Comprehensive National Development Planning

(with emphasis on energy and trade)

using the Threshold 21 (T21) model

Final Report

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List of Abbreviations

ANPA: Agenzia Nazionale per la Protezione dell'Ambiente

BAU: Business as usual

C-D: Cobb-Douglas production function

CGE: Computable general equilibrium

CH_4: Methane

CLD: Causal loop diagram

CO_2-eq: Carbon dioxide equivalent

CO_2: Carbon dioxide

EIA: Energy Information Administration of the United States

EM: Econometric modeling

EPU: Economic Planning Unit

ETP: Economic Transformation Programme

FAO: Food and Agricultural Organization of the United Nations

FAOSTAT: Food and Agricultural Organization statistical database

FDI: Foreign Direct Investment

FTA: Free trade agreement

GDP: Gross domestic product

GHG: Greenhouse gas

GNP: Gross National Product

GW: Gigawatt (1 billion watts)

GWh: Gigawatt-hours (1 billion watt-hours)

Ha: Hectare

HDI: Human Development Index

IEA: International Energy Agency

IMF: International Monetary Fund

IPCC: Intergovernmental Panel on Climate Change

K GWh: Thousand gigawatt-hours (1 trillion watt-hours)

Ktoe: Kilo (Thousand) tons of oil equivalent

KWh: Kilowatt-hours (1 thousand watt-hours)

MDGs: Millennium Development Goals

MDI: Malaysian Development Institute

ME: Macro-econometric model

MI: Millennium Institute

MIER: Malaysian Institute of Economic Research

Mtoe: Mega (Million) tons of oil equivalent

MWh: Megawatt-hours

N_2O: Nitrous oxide

NEAC: New Economic Model

O&M: Operations and maintenance

PEMANDU: Performance Management and Delivery Unit

PIM: Perpetual Inventory Model

PPP: Purchasing Power Parity

R&D: Research and development

RE: Renewable energy

RM: Malaysian Ringgit

ROW: Rest of the World

SAM: Social accounting matrix

SD: System Dynamics

SNA: System of National Accounts

SO_X: Sulfur Oxide

T21-Malaysia: Threshold 21 Malaysia model

T21: Threshold 21 model

TFP: Total factor productivity

TFR: Total Fertility Rate

TNB: Tenaga Nasional Berhad

UNDP: United Nations Development Program

UNESCO: United Nations Educational Scientific and Cultural Organization

UNPOP: United Nations Population Division

USD: United States dollar

WDI: World Bank's World Development Indicators

WEO: World Energy Outlook of IEA

WHO: World Health Organization

WPP: World Population Prospects

1. Executive Summary

1.1. Introduction

The energy and trade sectors have played an essential role in the growth of the Malaysian economy. In the case of the energy sector, the establishment of PETRONAS in 1974 has helped to strengthen the energy resource development in the country with the combined oil, gas and energy sectors represented Malaysian Ringgit[1] (RM) 127 billion or 19 percent of Gross domestic product (GDP) in 2009 according to national statistics. As for the trade sector, Malaysia's dramatic economic growth in recent years was underpinned by an open trade policy regime, and total trade in 2010 reached a value of RM1.169 trillion.

To sustain its current position as one of the most competitive and successful countries in the world, the successful implementation of the Economic Transformation Programme (ETP) is crucial. In relation to this, the Economic Planning Unit (EPU) in collaboration with the Millennium Institute (MI) undertook a Comprehensive National Development Planning exercise -with emphasis on energy and trade- to carry out an integrated assessment of the interventions planned and needed -and their impacts- in the energy and trade sectors to coherently and effectively support national development. The project utilizes System Dynamics to incorporate several methodologies in a single framework of analysis, namely the Threshold 21 (T21) model jointly developed and uniquely customized to Malaysia with the support of selected officers from EPU and other stakeholders.

1.2. Project Objectives and Setup

The main objective of this project is to provide the Government of Malaysia (Government) with a dynamic tool – "T21-Malaysia" – able to support policy formulation and evaluation in trade and energy sectors, as linked to broader

[1] The exchange rate for Malaysian Ringgit (RM) to US dollars (USD) in this study is 3.52 USD per RM, kept constant between 2010 and 2030.

economic, social and environmental ones. T21-Malaysia v.3.3 includes the major factors influencing the energy and trade sectors (e.g. demand and supply), including those belonging to the social, economic and environmental realms of the country.

This project consists of three phases, namely, (1) training (June through August), (2) model creation (July through October), (3) analysis and dissemination of the results (October through December).

1.3. T21-Malaysia

Threshold 21 (T21) is a System Dynamics based model designed to support medium-to-long term national development planning. T21 is structured to analyze medium-long term development issues at the national level and has been applied to over 40 countries in over 20 years of continuous research. The model integrates in a single framework, the economic, the social, and the environmental aspects of development. Its comprehensiveness and level of aggregation make it ideally suited to support comprehensive analysis of different governmental strategies. T21 can also serve as a complement to budgetary models and other short-medium term planning tools by providing a comprehensive and long-term perspective on development.

T21-Malaysia is a relatively large size model accounting for 87 stock variables and several thousand feedback loops. Given the size and the level of complexity of the model, its structure has been reorganized into smaller logical units, labeled as modules. The 45 modules comprising T21-Malaysia are grouped into 18 sectors: 6 social, 5 economic and 7 environmental sectors. With respect to the emphasis on energy and trade, the T21-Malaysia model generates projections for energy demand (by sector and energy source), energy supply (for primary and secondary energy sources), and for imports and exports (for the macro economic sectors of agriculture, industry and services). More details on the structure of the model are available in Annex IV.

1.4. Interventions and Scenarios

Several interventions are analyzed in this study, most of which are based on the 10th Malaysia Plan, the New Economic Model (NEAC) and the Economic Transformation Programme (PEMANDU, 2010). Certain interventions observed in recent history were also tested, to strengthen the transition to a transformed economy, based on high value products and services and focused on efficiency improvements to drive international competitiveness. It is worth noting that the Malaysia economy is very much linked to the global environment, and that trends in regional and global economic growth and trade are likely to influence Malaysia's economy significantly.

The interventions listed below are analyzed both independently (in isolation) and combined, to improve the understanding of specific contributions to reaching stated goals and eventual synergies and bottlenecks created within and across sectors.

- The Business as Usual (BAU) scenario assumes a continuation of existing trends, with no changes in policy and no reaction to eventual improvements of worsening of the economic performance of the country. Two BAU scenarios are simulated and analyzed:

  (1) Subsidized energy prices,

  (2) Subsidized energy prices, adjusting for imports at market price.

- For the alternative scenarios, a variety of interventions are analyzed, for both energy and trade, as listed below:

  - Oil and gas subsidy removal; energy efficiency improvement; renewable energy (power generation) expansion; avoided nuclear power generation; limited gas exports.

  - Port cargo, air cargo and passenger and broadband connectivity investments; research and development (R&D) investments; education investment; reduction in the taxation of income and profits; implementation of an Free Trade Agreement (FTA) aimed at increasing access to markets; increased public deficit; and assumptions related to increased propensity to save and higher FDI.

A few additional scenarios were considered to analyze the adequacy of policies and interventions currently being discussed under varying assumption on key macroeconomic themes, such as a potential economic crisis in 2015 (with two cases of different duration and strength) and higher energy prices (with two cases of a peak and steady increase).

These scenarios were selected to provide insights on the impact of selected interventions, shed light on potential policy response mechanisms and support the understanding of the complexity of the system analyzed. On the other hand, T21 being a "what if" modeling tool, there is virtually no limitation on the number of scenarios (and combinations of interventions) that can be simulated and analyzed with the model.

1.5. Main Results

The key results of the "All & Sustainability" scenario, the most comprehensive set of interventions simulated, are presented below. The key results are summarized in **Table 1** below:

- The real GDP growth rate averages 5.3% per year and results to be higher than BAU by 0.8% per year on average, reaching its highest value of 1.2% per year above BAU after 2020. Thanks to an increase in productivity, investment and market access, GDP will reach close to RM970 billion in 2020 and RM1,670 billion in 2030, 5.5% and 18% above BAU respectively.

- Comparing cumulative values by 2030 for additional GDP (approximately RM1,700 billion), the additional investment simulated (both public and private, approximately RM1,000 billion), as well as avoided costs (RM255 billion), positive economy-wide return on investment would be reached before 2030 (but certain economic actors would certainly see a net benefit well before 2030). This analysis should also be put in the context of the relevant (and growing) amount of international reserves being accumulated at the national level.

- Per capita income is projected to reach close to RM50,700 per capita (nominal, or current) and surpass the national target of RM49,500 in 2020. These projections are 8% and 20% above BAU in 2020 and 2030 respectively.

- Total employment is projected to reach close to 16.3 million people by 2020, reaching the target employment level and pushing a transition to high skill employment going forward.

- Matching the existing targets, imports are projected to reach close to 111% and 120% of GDP by 2015 in the BAU and "All & Sustainability" scenarios respectively. Exports are expected to reach 117% and 124% of GDP by 2015 in the BAU and "All & Sustainability" scenarios respectively.

- Energy demand is projected to grow at a much lower rate than BAU throughout the simulation, averaging 0.08% until 2015, 1.9% until 2020 and 2.7% between 2011 and 2030.

- Despite slightly lower power demand, the increasing use of renewables requires higher total installed capacity: 3 Gigawatt (GW) by 2020 and close to 10 GW by 2030 (or 16% above BAU). Higher capacity generates more employment, twice as much as in the BAU case, and requires higher investment.

- Levelized power generation costs, and prices are projected to increase above BAU in the short term (RM0.8 per kilowatt-hours (kWh) in 2017), due to the removal of subsidies and investments in renewable energy, and will remain about constant after 2015 (RM0.76 per kWh in 2030) and below BAU shortly after 2020.

- Fossil fuel Greenhouse gas (GHG) emissions intensity (calculated as emissions over GDP) declines by 10%, 18% and 25% relative to BAU by 2015, 2020 and 2030 respectively, or 35% below its 2005 value by 2020.

Table 1: Key indicators in the "All & Sustainability" scenario in selected years[2]

		2010	2015	2020	2030
		BAU	All & Sustainability		
Economic Sphere					
Real GDP	Constant Billion RM/Year	576	733	968	1,668
Real GDP annual growth	%	7.1%	5.0%	5.6%	5.1%
Nominal income per capita	RM/Person	25,334	35,407	50,685	101,492
Resources balance	Billion RM/Year	61	33	47	245
Total export	Billion RM/Year	854	1,437	2,380	6,728
Total export annual growth	%	11.8%	10.6%	10.6%	13.0%
Total import	Billion RM/Year	794	1,404	2,333	6,483
Total import annual growth	%	13.2%	10.6%	10.6%	12.6%
Social Sphere					
Total population	Billion people	28	31	33	38
Total population annual growth	%	1.6%	1.7%	1.5%	1.3%
Total employment	Million people	13,173	14,787	16,262	18,894
Environmental Sphere					
Fossil fuel GHG emissions	Million tons/Year	196	189	220	312
Primary energy demand	Mtoe/Year	61	62	74	105
Total power capacity	GW	26	28	39	61
Total power employment	Thousand people	13	30	54	81
Total energy expenditure	Billion RM/Year	9.6	12.6	15.4	22.2

[2] Note that projections of this report are highly dependent on the assumptions used to simulate the model. There might be variations relative to other models and existing projections due to different structural and numerical assumptions or due to methodological differences.

1.6. Policy Recommendations

The definition of a strategy for the energy and trade sector of Malaysia, in the context of national development (and therefore considering existing cross-sectoral targets), starts from the analysis of the relevant dynamics that are going to shape the energy sector in the next few years. With a growing volume of imports primarily for oil and gas in the years to come, maintaining energy price subsidies would have a relevant impact on government accounts. On the other hand, with the gradual removal of subsidies (reaching full market price by 2016), energy prices are expected to increase faster than in the BAU case. As a consequence, an integrated approach is needed to mitigate short-term negative impacts and maintain positive synergies in the longer term.

In light of these challenges, and to reach stated goals and ensure a coherent cross-sectoral development, the following steps and actions are proposed:

Energy sector:

- Energy demand:
  - Oil and gas subsidy removal: to reduce public expenditure and incentivize investments in energy efficiency and innovation.
  - Energy efficiency improvement: to reduce the impact of increasing energy prices (especially in the case of the removal of subsidies), reduce power supply costs and improve longer-term competitiveness for manufacturers and reduce energy costs for households.
- Energy supply and energy security:
  - Renewable energy power generation: to diversify the energy supply mix, reducing exposure to fossil fuels and creating cost reduction opportunities in the medium and longer term and, secondarily, to create employment.

    - Low carbon power generation: to reach challenging emission reduction targets.

    - Flexible agreements for gas exports: to improve energy security and reduce the economic risk related to imports.

<u>Trade sector:</u>

- Improving total factor productivity:

    - Infrastructure investment: port cargo, air cargo and passenger and broadband connectivity to improve industrial and services productivity, and create employment.

    - Research and Development: to support the transition to higher value production and services, and to make use of the investments made in the education sector and retain local talents.

- Increasing investment and market access:

    - Taxation (reduction of taxes on income and profits): to increase households' disposable income in the short term and encourage private investments.

    - FTA: to increase access to market and create synergies with investments in infrastructure and education, effectively making use of improvements in competitiveness from the supply (domestic) side.

    - Public borrowing (limited to the short term): to support short-term economic growth in case energy prices and regional economic growth do not support the transition as expected.

Finally, key risks to be considered include (1) the future rate of change of energy prices, (2) the future economic growth of the region, and (3) the rebound effect linking energy and economy.

1.7. Institutionalization and Next Steps

The adoption of the Threshold 21 Model by the Government of Malaysia is a significant effort aimed at long-term capacity and institutional development and should be considered an ongoing activity for the long term. To assure institutionalization of the model, MI recommends the following:

- An institutional home for the model, and a core team of modelers to manage and utilize T21-Malaysia should be identified before the end of the project.
- The model should be used on a continuous basis to support policy development, implementation, monitoring of progress and evaluation of impact.
- Multi-stakeholder participation should be instituted as a culture at all levels of the model's development and use.
- Continuous capacity development is paramount for the successful institutionalization of the model.
- Funding should be available at all times to support continuous development and use of the model.
- Cooperation between various national agencies is essential to ensure that good data and expert opinion/insight is continuously available for updating the model.

Concerning next steps and potential improvements, the T21-Malaysia model v.3.3 (the final version developed for this project), is highly focused on energy and trade but accounts for several sectors across social, economic and the environmental spheres. Several expansions and improvements can be contemplated going forward, to both add detail and cross-sectoral representation to the model. More specifically, the following are suggested: addition of sectors (e.g., a finer disaggregation of manufacturing sectors); geographical disaggregation; specific analyses for transport (disaggregating modes, vehicle and engine types, as well as energy sources), and the computation of competitiveness indicators using outputs from T21-Malaysia to directly evaluate areas of strength and weaknesses of Malaysia's economy.

Overall, it is envisaged that potential areas of improvement will be selected in concert with the needs and requirements of selected stakeholders, to make the best use of the cross-sectoral nature of the model, have access to the best available information to further customize the model, and carry out a thorough validation.

2. National Targets and Objectives

2.1. Energy Sector

A reliable, high-quality and cost-effective supply of energy is fundamental to attracting new investments as well as encouraging existing industries to expand into high value-added activities. The New Energy Policy (2011-2015) emphasizes energy security and economic efficiency as well as environmental and social considerations. The Policy will focus on five strategic pillars:

1. Initiatives to secure and manage reliable energy supply;
2. Measures to encourage energy efficiency (EE);
3. Adoption of market-based energy pricing;
4. Stronger governance; and
5. Managing change.

More details of each pillar are summarized in the **Table 3** below, with information collected from national sources and with the collaboration of stakeholders such as Tenaga Nasional Berhad (TNB) and Petronas when needed:

Table 2: National targets and interventions in energy sector

Intervention	Target
1. Initiatives to secure and manage reliable energy supply	
1) Import of gas (LNG)	• Regasification Terminal in Melaka to operate by 2012; • Regasification Terminal in Lahad Datu to operate by 2015; • Regasification Terminal in Tanjung Pengerang, Johor to operate by 2016; and • RAPID project (refinery and petrochemical development) in Tanjung Pengerang to operate by 2016.
2) Electricity Sector	• RE (985MW or 5.5% of total electricity

	generation mix) by 2015: 330MW Biomass, 100MW Biogas, 290 MW Mini Hydro, 65MW Solar PV, and 200MW Solid waste • Nuclear 2000MW post 2025 More specifically: • 300MW Kimanis Power Plant to be commissioned by 2013 • 100MW SPR Power Plant (Kimanis) to be commissioned by 2013 • 300 MW Lahat Datu to be commissioned by 2016 • 1000MW Janamanjung to be commissioned by 2015 • 1000MW Coal Plant to be commissioned by 2016 • Bakun 2400MW (commissioned in August 2011 for 300MW) • Ulu Terengganu 250MW to be commissioned by 2016 • Ulu Jelai 372MW to be commissioned by 2017
3) <u>Transmission and Distribution:</u>	• Peninsular Malaysia network expansion (allocation of RM4-5 billion annually by TNB) • Sabah Transmission line expanded by 93km in 2012 • To maintain the System Average Interruption Duration Index (SAIDI) in Sabah at 700 minutes/customer-RM200 million allocated for 2011
4) <u>Transport Sector</u>	• Usage of natural gas vehicle (NGV) (30% of total petrol usage for transport sector) with gradual removal of NGV subsidies. • Transport sector powered by electricity 5% of total transport consumption by 2020. • Renewable energy (RE) in transportation sector 5% Biofuel (B5) for transport by 2015

5) <u>Rural Electrification Projects:</u>	• 66,000 rural homes will have access to electricity by 2012
	• Electricity coverage by 2012:
	    ○ Peninsular 99.9 %
	    ○ Sabah & Sarawak 95 %

6) <u>Renewable Energy (Biomass, biogas, mini hydro, solar and solid waste):</u>	Target of RE in Energy Mix: • 985 Megawatt (MW) or 5.5% of generation mix by 2015 • RE Act 2011 passed in April 2011 • Sustainable Energy Development Authority (SEDA) was established in September 2011 • Feed-in-Tariff (FiT) –1% of consumers' monthly bill beginning December 2011

<u>2. Measures to encourage energy efficiency (EE)</u>
 	
1) <u>SAVE program entails rebate for energy efficient electrical appliances;</u>
2) <u>Energy labeling and Minimum Performance Standards; and</u>
3) <u>Green building Index (GBI).</u>
	GHG emission intensity is targeted to be reduced up to 40% relative to 2005 by 2020 (COP)
	Cumulative energy savings 4,000 Kilo tons of oil equivalent (ktoe) by 2015 (10^{th} MP): If possible want to see what is the required share of said savings by the following:
	• Industrial Sector (42% from energy savings 4,000 ktoe)
	    ○ Due to Industrial energy saving and EE investment required (TNB)
	    ○ On the Energy Intensive Industries (including iron & steel industry)
	• Transport Sector (36% from energy savings 4,000 ktoe)
	    ○ Due to GHG/Efficient vehicle policy (km/litre) or % reduction in fuel consumption
	    ○ Fuel substitution – oil to natural gas vehicle / hybrid vehicles
	    ○ Private transportation migrate to mass transportation mode
	• Commercial Sector (12% from energy savings 4,000 ktoe)
	    ○ Due to Imposition of LED lighting and efficient air conditioning for commercial buildings
	• Residential sector (10% from energy savings 4,000 ktoe)
	    ○ Due to rebate on purchases of energy efficient electrical appliances

<u>3. Adoption of market-based energy pricing</u> Reduce and itemize energy subsidies	Reduce energy subsidies, with the goal of achieving market pricing by 2016 • Gas prices for the power and non-power

	sectors will be revised every six months to gradually reflect market prices (RM3/Mmbtu every six months until 2015). A decoupling approach for energy pricing will be undertaken to explicitly itemize subsidy value in consumer energy bills and eventually delink subsidy from energy use.
Assistance for low-income households	For low-income households and other groups for which the social safety net is required, different forms of assistance will be provided. This will enhance transparency and improve targeting of assistance to consumers.
Market liberalization	Market liberalization for gas sector will be realized. External parties will be allowed to bring in and use the Peninsular Gas Utilization (PGU) network operated by PETRONAS in a Third-Party-Access arrangement.
4. Stronger governance	The goal of improved governance of the energy sector is to raise productivity and efficiency. In this regard, the gas supply industry will be further liberalized to facilitate the entry of new suppliers and third-party access arrangements. The electricity supply industry will also be restructured to instill greater market discipline. This will involve measures such as: • creating separate accounting for generation, transmission and distribution activities; • transparent and competitive bidding for new generation plants; • the renegotiation of power purchase agreements.
5. Managing change	The New Energy Policy necessitates fundamental structural changes during the Plan period. There will be a broad range of initiatives, covering pricing, supply-side and demand-side management, requiring new oversight mechanisms to ensure optimum benefit. Implementation of these initiatives will be undertaken on an integrated approach to achieve the targeted outcomes.

2.2. Trade Sector

Malaysia aspires to be one of the top trading nations by year 2015. In this regard, Malaysia's position as a major trading nation will continue to be enhanced through a number of measures specified under various plans. The sectors to implement trade-related targets and objectives include:

1. Labor force;
2. Investment;
3. Increasing productivity;
4. Free Trade Agreement (FTA);
5. Trade performance;
6. Manufacturing sector;
7. Services sector;
8. GDP growth;
9. Income;
10. Macroeconomic policy.

More details of each pillar are summarized in the **Table 4** below:

Table 3: National targets and interventions in trade sector

Intervention	Target
<u>1. Labor Force</u> The employment ratio needs to rise, indicating more effective absorption of the country's growing labor pool.	Skilled employment ratio to reach 62.3% by 2020.
Labor requirement	The labor requirements are projected to grow at an average annual rate of 3.6% between 2009 and 2020 to 16.3 million people by 2020.
Demand for skilled labor in the services sector Intervention: Flexible/liberal immigration policy to attract high skilled human capital from abroad	The demand for skilled labor in the services sector is expected to grow at an average annual growth rate of 6.8% to 10.1 million people by 2020. The unskilled segment is anticipated to remain the smallest component of labor.

<u>2. Investment</u> Private investment Total gross fixed capital formation or fixed investment, and investment-to-GDP ratio Transport Capacity	 Private investment is targeted to grow by 16.2% in 2011 Private investment grew at an estimated 2.0% per annum during the initial 5 years, is targeted to expand at 12.8% annually in 2011-15 (10MP) and 11.2% in 2016-20 (11MP), or an average annual growth of 12.0% for the remaining 10 years of the IMP3 (2011-20). Total gross fixed capital formation or fixed investment is targeted to increase at 8.9% per annum in 2011-15 and 8.4% in the following 5 years, or an average increase of 8.6% per annum for the remaining IMP3 period from 2011-20. Achieving the projected investment rate will see the investment-to-GDP ratio rising from 22.0% in 2010 to 25.1% by 2015 and 26.8% by 2020 Port activity is estimated to accelerate slightly faster relative to the original IMP3 estimate, growing 7.6% per annum on average, compared with an initial approximation of 7.4% for the remaining IMP period. Rail and air freight transport capacity are also expected to expand by 5% and 4.9% respectively to cope with increased economic activity and logistics requirements.
<u>3. Increasing productivity</u> Investment on infrastructure and infrastructure will boost up TFP Investment in R&D to boost up productivity and moving up the value chain Investment in Human Capital	 Contribution of growth from TFP is targeted at 2.3% (2011-2015) The total factor productivity (TFP) for manufacturing sector, is targeted to grow at 2.9 per cent annually and contribute 43.2 per cent to the GDP during the IMP3 period. For the non-Government services sector, is targeted to grow at 2.5 per cent annually and contribute 36.2 per cent to the GDP during the IMP3 period.
<u>4. FTA</u> Trade liberalization through Trans-Pacific Partnership and Asean Economic Community (AEC)	 A more liberal trade and investment regime, as has recently been adopted in some services subsectors, would contribute greatly to Malaysia's long term economic growth.

5. Trade performance	Total trade is targeted to increase to RM2.8 trillion and exports to RM1.4 trillion by 2020. Imports are expected to grow at an average 8.8% per annum to reach RM826.1 billion or 111% of GDP in 2015 and RM1,271.0 billion or 122% of GDP in 2020. (In 2010 imports totaled RM529.2 billion or 21.7%)
6. Manufacturing sector	The manufacturing sector is targeted to grow at 28.5 per cent in 2020. Investments in the sector are targeted to total RM412.2 billion during the IMP3 period, or RM27.5 billion annually From 2011-2015, manufacturing sector is projected to grow at 4.8% per year. From 2016-2020 it is projected to increase 2.9% per year.
7. Services sector	From 2011-2015, services sector is projected to grow at 7.4% per year. From 2016-2020 it is projected to increase by 7.3% per year, so as to achieve the target of increasing the services' share of GDP from around half to 60% by 2020. The non-Government services sector is targeted to expand at 7.5 per cent per year and contribute 59.7 per cent to the GDP by 2020.
8. GDP growth target (real)	From 2011-2015, GDP growth is projected at 6.0% per year. The GDP growth target (real) is raised from an average of 6.3% per annum to 6.5% for the remaining IMP3 period from 2011-20 in line with the NEM and 10MP. The economy is projected to grow at 6.0% annually during the 10th Malaysia Plan (2011-15) and accelerate to 5.5% per annum during the 11th Malaysia Plan (2016-20), as the efficiency and productivity improvements arising from the economic restructuring and transformation efforts undertaken in the earlier period are realized in the second half of the decade.
9. Income	Nominal income per capita is projected to RM28,175 in 2011. In 2015, nominal income per capita is projected at RM38,850 or USD12,140 and in 2020 RM49,500 (exchange rate of 3.3) or USD15,000.
10. Macroeconomic policy Prudent fiscal policy Structural reform	 The Government aims to balance the budget in the medium term, without cutting spending so substantially that it may slow the economy too abruptly. The Government's main objective for the structural reform is to promote competition, enhance the services sector, and move up the value chain in manufacturing.

3. Overview of the T21-Malaysia Model

3.1. Methodology

Threshold 21® (T21) is a System Dynamics based model designed to support national development planning. T21 is structured to analyze medium-long term development issues at the national level. The model integrates in a single framework, the economic, the social, and the environmental aspects of development. Its comprehensiveness and level of aggregation make it ideally suited to support comprehensive analysis of different governmental strategies. T21 can also serve as a complement to budgetary models and other short-medium term planning tools by providing a comprehensive and long-term perspective on development.

Over the last 40 years, a variety of applied models and modeling methods have been developed to support national planning. Among those tools, the most commonly used today include: Disaggregated Consistency models (DC), Computable General Equilibrium (CGE) models, Macro-Econometric models (ME), System Dynamics models (SD). These methods have proven useful to different degrees for various kinds of policy analyses, especially for mid-short term financial planning. While recent global developments have stressed the importance of jointly addressing the economic, social, and environmental dimensions of development, most of the methods mentioned above do not effectively support integrated long-term planning exercises. On the other hand, T21 harnesses the strengths of these tools, making it an essential complement to them. It can incorporate sections from these and other sector models into its overall framework to draw on high quality modeling work; or it can use outputs from these models as inputs into certain sectors.

More specifically, Econometric Modeling (EM) is a valuable approach to measure and understand correlation between variables. Hence, outcomes of EM can be used as input into T21, and more tightly define the causal relationships between variables. Although EM and T21 are complementary, EM lacks the capacity (it was not designed for this purpose) to model the complex causal relationships between economic, social and environmental spheres of development and forecast the effects of policy changes especially in the long run. Another strength of T21 over EM is its transparency where the formulae underpinning causal relationships between variables can be checked, verified, and amended as required to reflect real world conditions.

CGE models are computationally very intensive and require a lot of data and quantitative skills in modeling. They are very useful for the analysis of the optimal impacts of alternative policies. However, CGE models have generally a strictly economic focus and do not cover the social and environmental aspects that are relevant for comprehensive and long-term planning. It is also difficult for them to explain how the economy will reach the optimum conditions, or how long it will take to get there.

T21 can be used for medium-to-long term perspectives, making it complementary to CGE models. But unlike CGE, T21 endogenously represents the causal mechanisms underlying the development process and is less data intensive. The availability of additional (new) data is not used to run new models but to verify the accuracy of the model, and hence of the causal relationship between them. In CGE, models have to be re-computed upon availability of new data. Historical data in T21 are used to ensure that the causal relationships between variables are correct (i.e. comparing output of model with historical data), and time series data is not used to drive the model. In fact, causal relationships can be established even in the absence of historical data (a case wherein CGE would not be applicable) through the use of Monte Carlo simulations. T21 also permits causal tracing to track, both in terms of the factors involved and their quantitative effects, the variables and links that lead to any result over time.

The Growth Diagnostic Framework has gained increased support for use in identifying the most binding constraints to a country's development. This framework stresses the importance of the structural differences among countries, and that no silver bullet policy for faster development exists. The Growth Diagnostic consists principally in identifying the resources that are mostly needed for development by looking at the current symptoms of the economy. T21 is fully compatible with this framework, and the model undergoes a deep process of adaptation to a country's peculiarities before being used for policy making. However, T21 allows for a deeper analysis of a country's issues, not by simply looking at the symptoms, but by investigating the underlying mechanisms that drive development. Further, T21 helps to identify the possible constraints that the country might face in the future, and thus anticipate major issues before they emerge. T21 supports thus a dynamic and proactive approach to development planning.

T21 is useful at four levels in the long-term national and regional development planning:

1. The participatory process of the model's development provides insights on the coherence and consistency of objectives, hypotheses, and data used for policymaking across sectors of the macro economy. It further helps to elicit the human and institutional resource requirements required for effective modeling of the macro economy;

2. The base run simulation of the model provides insight into the key development issues a country or region might face in the future;

3. The alternative scenarios it presents based on policy propositions provide an understanding of how different strategic choices or external conditions can impact future development, and how sectoral policies synergistically interact; and

4. The resulting strategic plan provides a clear basis for improved decision making and action in the various sectors and across countries, as well as for monitoring and evaluation of performance and results over time.

3.2. Spheres, Sectors and Modules

T21-Malaysia is designed to cover the most important medium to long-term issues facing the country. Its absolute transparency enhances open and participatory policy debate and the Malaysia customization of T21 is unique as it fully incorporates the impacts of policy interventions on key trade and energy sectors. The major characteristics of the model are highlighted below.

Boundaries: Variables that are considered an essential part of the development mechanisms, object of the research, are endogenously calculated. For example, GDP and its main determinants, population and its main determinants, and the demand and supply of natural resources are endogenously determined. Variables that have an important influence on the issues analyzed, but that are only weakly influenced by the issues analyzed or that cannot be endogenously estimated with confidence, are exogenously represented.

