \tag{165}$$

$$G'\left(\frac{\tilde{M}_t^{Oil,X,j}}{\tilde{M}_{t-1}^{Oil,X,j}}\right) = \phi_{M,Oil,X,j}\left[\frac{\tilde{M}_t^{Oil,X,j}}{\tilde{M}_{t-1}^{Oil,X,j}} - 1\right] \tag{166}$$

$$G\left(\frac{\tilde{M}_t^{X,j}}{\tilde{M}_{t-1}^{X,j}}\right) = \frac{\phi_{M,X,j}}{2}\left[\frac{\tilde{M}_t^{X,j}}{\tilde{M}_{t-1}^{X,j}} - 1\right]^2 \tag{167}$$

$$G'\left(\frac{\tilde{M}_t^{X,j}}{\tilde{M}_{t-1}^{X,j}}\right) = \phi_{M,X,j}\left[\frac{\tilde{M}_t^{X,j}}{\tilde{M}_{t-1}^{X,j}} - 1\right] \tag{168}$$

Retailer firms $j \in \{C; Inv^N; Gov; Inv^{Gov}; Inv^H; Inv^N S(\cdot); Inv^H S(\cdot)\}$:

$$p_t^j = \left[\mu_{N,j}\left(p_t^N\right)^{1-\kappa_j} + \mu_{H,j}\left(p_t^H\right)^{1-\kappa_j} + \mu_{Oil,j}\left(\hat{p}_t^{Oil,Z,j}\right)^{1-\kappa_j} + (1-\mu_{N,j}-\mu_{H,j}-\mu_{Oil,j})\left(\hat{p}_t^{M,Z,j}\right)^{1-\kappa_j}\right]^{\frac{1}{1-\kappa_j}} \tag{169}$$

$$\tilde{Y}_t^{N,j} = \mu_{N,j}\left(\frac{p_t^N}{p_t^j}\right)^{-\kappa_j}\tilde{j}_t \tag{170}$$

$$\tilde{Y}_t^{H,j} = \mu_{H,j}\left(\frac{p_t^H}{p_t^j}\right)^{-\kappa_j}\tilde{j}_t \tag{171}$$

$$\tilde{M}_t^{Oil,j} = \mu_{Oil,j}\left(\frac{\hat{p}_t^{Oil,Z,j}}{p_t^j}\right)^{-\kappa_j}\tilde{j}_t \tag{172}$$

$$\tilde{M}_t^{j} = (1-\mu_{N,j}-\mu_{H,j}-\mu_{Oil,j})\left(\frac{\hat{p}_t^{M,Z,j}}{p_t^j}\right)^{-\kappa_j}\tilde{j}_t \tag{173}$$

$$1+\hat{\pi}_t^j = \frac{1+\pi_t^j}{1+\pi_t^{tar}} \tag{174}$$

$$1+\pi_t^j = \left(1+\pi_t^C\right)\frac{p_t^j}{p_{t-1}^j} \tag{175}$$

$$\begin{aligned}\hat{p}_t^{Oil,j} = p_t^{Oil} + p_t^{Oil} G\left(\frac{\tilde{M}_t^{Oil,j}}{\tilde{M}_{t-1}^{Oil,j}}\right) + p_t^{Oil} G'\left(\frac{\tilde{M}_t^{Oil,j}}{\tilde{M}_{t-1}^{Oil,j}}\right)\frac{\tilde{M}_t^{Oil,j}}{\tilde{M}_{t-1}^{Oil,j}} \\ -\mathbb{E}_t(1+g_{t+1})\frac{p_{t+1}^{Oil}}{1+r_t} G'\left(\frac{\tilde{M}_{t+1}^{Oil,j}}{\tilde{M}_t^{Oil,j}}\right)\left(\frac{\tilde{M}_{t+1}^{Oil,j}}{\tilde{M}_t^{Oil,j}}\right)^2\end{aligned} \tag{176}$$

$$\begin{aligned}\hat{p}_t^{M,j} = p_t^{M} + p_t^{M} G\left(\frac{\tilde{M}_t^{j}}{\tilde{M}_{t-1}^{j}}\right) + p_t^{M} G'\left(\frac{\tilde{M}_t^{j}}{\tilde{M}_{t-1}^{j}}\right)\frac{\tilde{M}_t^{j}}{\tilde{M}_{t-1}^{j}} \\ -\mathbb{E}_t(1+g_{t+1})\frac{p_{t+1}^{M}}{1+r_t} G'\left(\frac{\tilde{M}_{t+1}^{j}}{\tilde{M}_t^{j}}\right)\left(\frac{\tilde{M}_{t+1}^{j}}{\tilde{M}_t^{j}}\right)^2\end{aligned} \tag{177}$$