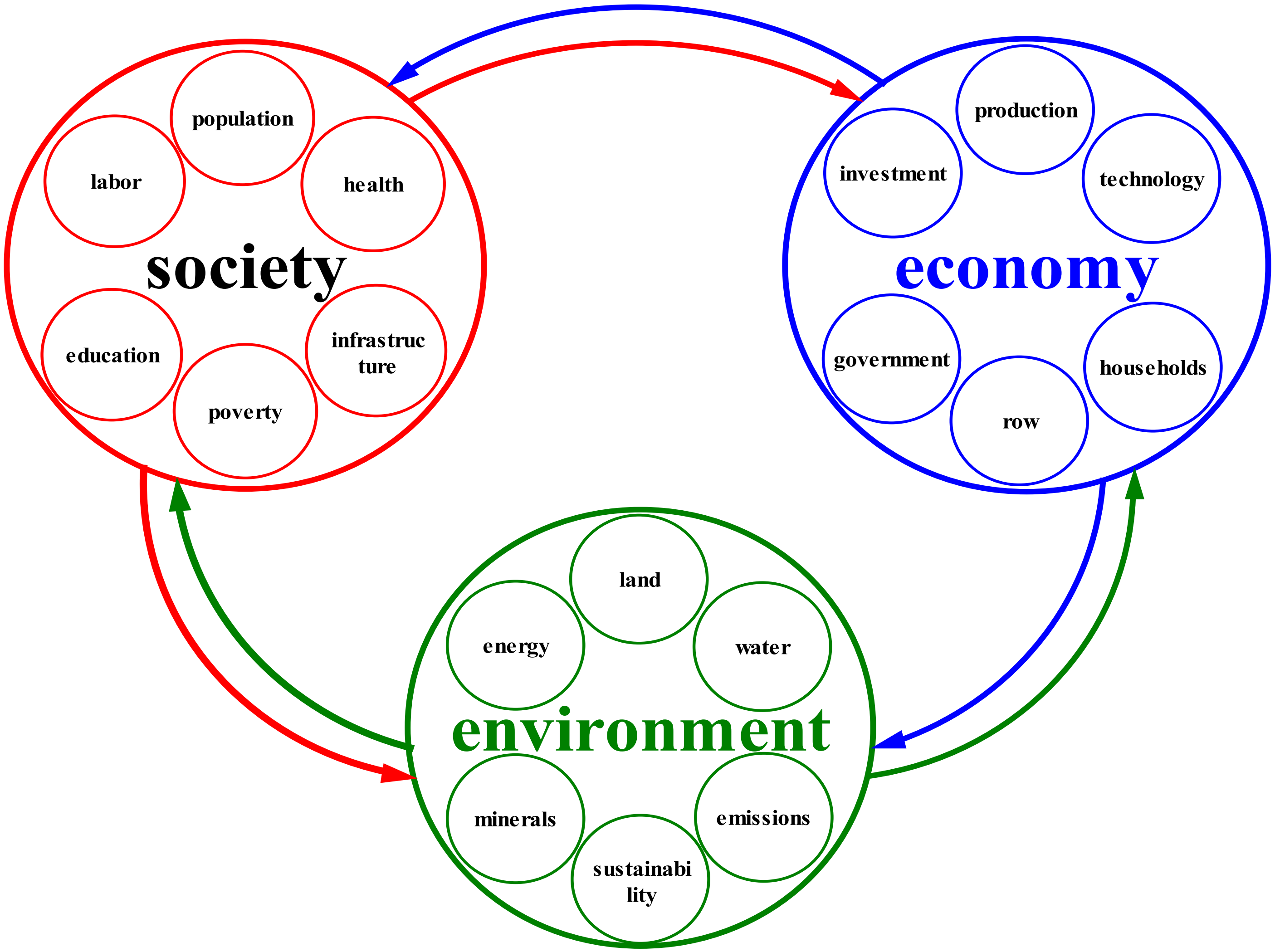
Granularity: The T21-Malaysia model presented in this report is a national model that focuses on key issues in Malaysia, as well as international trade with the rest of the world. The main social, economic and environmental variables of T21-Malaysia are broken down in sub-components as required in order to analyze the focus issues. For example, population is divided into 82 age-cohorts and 2 genders, and the age-gender distinction is used in most social indicators; production is divided into industry, services and agriculture, with the latter further divided into crops, fishery, animal husbandry and forestry; land is divided into forest, agriculture, fallow, urban and desert. Finally, given its level of aggregation, the model is generally based on global average values for variables such as unit costs and prices.

Time horizon: T21-Malaysia is built to analyze medium to long-term development issues. The time horizon for simulation starts back in 1980 and extends up to 2050. Beginning the simulation in 1980 ensures that, in most cases, the patterns of behavior characterizing the issues being investigated can be fully observed and replicated.

Modules, sectors and spheres: As a result of the variety of issues considered, T21-Malaysia is a relatively large size model accounting for 87 stock variables and several thousand feedback loops (see **Table 5**). Given the size and the level of complexity of the model, its structure has been reorganized into smaller logical units, labeled as modules. A module is a structure, whose internal mechanisms can be understood in isolation from the rest of the model. The 45 modules comprising T21-Malaysia are grouped into 18 sectors: 6 social, 5 economic and 7 environmental sectors. Sectors are groups of one or more modules of similar functional scope. For example, the energy sector groups the energy demand, energy supply, energy prices, power employment, electricity generation cost and fossil fuel production modules. Finally, the three (social, economic and environmental) spheres compose of T21-Malaysia. All sectors in T21 belong to one of the three spheres, depending on the type of issue they are designed to address. Modules are built to be in continuous interaction with other modules in the same sector, across sectors, and across spheres (See **Figure 1**).

As is illustrated in **Figure 1**, the social, economic and environmental spheres represent the highest level of aggregation in the model (See top figure). Although our environment encompasses society and the economy, for simplicity we represent them separately in this report, to highlight the interconnections existing across them (See bottom figure).

Figure 1: Conceptual overview of T21- Starting Framework.



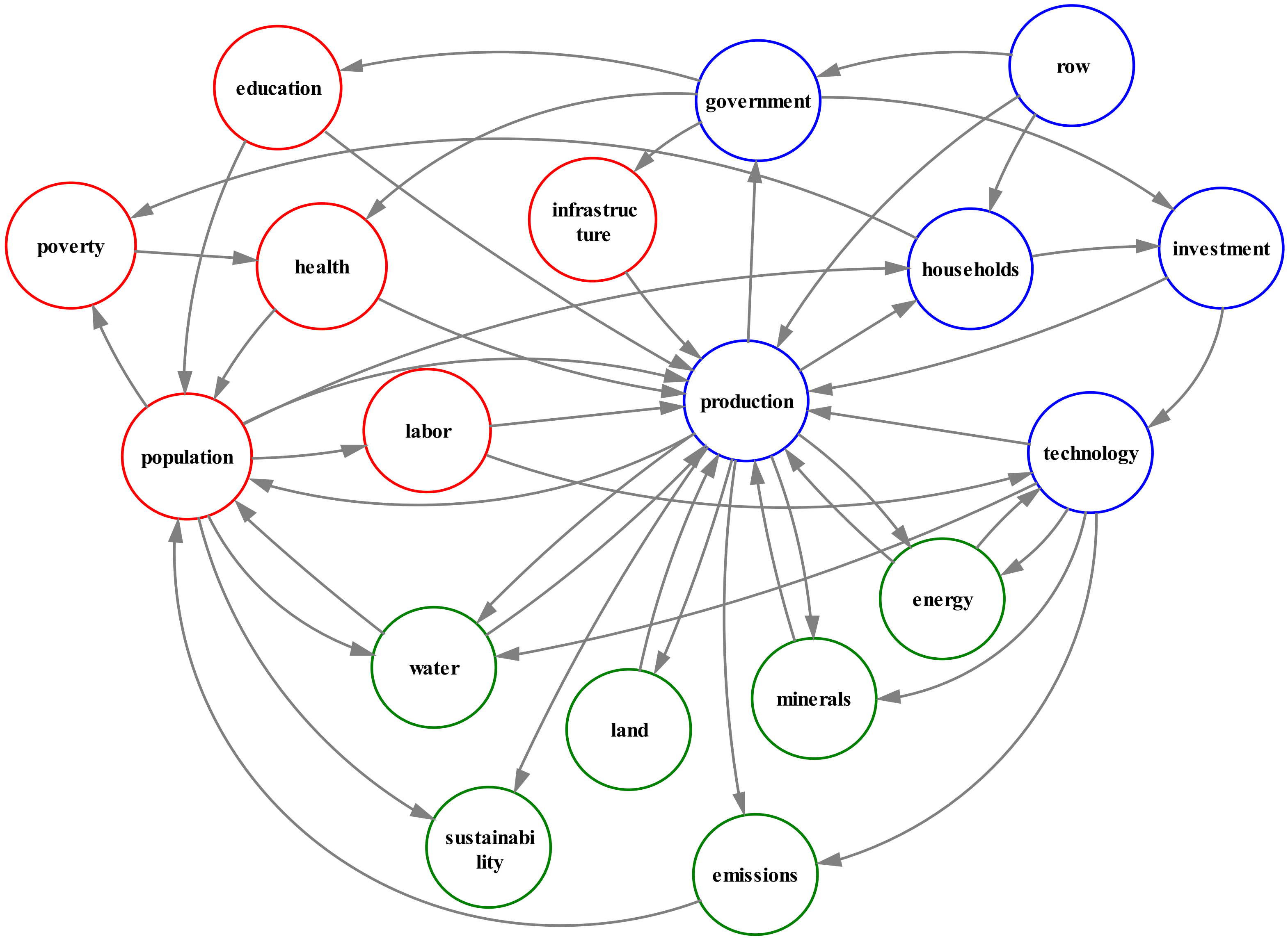

education
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Table 4: Modules, Sectors and Spheres of the T21-Malaysia Model

(This table excludes the "44. Indicators" and "45. Policies" modules)

SOCIAL SPHERE	ECONOMIC SPHERE	ENVIRONMENTAL SPHERE
Population Sector:	**Production Sector:**	**Land Sector:**
1. Population	16. Aggregate production and income	31. Land
2. Fertility	17. Agriculture	**Water Sector:**
3. Mortality	18. Husbandry, Fishery and Forestry	32. Water demand
Health Sector:	19. Industry	33. Water supply
4. Healthcare	20. Services	**Energy Sector:**
Education Sector:	**Government Sector:**	34. Energy demand
5. Primary education	21. Government revenue	35. Energy supply
6. Secondary education	22. Government expenditure	36. Energy prices
7. Tertiary education	23. Government balance and financing	**Power Sector:**
8. Nutrition	24. Public investment and consumption	37. Power employment
Infrastructure Sector:	25. Government debt	38. Electricity generation cost
9. Roads	**Households Sector:**	**Minerals Sector:**
10. Port cargo	26. Households accounts	39. Fossil Fuel production
11. Air transport	**ROW Sector:**	**Emissions Sector:**
12. Broadband	27. International trade	40. Fossil Fuel GHG emissions
Labor Sector:	28. Balance of payments	**Sustainability Sector:**
13. Employment	**Investment Sector:**	41. Ecological footprint
14. Labor Availability	29. Relative prices	42. MDGs
Poverty Sector:	30. Investment	43. HDI and GDI
15. Income distribution		

The Social sphere contains detailed population dynamics by sex and age cohort; health and education challenges and programs; basic infrastructure; employment; and poverty levels and income distribution. These sectors take into account, for example, the interactions of income, healthcare, and adult literacy rates on fertility and life expectancy, which in turn determine population growth. Population determines the labor force over time, which shapes employment. Education and health, together with other factors, influence labor productivity and life expectancy. Employment and labor productivity affect the level of production from a given capital stock. Food sufficiency and nutrition, reproductive health, and vocational training are also addressed.

The Economy sphere contains major production sectors (agriculture, industry and services), which are characterized by Cobb-Douglas production functions with inputs of resources, labor, capital and an inclusive total factor productivity (TFP) variable, with more details discuss below. A social accounting matrix (SAM) is used to elaborate the economic flows and to balance supply and demand in each of the sectors. Demand is based on population and per capita income and distributed among sub-sectors using Engle's Curves. This helps calculate relative prices, which are the basis for allocating investment among the sectors. The government sector generates taxes based on economic activity and allocates expenditures by major category. Public expenditure impacts on the overall economic performance and on the delivery of public services. Standard IMF budget categories are employed and key macro balances are incorporated into the model. The trade-related sector comprises international trade, balance of payments, and relative prices.

The Environment sphere estimates the availability and consumption of both renewable and non-renewable natural resources by tracking the land allocation, water consumption, and energy stock, supply and consumption. It further calculates energy prices and expenditure, emissions (CO_2, CH_4, N_2O, SO_X and their conversion to greenhouse gas, or CO_2 equivalent) and the ecological footprint. These allow for evaluating the impact of the depletion of these resources on the social and economic sectors.

The three spheres can be exploded to highlight the inter-sector and intra-sector linkages, which create a complex network of feedback loops. In order to analyze the structure of trade and energy sectors, which are of fundamental importance in Malaysia, and understand their functioning, the network is broken down into smaller pieces –individual feedback loops of trade and energy– and separately presented in the following sections.

3.3. Structure of the Energy and Trade Sectors

3.3.1. Causal Loop Diagrams (CLDs)

Starting from June 1, 2011 Dr. Bassi has initiated an in depth review of two key documents to be utilized in the project: the 10th Malaysia Plan and the New Economic Model. This background reading was specifically intended to reduce the learning time to the minimum, for Dr. Bassi to be able to inform and guide the creation of causal loops diagrams for energy and trade during the first week of work in Putrajaya, at EPU. The review of other existing documents continued as an ongoing activity, especially concentrated in the months on June and July.

3.3.2. Energy CLD

During June 13-17 the energy and trade teams, under the supervision and guidance of Dr. Andrea M. Bassi, have created Causal Loop Diagrams (CLD)[3] for the energy and trade sectors. The process was guided, with the collective knowledge and understanding of the sectors being added to the diagrams. Further, both diagrams were analyzed in detail, validated and presented to the other group for ensuring full understanding of the work done. Finally, the two diagrams were merged on Friday, June 17 for a more integrated analysis of how the energy and trade sectors interact with each other and how they affect social, economic and environmental development (and are influenced by these spheres as well).

There are several insights emerging from the Energy CLD (see **Figure 2** below). We started form the definition of the key indicators that would highlight the performance of the sector: energy security, being driven by (1) energy access, (2) energy affordability and (3) energy availability and security. These in turn are driven by several other factors, such as power supply and the transmission and distribution network (for -1-), energy prices and per capita income (for -2-), and fuel imports (or a proxy for energy self sufficiency, for -3-). Further factors, many of which interrelated, drive these key variables. Overall, we have identified 8 relevant feedback loops, all balancing, within the energy sector. These loops highlight the interdependence of the energy sector, inner and cross-sectoral, indicating that

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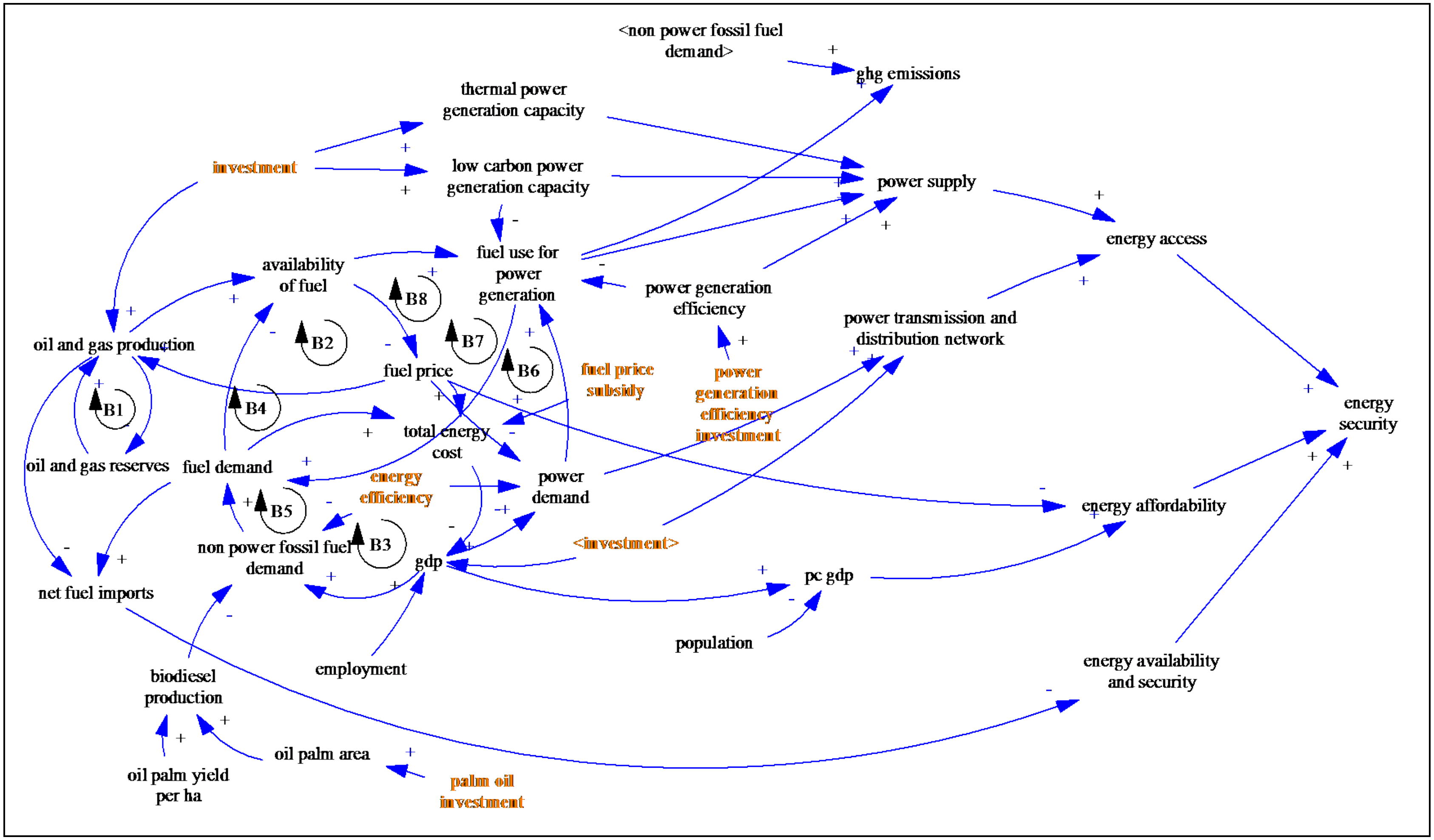
[3] A CLD is a map of system analyzed, making explicit reference to feedback loops, non-linearity and delays. CLD support the sharing of mental models to better understand how systems function.
Feedback is a process whereby an initial cause ripples through a chain of causation ultimately to re-affect itself (Roberts et al., 1983).
Non-linear relationships cause feedback loops to vary in strength, depending on the state of the system (Meadows, 1980), and determine how structure defines behavior. For instance, with oil demand being influenced simultaneously by GDP, oil prices, energy efficiency, each embedded in a variety of feedback loops, non-linear behavior emerges from the model.
Delays in this context are characterized as "a phenomenon where the effect of one variable on another does not occur immediately" (Forrester et al., 2002). These can in fact lead to instability, such as overshoot and oscillations, when coupled with balancing processes. Since delays influence the efficacy of policies in both the short and the longer term, their explicit representation generates many advantages. Among others, the direct understanding that integrated complex systems are dominated by inertia in the short term, therefore the implementation of policies does not produce immediate significant impacts. As Jay Forrester states "A system variable has a past path leading up to the current decision time. In the short term, the system has continuity and momentum that will keep it from deviating far from an extrapolation of the past" (Forrester, 2008).

energy demand and supply are tightly coupled with other key social, economic and environmental drivers and exponential growth or decline cannot originate exclusively from with the energy sector.

Figure 2: Energy CLD[4]



[4] See footnote 2 on characteristics of variable names.

The key loops identified indicate the following phenomena and characteristics of the energy system in Malaysia:

- Oil and gas production and reserves (B1): oil and gas production reduces reserves, as non renewable resources, which will ultimately make production decline in the future, unless new discoveries are made.

- Oil and gas prices and profitability (B2): oil and gas production affect the overall availability of fuel, which in turn affects energy prices and the profitability of production – which impacts production (exploration, recovery, refining, etc.).

- Energy demand and costs (B3): GDP growth pushes demand higher, which increases overall energy costs, in turn negatively affecting GDP. Similarly (B4), higher GDP growth and energy demand reduce fuel availability and increase fuel prices, increasing energy costs and having a negative impact on GDP.

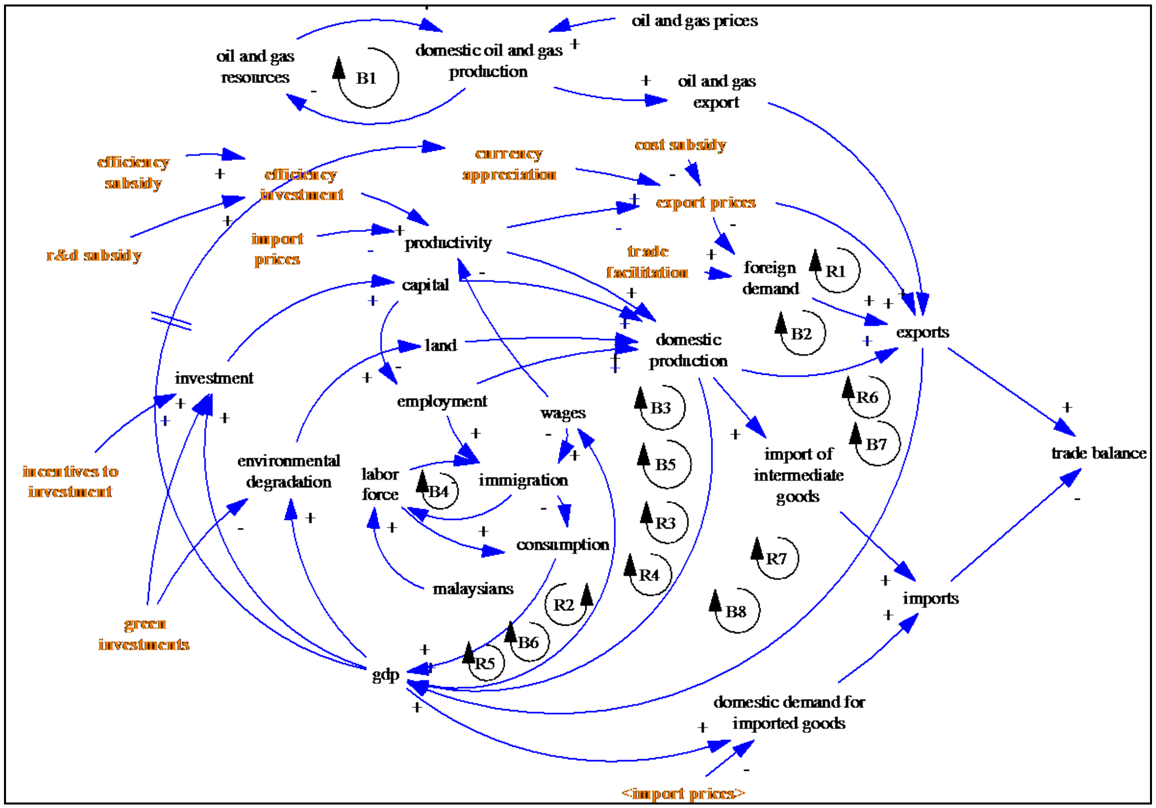
- Power demand and generation (B5, B6, B7 and B8): all these feedback loops highlight the same mechanisms mentioned above, but with a specific focus on power demand and power generation and the effect these have on fuel availability, fuel prices and GDP.

The key intervention areas identified include palm oil investment, energy efficiency, oil and gas expansion (upstream and downstream), thermal and renewable power generation expansion, power generation efficiency investments and fuel price subsidies.

3.3.3. Trade CLD

The Trade CLD is illustrated in **Figure 3** below.

Figure 3: Trade CLD[5]



[5] In the Trade CLD, there is a delay mark (parallel bars) on the arrow from "GDP" to "currency appreciation", implying a time lag between changes in GDP and the impact on currency value. A delay is defined as "a phenomenon where the effect of one variable on another does not occur immediately" (Forrester et al., 2002). It can in fact lead to instability, such as overshoot and oscillations, when coupled with balancing processes. Since delays influence the efficacy of policies in both the short and the longer term, their explicit representation generates many advantages. Among others, the direct understanding that integrated complex systems are dominated by inertia in the short term; therefore the implementation of policies does not produce immediate significant impacts. As Jay Forrester states "A system variable has a past path leading up to the current decision time. In the short term, the system has continuity and momentum that will keep it from deviating far from an extrapolation of the past" (Forrester, 2008).

As in the case of energy, for trade we started from the key indicators in the sector. These are trade balance, being driven by (1) exports and (2) imports, also driven by energy and other import/export. We further disaggregated the key drivers for exports into prices, foreign demand and domestic production. The main drivers identified for imports include domestic demand for imported intermediate goods (driven by domestic production) and for final imported goods (driven by GDP and income).

Several feedback loops were identified in this case as well: 7 reinforcing and 8 balancing.

- Fossil fuel depletion (B1): same as for energy, it represents the depletion of non renewable fossil fuels.

- Currency appreciation (R1 and B2): indicates the impact of increasing exports and GDP, which ultimately leads to currency appreciation (all else equal) and two different impacts: a negative one on demand (B1) and a positive one on the actual value of exports (R1).

- Capital and labor (R3 and R4): these loops represent the contribution of capital and labor to economic growth. Consistent with neoclassical economic production functions, capital and labor support reinforcing mechanisms for domestic production.

- Environmental and social constraints to production (B3 and B5): these loops represent constraints to production coming from environmental degradation (B3) and a social impact (B5): with higher production and GDP wages tend to increase, practically reducing profitability and productivity in the economy.

- Impact of immigration on employment and economic performance (B4, B6, R2 and R5): these loops represent the impact of immigration on employment and economic performance. Key concepts include the fact that higher immigration leads to lower consumption (than otherwise would be) due to lower salaries and to remittances sent to their country of origin. This potentially reduces investment and GDP growth (B6). On the other hand, more immigrants make so that the local labor force grows, increasing overall consumption, which stimulates investments (R2 and R5). Further, the higher the labor force, the lower immigration going forward – depicting a common labor balancing loop (B4).

- Key contribution of exports (R6, R7, B7 and B8): these loops identify the key contribution of exports to the economy (excluding currency appreciation), through domestic production and productivity. When considering foreign demand the effect is negative (B7 and B8), and when considering prices (also through productivity) the effect is positive (R6 and R7).

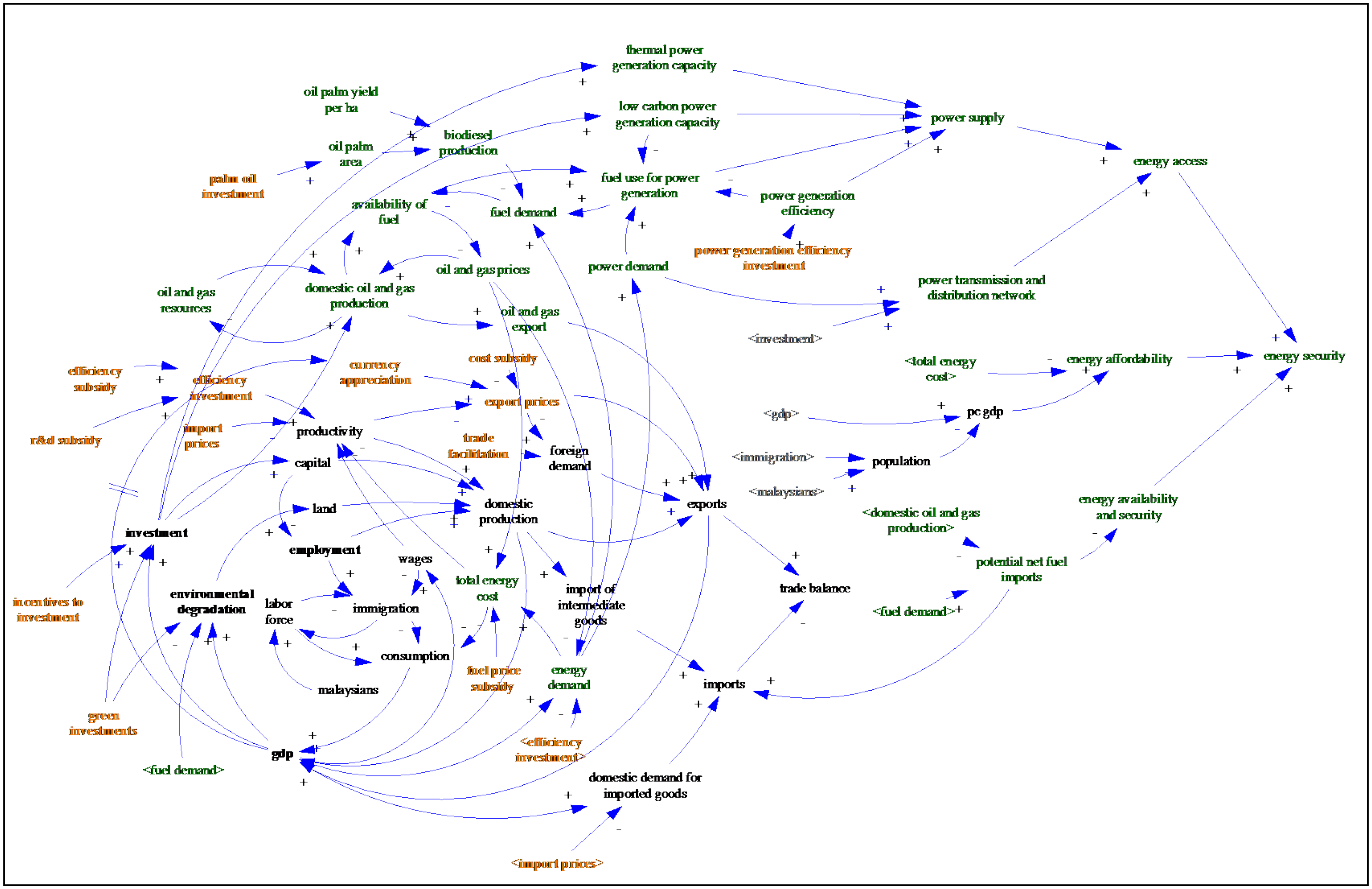
The key areas of intervention identified for trade include green investments, incentives to investments, R&D and efficiency subsidies, modifications to import and export prices and currency evaluation, cost subsidies and trade facilitation.

3.3.4. Combined Energy and Trade CLDs

Figure 4 below shows the combined CLD of energy and trade sectors.

In the combined CLD, the relationships within the energy and trade sectors remain the same as in the separate CLDs, but additional value and insights emerge from the combination of the two sectors. The presentation of the key value added originating from the combination of energy and trade is presented in the following paragraphs.

Figure 4: Energy and Trade CLD



The combination of the energy and trade sectors highlights the relations between these two sectors and social, economic and environmental factors characterizing Malaysia. All interventions are included in this diagrams (highlighted in orange), all energy variables are colored in green and the trade ones in black. All feedback loops highlighted in the sectoral diagrams are present here and more emerge from the combination of all variables across sectors. This diagram, although very comprehensive and complex, gives a good idea of the dynamic complexity of the systems analyzed and how difficult it could be to find synergetic interventions to maximize the return (or effectiveness) of the investment allocated to each intervention area. Further it highlights the numerous potential side effects (some of which are depicted in balancing loops) that would make the investment ineffective. Finally, good insights come out of the inclusion of a time component in the analysis: interventions that support economic growth in the short term may be counterproductive in the future. As a consequence, interventions have to be carefully planned to achieve the highest payoff possible compared to both short term and medium to long term goals and objectives.

3.3.5. Technical Specifications of the T21-Malaysia Model

This section presents selected key relationship across sectors, especially the calculation of industry and services production. Also presented are the main relationships and key indicators in the energy and trade sectors, which are the main sectors analyzed in this study.

Selected key relationships across sectors

The production function used in the industry and services module is based on the Cobb-Douglas production function. Capital and labor are the production factors considered, and the total factor productivity (TFP) depends on education, health, energy, infrastructure capacity (of roads, rail, ports, air transport), broadband penetration, and research and development.

The equation used to estimate industry production is as shown below:

$$yi_t = yi_{t-1} * ric_t^{\alpha} * ril_t^{\beta} * fpi_t$$

Where yi_t is the current industry production, yi_{t-1} is the initial industry production, ric_t is the relative industry capital (relative to 1980), ril_t is the relative industry labor and fpi_t is the industry TFP. α is the elasticity of capital and β is the elasticity of labor.

Moreover, industry TFP *fpi* is determined by health (relative life expectancy *rle*), education (relative years of schooling *rys*), energy (relative energy price *rep*), transport capacity -of roads (relative road density *rrd*), ports (*pc*), freight rail (*fr*) and freight air (*fa*)-, broadband penetration (broadband penetration *bp*), and research and development (relative R&D investment *rrd*). Thus, the total factor productivity of industry is calculated as follows, with relative oil price and water stress having a negative impact on productivity:

$$fpi = rle^{a} * rys^{b} * rep^{c} * rrd^{d} * pc^{e} * fr^{f} * fa^{g} * bp^{h} * rrd^{i}$$

Where letters *a* to *i* are elasticity of industry TFP to each factor.

Similarly, services production is also calculated as a function of initial services production, relative services capital, relative services labor and services TFP. However, the drivers identified for services TFP (*fps*) are not the same.

$$fps = rle^{j} * rte^{k} * rep^{l} * rrd^{m} * pa^{n} * bp^{p} * rrd^{q}$$

As in the equation above, the factors for the services TFP include health (relative life expectancy *rle*), skilled labor force (relative tertiary students enrollment *rte*), energy (relative energy price *rep*), transport capacity of roads (relative road density *rrd*) and passenger air (*pa*), broadband penetration (broadband penetration *bp*), and research and development (relative R&D investment *rrd*). Letters *j* to *q* are elasticity of services TFP to each factor.

Energy sector relations

The key indicators to measure the energy sector performance are energy security and energy affordability.

Energy security, or the dependence of national energy supply on imports, is determined by energy supply and demand. Energy supply is affected by fossil fuel stocks, and investment-driven production capacity and power transmission and distribution network, while energy demand is driven by population and economic development, and energy efficiency. Fuel prices, among the primary energy sector indicators, influence energy security through both fossil fuel exploration and discovery and energy demand, while in turn the prices are dependent on the amount of energy import. Energy prices and consumption allow the calculation of energy expenditure, measuring energy affordability.

More specifically, fossil fuel production is a function of fuel reserves, the capital level (as the accumulation of annual investments), the initial production as a fraction of reserves and the production limit:

oil production = MIN(Oil Reserves*relative capital by fossil fuel type[OIL]*INITIAL PRODUCTION FRACTION OIL, oil production limit)

Note that the formulation MIN is used to make sure that the volume oil production never exceeds the production limits.

The power generation from each source, on the other hand, is calculated as power generating capacity, multiplied by a load factor. Power generating capacity is accumulated through annual construction (driven by investments) and reduced by power plant discard (dependent on capital lifetime):

Hydro Power Generation Capacity=INTEG (hydro power construction-hydro power discard), INITIAL (INITIAL COAL CAPITAL OR RELATIVE VALUE)

Total primary energy demand is calculated as the sum of primary energy demand by source (oil, gas, coal and electricity). The primary energy demand of each fossil fuel is obtained by totaling final energy demand by end-sector (agriculture, industry residential and commercial, and transport) and fuel inputs in power generation. The formulation of oil demand, as an example of fossil fuels, is:

primary energy demand oil = oil demand for electricity in ktoe + final energy demand oil

final energy demand oil = agriculture energy demand oil + industrial energy demand oil + "resid & comm energy demand oil" + transport energy demand oil

The final energy demand of end-sectors in the equation above is a function of the initial demand, relative population, relative GDP, energy efficiency, and the effect of energy prices. For instance, the final oil demand by transport sector is calculated as:

transport energy demand oil = INITIAL TRANSPORT ENERGY DEMAND OIL* relative gdp^ELASTICITY OF TRANSPORT OIL DEMAND TO GDP(Time) *relative population ^ELASTICITY OF TRANSPORT OIL DEMAND TO POPULATION *Effect Of Prices On Energy Demand[OIL] /energy efficiency ratio transport

The calculation of gas and coal demand follows the same approach.

On the other hand, primary energy demand of electricity is obtained as final energy demand for electricity less the amount of thermal energy in power generation plus electricity transmission loss. Furthermore, final energy demand for electricity is not only affected by the demand of each end-sector, but is also constrained by the coverage of electricity network.

final energy demand electricity = (industrial energy demand electricity + residential energy demand electricity +commercial energy demand electricity) *effect of network coverage on energy intensity /energy efficiency ratio residential and commercial

The impact is calculated as:

effect of network coverage on energy intensity = relative electricity network coverage ^ELASTICITY OF ENERGY INTENSITY TO NETWORK COVERAGE

Moreover, energy prices have impacts on the national GDP through total factor productivity (see TFP equations above) and exports. As is indicated above, economic growth, in turn, put more pressure on energy consumption.

Trade sector relations

The primary indicator in the trade sector is resource balance, dependent on exports and imports, each further driven by several endogenously calculated factors.

Exports of goods and services are both affected by the rest of the world (ROW) and domestic production, relative price levels, currency exchange rate, energy prices and broadband connection penetration, while they are each influenced by a number of different factors in the three spheres:

- Economic sphere: airline passengers and freight capacity on services and goods respectively, port capacity on goods.
- Social sphere: availability of skilled labor force on services.
- Environmental sphere: forests that provides biodiversity on services, carbon payments and emission intensity on goods.

More specifically, the exports for each production sector (agriculture, industry and services) is determined based on the initial level of export, the ROW GDP growth, relative prices, the sectoral production. For industry and services, the exports are further affected by a number of extra drivers, as listed above in the three spheres.

The *effect of ROW GDP on export* is determined by applying to the relative (normalized) ROW GDP the *elasticity of export to ROW GDP*:

Effect of ROW GDP on export [sectors] = Relative ROW GDP^ ELASTICITY OF EXPORT TO ROW GDP[sectors]

Note that the subscript [sectors] is used to keep track separately of the intensity of the effect on the various types of export products (agricultural, industrial and services).

Similarly, the *effect of relative prices on export* is calculated as:

Effect of relative prices on export [sectors] = (Perceived Relative Prices[sectors])^ELASTICITY OF EXPORT TO RELATIVE PRICES[sectors]

Finally, *export* is calculated as:

Real export[AGRI] = INITIAL REAL EXPORT[AGRI]* effect of row gdp on export[AGRI]* effect of relative prices on export[AGRI]*effect of sector production on export[AGRI]

Real export[IND] = INITIAL REAL EXPORT[IND]* effect of row gdp on export[IND]* effect of relative prices on export[IND]*effect of sector production on export[IND]*effect of extra variables to real goods exports

Real export[SERV] = INITIAL REAL EXPORT[SERV]* effect of row gdp on export[SERV]* effect of relative prices on export[SERV]*effect of sector production on export[SERV]*effect of extra variables to real services exports

In the formulation above, the effects previously described are combined together and extra variables for industrial and services listed above.

Import is not only affected by domestic import demand for goods and services (driven by domestic production, producer's and consumer's price levels), but its total volume is also determined by the endogenously calculated level of production, investment, consumption and export. I.e., the total volume of imports is determined as the residual in the GDP identity. Using the classical economic nomenclature, given the level of production (Y), investment (I), consumption (C) and export (X), import (M) is calculated as:

$$M = + I + C + X - Y$$

In T21, the equation for total import is:

Total import = consumption + investment+ total export - nominal GDP at market prices

The distribution of *total import* among the types of goods and services is calculated based on *initial import* and the effect of convenience of domestic goods (with respect to imported goods), the effect of relative prices, and the effect of domestic GDP.

The *effect of convenience of domestic goods on imports* is calculated elevating the relative (normalized) convenience of domestic goods to the power of the elasticity of imports to such variable:

Effect of convenience of domestic goods on imports [sectors] = relative
convenience of domestic goods[sectors]^ELASTICITY OF IMPORTS TO
IMPORT PRICES[sectors]

Similarly, *effect of GDP on import* is calculated as:

Effect of GDP on import [sectors] = (nominal gdp at market prices/INITIAL
NOMINAL GDP MP)^ELASTICITY OF IMPORT TO GDP[sectors]

The effect or *relative prices on import* is calculated as:

Effect of relative prices on import [sectors] = relative producer
prices[sectors]^ELASTICITY OF IMPORT TO RELATIVE PRICES[sectors]

Import demand, which is only used to determine the fraction of imports per type of goods and services and not the total level of import, is subsequently calculated as:

Import demand [sectors] = INITIAL IMPORTS [sectors]* Effect Of Convenience
Of Domestic Goods On Import[sectors]* Effect Of Gdp On Import[sectors]*
effect of relative prices on imports[sectors]

Finally, the *import* for each type of goods and services are calculated as:

Import [sectors] = import demand[sectors]*fraction of import demand satisfied by
import

The *fraction of import demand satisfied by import* is determined as total imports calculated as the residual of the GDP identity, divided by total import demand.

In return, the volumes of exports and imports affect the balance of supply and demand, and consequently domestic price levels, with the latter driving exports and imports again.

3.4. Data Collected

This sections presents the data collected for the key socio-economic and environmental variables included the model, along with their sources.

Much of the social data are derived from the sectoral tables in Malaysian Economy in Figures 2011. The variables used in the data covers primary and secondary education, employment by sector and poverty. Data for demographic variables (including population by age and gender, and gender-specific net migration, fertility and mortality rate and life expectancy) are obtained from WPP (World Population Prospects) of UNPOP. When available, these data are further compared with time series from the World Development Indicators (WDI) database to check data consistency. Data on basic healthcare are from WDI.

In the economic sector, most data are collected from the Malaysian Economy in Figures 2011 report. This study is used to estimate the SNA table and to obtain value-added from key production sectors. In terms of agriculture production, data for the production, price and area of agricultural crops, animals and livestock production, forestry and fisheries production are obtained from Malaysian Economy in Figures 2011 and the FAOSTAT database.

The main environmental sectors are land use from FAOSTAT, water from WDI and energy from the Malaysia National Energy Balance 2008, EIA (the U.S. Department of Energy's Energy Information Administration) and IEA's WEO. More specifically on energy data, The Malaysia National Energy Balance 2008 is used as the main data source for energy stocks and flows, including energy consumption by source and user (consumption of oil, gas, coal and electricity, each disaggregated into residential and commercial, agricultural, industrial, transport and non-energy uses) and energy exports, and electricity generation by source. Data on fossil fuel production, reserves and emissions, along with energy prices, taxes, and oil and gas subsidies are obtained from EIA's international energy statistics. The electricity generation factors and costs are derived from IEA's WEO 2008. Power employment data is derived from TNB.

Data on the area of land use (in total and disaggregated into arable and pasture land for agriculture, and forestland) are obtained from the Land sector of the FAOSTAT database. Water consumption data (by domestic, agricultural and industrial sectors) and total water resources are derived from WDI, although only a few data points are reported. Other climate-related data, such as precipitation, temperature, are obtained from local sources.

3.5. Model Validation

The structure of T21-Malaysia was carefully built and validated, integrating sectoral knowledge from selected studies and from expertize and skills of the T21 team members from EPU and other stakeholders.

All sectors have been verified and validated comparing the behavior of the model against historical data. More detailed analyses were then performed to identify and analyze the causal relations included in the model and the relevance of exogenous assumptions (or drivers), through the simulation of sensitivity analyses for selected variables. Further, extreme condition tests, feedback loop analysis as well as unit consistency tests were frequently performed on all models. Boundaries as well as structural (i.e. causal relations and equations) and parameter consistency tests were normally checked with the T21 core team.

Concerning behavioral validation, around 600 variables across energy sector, and social, economic and environmental sphere were simulated against as many historical and future projections from the data collected –as discussed in section 4.4 above– as possible to check the validity of equations and consistency of the projections. The simulation results generally match very well with data of major national and global institutions. Particular emphasis during the modeling process was devoted to the analysis of the performance of aggregated indicators (e.g. final energy demand for gas as opposed to industrial natural gas demand), for which more information is available on the actual functioning of the system.

Detailed statistical results of each key variable are discussed in the following pages.

3.5.1.Social Indicators

<u>Population</u>

The main output from the demographic sector is population. The simulation result of total population is compared with historical and projected data from United Nations Population Division (UNPOP)'s World Population Prospects (WPP).

Total population is a function of annual births, deaths and net migration, along with initial population, while births and deaths are further driven by a number of endogenous socio-economic factors in the model, such as income, education and healthcare.

As is illustrated in **Figure 5** to **Figure 10** below, for past and future projections (1980 to 2050), the simulation results of total population are very similar to the population values from WPP, with an R-square of 99.9% and an average point-to-point difference of 0.7% (**Table 6**).

Statistical tests are conducted also on the relevant demographic variables and the driving factors mentioned above, which perform well compared with external data (**Table 6**).

Table 5: Statistical results of key social indicators

Variable	R-square[6]	Point-to-point % difference
Total population	99.9%	0.7%
Total births	68.5%	4%
Total deaths	93.3%	3%
Life expectancy	98.2%	5%
Access to basic health care	85.8%	0.2%
Adult literacy rate	98.2%	0.9%

[6] Range to be considered for the evaluation of the R-square results provided: 80-100% (Good), 60-80% (Medium), 0-60% (Poor).

Figure 5: Simulation of population in BAU compared with WPP data.

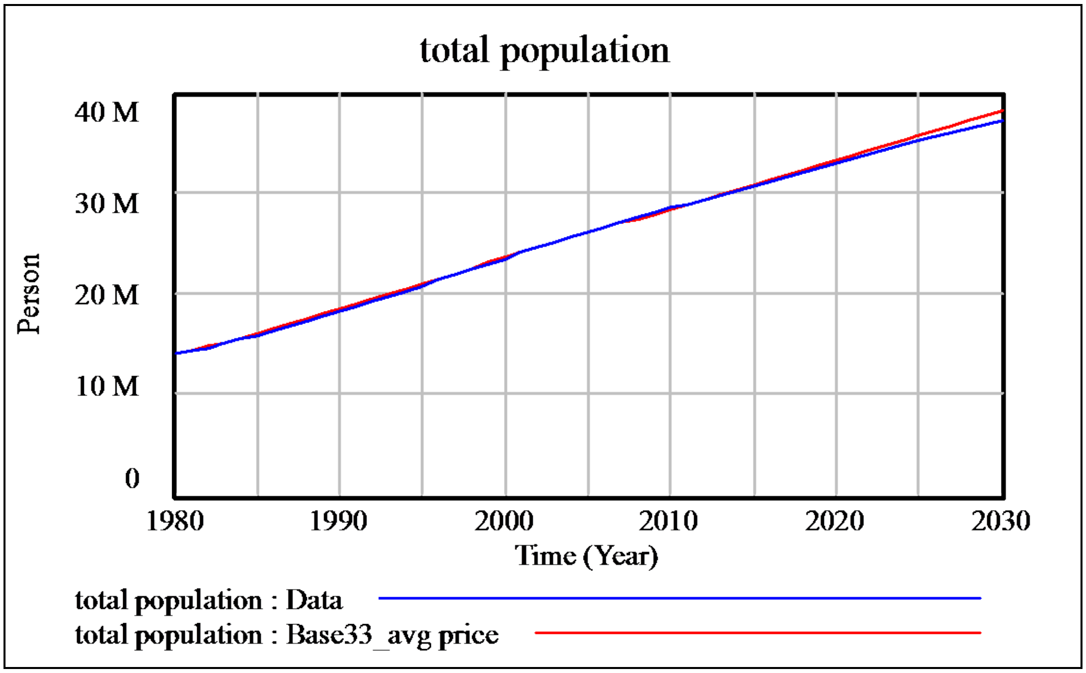


Figure 6: Simulation of total births in BAU compared with WPP data.

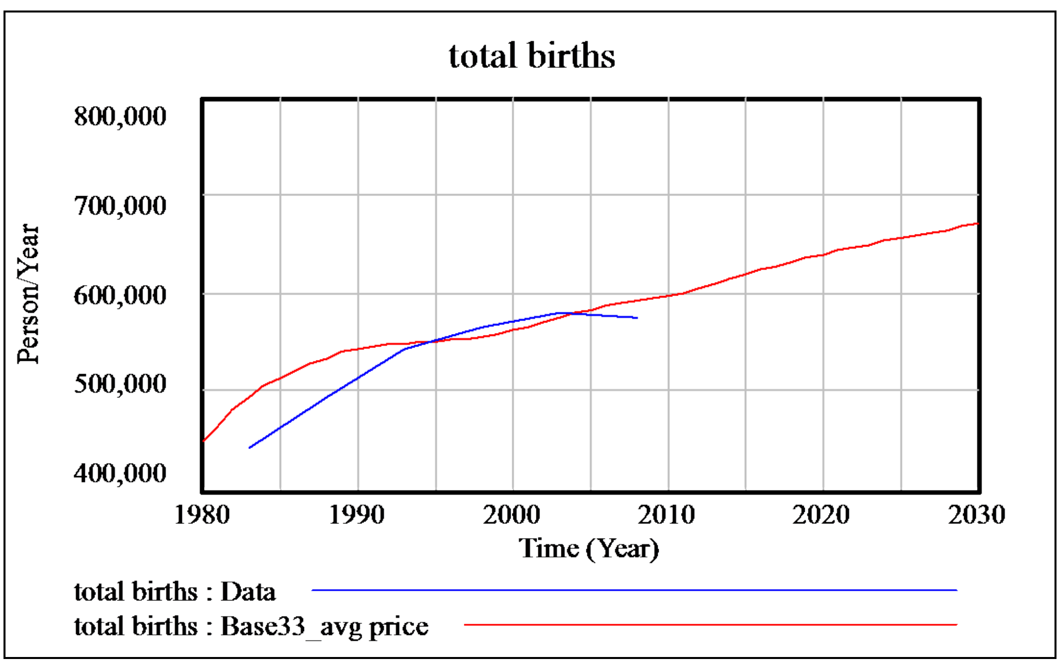


Figure 7: Simulation of total deaths in BAU compared with WPP data.

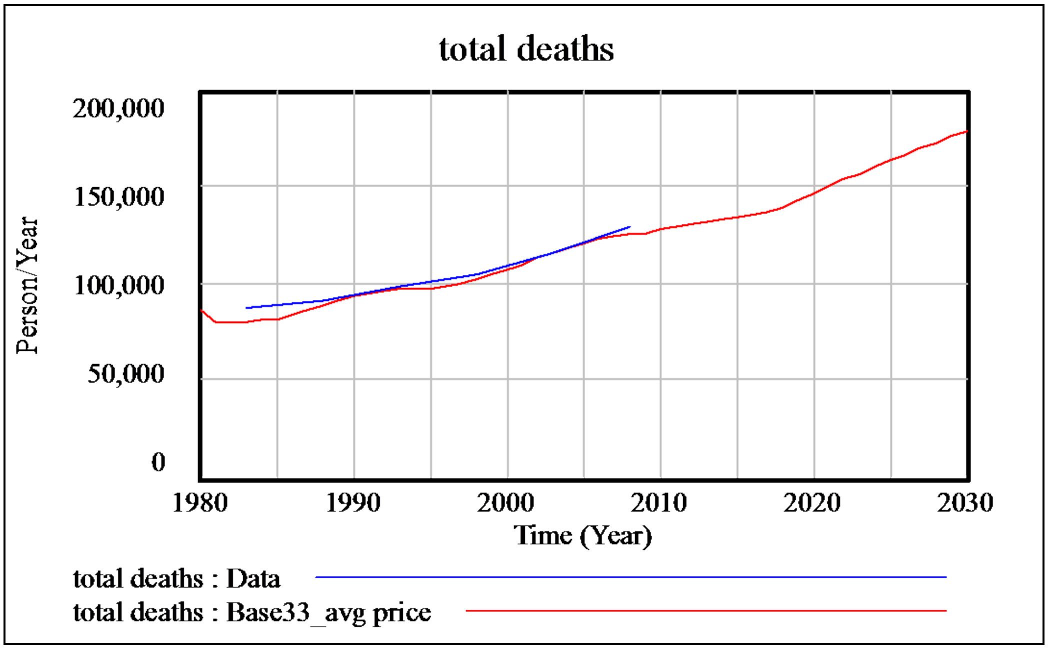


Figure 8: Simulation of life expectancy in BAU compared with WPP data.

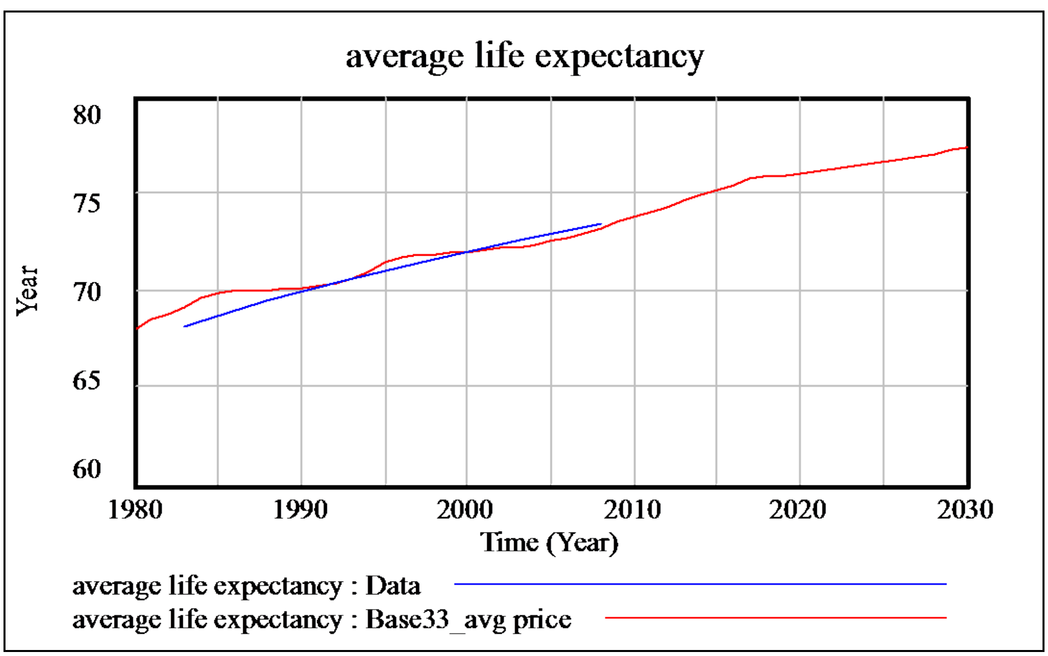


Figure 9: Simulation of access to basic health care in BAU compared with WDI data.

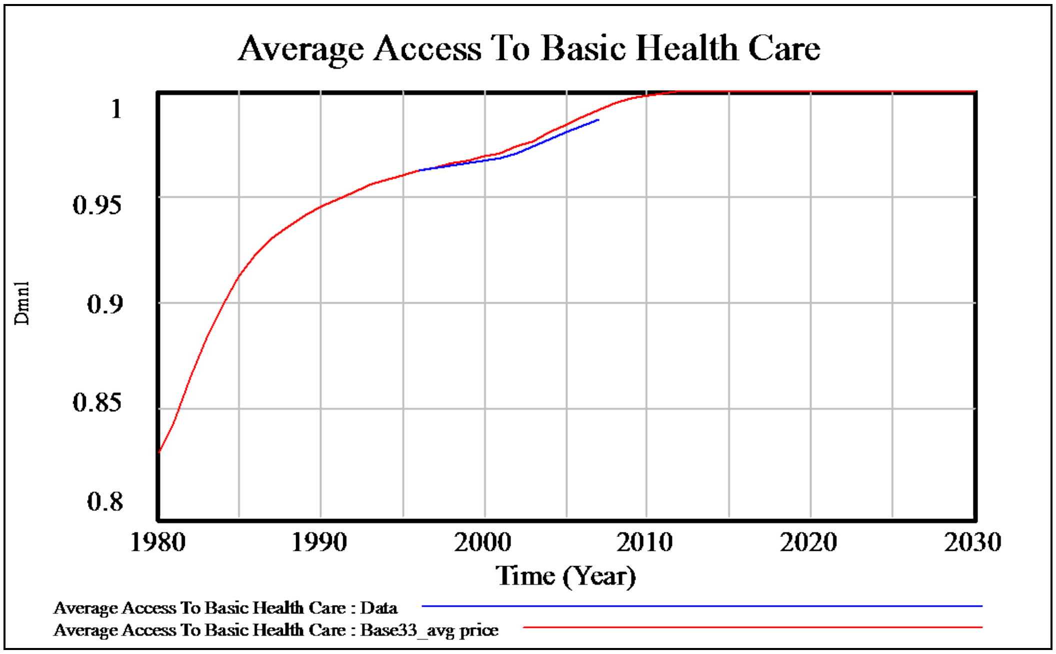
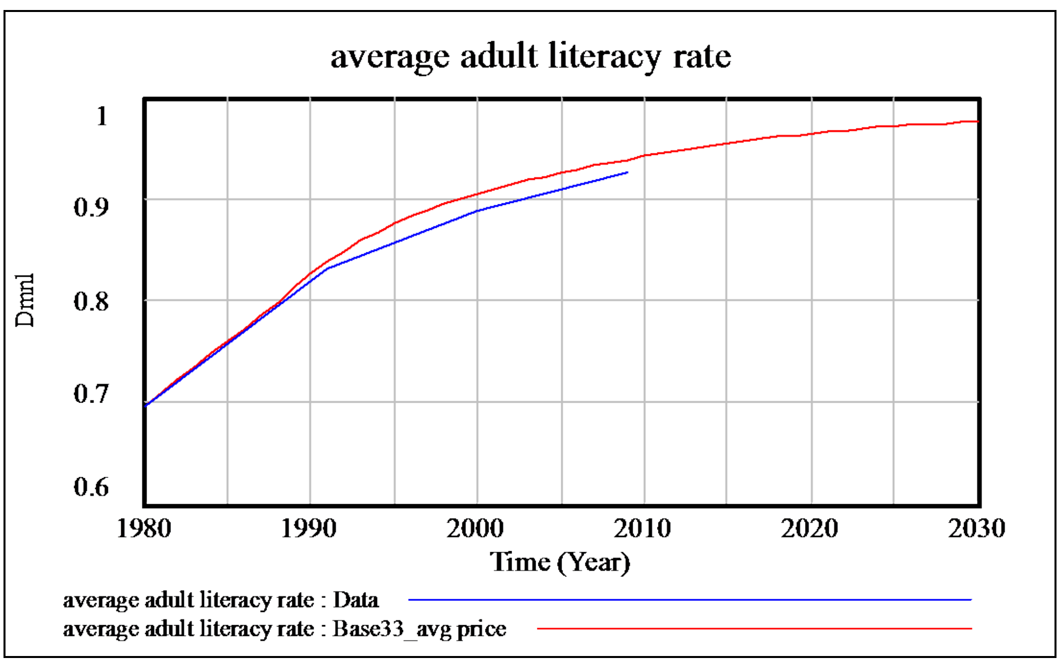


Figure 10: Simulation of adult literacy rate in BAU compared with Malaysian Economy in Figures 2011 data.

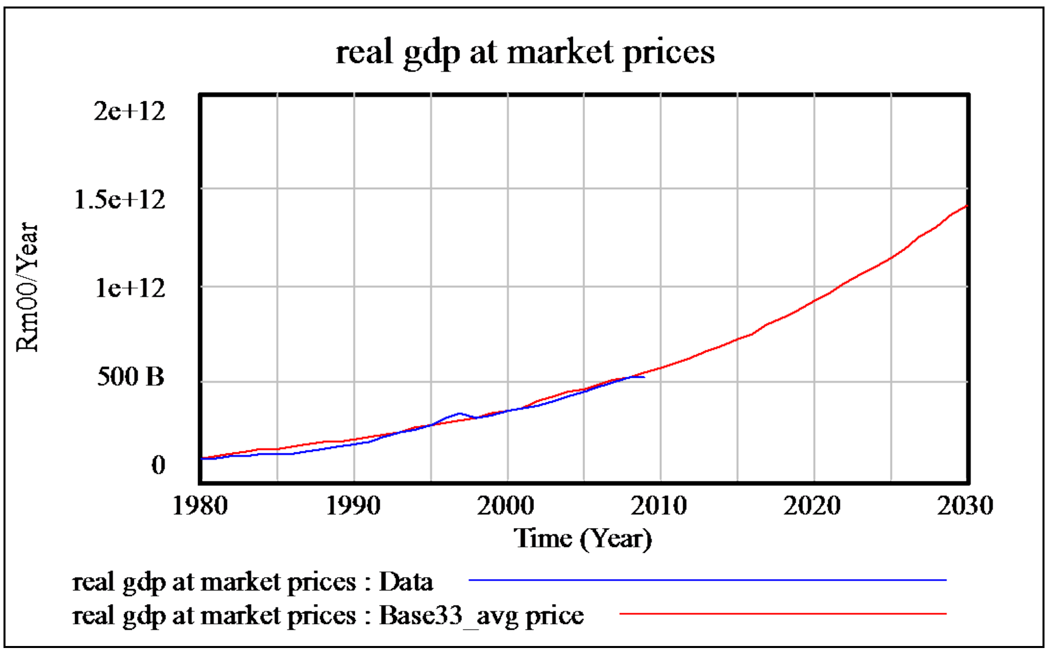


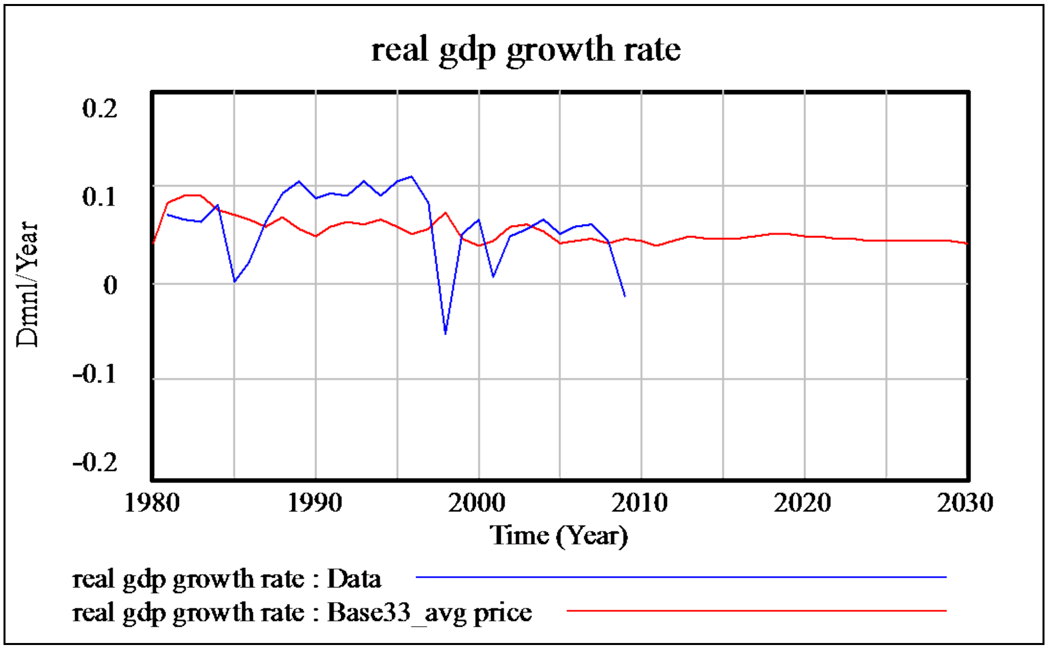
3.5.2.Economic Indicators

Gross Domestic Product

The main output of the economic sector of the model is the gross domestic product (GDP). The simulation result of the gross domestic product is compared with the Malaysian Economy in Figures 2011 report. For past projections (1980 – 2009), the model performs well, with an R-square of 97.8% and an average point-to-point difference of 0.8% (see **Figure 11**).