$$G\left(\frac{\tilde{M}_t^{Oil,j}}{\tilde{M}_{t-1}^{Oil,j}}\right) = \frac{\phi_{M,Oil,j}}{2}\left[\frac{\tilde{M}_t^{Oil,j}}{\tilde{M}_{t-1}^{Oil,j}} - 1\right]^2 \tag{178}$$

$$G'\left(\frac{\tilde{M}_t^{Oil,j}}{\tilde{M}_{t-1}^{Oil,j}}\right) = \phi_{M,Oil,j}\left[\frac{\tilde{M}_t^{Oil,j}}{\tilde{M}_{t-1}^{Oil,j}} - 1\right] \tag{179}$$

$$G\left(\frac{\tilde{M}_t^{j}}{\tilde{M}_{t-1}^{j}}\right) = \frac{\phi_{M,j}}{2}\left[\frac{\tilde{M}_t^{j}}{\tilde{M}_{t-1}^{j}} - 1\right]^2 \tag{180}$$

$$G'\left(\frac{\tilde{M}_t^{j}}{\tilde{M}_{t-1}^{j}}\right) = \phi_{M,j}\left[\frac{\tilde{M}_t^{j}}{\tilde{M}_{t-1}^{j}} - 1\right] \tag{181}$$

Fiscal policy:

$$\tilde{Rev}_t = \tilde{T}_t + \tilde{Tax}_t^C + \tilde{Tax}_t^L + \tilde{Tax}_t^K \tag{182}$$

$$\tilde{Tax}_t^C = \tau_t^C \tilde{C}_t \tag{183}$$

$$\tilde{Tax}_t^L = \tau_t^{L,OLG}\tilde{w}_t^{OLG,r}\tilde{L}_t^{OLG} + \tau_t^{L,LIQ}\tilde{w}_t^{LIQ,r}\tilde{L}_t^{LIQ} \tag{184}$$

$$\begin{aligned}\tilde{Tax}_t^K = \tau_t^K\Bigg(r_t^{K,N}\tilde{K}_{t-1}^N\frac{1}{1+g_t} + r_t^{K,H}\tilde{K}_{t-1}^H\frac{1}{1+g_t} - p_t^{Inv,N}\tilde{Inv}_t^N - p_t^{Inv,H}\tilde{Inv}_t^H \\ -p_t^{Inv,H}\tilde{Inv}_t^H S(\cdot) - p_t^{Inv,N}\tilde{Inv}_t^N S(\cdot)\Bigg)\end{aligned} \tag{185}$$

$$\tilde{Exp}_t = \tilde{TR}_t + p_t^{Gov}\tilde{Gov}_t + p_t^{Inv^N}\tilde{Inv}_t^{Gov} \tag{186}$$

$$\tilde{K}_t^{Gov} = e_t\tilde{Inv}_t^{Gov} + \frac{1-\delta^{Gov}}{1+g_t}\tilde{K}_{t-1}^G \tag{187}$$

$$e_t = e_{t-1} + \varepsilon_t^e \tag{188}$$

$$\tilde{PS}_t = \tilde{Rev}_t - \tilde{Exp}_t \tag{189}$$

$$\tilde{GS}_t = \tilde{PS}_t - Int\tilde{C}ost_t \tag{190}$$

$$Int\tilde{C}ost_t = \frac{i_{t-1}}{(1+g_t)(1+\pi_t)}\tilde{Debt}_{t-1}^{Dom} + \frac{(1+i_{t-1}^*)(1+prem_{t-1})-1}{(1+g_t)(1+\pi_t^*)}REER_t\tilde{Debt}_{t-1}^* \tag{191}$$

$$\tilde{Fin}_t = \mathcal{K}_t \cdot \tilde{GS}_t \tag{192}$$

$$\tilde{Fin}_t^* = (1-\mathcal{K}_t) \cdot \tilde{GS}_t \tag{193}$$

$$\tilde{Debt}_t^{Dom} = \frac{1}{(1+g_t)(1+\pi_t)}\tilde{Debt}_{t-1}^{Dom} - \tilde{Fin}_t \tag{194}$$

$$REER_t\tilde{Debt}_t^* = \frac{REER_t}{(1+g_t)(1+\pi_t^*)}\tilde{Debt}_{t-1}^* - \tilde{Fin}_t^* \tag{195}$$