Figure 11: Simulation of GDP and GDP growth rate in BAU compared with values of Malaysian Economy in Figures 2011.





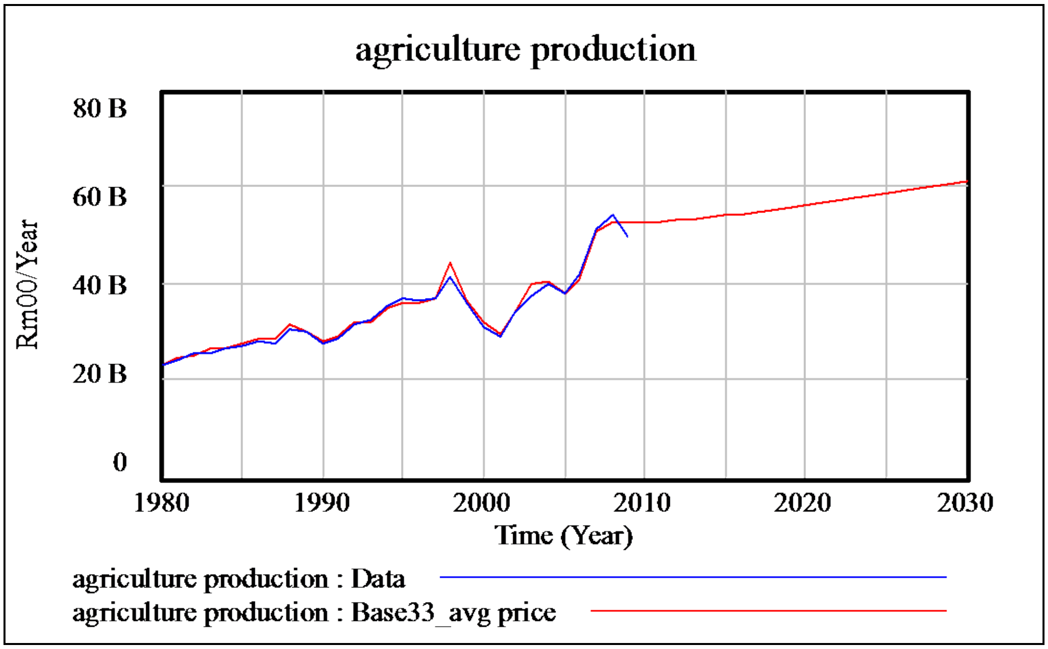
Agriculture, industry and services production

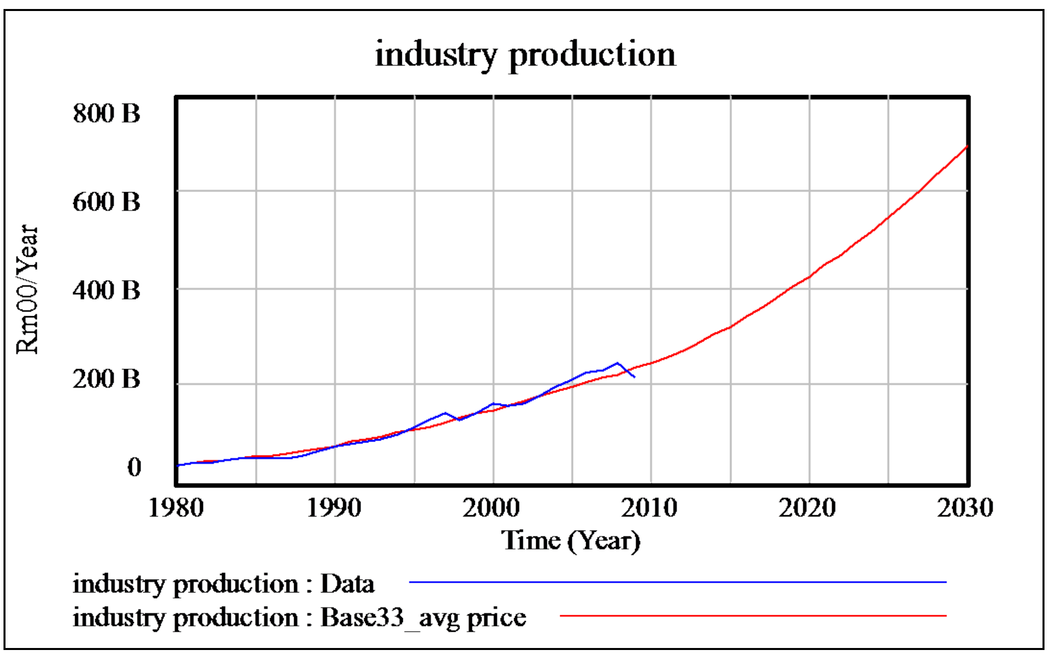
In terms of the contribution of GDP from the three main production sectors, i.e., agriculture, industry and services, the results of the simulation of the model are compared with values from the Malaysian Economy in Figures 2011 report. For past values (1980 – 2009), the model performs well (see **Figure 12** and **Table 7** below).

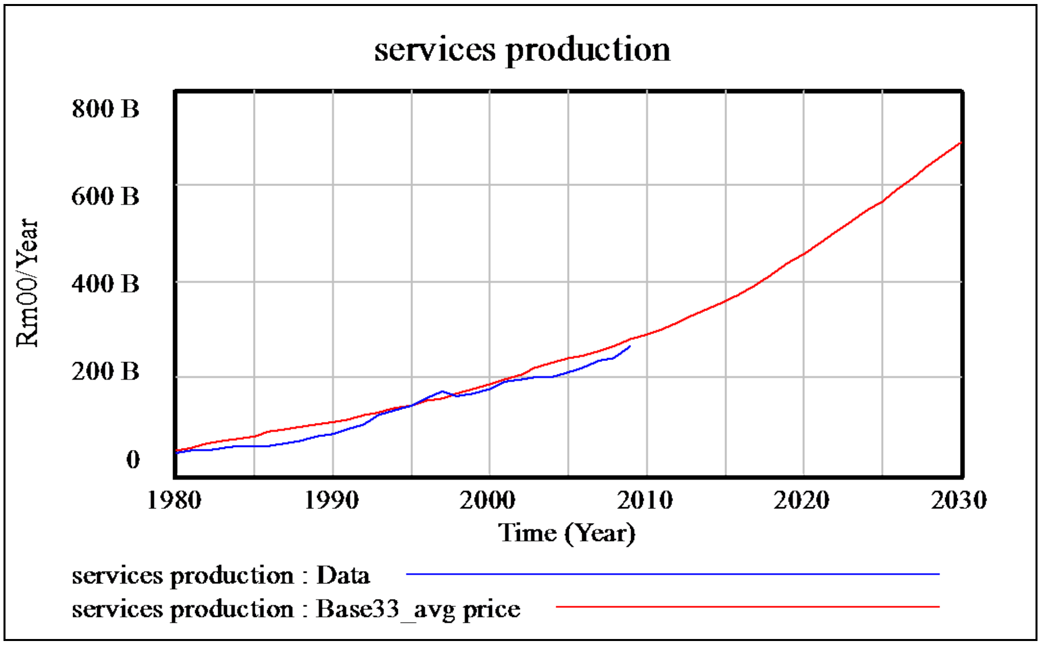
Table 6: Statistical results of agriculture, industry and services production

Variable	R-square	Point-to-point % difference
Agriculture production	98%	2%
Industry production	97.9%	6%
Services production	93.1%	17%

Figure 12: Simulation of agriculture, industry and services production in BAU compared with values of Malaysian Economy in Figures 2011.







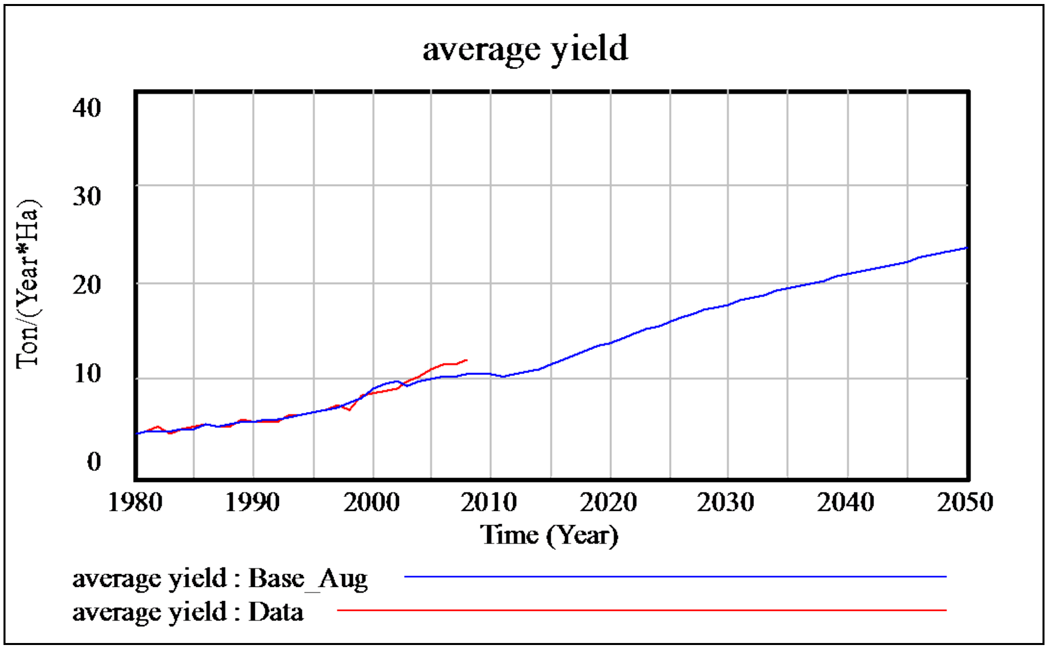
<u>Crops yield and production</u>

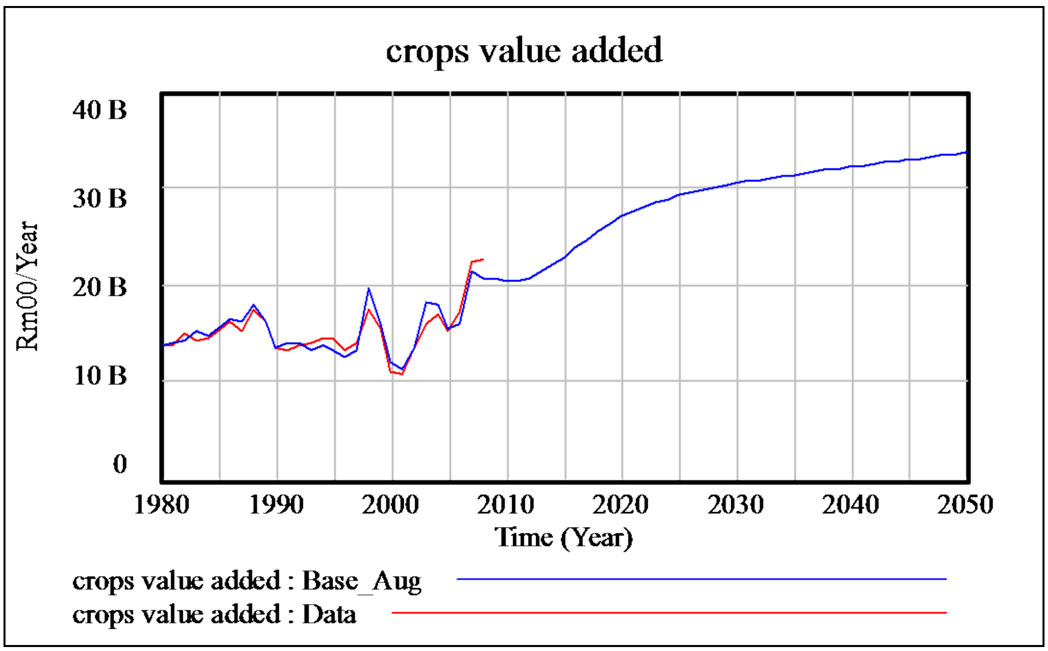
Within the agriculture sector, the simulation results of crop yield and value added, and animal stock from the model are compared with historical values (1980 – 2009) of the Malaysian Economy in Figures 2011. The model outcomes fit well with the data (see **Figure 13** and **Table 8** below).

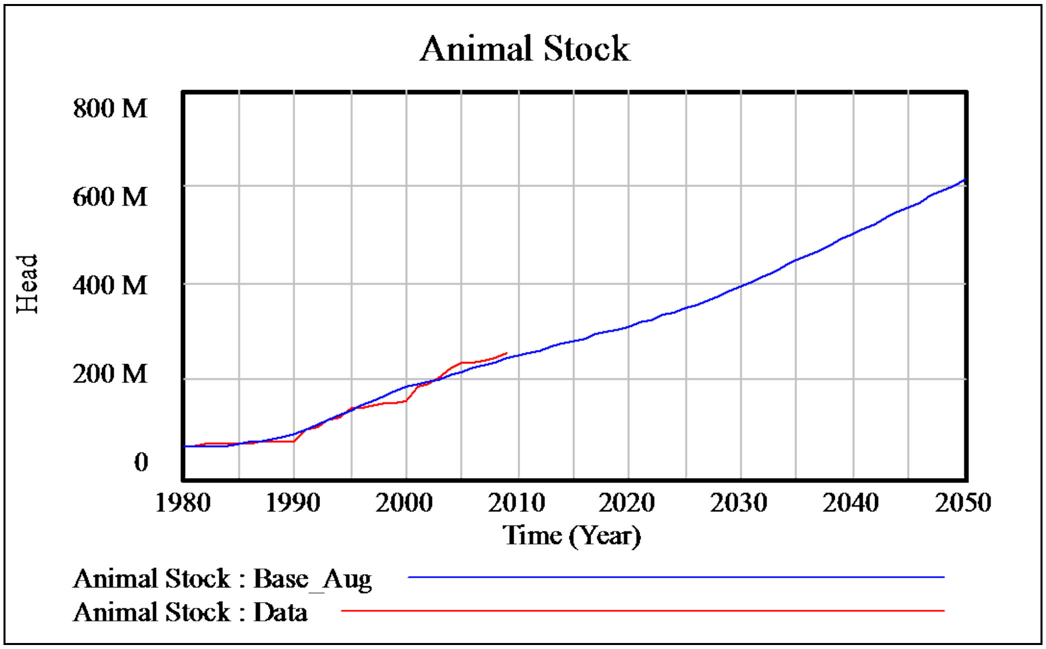
Table 7: Statistical results of key agriculture sector indicators

Variable	R-square	Point-to-point % difference
Crops yield	96%	5%
Crops value added	86.7%	4%
Animal stock	97.4%	6%

Figure 13: Simulation of crops yield, crops value added, animal stock in BAU compared with values of Malaysian Economy in Figures 2011.







3.5.3. Trade Indicators

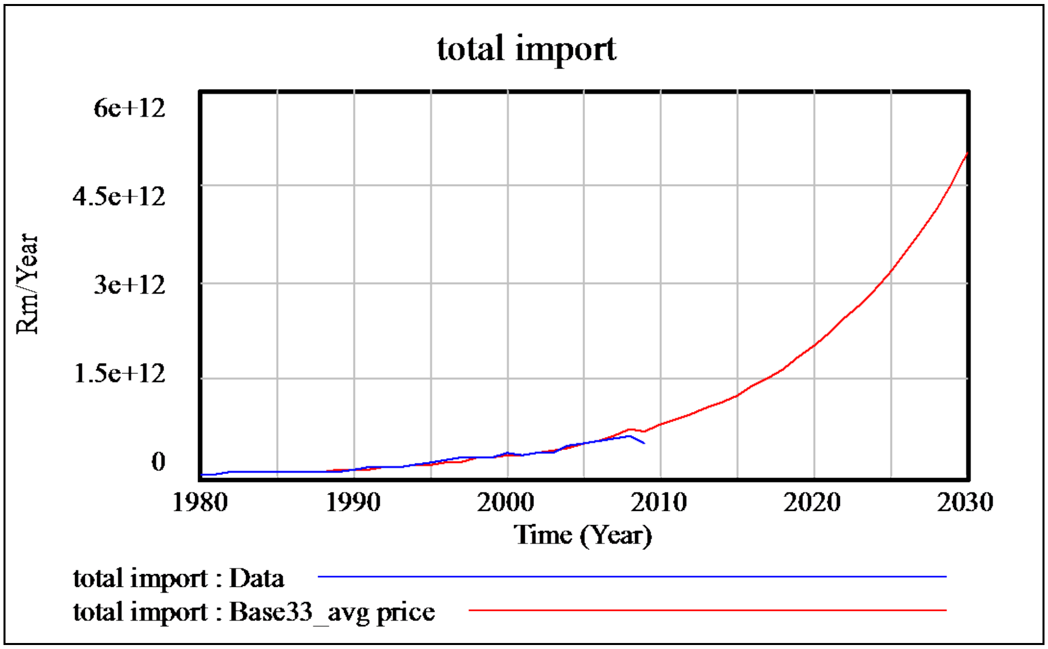
Imports and exports

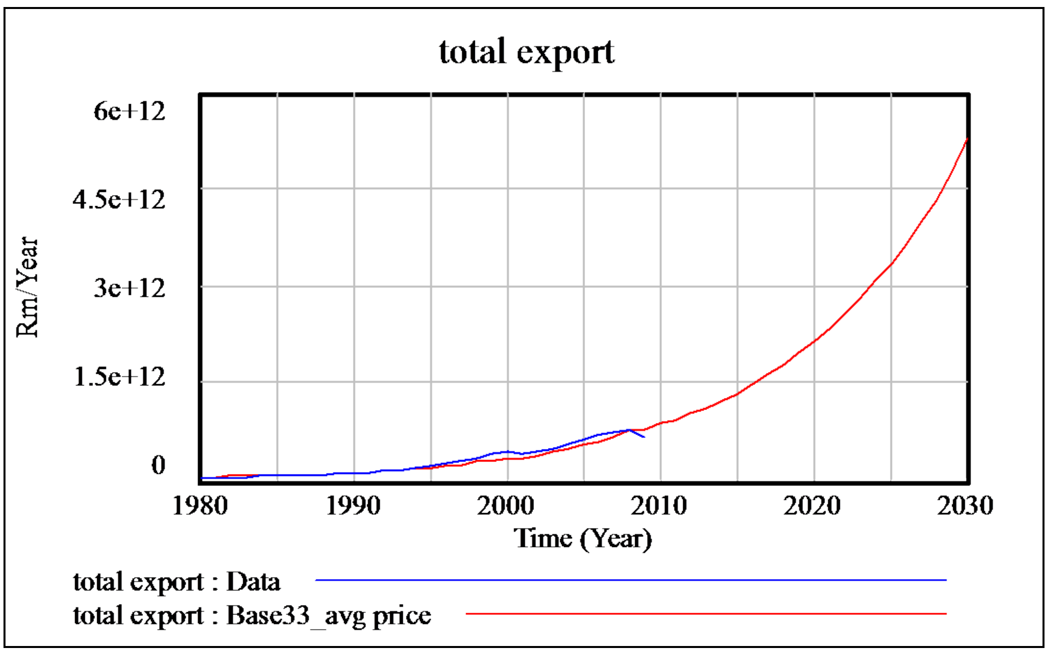
Concerning the trade sector, the main outputs of the model are the total import and export, and their disaggregation by main sectors. The simulation results of the import and export are compared with the Malaysian Economy in Figures 2011. For past projections (1980 – 2009), the model performs well, with an R-square of 95.4% and an average point-to-point difference of 0.12 for total import and an R-square of 93.8% and an average point-to-point difference of 0.15 for total export (see **Figure 14** and **Table 9** below).

Table 8: Statistical results of total import and export

Variable	R-square	Point-to-point % difference
Total import	95.4%	12%
Total export	93.8%	15%

Figure 14: Simulation of total import and export in BAU compared with values of Malaysian Economy in Figures 2011.





3.5.4. Environmental Indicators

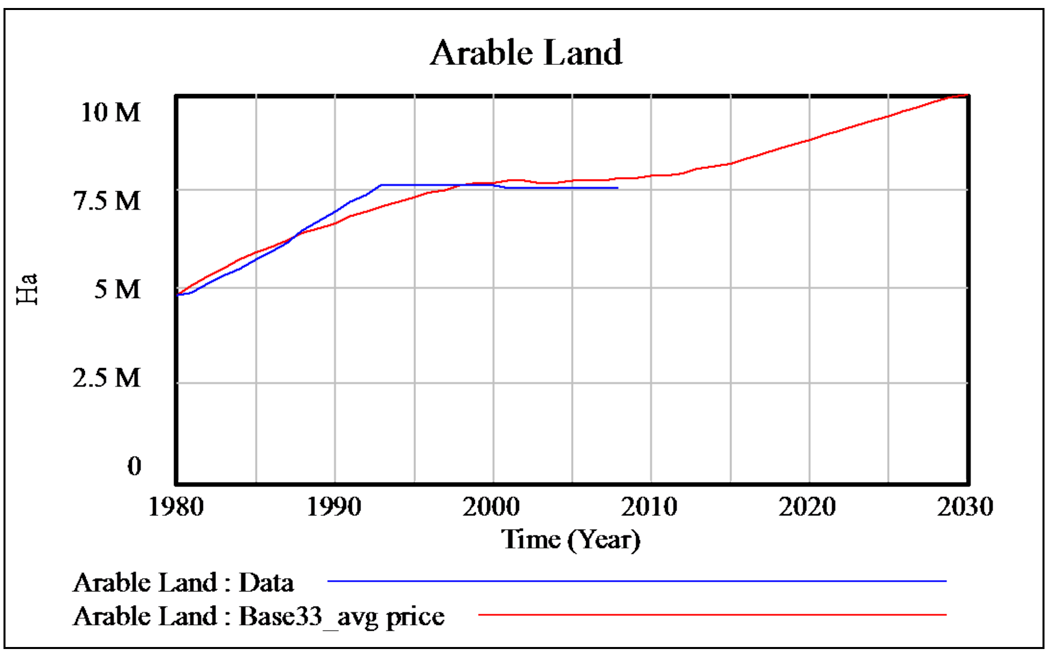
<u>Land</u>

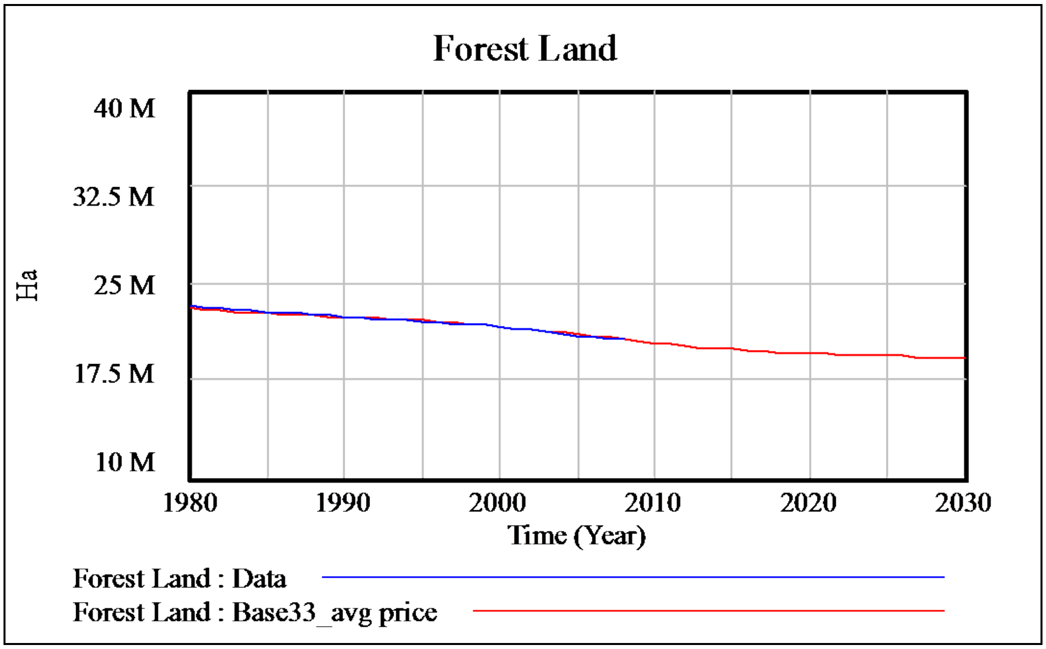
The main output of the environmental sector of the model is the land area. The simulation results of the arable and forestland are compared with the FAO statistics. For past projections (1980 – 2008), the model performs well (see **Figure 15** and **Table 10** below).

Table 9: Statistical results of arable and forestland

Variable	R-square	Point-to-point % difference
Arable land	94.8%	3%
Forest land	98.1%	4%

Figure 15: Simulation of arable and forestland in BAU compared with values of FAO.





3.5.5. Energy Indicators

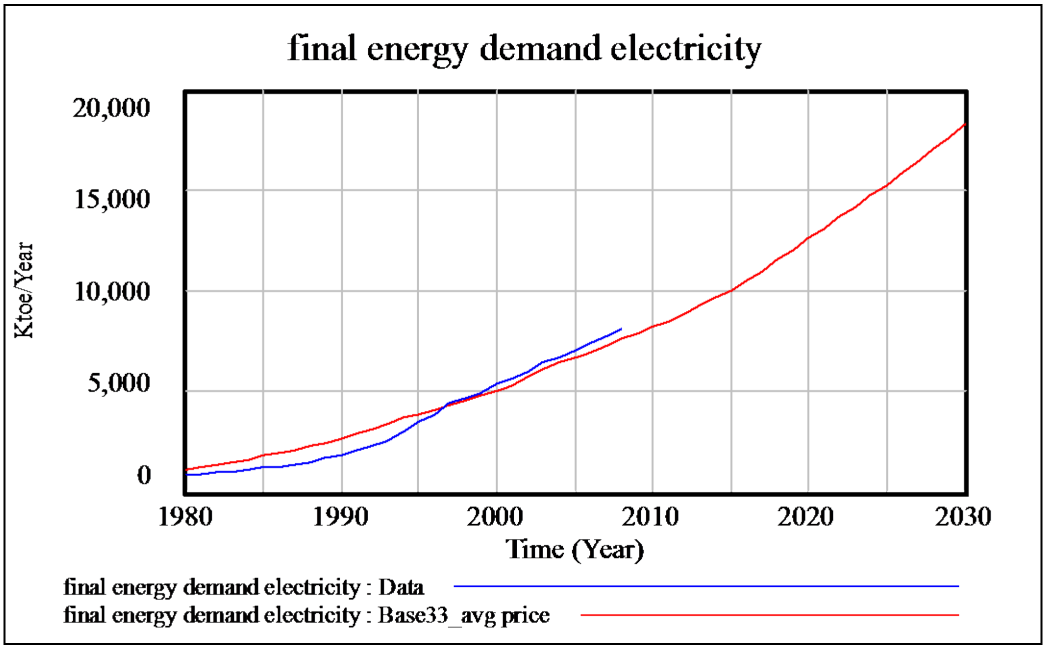
Final energy demand by source

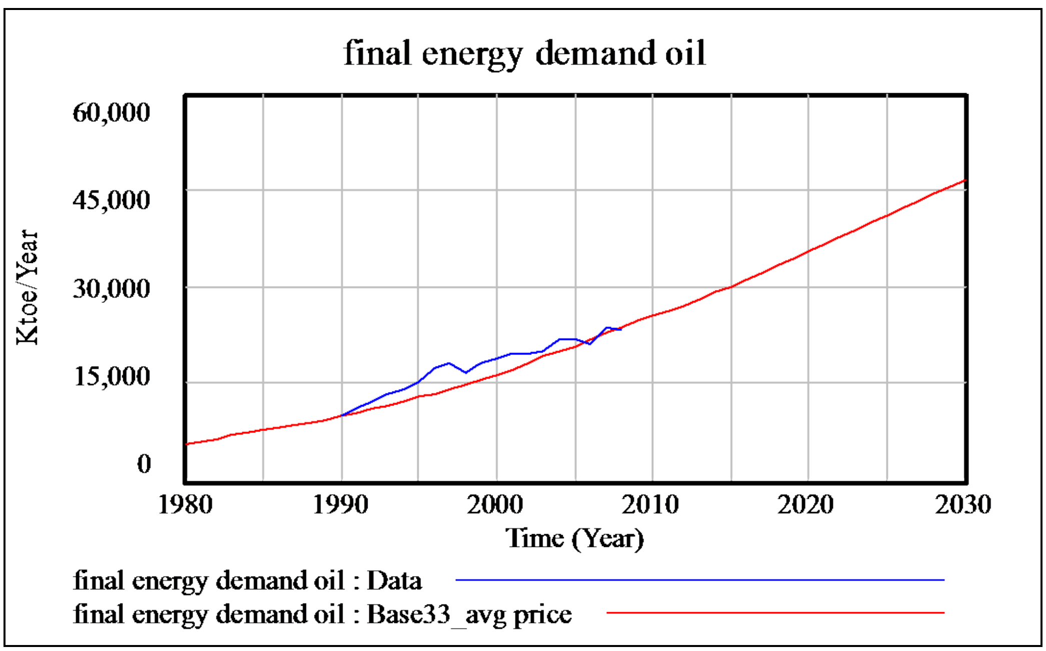
The simulation results of final demand for oil, gas, coal and electricity are compared to the historical data from Malaysia National Energy Balance 2008. The model fits well with the energy balance data (see **Figure 16** and **Table 11** below).