$$\tilde{Debt}_t = \tilde{Debt}_t^{Dom} + REER_t\tilde{Debt}_t^* \tag{196}$$

$$\frac{\tilde{PS}_t}{\tilde{GDP}_t} = \rho_1\frac{\tilde{PS}_{t-1}}{\tilde{GDP}_{t-1}} + (1-\rho_1)\left(\frac{\bar{PS}_t}{\bar{GDP}_t} + \vartheta^D Debt_t^{Dev}\right) \tag{197}$$

$$Debt_t^{Dev} = \rho_2\left(\frac{\tilde{Debt}_t}{\tilde{GDP}_t} - \frac{\bar{Debt}_t}{\bar{GDP}_t}\right) + (1-\rho_2)\mathbb{E}_t Debt_{t+1}^{Dev} \tag{198}$$

Monetary policy:

$$1+i_t = (1+i_{t-1})^{\rho_i}\left[(1+i)\left(\frac{1+\pi_{t+1}^C}{1+\pi_t^{tar}}\right)^{\phi_\pi}\right]^{1-\rho_i} e^{\epsilon_t^i} \tag{199}$$

$$1+i_t = \mathbb{E}_t(1+r_t)(1+\pi_{t+1}^C) \tag{200}$$

$$1+i_t^* = \mathbb{E}_t(1+r_t^*)(1+\pi_{t+1}^{C,*}) \tag{201}$$

$$1+i_t = (1+i_t^*)(1+prem_t)\frac{S_{t+1}}{S_t} \tag{202}$$

$$\frac{REER_t}{REER_{t-1}} = \frac{S_t}{S_{t-1}}\frac{1+\pi_t^*}{1+\pi_t^C} \tag{203}$$

Foreign trade:

$$\tilde{X}_t^N = \left(\frac{p_t^{X,N}}{REER_t}\right)^{-\theta_N} G\tilde{D}P_t^* \tag{204}$$

$$\tilde{X}_t^H = \left(\frac{p_t^{X,H}}{REER_t}\right)^{-\theta_H} G\tilde{D}P_t^{H,*} \tag{205}$$

$$\tilde{TB}_t = p_t^{X,N}\tilde{X}_t^N + p_t^{X,H}\tilde{X}_t^H - REER_t\tilde{M}_t^{Noil} - REER_t p_t^{Oil,*}\tilde{M}_t^{Oil} \tag{206}$$

$$\tilde{TB}_t = -REER_t\mathbb{D}_t^* + \frac{1+r_{t-1}^*}{1+g_t}REER_t\mathbb{D}_{t-1}^* \tag{207}$$

$$\mathbb{D}_t^* = D\tilde{ebt}_t^* - \tilde{B}_t^* \tag{208}$$

$$1 + prem_t = e^{\chi\left(REER_t\frac{\mathbb{D}_t^*}{GDP_t} - \bar{REER}\frac{\bar{\mathbb{D}}^*}{\bar{GDP}}e^{\epsilon_t^{\mathbb{D},*}}\right)} e^{\epsilon_t^{Prem}} \tag{209}$$

Equilibrium conditions:

$$\tilde{B}_t = D\tilde{ebt}_t^{Dom} \tag{210}$$

$$\begin{aligned}\tilde{Y}_t^N = \tilde{Y}_t^{N,C} + \tilde{Y}_t^{N,Inv^N} + \tilde{Y}_t^{N,Inv^{Gov}} + \tilde{Y}_t^{N,Inv^H} + \tilde{Y}_t^{N,Gov} + \tilde{Y}_t^{N,X,N} + \tilde{Y}_t^N R(\cdot) + \\ \tilde{Y}_t^{N,Inv,N} S(\cdot) + \tilde{Y}_t^{N,Inv,H} S(\cdot) + (\tilde{w}_t^{OLG}/p_t^N)\tilde{L}_t^{OLG,N} H_{OLG,N}(\cdot) + (\tilde{w}_t^{LIQ}/p_t^N)\tilde{L}_t^{LIQ} H_{LIQ}(\cdot)\end{aligned} \tag{211}$$

$$\begin{aligned}\tilde{Y}_t^H = \tilde{Y}_t^{H,C} + \tilde{Y}_t^{H,Inv^N} + \tilde{Y}_t^{H,Inv^{Gov}} + \tilde{Y}_t^{H,Inv^H} + \tilde{Y}_t^{H,G} + \tilde{Y}_t^{H,X} + \\ + \tilde{Y}_t^{H,Inv,N} S(\cdot) + \tilde{Y}_t^{H,Inv,H} S(\cdot) + (\tilde{w}_t^{OLG}/p_t^H)\tilde{L}_t^{OLG,H} H_{OLG,H}(\cdot)\end{aligned} \tag{212}$$

$$\begin{aligned}G\tilde{D}P_t = \tilde{C}_t + p_t^{Inv^N} I\tilde{n}v_t^N + p_t^{Inv^N} I\tilde{n}v_t^{Gov} + p_t^{Inv^H} I\tilde{n}v_t^H + p_t^G G\tilde{o}v_t \\ + p_t^{X,N}\tilde{X}_t^N + p_t^{X,H}\tilde{X}_t^H - p_t^M\tilde{M}_t^{Noil} - p_t^{Oil}\tilde{M}_t^{Oil} + p_t^{Inv^N} I\tilde{n}v_t^N S(\cdot) + \\ + p_t^{Inv^H} I\tilde{n}v_t^H S(\cdot) + p_t^N\tilde{Y}_t^N R(\cdot) + p_t^M\tilde{M}_t R(\cdot) + \tilde{w}_t^{OLG}\tilde{L}_t^{OLG,N} H_{OLG,N}(\cdot) + \\ + \tilde{w}_t^{OLG}\tilde{L}_t^{OLG,H} H_{OLG,H}(\cdot) + \tilde{w}_t^{LIQ}\tilde{L}_t^{LIQ} H_{LIQ}(\cdot)\end{aligned} \tag{213}$$

where we also know that the GDP can be given from the supply side:

$$G\tilde{D}P_t = p_t^N\tilde{Y}_t^N + p_t^H\tilde{Y}_t^H - p_t^{Oil}\tilde{M}_t^{Oil,N} \tag{214}$$

Foreign variables:

$$1 + i_t^* = (1 + i_{t-1}^*)^{\rho_{i*}}\left[(1+\bar{r}*)(1+\bar{\pi}^{tar*})\mathbb{E}_t\left(\frac{1+\pi_{t+1}^*}{1+\bar{\pi}^{tar*}}\right)^{\phi_{i*}}\right]^{1-\rho_{i*}} e^{\epsilon_t^{i*}} \tag{215}$$

$$1 + \pi_t^* = (1 + \pi_{t-1}^*)^{\rho_{\pi*}}\left[(1+\bar{\pi}^{tar*})\left(\frac{P_t^{Oil,*}}{\bar{P}^{Oil,*}}\right)^{\phi_{\pi*}}\right]^{1-\rho_{\pi*}} e^{\epsilon_t^{\pi*}} \tag{216}$$

$$P_t^{Oil,*} = (P_{t-1}^{Oil,*})^{\rho_{Oil,*}} (\bar{P}^{Oil,*})^{1-\rho_{Oil,*}} e^{\epsilon_t^{Oil,*}} \tag{217}$$

$$X_t^N = GDP_t^{*,N} \left( \frac{p_t^{X,N}}{REER_t} \right)^{-\theta_N} \tag{218}$$

$$\begin{aligned} \ln(GDP_t^{*,N}) = \rho_{GDP^{*,N}} \ln(GDP_{t-1}^{*}) + (1 - \rho_{GDP^{*,N}})(\ln(GDP_{SS}^{*,N}) \\ -\phi_{r,*}(r_t^* - \bar{r}^*)) + \epsilon_t^{GDP^{*,N}} \end{aligned} \tag{219}$$

$$X_t^H = GDP_t^{*,H} \left( \frac{p_t^{X,H}}{REER_t} \right)^{-\theta_H} \tag{220}$$

$$\ln(GDP_t^{*,H}) = \rho_{GDP^{*,H}} \ln(GDP_{t-1}^{*,H}) + (1 - \rho_{GDP^{*,H}})(\ln(GDP_{SS}^{*,H}) + \epsilon_t^{GDP^{*,H}} \tag{221}$$