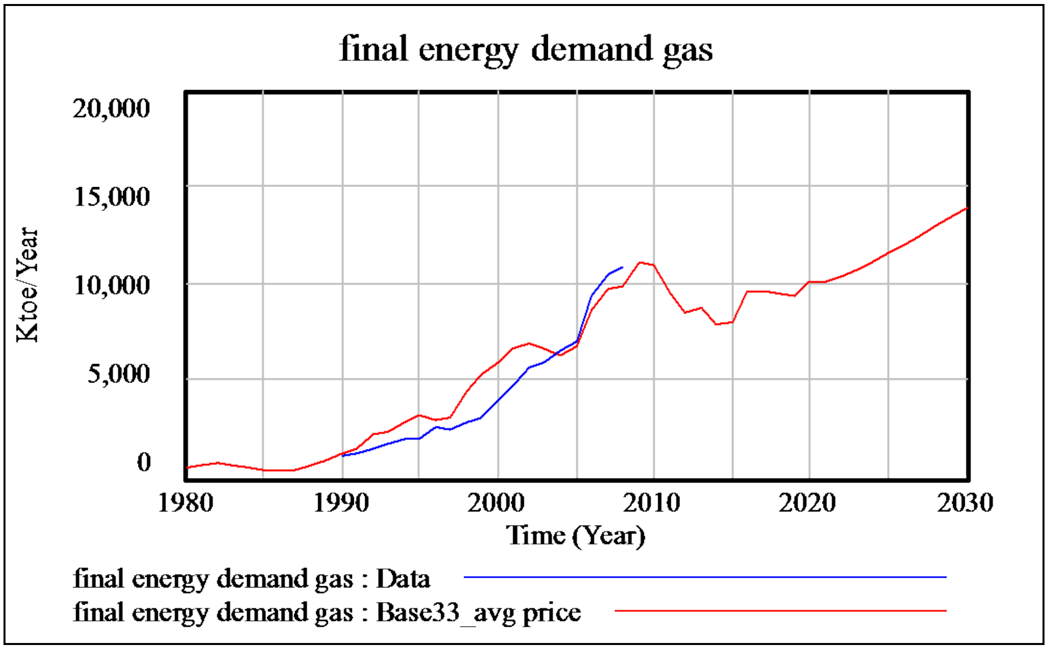
Table 10: Statistical results of final energy demand by source

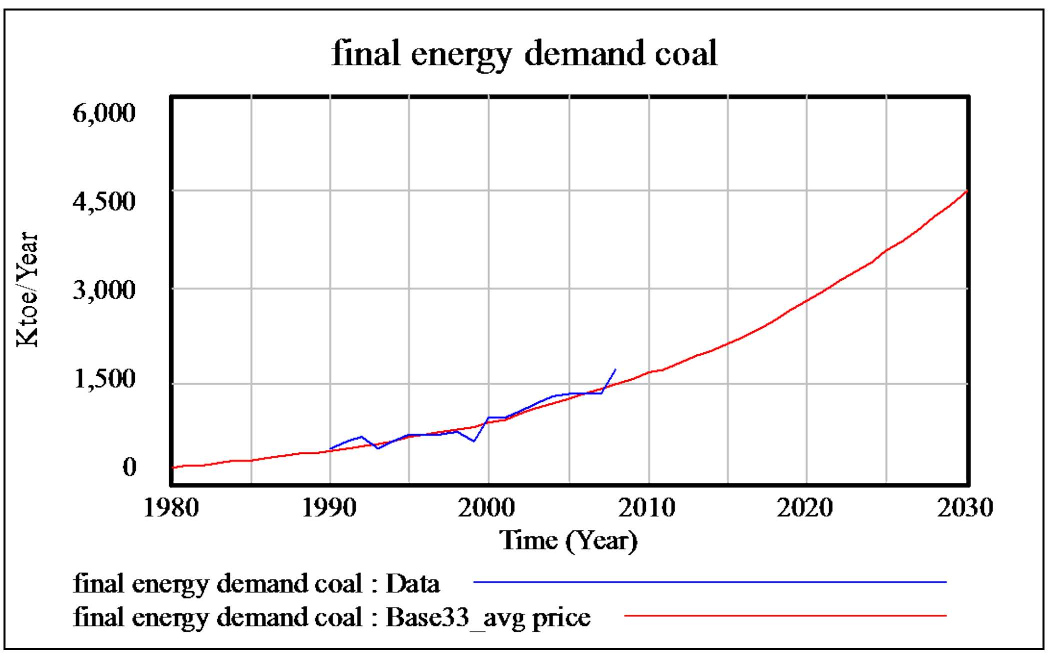
Variable	R-square	Point-to-point % difference
Final energy demand for electricity	95%	19%
Final energy demand for oil	74%	12%
Final energy demand for gas	92.3%	21%
Final energy demand for coal	86.8%	9%

Figure 16: Simulation of final energy demand by source compared with values of Malaysia National Energy Balance 2008.









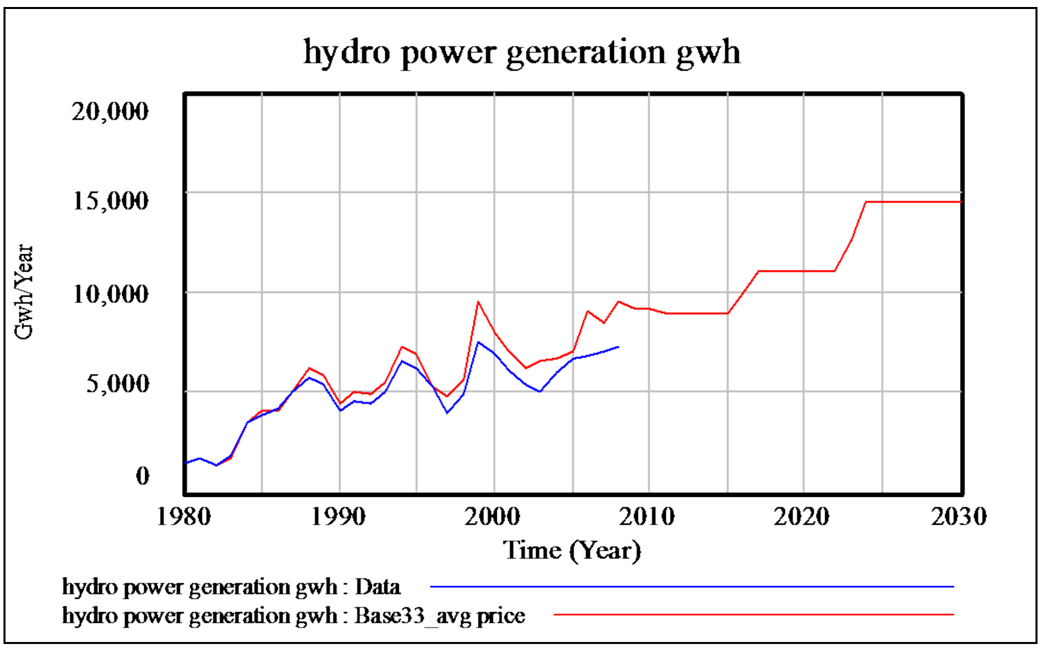
Electricity generation by source

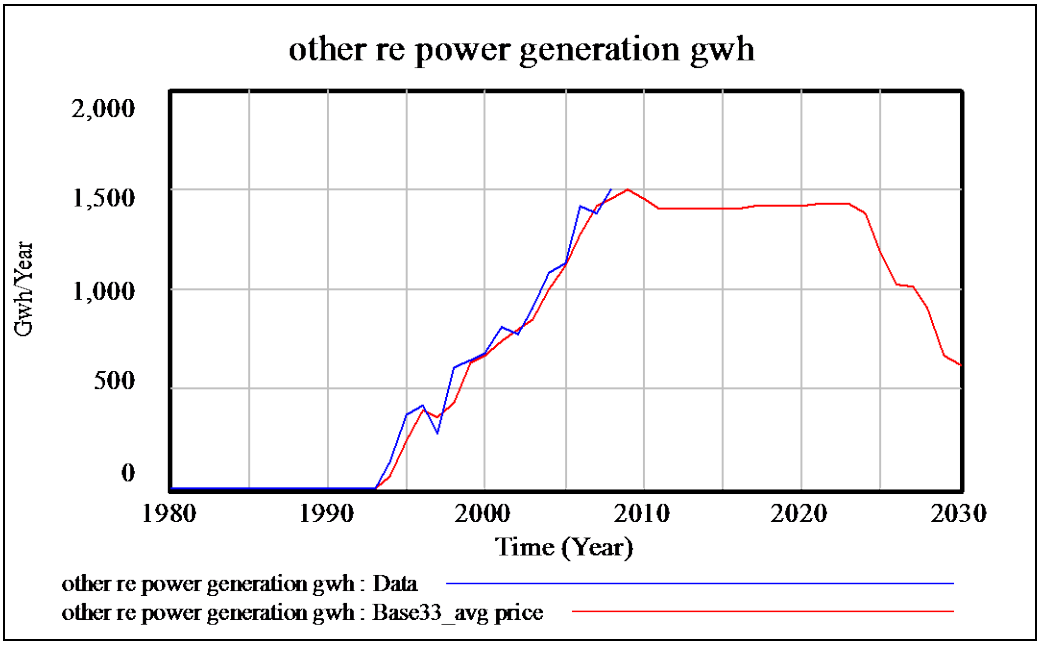
The simulation results of electricity generation from hydropower, other renewables, and conventional sources (oil, gas, coal) also fits well with the historical values from Malaysia National Energy Balance 2008 (see **Figure 17** and **Table 12** below).

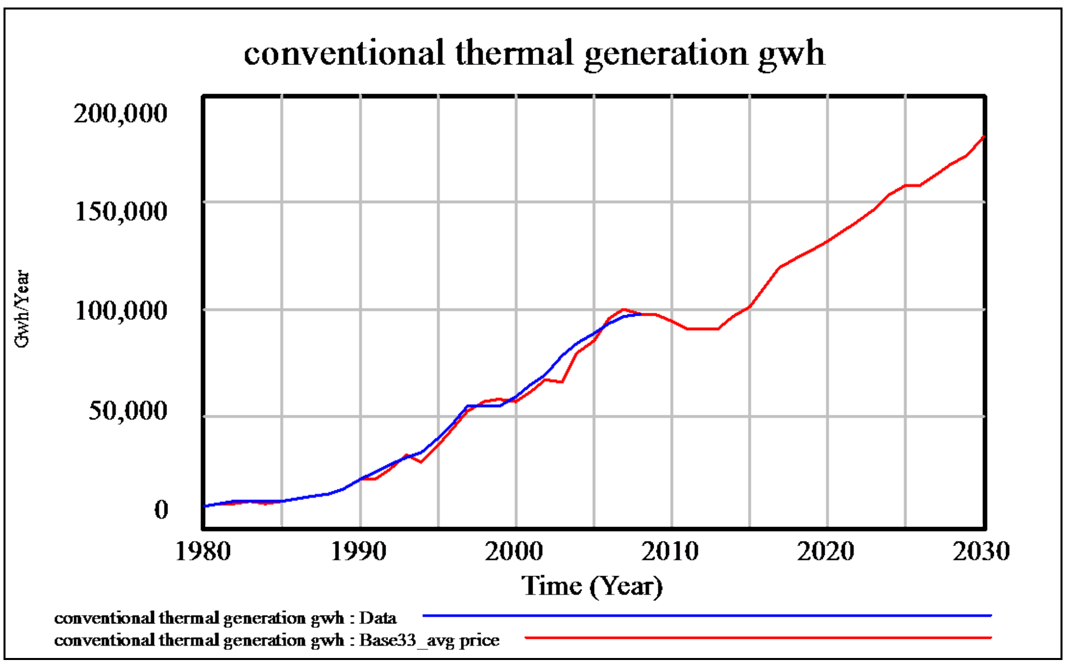
Table 11: Statistical results of electricity generation by source

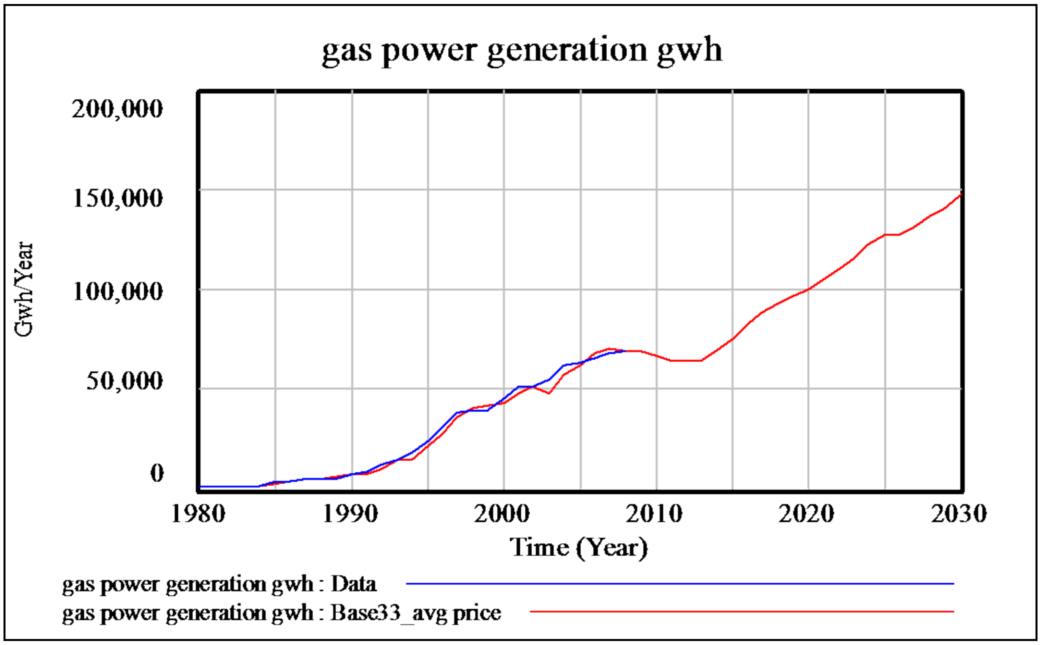
Variable	R-square	Point-to-point % difference
Hydro electricity generation	71.1%	10%
Other renewables electricity generation	98.5%	20%
Conventional thermal electricity generation	98.9%	5%
Gas electricity generation	99.4%	11%

Figure 17: Simulation of electricity generation by source compared with values of Malaysia National Energy Balance 2008.




other re power generation gwh
2,000
1,500
1,000
500
0
Gwh/Year
1980
1990
2000
2010
2020
2030
Time (Year)
other re power generation gwh : Data
other re power generation gwh : Base33_avg price


conventional thermal generation gwh
200,000
150,000
100,000
50,000
0
Gwh/Year
1980
1990
2000
2010
2020
2030
Time (Year)
conventional thermal generation gwh : Data
conventional thermal generation gwh : Base33_avg price



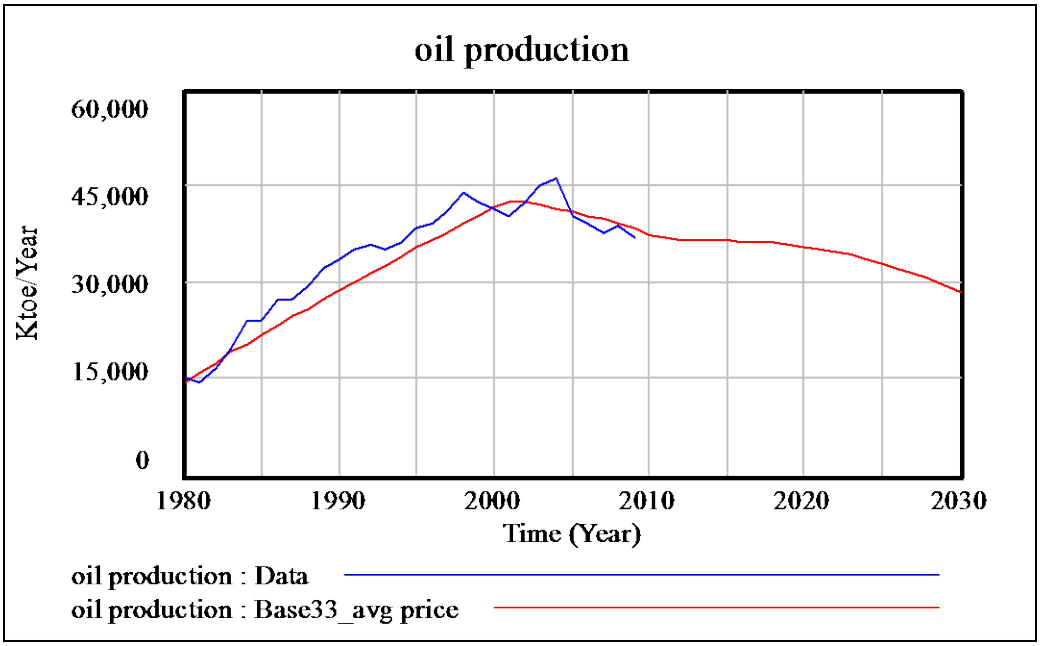
Fossil fuel production by source

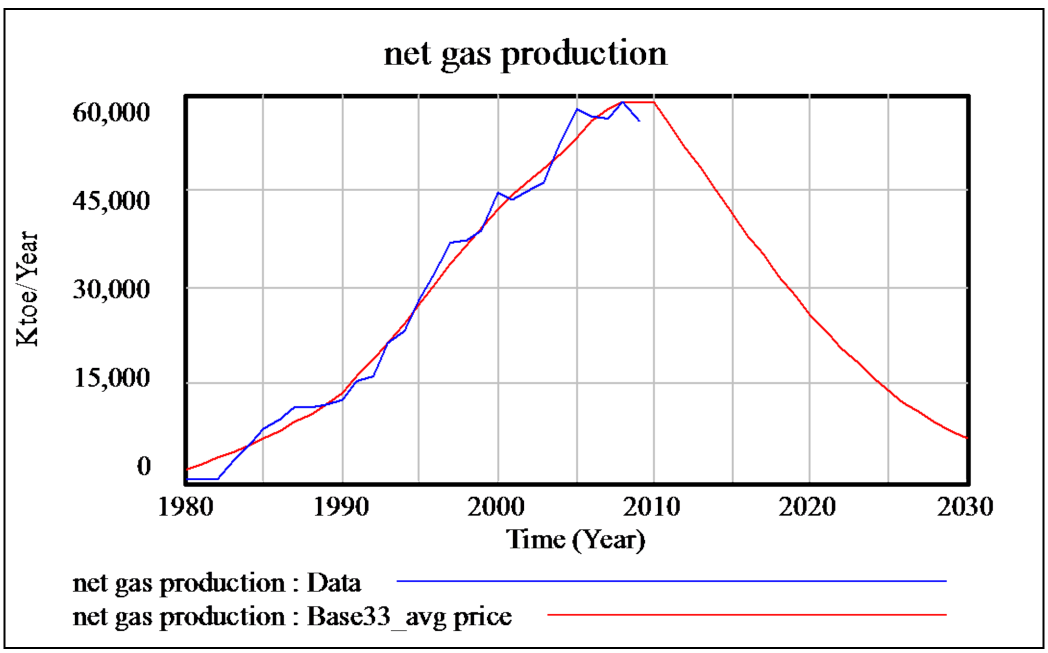
The simulation results of production of oil, gas and coal are compared with the historical data of EIA, and the values fit well (see **Figure 18** and **Table 13** below).

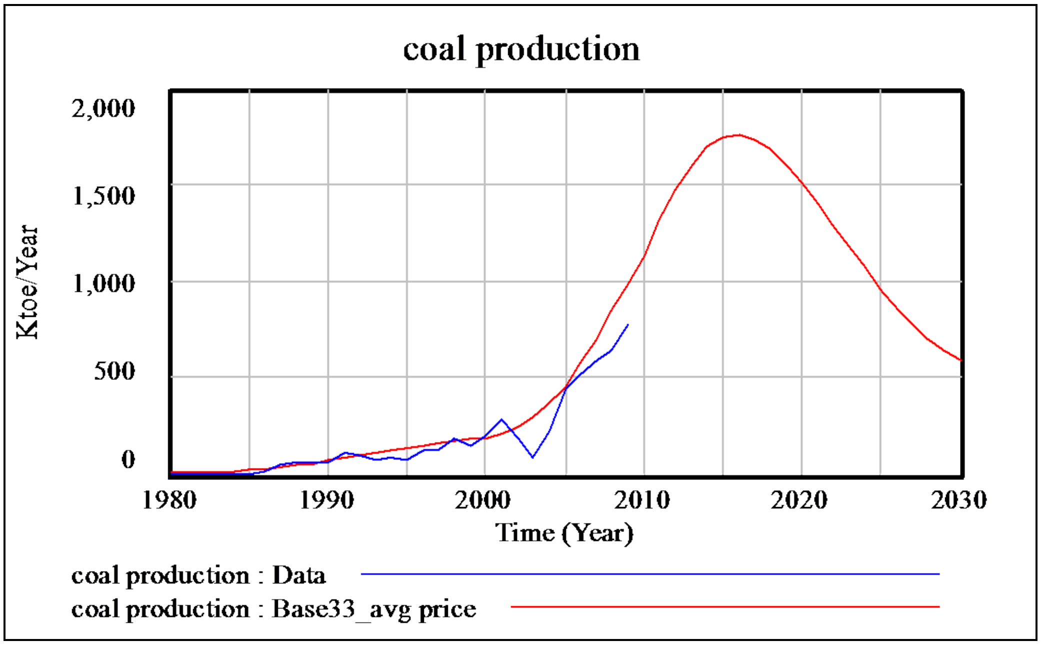
Table 12: Statistical results of oil, gas and coal production

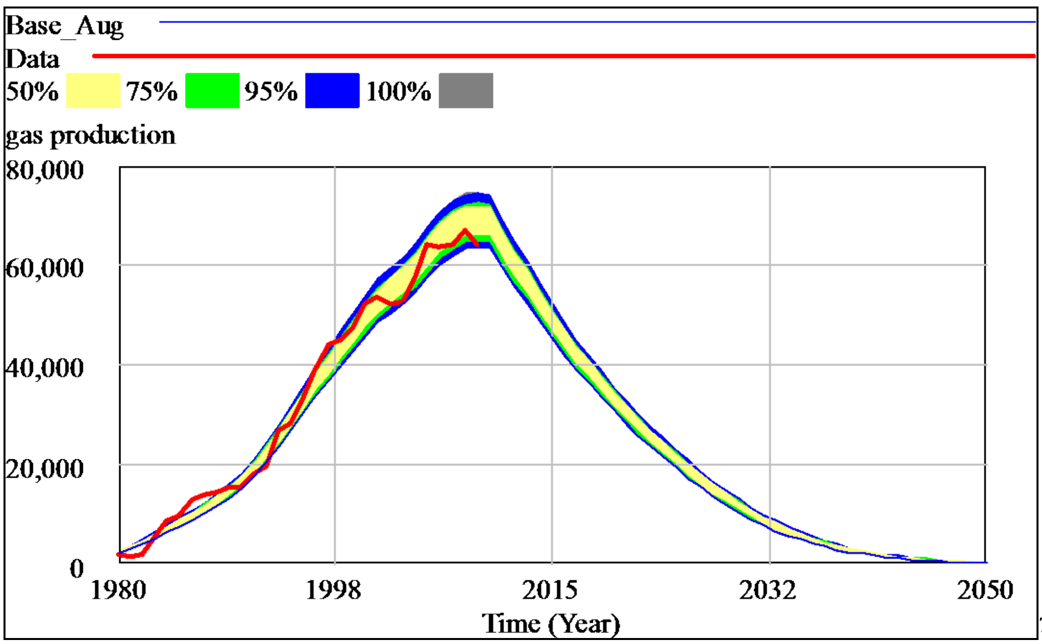
Variable	R-square	Point-to-point % difference
Oil production	99%	9%
Gas production	99.6%	17%
Coal production	98.8%	42%

Figure 18: Simulation of oil, gas and coal production compared with values of EIA.









[7]

[7] Note that the results of gas production are displayed in this figure with different confidence intervals. The yellow area in the figure represents a 50% confidence interval, meaning that 50% of the outputs of gas production fall in this area. Similarly, 25% of gas production results that is outside the 50% confidence interval fall in the green area (75% confidence interval outside the yellow area), while the total area in blue, green and yellow represents a 95% confidence interval (95% of gas production results). The sum of 95% confidence interval and the grey area covers all possible results of gas production values (100% confidence interval)

4. Analysis of Results

4.1. Definition of BAU and Alternative Scenarios

The policies and interventions simulated are predominantly based on the ones proposed in the 10th Malaysia Plan (EPU), the New Economic Model (NEAC) and Economic Transformation Programme (PEMANDU, 2010). Certain interventions observed in recent history were also tested, to strengthen the transition to a transformed economy, based on high value products and services and focused on efficiency improvements to drive international competitiveness.

The interventions listed below are analyzed both independently (in isolation) and combined, to improve the understanding of specific contributions to reaching stated goals and eventual synergies and bottlenecks created within and across sectors.

The Business as Usual (BAU) scenario assumes a continuation of existing trends (including all planned investments), with no changes in policy and no reaction to eventual improvements of worsening of the economic performance of the country. Given the relevance of upcoming changes in the energy sector, two BAU scenarios are simulated and analyzed, with the latter being used as benchmark.

- Subsidized energy prices: this scenario assumes that energy prices (for domestic consumption) will continue to be subsidized going forward, regardless of the provenience of the energy consumed.

- Subsidized energy prices, adjusting for imports at market price: this scenario assumes that the energy imported will not be subsidized, creating a gradual adjustment of (subsidized) domestic prices to (unregulated) market prices. With imports becoming more and more relevant in the energy supply mix of

Malaysia, the domestic energy price is calculated as a weighted average of the price of domestically produced (and consumed) and imported energy.

For the alternative scenarios, a variety of interventions are analyzed, for both energy and trade. These are listed below, with a brief explanation of the rationale for such interventions[8]:

- Energy sector:
    - Gas subsidy removal: it is assumed that gas price subsidies will be gradually (and linearly) removed to reach market price by 2016.
    - Oil subsidy removal: it is assumed that oil price subsidies will be gradually (and linearly) removed to reach market price by 2016.
    - Energy efficiency improvement: it is assumed that a total of 4,000 ktoe of energy demand will be avoided through energy efficiency improvements in the residential and commercial (22%), industrial (42%) and transport (36%) sectors.
    - Renewable energy (power generation): it is assumed that, by 2015, renewable energy will generate 5.5% of total power supply. Generation is expected to come primarily from biomass and solar power.
    - No nuclear power generation: it is assumed that current plans (as per TNB capacity construction to 2030) for nuclear power generation will not be implemented, avoiding the creation of 4 GW of generating capacity by 2030.
    - Low gas exports: it is assumed that gas exports will be rapidly reduced after 2016 to increase the availability of domestic supply and, in the longer term, to adjust with declining output.

[8] Note that all the interventions described in this paragraph have been simulated and analyzed, in isolation or in combination with others. On the other hand, several more interventions could be simulated, and as well as numerous additional combinations.

    - Sustainability scenario: a combination of the interventions listed above is simulated to reduce fossil fuel GHG emissions intensity.
        - Oil and gas subsidy removal: full removal by 2015.
        - Energy efficiency improvement: 30% improvement (relative to BAU) by 2030.
        - Renewable energy (power generation): 25% penetration by 2020.

- Trade sector:
    - Port cargo, air cargo and passenger and broadband connectivity: it is assumed that investments will increase in infrastructure development (both private and public investments, depending on the sector analyzed).
    - Research and Development: it is assumed that investments in R&D will increase to support the transition to higher value production and services, and to make use of the investments made in the education sector and retain local talents.
    - Education (investment and practices): it is assumed that investments will increase in tertiary educations, especially in science, technology, engineering and mathematics (STEM) to support the economic transformation. It is also assumed that attention will be given to the effectiveness of education expenditure, targeting higher graduation rates.
    - Taxation: it is assumed that taxation on income and profits will be slightly reduced to increase disposable income in the short term and encourage investments.
    - Propensity to save: it is assumed that, with the country effectively moving towards developed status, the cost of basic needs will become a smaller portion of income. In synergy with the reduction in taxation it is assumed

that the propensity to save will increase, making so that more resources could be made available for savings and investments.

   - FTA: it is assumed that an FTA targeting access to market across sectors (5% increase in the total volume of trade, not specific to a sector, due to data limitations) could be signed to create synergies with investments in infrastructure and education, effectively making use of improvements in competitiveness from the supply (domestic) side.

   - Foreign Direct Investment (FDI): it is assumed that FDI would increase (from 2% to 4% of GDP) due to the improved performance of Malaysia, and higher competitiveness and to the implementation of an FTA that would create market access.

   - Borrowing: in order to support short-term economic growth (offsetting the negative economic impacts created by the removal of energy subsidies and promoting the economic transformation) it is assumed that a higher deficit -5%, instead of 3%, of GDP- is accepted and approved between 2012 and 2020.

A few additional extra scenarios were considered to analyze the adequacy of policies and interventions currently being discussed under varying assumption on key macroeconomic themes:

- Regional/worldwide economic crisis in 2015: a crisis scenario was analyzed, to evaluate the resilience and responsiveness of Malaysia to a new economic downturn in the region or worldwide. Two specific cases have been analyzed:

   - Rapid recovery: it is assumed that a crisis as strong as the one of 2008-2010 would reach full recovery by 2018.

   - Lasting impact: it is assumed that a crisis as strong as the one of 2008-2010 would reach half recovery by 2018, and would have lasting impacts through 2030.

- High energy prices: two alternative scenarios, on top of two BAU cases, were analyzed for energy prices. The alternative scenarios regard increasing prices, as follows:
    - Constantly rising: it is assumed that world energy prices will constantly rise in the future, remaining always above BAU.
    - With peak in the medium term: it is assumed that world energy prices will suddenly rise in the medium term, to then adjust and grow according to the scenario above after 2020.

These scenarios were selected to provide insights on the impact of selected interventions, shed light on potential policy response mechanisms and support the understanding of the complexity of the system analyzed. On the other hand, T21 being a "what if" modeling tool, there is virtually no limitation on the number of scenarios (and combinations of interventions) that can be simulated and analyzed with the model.

4.2. Analysis of BAU

Under the BAU scenario, the Malaysia population will grow to 38 million in 2030 and 47 million in 2050 from 28 million in 2010 (see **Table 14** below). While total births per year continue to increase, the total fertility rate will decline, leading to a decreased rate of population growth. Life expectancy of the population is expected to further improve, thanks to improved health care services (around 100% coverage in 2030) and economic conditions, among other factors.

In terms of education, average literacy rate of will increase from 94% in 2010 to 98% in 2030, along with the expansion of secondary and tertiary students enrollment. With higher skills, together with better economic performance, among others, total employment will increase from 13 million in 2010 to 19 million in 2030, 23% of which are skilled workforce with tertiary education compared to 13% in 2010. In 2030, the services sector takes up 81% of the total employment (from

76% in 2010), while agriculture sector shrinks to 4% from 10% and industry sector remaining at 14%.

In the future, real GDP, endogenously simulated by the model, is projected to grow by 4.6% per year on average between 2010 and 2030, reaching RM1.42 trillion in 2030 from RM0.58 trillion in 2010. This allows nominal GDP per capita to almost triple from around RM27,130 in 2010 to RM91,095 in 2030. In the same line, nominal disposable income per capita increases from RM26,516 in 2010 to RM84,342 in 2030 (or in real terms, almost doubling from RM18,469 in 2010 to RM34,349 in 2030). As a result of the economic growth, nearly all the population will be above a poverty line of RM450 in 2030.

Considering the composition of GDP, both industry and services production are expected to increase, both reaching around RM0.7 trillion in 2030, from RM0.25 and RM0.29 trillion in 2010 respectively. The average annual growth rates are 5.3% for industry and 4.4% for services sector in this period, driven by larger employment, capital along with higher productivity due to better education, health, infrastructure (of roads, air, ports, broadband), and research and development, among others.

Crop production will increase to RM44 billion in 2030 and from 21 billion in 2010. This is attributable to both the improvements in average yield driven by a higher amount of capital available and the growing area of arable land from 8 million hectare (Ha) by 2010 to over 10 million Ha by 2040. Total agriculture production will reach RM19 million in 2030 from RM53 million 2010. Thus, quality of nutrition will be on the rise. On the other hand, the expansion of arable land and agriculture and settlements, forest area will slightly shrink to 19 million Ha in 2030 from 20 million Ha in 2010.

In terms of trade, total exports of the country is expected to increase to RM5.3 trillion in 2030, above the total import value of RM5 trillion, around 1.5 times of its national GDP. While total resources balance is projected to remain positive throughout the period from 2010 to 2030, the value declines slightly from RM67 billion in 2008 to RM51 billion in 2011 due to the global economic downturn before increasing again to reach RM0.25 trillion in 2030, primarily driven by services.

Driven by population and economic development, total primary energy consumption is projected to grow at an average rate of 2.9% per year from 61 thousand Ktoe in 2010 to 110 thousand Ktoe in 2030 under BAU, in which 97% will be in fossil fuels. By then, the primary fuels, oil and gas (that now each account for more than 40% of the total market), will increase their share to 88%, from 86% in 2010. The share of coal instead shrinks slightly from 14% in 2010 to 12% in 2030. Considering the use of energy, about 65%-70% of gas and coal consumption will used to generate electricity, with the share for total fossil fuels at 39%.