# Appendix B Other Parametrization

### Table 5: Other Steady-State Variables

| Parameter | Value | Definition |
|---|---|---|
| | | **Firms** |
| $\frac{\tilde{M}^{Oil,C}}{\tilde{C}}$ | 0.04 | Share of oil imports for private consumption-to-total private consumption |
| $\frac{\tilde{M}^{Oil,Inv^N}}{\tilde{Inv}^N}$ | 0.001 | Share of oil imports for non-HT investment-to-total non-HT investment |
| $\frac{\tilde{M}^{Oil,Inv^H}}{\tilde{Inv}^H}$ | 0.001 | Share of oil imports for HT investment-to-total HT investment |
| $\frac{\tilde{M}^{Oil,Gov}}{p^{Gov}\tilde{Gov}}$ | 0.001 | Share of oil imports for government consumption-to-total government consumption |
| $\frac{\tilde{M}^{Oil,X^N}}{\tilde{X}^N}$ | 0.02 | Share of oil imports for non-HT exports-to-total non-HT exports |
| $\frac{\tilde{M}^{Oil,X^H}}{\tilde{X}^H}$ | 0.001 | Share of oil imports for HT exports-to-total HT exports |
| $\frac{\tilde{M}^{Noil,Inv^N}}{\tilde{Inv}^N}$ | 0.31 | Share of non-oil imports for non-HT investment-to-total non-HT investment |
| $\frac{\tilde{M}^{Noil,Inv^H}}{\tilde{Inv}^H}$ | 0.9 | Share of non-oil imports for HT investment-to-total HT investment |
| $\frac{\tilde{M}^{Noil,Gov}}{p^{Gov}\tilde{Gov}}$ | 0.09 | Share of non-oil imports for government consumption-to-total government consumption |
| $\frac{\tilde{M}^{Noil,X^H}}{\tilde{X}^H}$ | 0.17 | Share of non-oil imports for HT exports-to-total HT exports |
| $\frac{\tilde{M}^{Noil,X^N}}{\tilde{X}^N}$ | 0.28 | Share of non-oil imports for non-HT exports goods-to-total non-HT exports |
| $\frac{\tilde{Y}^{H,C}}{\tilde{C}}$ | 0.06 | Share of HT production for consumption-to-total consumption goods |
| $\frac{\tilde{Y}^{H,Inv^H}}{\tilde{Inv}^H}$ | 0.05 | Share of HT production for HT investment-to-total HT investment |
| $\frac{\tilde{Y}^{H,Inv^N}}{\tilde{Inv}^N}$ | 0.01 | Share of HT production for non-HT investment-to-total non-HT investment |
| $\frac{\tilde{Y}^{H,Gov}}{p^{Gov}\tilde{Gov}}$ | 0.0001 | Share of HT production for government consumption-to-total government consumption |

Sources: Authors' expert judgement, input-out table, and empirical estimates.

## Table 6: Calibration of Other Parameters

| Parameter | Value | Definition |
|---|---|---|
| | | **Other fiscal policy parameters** |
| $\rho_{\tau_C}$ | 0.4 | Persistence parameter of consumption tax shock |
| $\rho_{\tau_{L,OLG}}$ | 0.4 | Persistence parameter of OLG HH personal income tax shock |
| $\rho_{\tau_{L,LIQ}}$ | 0.4 | Persistence parameter of LIQ HH personal income tax shock |
| $\rho_{\tau_K}$ | 0.4 | Persistence parameter of capital gains tax shock |
| $\rho_T$ | 0.75 | Persistence parameter of lump sum tax shock |
| $\rho_{Dom}$ | 0.75 | Share of the domestic debt |
| $\rho_{Gov}$ | 0.5 | Persistence parameter of government consumption shock |
| $\rho_{Inv,Gov}$ | 0.6 | Persistence parameter of government investment shock |
| $\rho_{TR}$ | 0.5 | Persistence parameter of financial transfers shock |
| $\rho_{PS}$ | 0.5 | Persistence parameter of primary surplus shock |
| $\chi$ | 0.01 | Sensitivity parameter of risk premium to foreign debt |
| | | **Foreign block** |
| $\pi^{C,*}$ | 0.02 | Steady-state foreign inflation |
| $p^{Oil*}$ | 1 | Normalized foreign oil price |
| $\rho_{\pi^{C,*}}$ | 0.99 | Persistence of foreign inflation |
| $\rho_{i^*}$ | 0.4 | Persistence parameter of foreign interest rate shock |
| $\rho_{\pi^{C,Oil*}}$ | 0.99 | Persistence parameter of foreign oil inflation shock |
| $\rho_{i^*}$ | 0.4 | Persistence parameter of foreign interest rate shock |
| $\rho_{GDP,*}$ | 0.5 | Persistence parameter in the external GDP shock |
| $\rho_{Debt,*}$ | 0.5 | Persistence parameter of foreign debt shock |

Source: Authors' expert judgement and empirical estimates.

# Table 7: Calibration of Other Parameters

| Parameter | Value | Definition |
|---|---|---|
| | | **Firms** |
| $\phi_{P^N}$ | 20 | Rotemberg adjustment cost parameter for non-HT goods intermediate producers |
| $\phi_{P^H}$ | 20 | Rotemberg adjustment cost parameter for HT goods intermediate producers |
| $\phi_{P,M}$ | 40 | Rotemberg adjustment cost parameter for non-oil importers |
| $\vartheta_N$ | 0.25 | Degree of inflation indexation parameter for non-HT goods intermediate producers |
| $\vartheta_H$ | 0.25 | Degree of inflation indexation parameter for HT goods intermediate producers |
| $\vartheta_M$ | 0.5 | Degree of inflation indexation parameter for non-oil importers |
| $\varphi_H$ | 11 | Price elasticity parameter for HT goods |
| $\varphi_M$ | 11 | Price elasticity parameter for non-oil imports |
| $\phi_{M,C}$ | 0.1 | Non-oil imports adjustment cost parameter for final goods production of private consumption |
| $\phi_{M,Inv^N}$ | 0.001 | Non-oil imports adjustment cost parameter for final goods production of non-HT investments |
| $\phi_{M,Inv^H}$ | 0.001 | Non-oil imports adjustment cost parameter for final goods production of HT investments |
| $\phi_{M,Inv^{Gov}}$ | 0.001 | Non-oil imports adjustment cost parameter for final goods production of government investment |
| $\phi_{M,Gov}$ | 0.001 | Non-oil imports adjustment cost parameter for final goods production of government consumption |
| $\phi_{M,X^N}$ | 0.5 | Non-oil imports adjustment cost parameter for final goods production of non-HT exports |
| $\phi_{M,X^H}$ | 0.5 | Non-oil imports adjustment cost parameter for final goods production of HT exports |
| $\phi_{M,Oil,C}$ | 0.1 | Oil imports adjustment cost parameter for final goods production of private consumption |
| $\phi_{M,Oil,Inv^N}$ | 0.001 | Oil imports adjustment cost parameter for final goods production of non-HT investment |
| $\phi_{M,Oil,Inv^H}$ | 0.001 | Oil imports adjustment cost parameter for final goods production of HT investment |
| $\phi_{M,Oil,Inv^{Gov}}$ | 0.001 | Oil imports adjustment cost parameter for final goods production of government investment |
| $\phi_{M,Oil,Gov}$ | 0.001 | Oil imports adjustment cost parameter for final goods production of government consumption |
| $\phi_{M,Oil,X^N}$ | 0.5 | Oil imports adjustment cost parameter for final goods production of non-HT exports |
| $\phi_{M,Oil,X^H}$ | 0.5 | Oil imports adjustment cost parameter for final goods production of HT exports |
| $\kappa_C$ | 0.5 | Elasticity of substitution parameter of final private consumption goods |
| $\kappa_{Inv^N}$ | 0.5 | Elasticity of substitution parameter of final private investment for non-HT goods |
| $\kappa_{Inv^H}$ | 0.5 | Elasticity of substitution parameter of final private investment for HT goods |
| $\kappa_{Inv^{Gov}}$ | 0.5 | Elasticity of substitution parameter of final government investment goods |
| $\kappa_{Gov}$ | 0.5 | Elasticity of substitution parameter of final government consumption goods |
| $\kappa_{X^N}$ | 0.4 | Elasticity of substitution parameter of exports for non-HT goods |
| $\kappa_{X^H}$ | 0.4 | Elasticity of substitution parameter of exports for HT goods |
| $\theta_N$ | 0.5 | Sensitivity parameter of exports demand for non-HT goods |
| $\theta_H$ | 3 | Sensitivity parameter of exports demand for HT goods |
| | | **Stochastic shocks** |
| $\rho_{\xi,Inv}$ | 0.5 | Persistence parameter of investment efficiency shock |
| $\rho_C$ | 0.5 | Persistence parameter of consumption preference shock |
| $\rho_A$ | 0.75 | Persistence parameter of productivity shock |
| $\rho_{Prem}$ | 0.5 | Persistence parameter of risk premium shock |
| $\rho_{GR,H}$ | 0.8 | Persistence parameter of HT sector growth |

Sources: Authors' expert judgement, input-out table, and empirical estimates.

PUBLICATIONS

**The Israeli Structural Model**
Working Paper No. WP/2025/213