In the power sector, both electricity generation and demand are projected to more than double from 100 thousand GWh in 2010 up to 211 thousand GWh in 2030. While power generating capacity from almost all sources are expected to expand, with the exception of non-hydro renewables remaining at the same level, the power generation composition will change.

The power generation in Malaysia depends primarily on gas as fuel input, which currently takes up 63% of total generation and will further increase to 69% in 2030. However, with the projected decline of share in coal (steam) power plant from 22% to 13%, the total share in conventional thermal (i.e., oil, gas, coal) will decrease. The largest growth of share is expected in nuclear from null in 2010 to 8% in 2030. As a result, the renewable penetration rate (excluding nuclear) in power will decline from 9% to 6% in this period, with non-hydro renewables accounting for less than 1.5%.

Driven by the development of power generation infrastructure, the labor force in power plant construction, operations and maintenance will more than triple, from 13 thousand in 2010 to 37 thousand in 2030, in which around 2.4 thousand in both renewables and nuclear and 34 thousand in conventional thermal (oil: 418, gas: 20

thousand, coal: 14 thousand). The share of power sector employment in renewables and nuclear remains at the level of around 1%-5%.

Due to the subsidies on oil and gas, domestic energy prices are lower than the market prices. However, if calculated as a weighted average of subsidized and market prices, domestic energy prices will rise in the future to reach closer to market prices –lower than market prices by 13% and 55% for oil and gas respectively in 2010, and by 4% for both in 2030-, as the volume of energy imports is projected to increase to meet the rapidly growing demand. As a result, the average power generation cost will increase from RM0.34 to 0.56 per KWh of power produced. Total energy expenditure will reach RM35 billion in 2030 from 10 billion in 2010, due to rising fuel prices and consumption.

Considering a “Subsidized” BAU scenario where domestic energy prices follow completely the subsidized prices, domestic energy prices remain at about the same level, with an average power generation cost of RM0.39 per KWh. However, the lower fuel costs would encourage higher energy consumption that offsets the reduced prices, thus leading to higher total energy expenditure, reaching RM37 billion in 2030.

Fossil fuel production is expected to decline in the future, after reaching its peak in 2008. Oil production peaked in 2004 at around 45,000 ktoe, and is projected to decline to 37,000 ktoe in 2010 and 30,000 ktoe in 2030. Gas is projected to have peaked in 2010 at 59,000 ktoe, to reach 6,600 ktoe by 2030. As the fuel supply is not sufficient to keep the pace of the growth in demand, Malaysia will largely and increasingly depend on imports for oil and gas after 2020.

Driven by the increasing consumption of fossil fuels, the nation is expected to generate increasing amounts of GHG emissions from fossil fuels, reaching 347 billion tons per year in 2030, from 190 billion tons in 2010. However, GHG emissions intensity, defined as emission per unit of GDP produced, is expected to decline.

Table 13: Key indicators in BAU scenarios in selected years[9]

	Unit	2010	2015		2020		2030	
		BAU	BAU avg price	BAU subsidy	BAU avg price	BAU subsidy	BAU avg price	BAU subsidy
Economic Sphere								
Real GDP	Billion RM/Year	576	718	728	917	946	1,416	1,509
Real GDP growth rate	%	4.2%	4.5%	5.2%	4.9%	5.2%	4.2%	4.4%
Nominal GDP per capita	RM/person	27,974	36,896	37,422	50,445	52,068	91,095	97,108
Agriculture production	Billion RM/Year	53	54	54	56	57	61	61
Industry production	Billion RM/Year	246	320	324	423	438	695	744
Services production	Billion RM/Year	289	359	364	457	472	689	734
Resources balance	Billion RM/Year	61	75	78	118	127	255	288
Total export	Billion RM/Year	854	1,330	1,353	2,128	2,218	5,281	5,780
Total import	Billion RM/Year	794	1,256	1,275	2,009	2,091	5,026	5,491
Social Sphere								
Total population	Million people	28	31	31	33	33	38	38
Population below RM450/day	%	3.5%	2.7%	2.7%	2.1%	2.0%	0.0%	0.0%
HDI	Index	0.83	0.85	0.85	0.88	0.88	0.92	0.92
Tertiary enrollment rate	%	39%	47%	47%	57%	57%	62%	63%
Total employment	Thousands	13,173	14,784	14,787	16,258	16,260	18,874	18,879
Power employment	Thousands	13	18	19	19	20	39	41
Environmental Sphere								
Forest land	Million ha	20.3	19.8	19.8	19.5	19.5	19.2	19.2
Oil and gas supply	Mtoe/Year	96	78	78	61	62	35	35
Fossil fuel GHG emissions	Million tons/Year	196	204	208	255	265	347	373
Primary energy demand	Mtoe/Year	61	66	67	81	84	109	117
Coal production	Mtoe/Year	37	36	36	35	36	28	29
Oil production	Mtoe/Year	1	2	2	2	2	1	1
Gas production	Mtoe/Year	59	41	41	26	26	7	7
Total electricity generation	K GWh/Year	105	111	112	143	148	211	225
Hydro power	K GWh/Year	9	9	9	11	11	14	14
Other RE power	K GWh/Year	1.4	1.4	1.4	1.4	1.4	0.6	0.6
Nuclear power	K GWh/Year	0.0	0.0	0.0	0.0	0.0	16.2	16.2
Conventional thermal power	K GWh/Year	94	101	102	131	136	180	194
RE power penetration	%	1.4%	1.3%	1.2%	1.0%	1.0%	0.3%	0.3%
Total energy expenditure	Billion RM/Year	9.6	13.4	13.6	16.2	16.7	22.4	23.6

[9] Note that projections of this report are highly dependent on the assumptions used to simulate the model. There might be variations relative to other models and existing projections due to different structural and numerical assumptions or due to methodological differences.

4.3. Analysis of Alternative Scenarios

4.3.1. Overall Assessment of the Interventions Simulated

A variety of alternative scenarios are simulated to evaluate the impact of specific policy interventions across social, economic and environmental spheres. The combination of all interventions is presented first, to provide an overview of the combined effect of all policies. Specific impacts of each provision are then presented and analyzed independently, to better understand the contribution of each of them on selected variables of interest.

As described above, the interventions simulated represent a broad range of policies across sectors aimed at reaching specific targets. Their combination is expected to support the transition of the country towards the status of developed economy, while reducing risks and vulnerabilities and supporting low carbon development. Overall, the key goal consists in improving the value-added of present and future trade-exposed sectors by moving up the value-chain, as it serves to enhance domestic competitiveness by, among others, reducing energy consumption and costs.

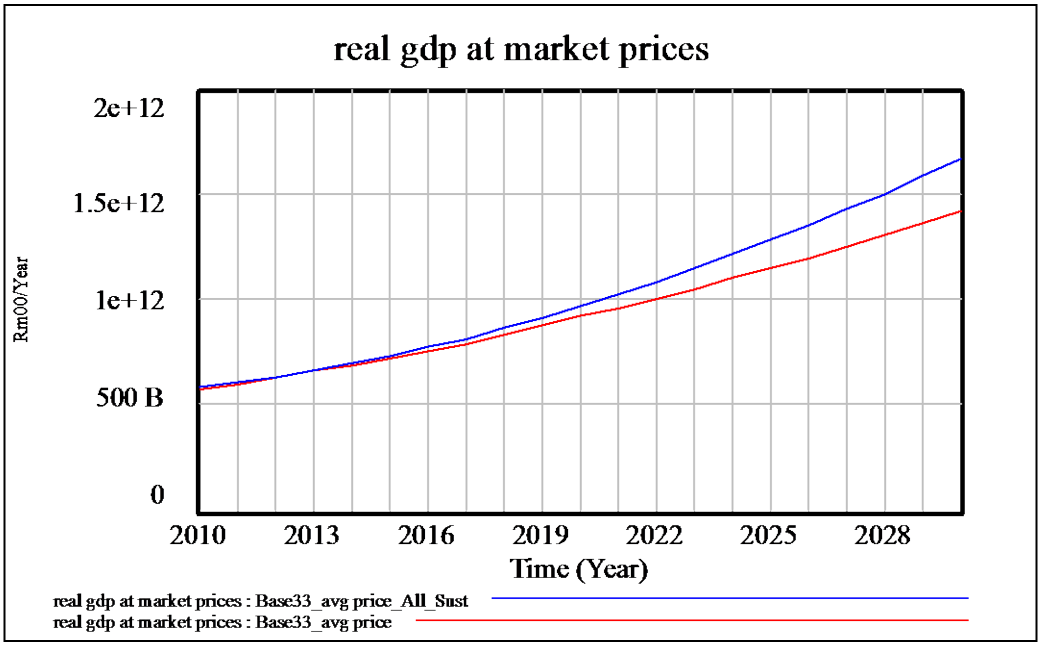
The combination of all provisions simulated, hereby referred to as the "All" scenario can be compared with a more aggressive case for sustainability that goes beyond existing policies and plans. In this "All & Sustainability" scenario higher targets for RE are assumed, to move closer to the stated emission reduction targets. For simplicity, results of the "All & Sustainability" scenario will be presented in detail below, and a brief comparison with the "All" scenario and specific impacts of each intervention will be presented next. Simulations are compared with the BAU case assuming the use of average domestic energy prices going forward (BAU_Avg Price).

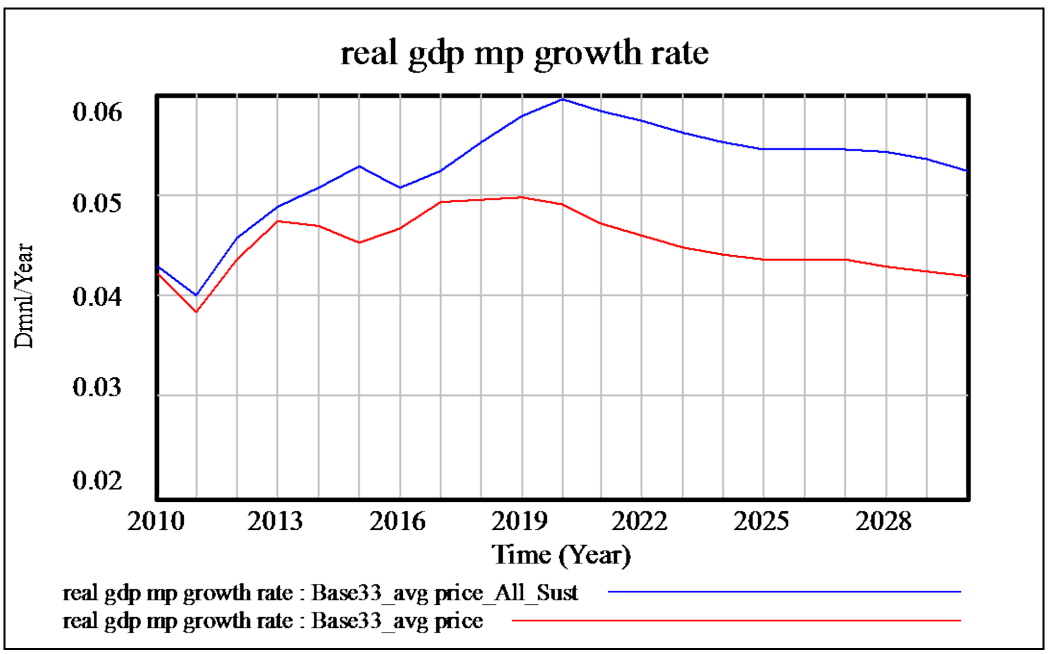
Overall, the "All & Sustainability" scenario performs better than BAU across the board. The GDP growth rate averages 5.3% per year and results to be higher than BAU by 0.8% per year on average, reaching its highest value of 1.2% per year above BAU after 2020. Thanks to an increase in productivity, investment and market access, GDP will reach close to RM970 billion in 2020 and RM1,670 billion in 2030, 5.5% and 18% above BAU respectively (see **Figure 19** and **Table 15**).

It is worth noting that, when simulating an alternative “All & Sustainability” scenario, using subsidized prices going forward, the growth of GDP would be higher in the short and medium term, reaching closer to the national target of over 6%, but would be lower beyond 2020 due to the increasing pressure of growing subsidies on government accounts.

Analyzing more in detail the projected GDP growth rate it can be noted that the combination of interventions simulated, both on energy and trade, yield a similar growth rate as BAU until 2013, to then show higher growth throughout 2030. The short term, due to the removal of energy subsidies is the most critical period analyzed, and specific interventions, especially on economic development have been tested to offset the negative impacts of higher energy prices. More details on the individual contribution of each intervention simulated are presented in Section 5.3.3 below. Reduced pressure from energy prices and more coordinated economic development make so that GDP growth remains constantly above BAU in the medium and longer term, when the advantages of short-term investments come to fruition.

Figure 19: GDP growth rate and GDP

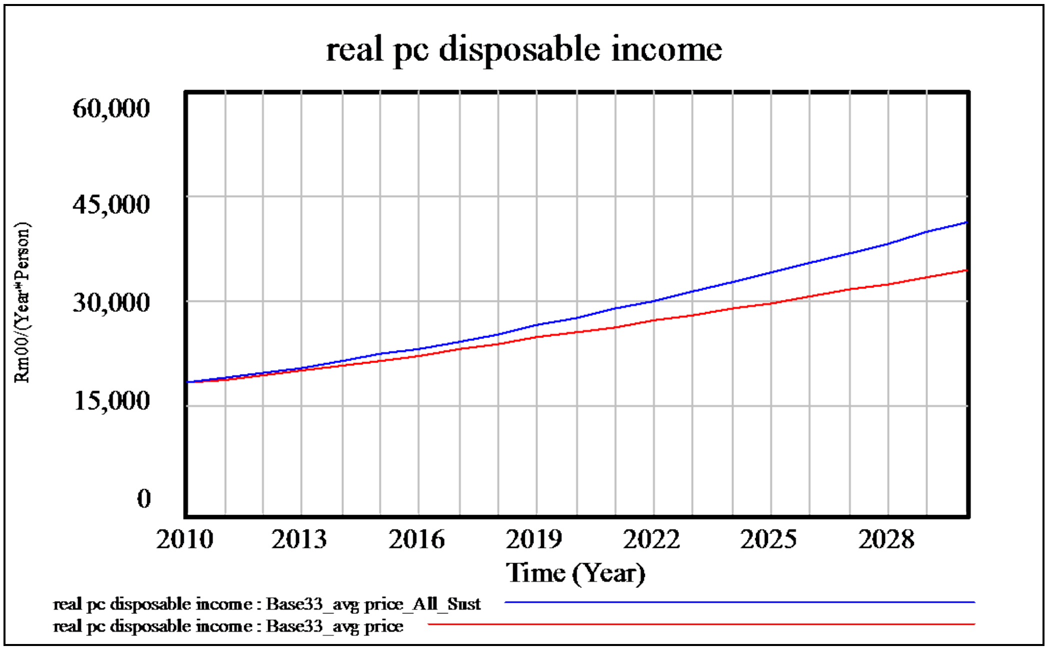


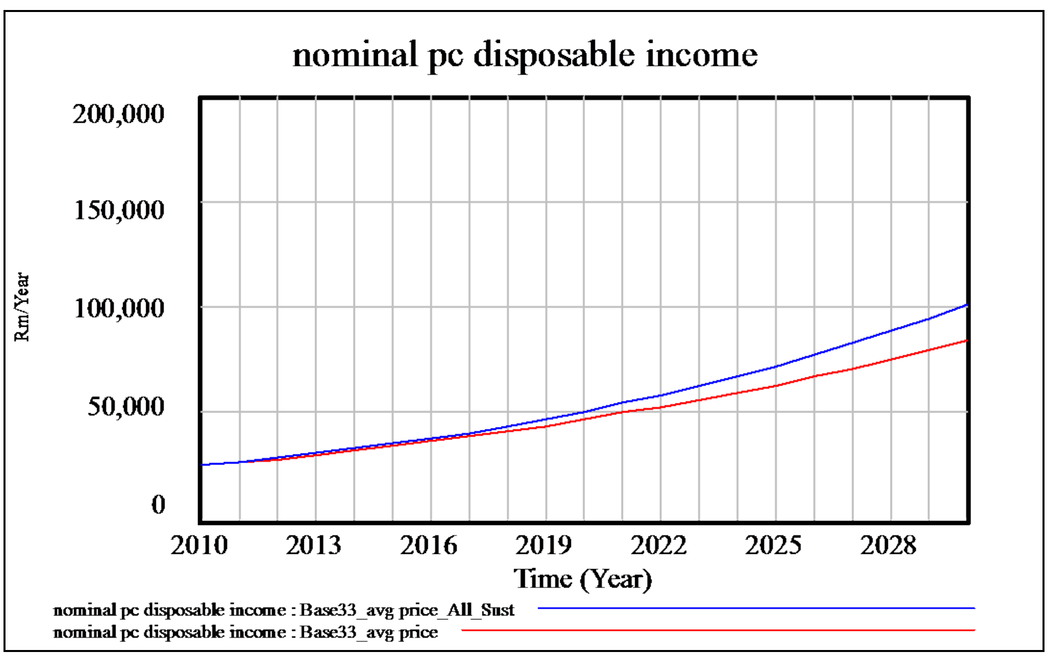


Per capita income, on the other hand, thanks to the combination of interventions simulated, including a reduction in selected taxation and a projected increase in investments targeting domestic activities, is projected to reach close to RM50,700 per capita (nominal, or current) and surpass the national target of RM49,500 in

2020 (see **Figure 20**). Per capita nominal income is expected to be above RM100,000 per capita by 2030, or RM73,000 per capita in real (or constant) terms. These projections are 8% and 20% above BAU in 2020 and 2030 respectively.

Figure 20: Real pc disposable income rate and nominal pc disposable income



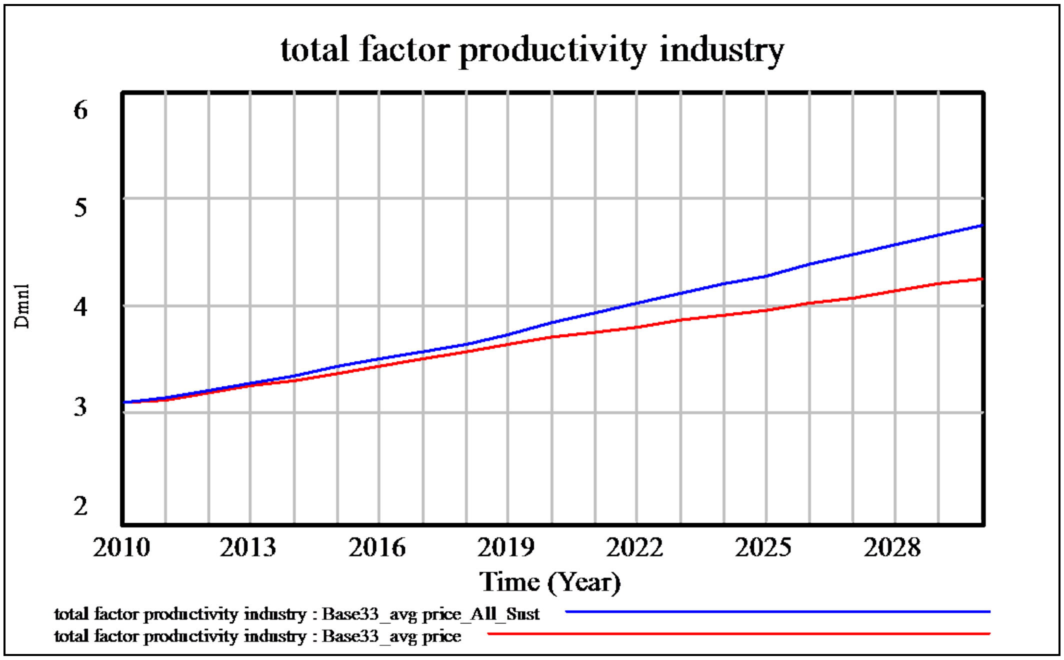


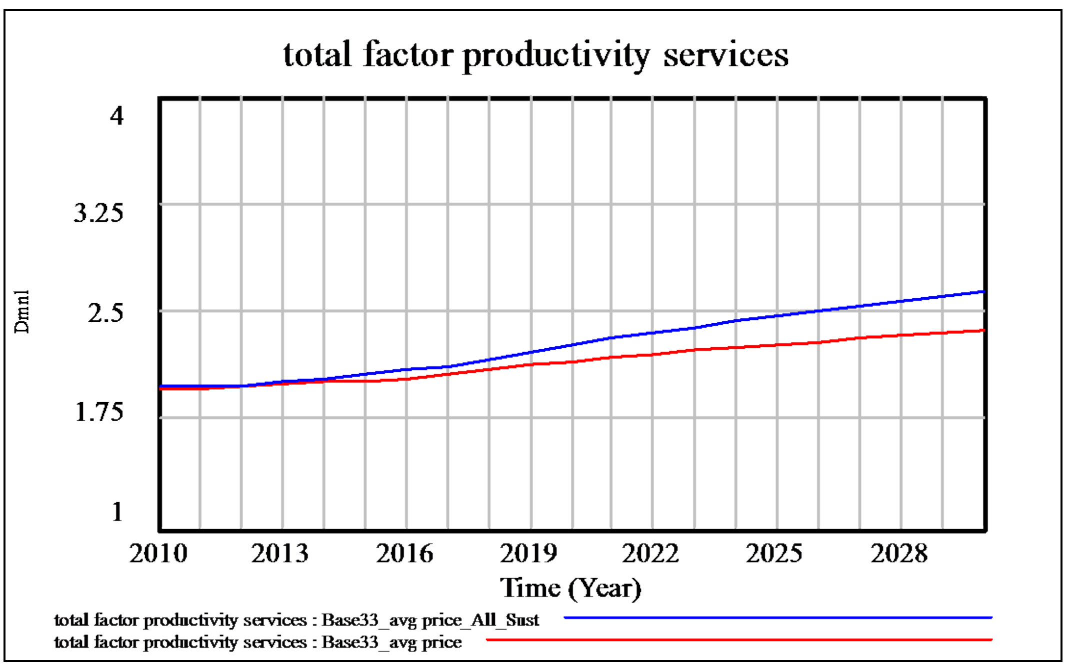
Total factor productivity for the industrial and services sectors is a key indicator of the performance (effectiveness) of production. Several trade and energy provisions are aimed at improving productivity, either by improving capital and labor characteristics or by removing constraints to growth.

Our projections indicate that TFP for manufacturing sector, targeted to grow at 2.9% annually during the IMP3 period, would grow by approximately 2.2% between 2011 and 2030 (see **Figure 21**). To put this result into perspective, industrial TFP only grew by 1% on average during the last 10 years, and close to 4.8% pear year between 1980 and 2000. This indicates that a transition has already taken place, and that further step increases in productivity in the industrial sector (especially if focused on low cost manufacturing) would be harder and harder to achieve in the future.

Concerning the services sector, TFP is projected to grow at approximately 1.5% per year (see **Figure 21**), supported by higher skills and better infrastructure. The targeted growth in this case is 2.5% per year, with the last 10 years recording an average growth of 1.17%. In the case of services, given that skills and quality infrastructure are currently underutilized, the main limiting factor seems to be access to investment.

Figure 21: Total factor productivity industry and total factor productivity services

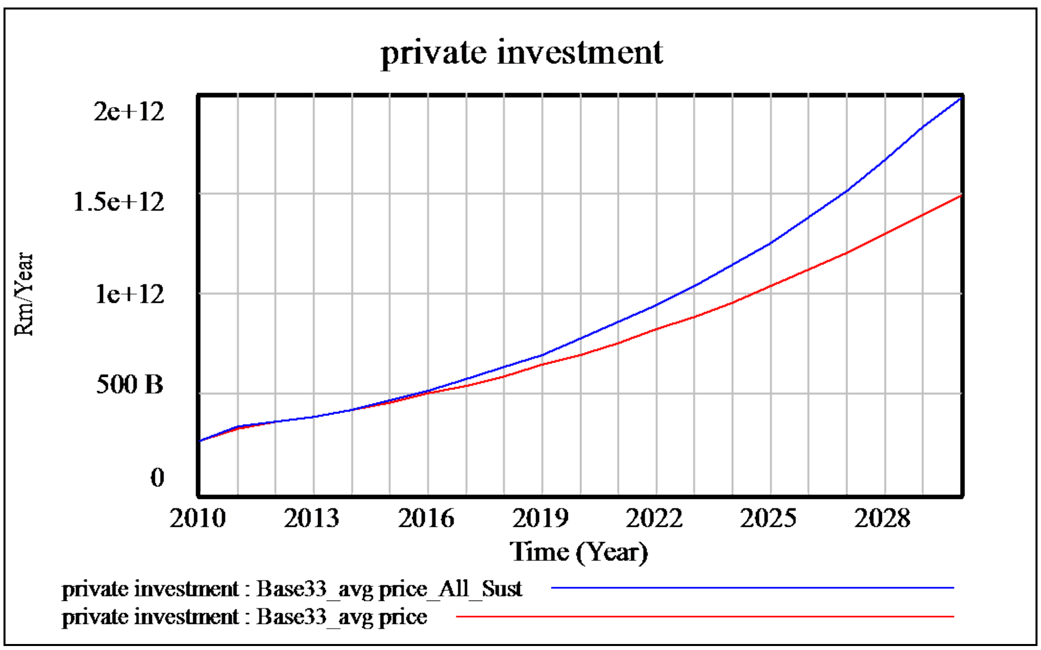


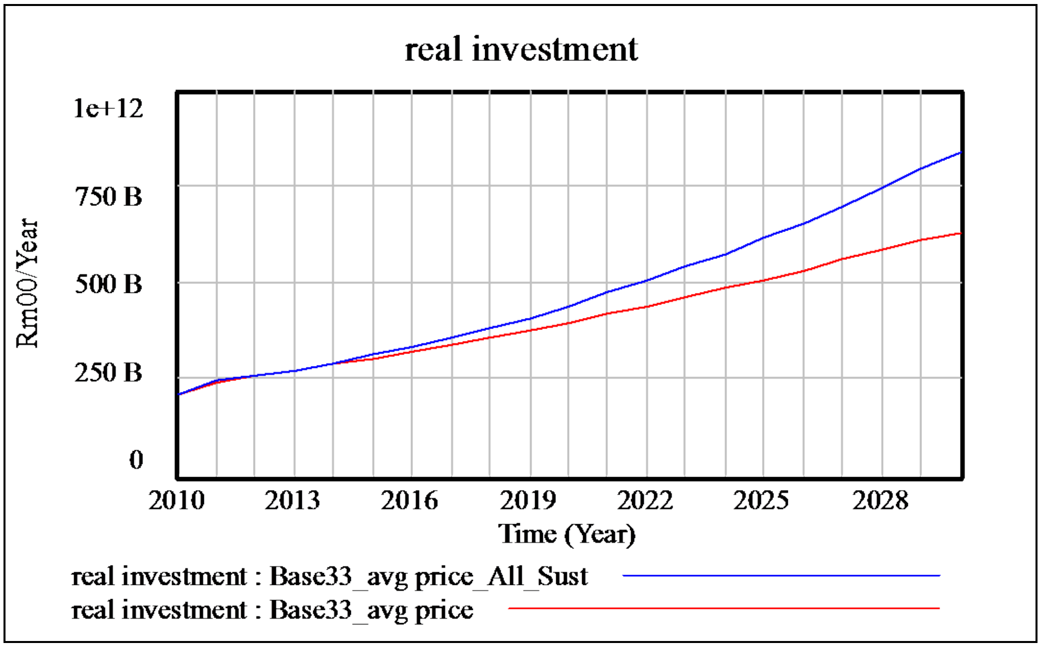


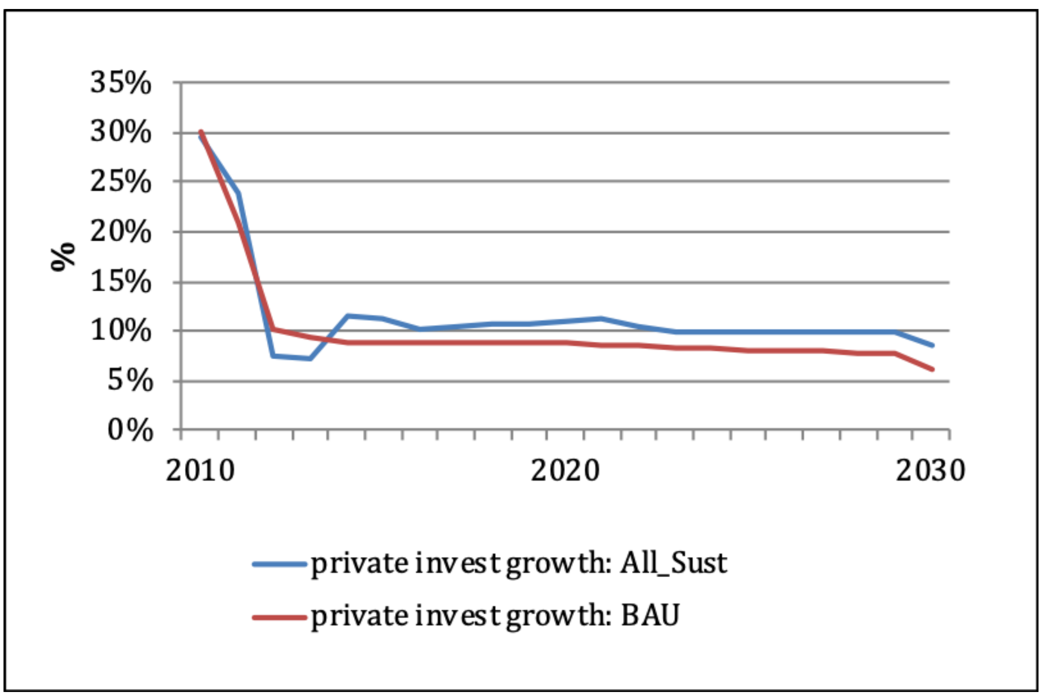
Private investment is projected to increase well above BAU in the alternative scenarios. This is due to a combination of selected provisions, but also to a general improvement of economic conditions, stimulating the inner mechanisms of domestic economic growth and investment. Private investment is projected to growth at a rate of 10.7% between 2011 and 2030 (with higher growth expected until 2020), or 1.5% higher than BAU on average (see **Figure 22**). This is short of the target of 12%, and it is mostly due to the assumption of an energy price adjustment to market conditions for all imports. Alternatively, the projected growth of investment, at least in the short term (up to 2015) would be close to 12%, to progressively decline, and reach below 10.7%, after that date.

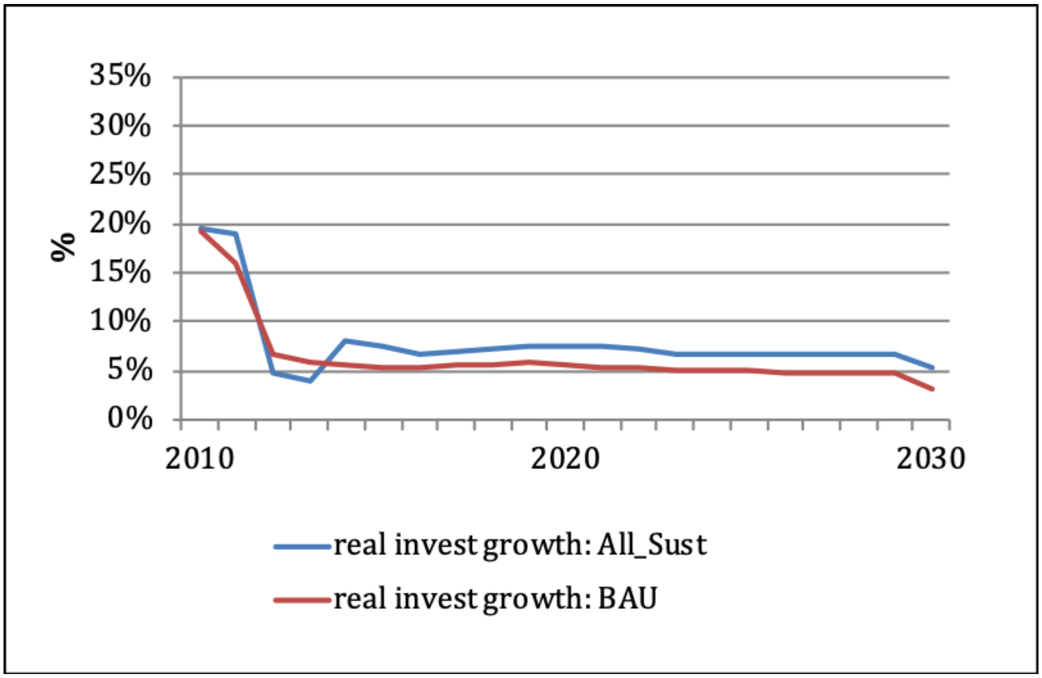
In absolute terms, private investment is projected to reach 11% and 34% above BAU by 2020 and 2030 respectively.

Figure 22: Private investment and real investment, absolute (left) and growth (right)




real investment
1e+12
750 B
500 B
250 B
0
Rm00/Year
2010
2013
2016
2019
2022
2025
2028
Time (Year)
real investment : Base33_avg price_All_Sust
real investment : Base33_avg price

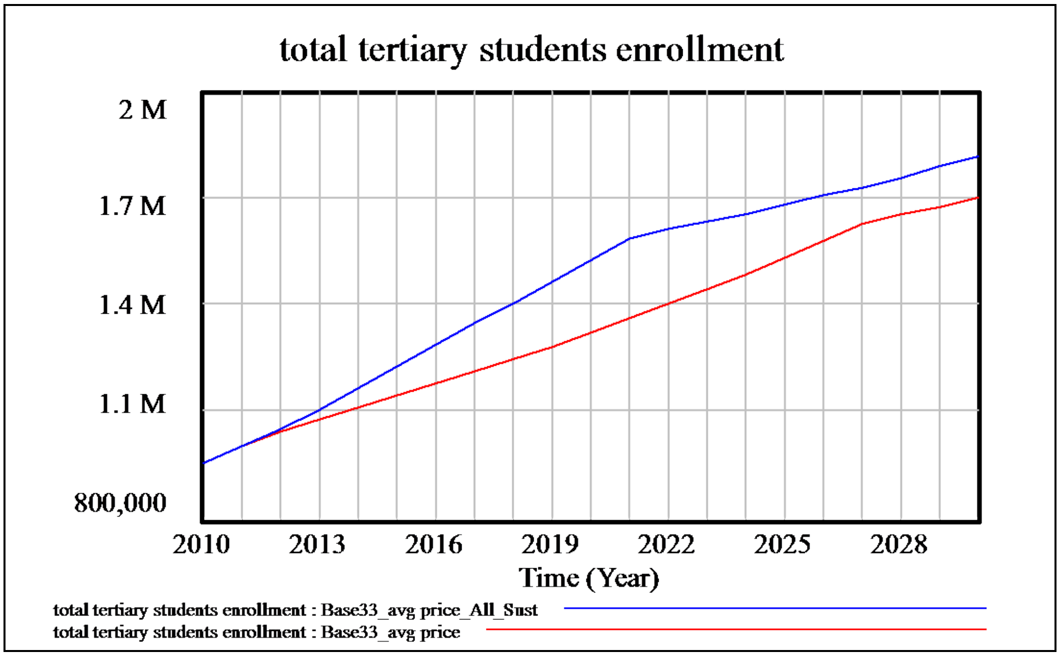

35%
30%
25%
20%
15%
10%
5%
0%
%
2010
2020
2030
private invest growth: All_Sust
private invest growth: BAU

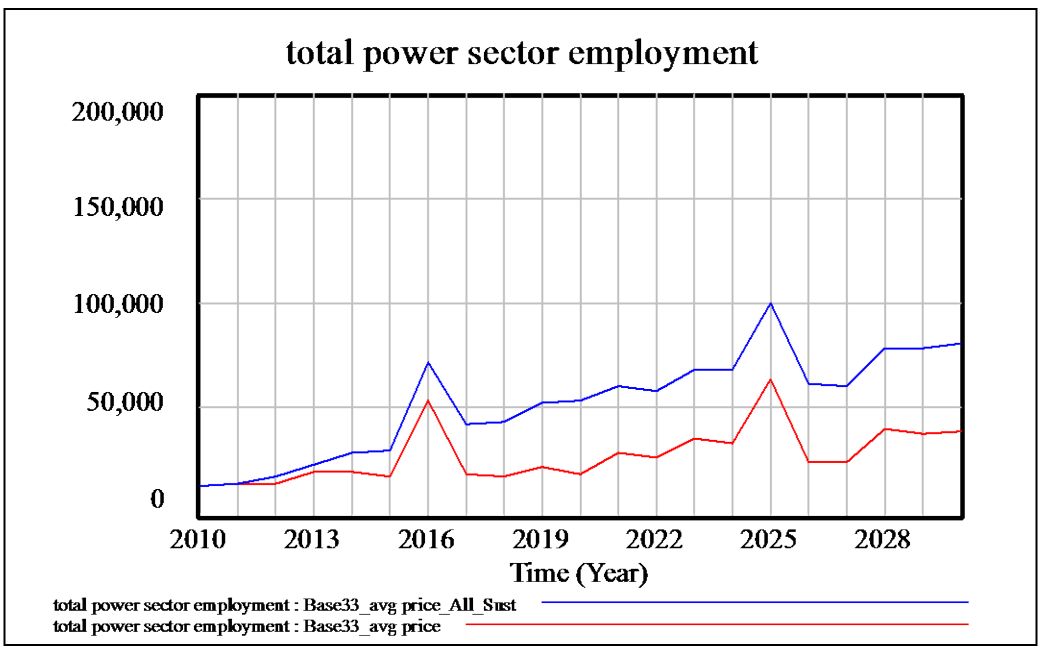


As a result of the interventions simulated, and of the cross-sectoral feedbacks represented in the model, total employment is projected to reach close to 16.3 million people by 2020, reaching the target employment level and pushing a transition to high skill employment going forward. It is in fact expected that skilled employment, a direct result of the shift to higher value sectors and efforts in the education sector, will grow considerably faster than BAU. Among other indicators, tertiary enrollment will be 16% above BAU by 2020 (see **Figure 23**) and the total number of tertiary graduates will surpass 4.5 million people, or 250,000 more than in BAU.

More specifically on energy, one of the key sectors analyzed in this study, it is projected that total employment in the power sector would be on average 90% higher than BAU between 2011 and 2030 due to the aggressive expansion of RE aimed at reducing GHG emissions and vulnerability to fossil fuel prices. The employment level is projected to reach close to 54,000 people by 2020 and approximately 81,000 by 2030, considering both construction and Operations and maintenance (O&M) activities.

Figure 23: Tertiary enrollment and power sector employment

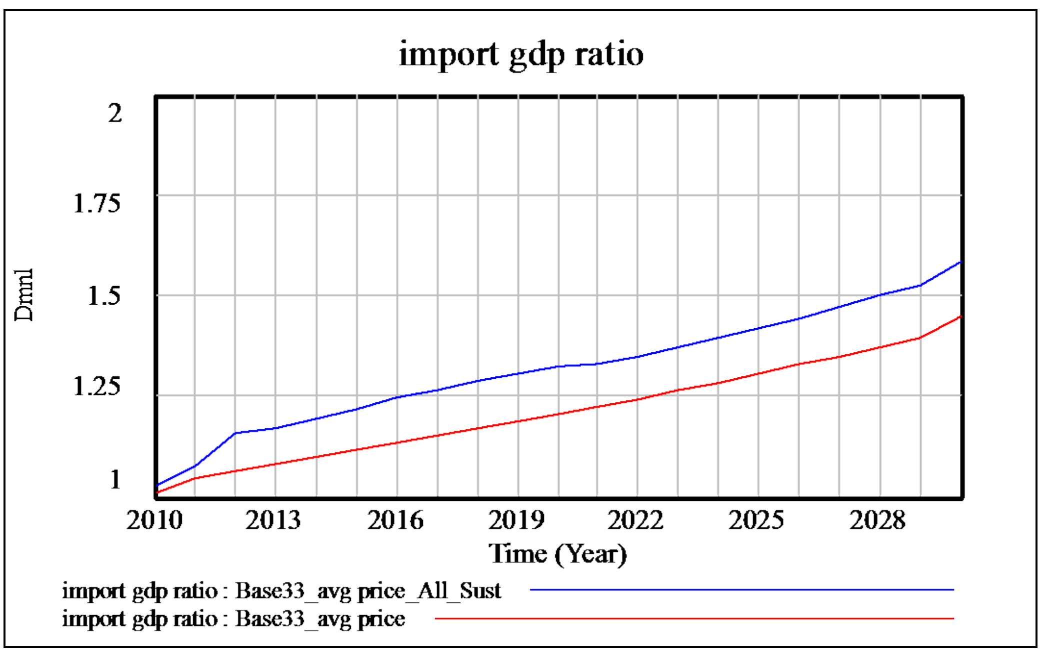




The performance of trade is key for Malaysia's economy. Total trade is targeted to increase to RM2.8 trillion and exports to RM1.4 trillion by 2020. This indicates expectations that the resources balance will reach close to zero by 2020. Our projections indicate instead that the resources balance would remain positive, but below BAU until 2020 and will rapidly growth to reach back to BAU by 2030. These results are driven by two competing factors: (1) investments in infrastructure and FTAs, among others, support the growth of exports, which is partially offset by growing imports; (2) the impact of all provisions simulated, by increasing GDP and income, also increases the import of final goods, making so that imports would be higher than BAU. Between goods and services, the latter shows the strongest performance in the medium and longer term, indication that the interventions simulated would effectively support a transition to the tertiary sector and higher value products and services.

Matching the existing target for imports and exports, the former are projected to reach close to 111% and 120% of GDP by 2015 in the BAU and “All & Sustainability” scenarios respectively (see **Figure 24**). Exports are expected to reach 117% and 124% of GDP by 2015 in the BAU and “All & Sustainability” scenarios respectively.

Figure 24: Import to GDP ratio.



In the energy sector, also subject to several interventions, projections show a reduction in energy and GHG emissions intensity, triggered by efforts to deregulate energy prices, improve energy efficiency and diversify the energy supply mix.

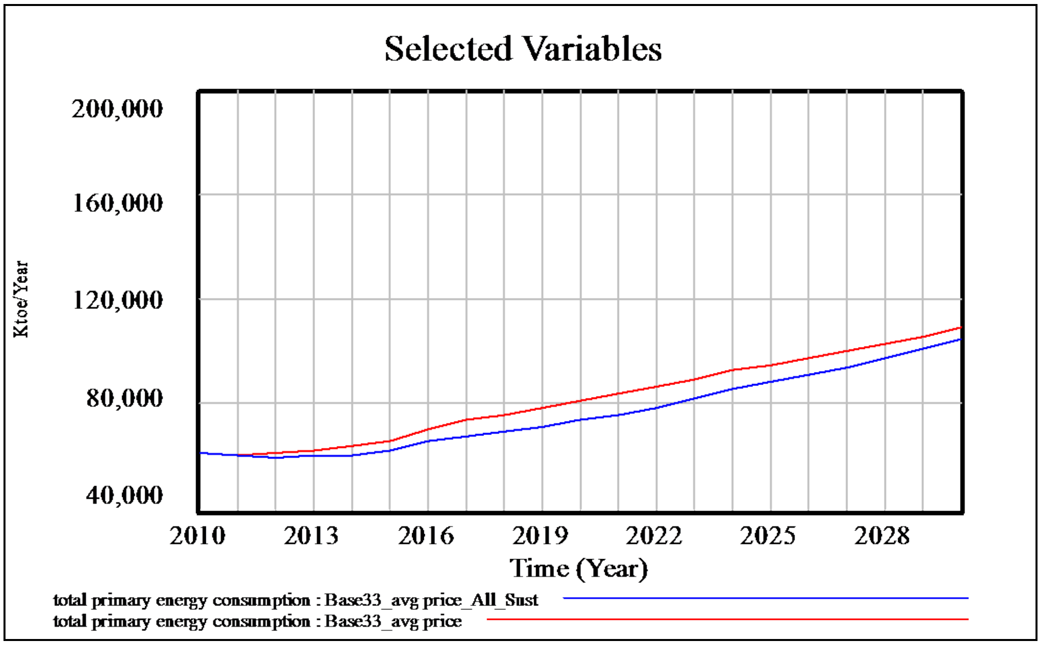
More specifically, energy demand is projected to grow at a much lower rate than BAU throughout the simulation, averaging 0.08% until 2015, 1.9% until 2020 and 2.7% between 2011 and 2030 (see **Figure 25**). These results indicate that interventions to limit the growth of energy demand are very effective as planned, especially when put into context, considering that GDP growth is projected to average 5.3% per year between 2011 and 2030. On the other hand, energy efficiency improvements should be extended well beyond 2015 in order to reach the more ambitious targets of 40% reduction in emissions intensity by 2020.

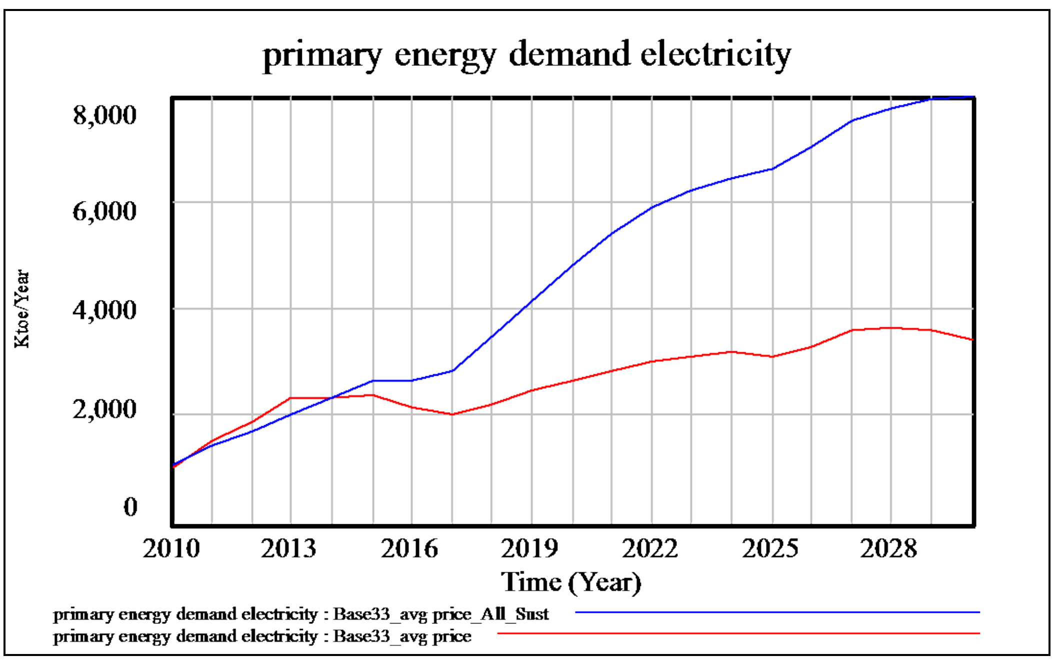
Concerning the breakdown of energy demand by source, considering primary fuels, currently oil and gas dominate consumption in Malaysia sharing about equally 85% of the market. Projections from the "All & Sustainability" scenario indicate that the combined total will decline to 81% by 2015 (primarily due to gas, reducing its share from 41% to 34% between 2010 and 2015) and to 79% by 2020. While this reduction seems small, it has to be noted that total demand also declines (practically lifting the share of oil and gas) and that oil and gas demand is projected to be 5% and 24% below BAU respectively by 2020. Renewable energy is projected to make up for the decline in oil and gas, as well as for a slight reduction in the use of coal, reaching 6.5% in 2020 and close to 8% by 2030.

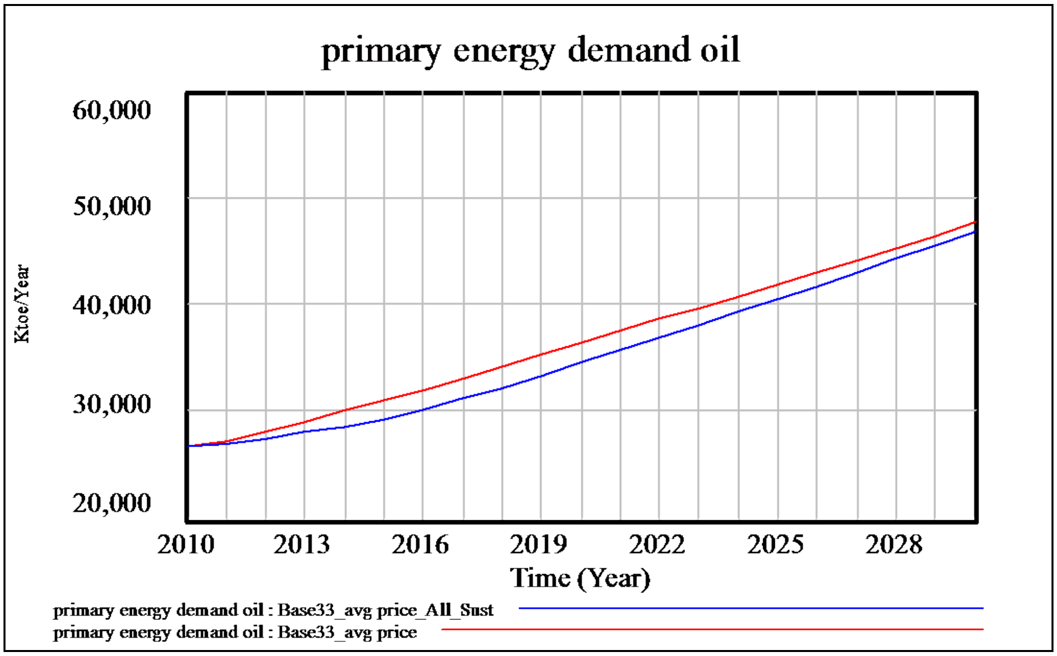
Worth noting, it is estimated that about 36% of total fossil fuel consumption currently is used to generate electricity. By 2030 this share is projected to decline to 33.5% in the "All & Sustainability" scenario (as a result to investments in renewable energy), and increase to 38.7% in the BAU case.

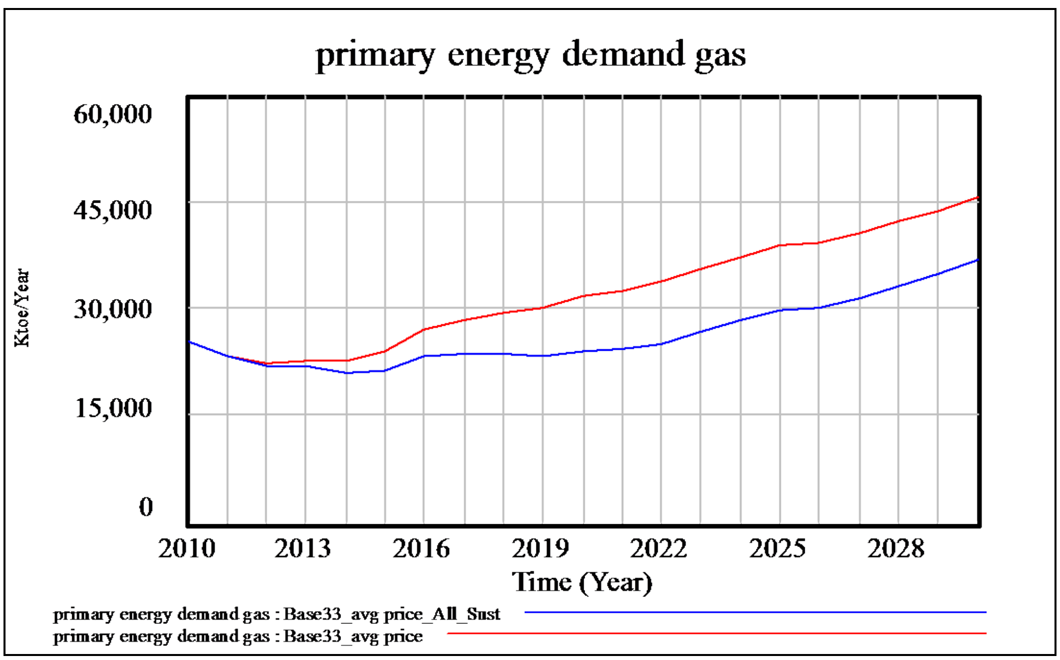
Further, considering GDP growth, results clearly indicate that the "rebound effect" plays an important role in defining the effectiveness of energy efficiency interventions on total energy consumption. In fact, improvements in energy efficiency reduce energy costs, practically freeing up resources for consumption and investments. This process makes so that, with lower consumption comes higher GDP, which is one of the main drivers of demand, together with prices and efficiency. Having analyzed GDP and efficiency, a presentation on projected energy prices follows.

Figure 25: Total primary energy consumption, and energy demand by primary sources






primary energy demand oil
60,000
50,000
40,000
30,000
20,000
Ktoe/Year
2010
2013
2016
2019
2022
2025
2028
Time (Year)
primary energy demand oil : Base33_avg price_All_Sust
primary energy demand oil : Base33_avg price


primary energy demand gas
60,000
45,000
30,000
15,000
0
Ktoe/Year
2010
2013
2016
2019
2022
2025
2028
Time (Year)
primary energy demand gas : Base33_avg price_All_Sust
primary energy demand gas : Base33_avg price

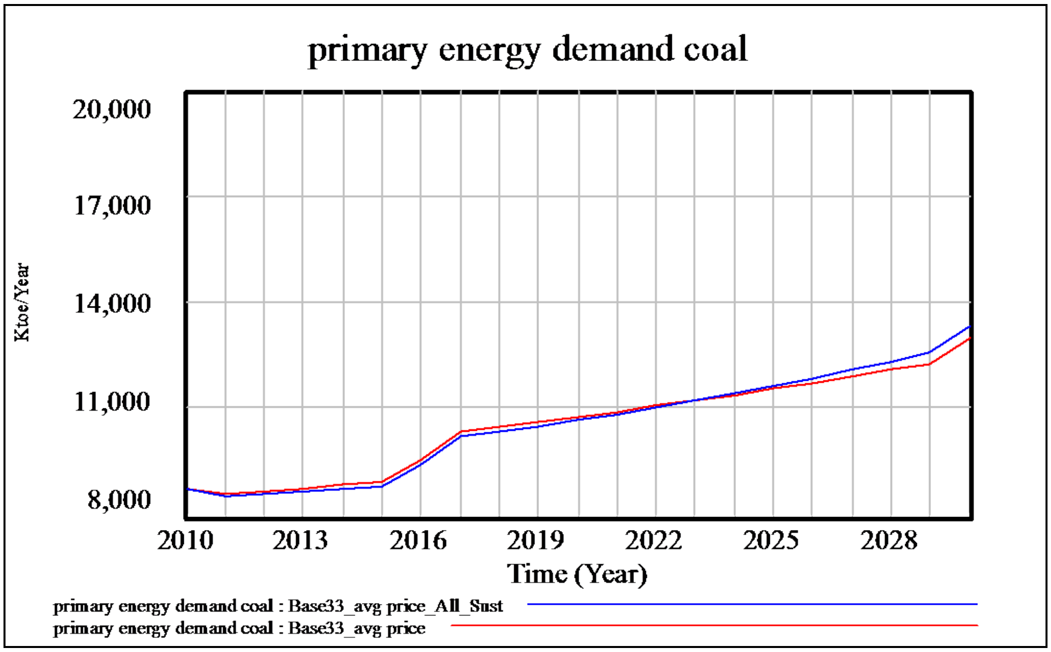
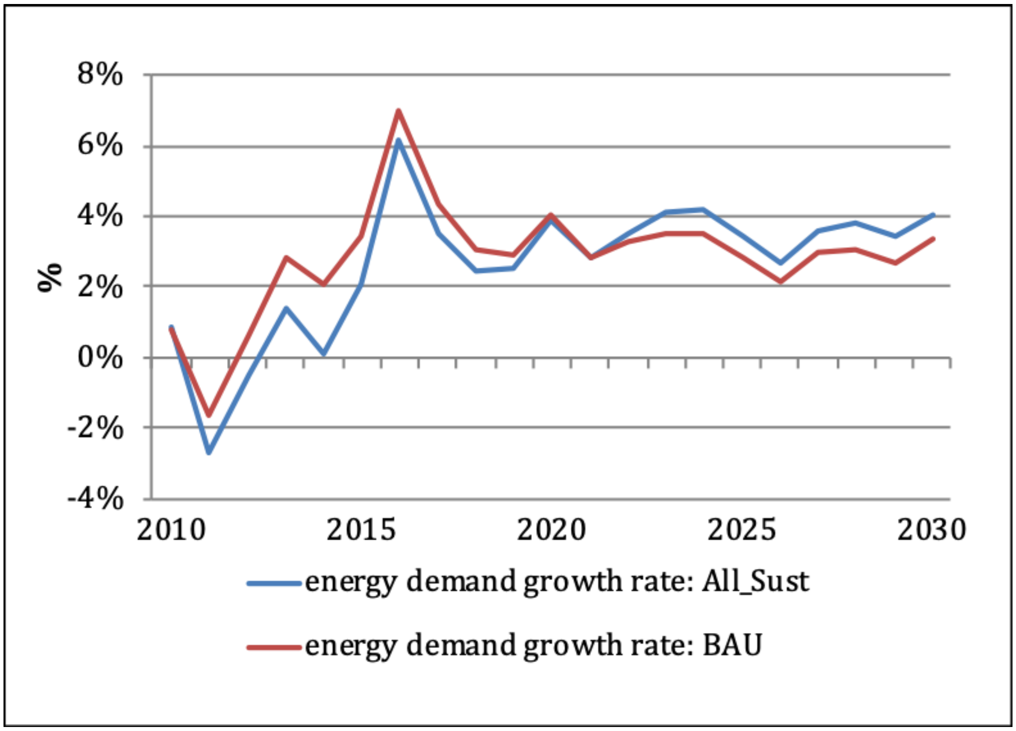
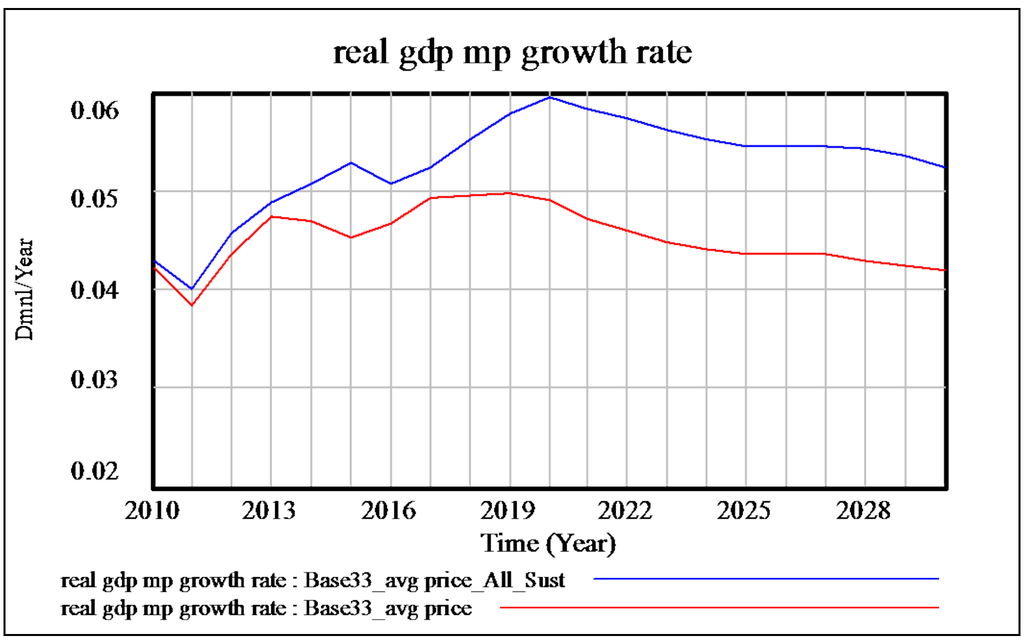

primary energy demand coal
20,000
17,000
14,000
11,000
8,000
Ktoe/Year
2010
2013
2016
2019
2022
2025
2028
Time (Year)
primary energy demand coal : Base33_avg price_All_Sust
primary energy demand coal : Base33_avg price

Figure 26: Total primary energy consumption growth and GDP growth



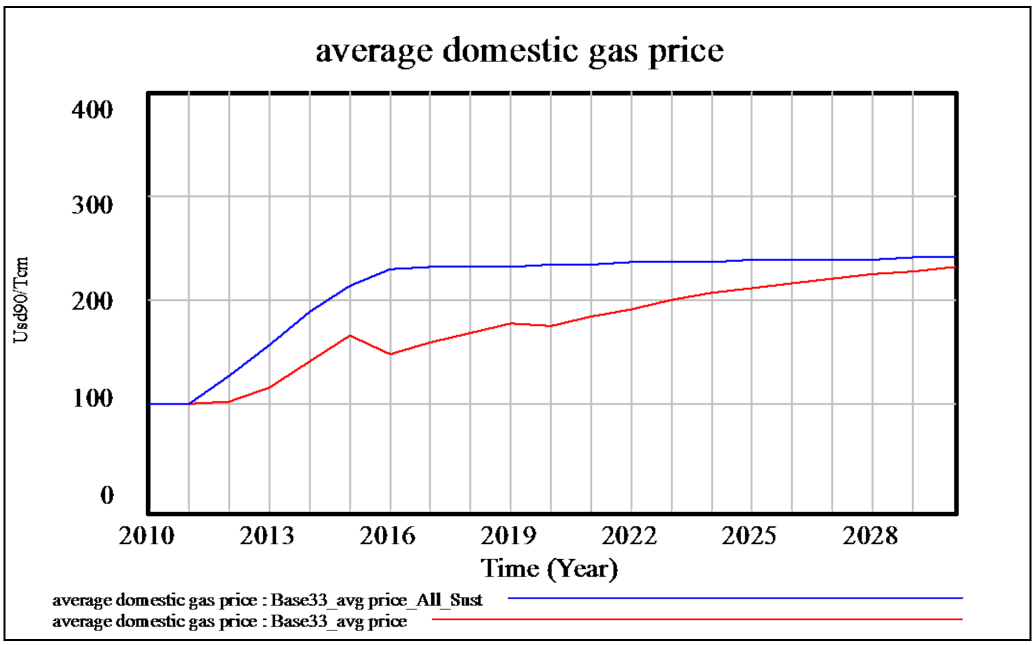


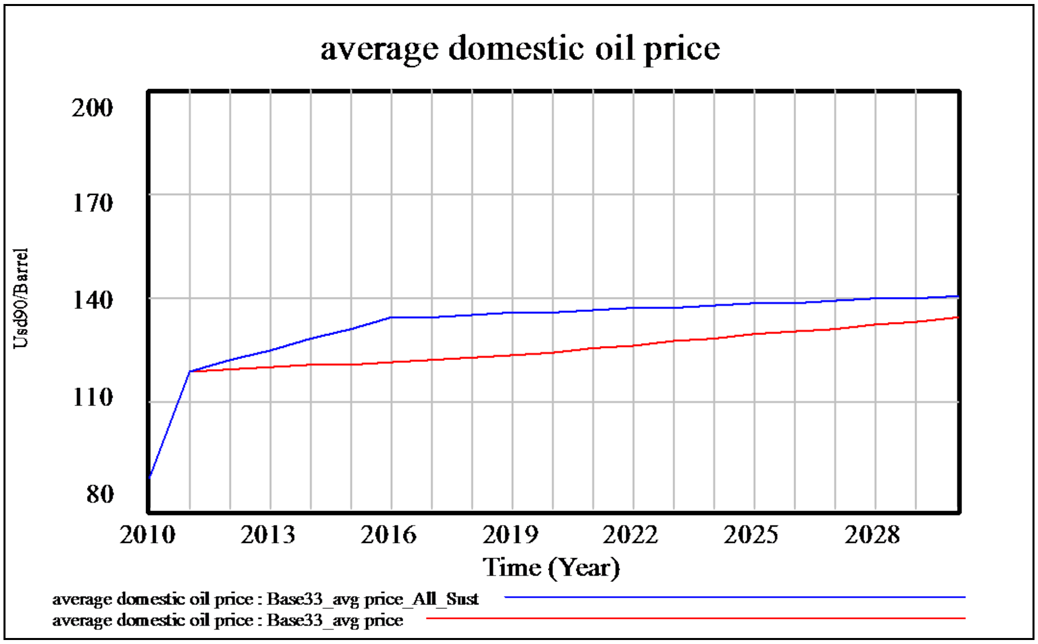
With the gradual removal of subsidies until 2016 and the growing volume of imports primarily for oil and gas, energy prices are expected to increase faster than in the BAU case (see **Figure 27**). It is in fact projected that oil and gas prices will be aligned with market prices by 2017 and will entirely follow market dynamics after then. Such an increase would be more gradual in the BAU case, where import are the sole determinants of prices together with subsidies, practically leading to a weighted average of subsidized and market prices. On the other hand, in the "All & Sustainability" scenario a considerable amount of money would be saved from phasing out subsidies by 2016 (in the range of RM30 billion per year).

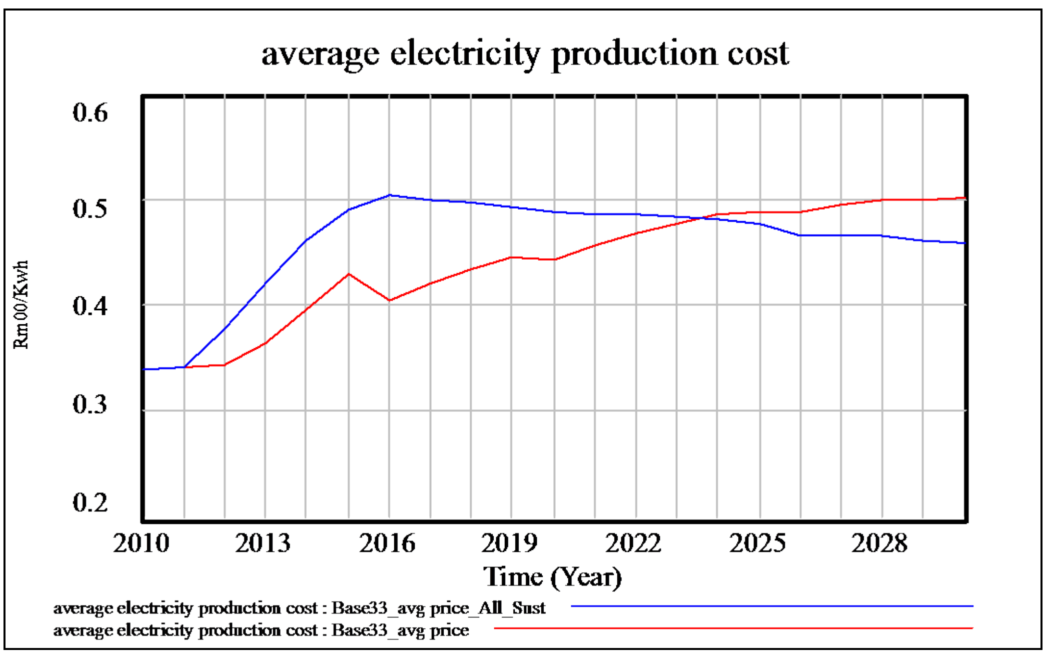
The increase in gas prices is certainly more marked than oil, due to the existing subsidies, and simulations project a price 22.8% and 6.8% higher than BAU between 2011 and 2030 for gas and oil respectively. To put these results into perspective, the market price of gas and oil has increased by 91% and 18% respectively in the last 10 years, making the increase due to subsidy removal less relevant when compared to market price oscillations. This consideration indicates that the timing for the removal of subsidies, and future trend in prices, could possibly lead to very small, or considerable impacts on consumption and households. In fact, if domestic energy prices are expected to adjust based on the amount and price of imports, delaying the removal of subsidies will primarily increase costs to the government and leave little room for policy space in case market prices are higher than expected. This will, in turn, create more costs by limiting the scope of government intervention (excluding the option to keep or increase energy subsidies). Further, it is noted that productivity is mostly damaged by rising prices, rather than by absolute price levels. In fact, countries with different price levels can compete equally in the global market thanks to other competitiveness factors (e.g., infrastructure and human capital, or knowledge). In this context, countries with lower energy intensity, which are often the ones with higher energy prices, will be less vulnerable to future energy price increases. Malaysia in this respect is in a disadvantageous situation relative to current competitors that face higher absolute prices, but have reached lower energy intensity. Delaying the removal of subsidies will further exacerbate this disadvantage, reducing Malaysia's competitiveness if market prices increase.

As indicated earlier, the projected increase in energy prices is likely going to have a negative impact on energy demand and productivity. While a reduction in demand is welcome, and it is important that the rebound effect does not fully offset the gains made in efficiency, the reduction in productivity in this scenario is going to be more than offset by the implementation of other cross-sectoral measures that would secure a smooth transition to potentially higher energy prices.

Figure 27: Average domestic gas price, average domestic oil price and power generation cost







Regarding power generation supply, the combination of the several interventions simulated generates the following results.

- Despite slightly lower power demand, the increasing use of renewables requires higher total installed capacity: 3 GW by 2020 and close to 10 GW by 2030 (or 16% above BAU). Higher capacity generates more employment, twice as much as in the BAU case, and requires higher investment.

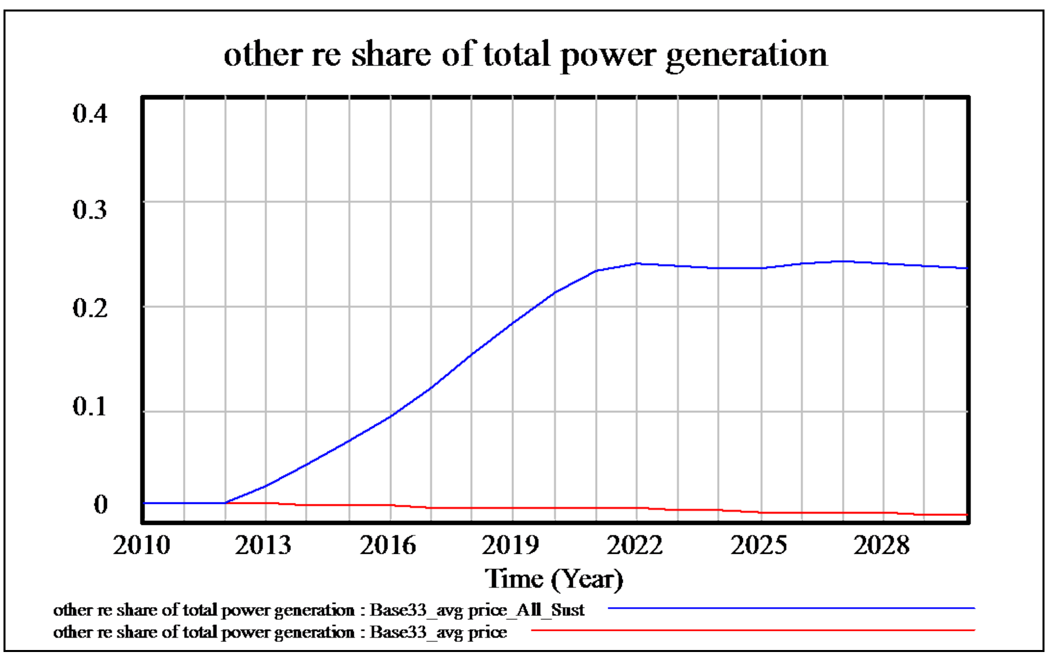
- Due to the higher capacity needs, the total investment in power generating capacity averages RM10.5 billion per year, twice as much as in the BAU case for a cumulative additional investment of about RM100 billion in 20 years (which is relatively small if compared with the amount of funding saved from phasing out subsidies).

- New renewables (primarily biomass and solar) are projected to reach 20% of power generation by 2020 in the "All & Sustainability" scenario (well above of the current 5.5% target) to support a further reduction in emissions and move closer to the 40% GHG emission intensity reduction target (see **Figure 28** and **Figure 29**). Concerning the share of capacity, comparing 2011 and 2030, gas is projected to decline from 62% to 43%, hydro from 10% to 7%, nuclear to grow from 0 to 7%, oil to decline from 3% to 1%, other renewables to increase from 2% to 30% and coal to decline from 23% to 12%.

- Power generation costs, and prices are projected to steadily increase in the BAU case, reaching RM0.64 per kWh in 2015 and close to RM0.9 per kWh in 2030. Results of the "All & Sustainability" scenario instead show a faster increase in the short term (RM0.8 per kWh in 2017), due to the removal of subsidies and investments in renewable energy, and a constant price level after 2015 (RM0.76 per kWh in 2030). The decline in the medium and longer term is due to the reduced reliance on fossil fuels that tend to become more expensive and to the technological improvement of renewable sources (and resulting reduced costs). Apart from the absolute value of production costs, the alternative scenario shows more resilience relative to world prices, which would allow making more reliable and consistent planning on the supply side. Also, while reducing overall economic productivity in the short term, this scenario supports the growth of productivity in the longer term by pressing for efficiency improvements first, and then by releasing pressure at a later time.

- Fossil fuel production, with emphasis on oil and gas, is expected to decline in the medium and longer term. Oil production peaked in 2004 slightly above 45,000 ktoe and is projected to reach 30,000 ktoe by 2030. Gas is projected to have peaked in 2010, to reach 47,000 ktoe by 2015 and 7,500 ktoe by 2030. In order to increase gas availability and import excessive amount of gas, exports are assumed to decline starting from 2015, to adjust their volume to the actual output. Malaysia is expected to become a net oil and gas importer approximately by 2020, with growing imports of gas over time, starting already in 2012/2013.

Figure 28: RE penetration, relative average electricity production costs



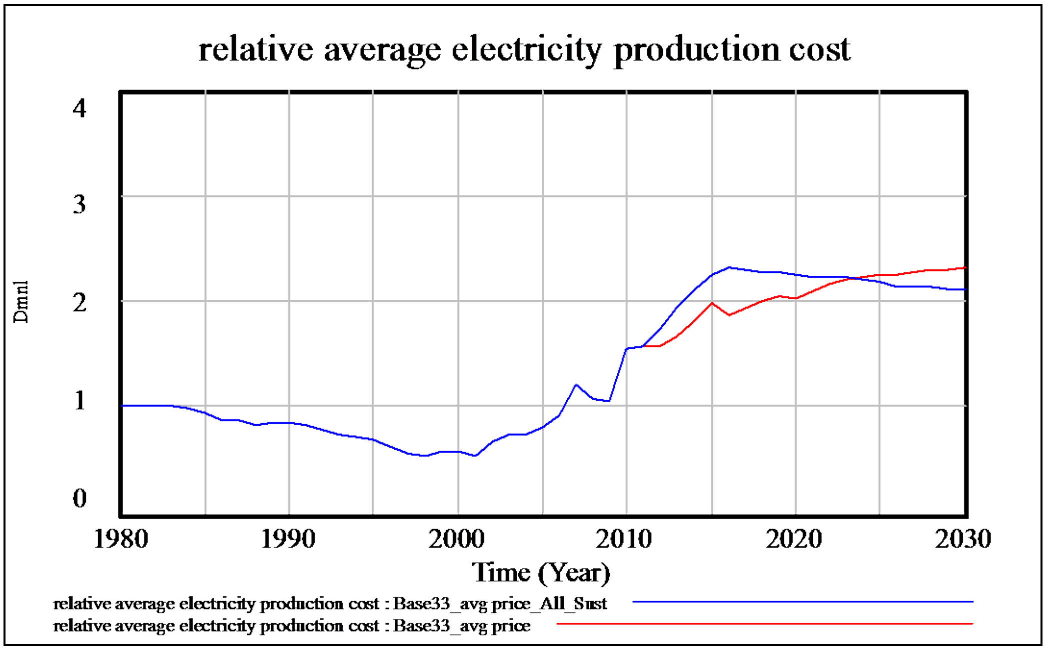
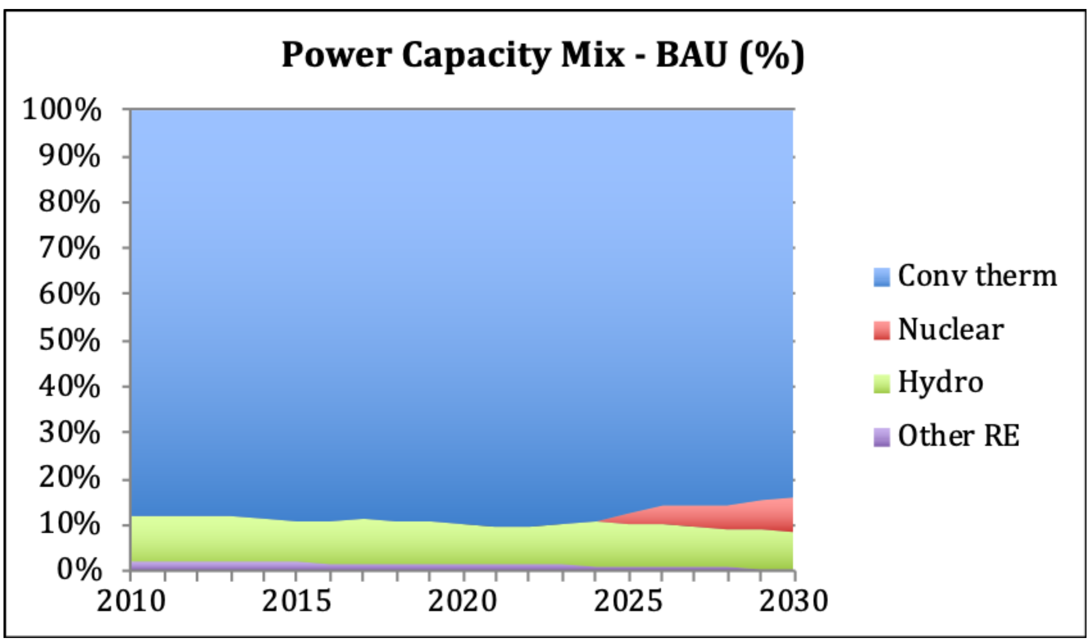
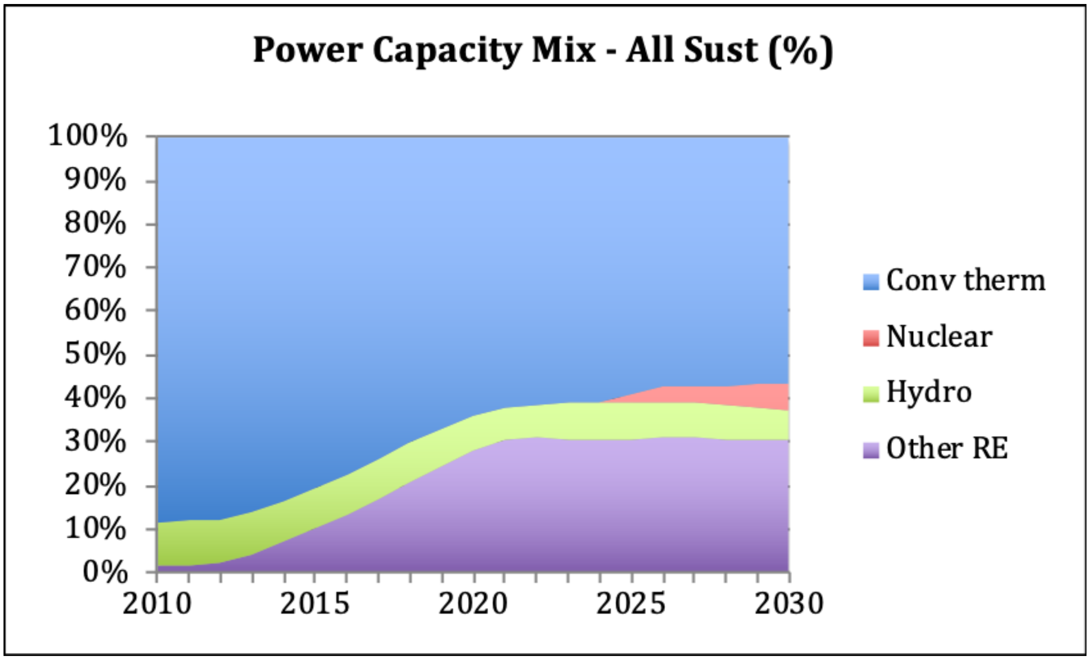


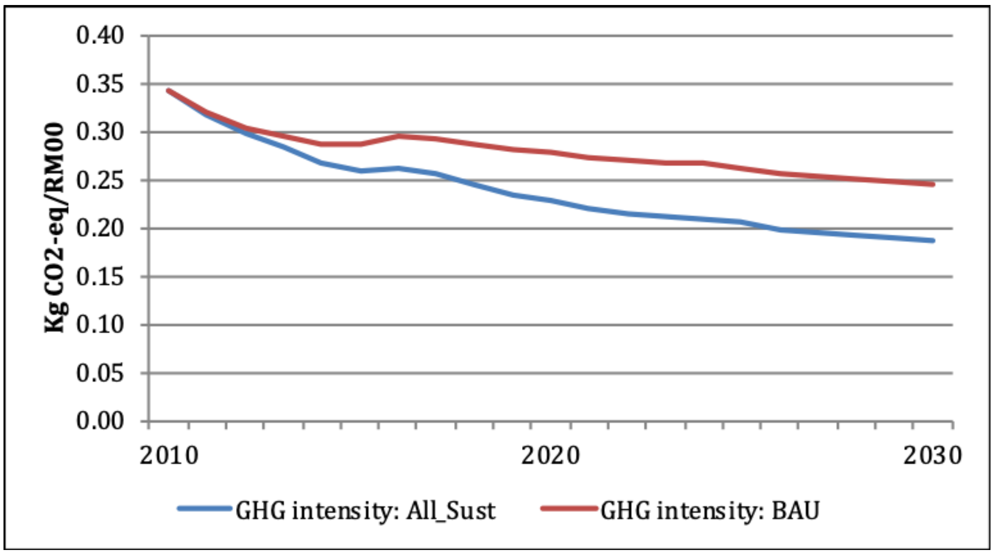
Figure 29: Power capacity mix





Energy demand and supply have a direct impact on fossil fuel emissions. While supply is primarily impacted by the availability of natural resources, demand is influenced by GDP (or income), population, energy prices and energy efficiency. All these factors are calculated endogenously and are subject to changes in policy decisions and interventions. The combination of all these factors in the "All & Sustainability" scenario makes so that fossil fuel GHG emissions intensity (calculated as emissions over GDP) would decline by 10%, 18% and 25% relative to BAU by 2015, 2020 and 2030 respectively (see **Figure 30**), or 35% less than its 2005 value by 2020. This result is driven by a push to reduce energy consumption (driven by energy efficiency improvements and higher energy prices) and a diversification of energy supply (with more power generation from renewable sources), but it is countered by the projected increase in GDP and population (due to a better economic performance that would both increase life expectancy and attract more immigrants). It is evident that both positive (reinforcing) and negative (balancing) feedback loops have strong impacts on fossil fuel emissions, with the negative ones being dominant in the short term and the positive ones being stronger in the medium and longer term. Further, projections indicate that fossil fuel GHG emissions will stay about constant until 2015, at a level of 190 million tons (as opposed to 200 million tons in the BAU case), and will grow to 220 million tons by 2020 and 310 million tons by 2030. These results indicate that more efforts should be put into managing energy demand (especially transport) to further reduce emissions intensity by 2015 and 2020 and reach stated targets. It is worth noting that the diversification of power supply is effective, but with most of the investments in low carbon power generation being planned for after 2020, the overall impact on emissions is marked until 2025.

Figure 30: GHG intensity of GDP and GHG emissions in tons



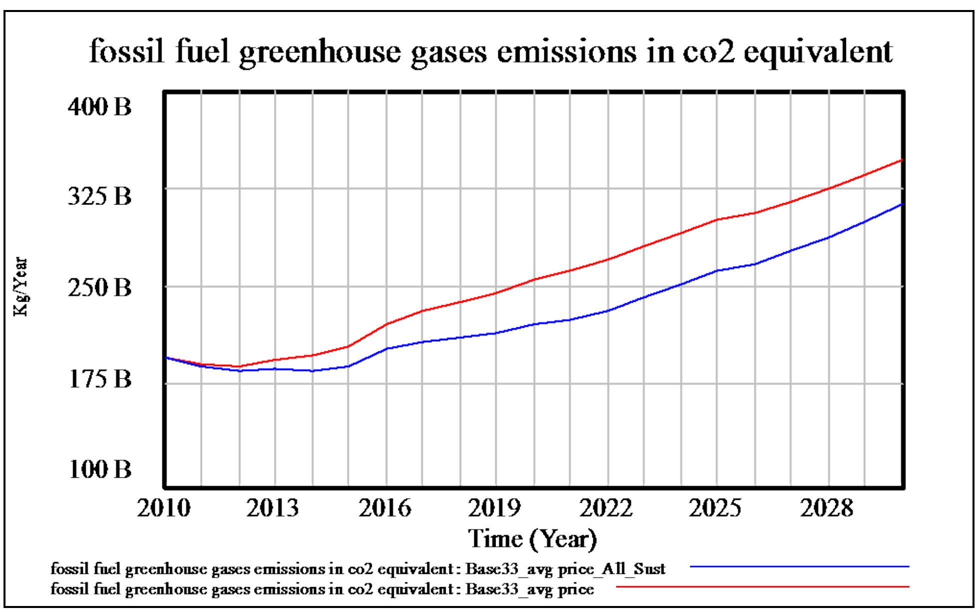


Table 14: Key indicators under BAU and alternative scenarios ("All" and "All sust."), selected years[10]

	Unit	2010	2015			2020			2030		
		BAU	BAU avg price	All	All sust.	BAU avg price	All	All sust.	BAU avg price	All	All sust.
Economic Sphere											
Real GDP	Billion RM/Year	576	718	733	733	917	962	968	1,416	1,639	1,668
Agriculture production	Billion RM/Year	53	54	54	54	56	56	56	61	61	61
Industry production	Billion RM/Year	246	320	327	327	423	442	445	695	812	828
Services production	Billion RM/Year	289	359	367	367	457	484	487	689	799	814
Resources balance	Billion RM/Year	61	75	33	33	118	45	47	255	233	245
Total export	Billion RM/Year	854	1,330	1,436	1,437	2,128	2,363	2,380	5,281	6,553	6,728
Total import	Billion RM/Year	794	1,256	1,403	1,404	2,009	2,318	2,333	5,026	6,319	6,483
Social Sphere											
Total population	Billion people	28	31	31	31	33	33	33	38	38	38
Tertiary enrollment rate	%	39%	44%	47%	47%	49%	57%	57%	59%	62%	63%
Total employment	Million people	13,173	14,784	14,787	14,787	16,258	16,262	16,262	18,874	18,892	18,894
Environmental Sphere											
Fossil fuel GHG emissions	Million tons/Year	196	204	191	189	255	243	220	347	373	312
Primary energy demand	Mtoe/Year	61	66	62	62	81	78	74	109	119	105
Coal production	Mtoe/Year	37	36	36	36	35	36	36	28	29	29
Oil production	Mtoe/Year	1	2	2	2	2	2	2	1	1	1
Gas production	Mtoe/Year	59	41	42	42	26	26	26	7	7	7
Total electricity generation	Mtoe/Year	105	111	108	109	143	141	143	211	235	224
RE power penetration	%	1.4%	1.3%	4.1%	7.4%	1.0%	5.3%	21.3%	0.3%	5.2%	23.7%
Total energy expenditure	Billion RM/Year	9.6	13.4	12.6	12.6	16.2	15.8	15.4	22.4	24.1	22.2

[10] Note that projections of this report are highly dependent on the assumptions used to simulate the model. There might be variations relative to other models and existing projections due to different structural and numerical assumptions or due to methodological differences.

4.3.2. Performance of the Interventions Simulated Under Various Scenarios

Several additional scenarios were simulated to test the adequacy of the interventions simulated under varying baseline assumptions on exogenous events. A few selected simulations are presented below, with emphasis on the key aspects and results introduced by each scenario.

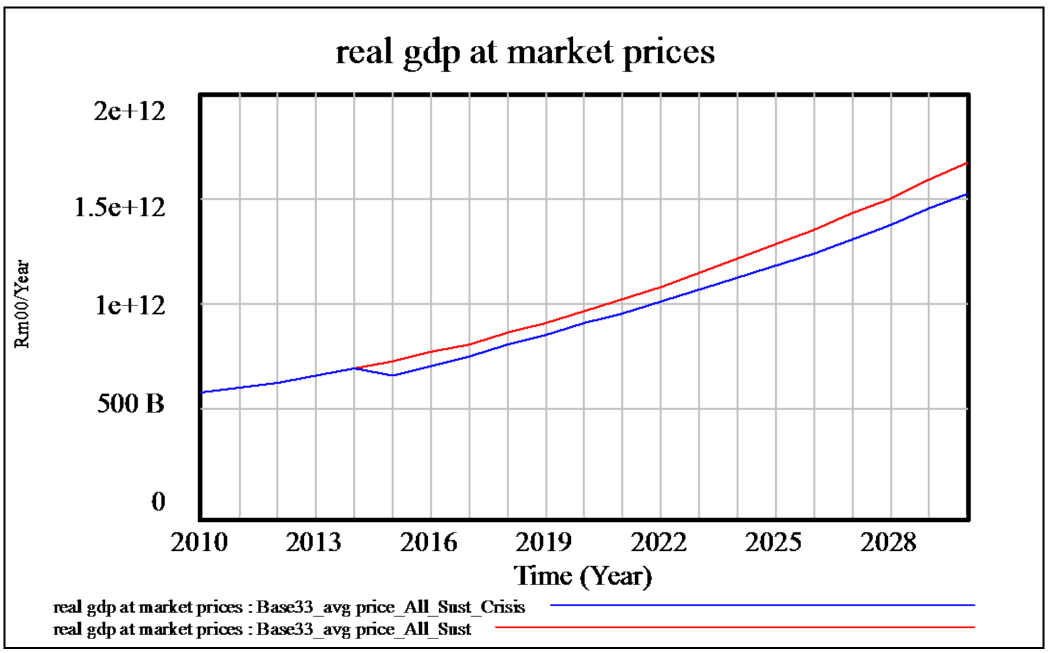
More specifically, the following simulations are introduced:

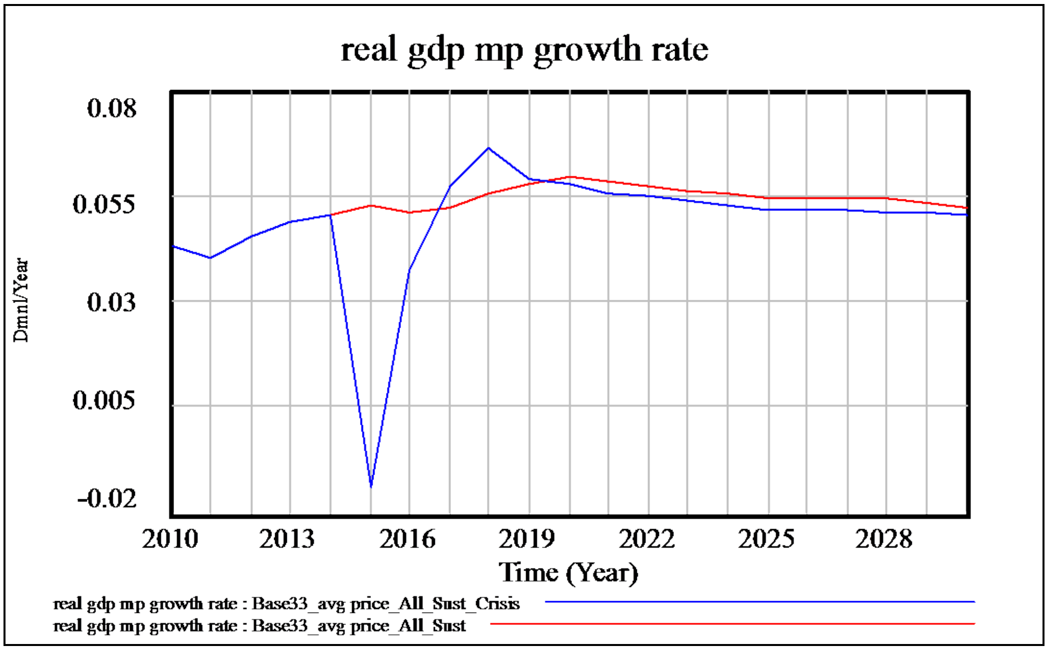
- Regional/worldwide economic crisis in 2015. It is assumed that a crisis the same size of the 2008-2010 economic slowdown would take place in 2015. While we can't forecast such event, the analysis focuses on the adequacy of policies currently being planned to limit the damage created by such event and support a rapid economic recovery. Two specific cases are considered in this scenario:
  - Rapid recovery: it is assumed that capacity utilization will suddenly decline by 10% between 2014 and 2015, to then reach business as usual utilization rates by 2018.
  - Lasting impact: it is assumed that capacity utilization will suddenly decline by 10% between 2014 and 2015, to never reach full utilization, but recovering to 5% by 2018. Such a long lasting impact assumes permanent changes in market conditions for which the domestic economy would need to transform in order to gain competitiveness in the region and worldwide (see **Figure 31** and **Table 16**).

Results of these simulations of the "Short Crisis" scenario indicate that the economy will enter a recession in 2015, with GDP growth reaching -1.5% to then bounce back reaching 8.25% by 2018 and adjusting to the "All & Sustainability" scenario in the longer term. Growth is projected to be lower in both BAU cases than in the "All & Sustainability" simulation, indicating that, while the short-term impact will be very similar, the recovery will be faster and stronger when the interventions analyzed are implemented. In order to mitigate the impacts of such a recession, and possibly avoid worst of the short-term decline, public spending could be increased to reach 7% or 8% of deficit as a share of GDP as done in 2009. Worth noting, the "All & Sustainability" scenario already assumes that the desired deficit will be increased from 3% to 5% of GDP in the medium term.

Results of these simulations of the "Lasting Crisis" scenario instead show a weaker bounce after the recession of 2015, with GDP growth reaching 6.6% in 2018 and adjust below to the "All & Sustainability" scenario in the longer term (0.3% below BAU per year on average between 2020 and 2030).

Figure 31: GDP growth rate and GDP



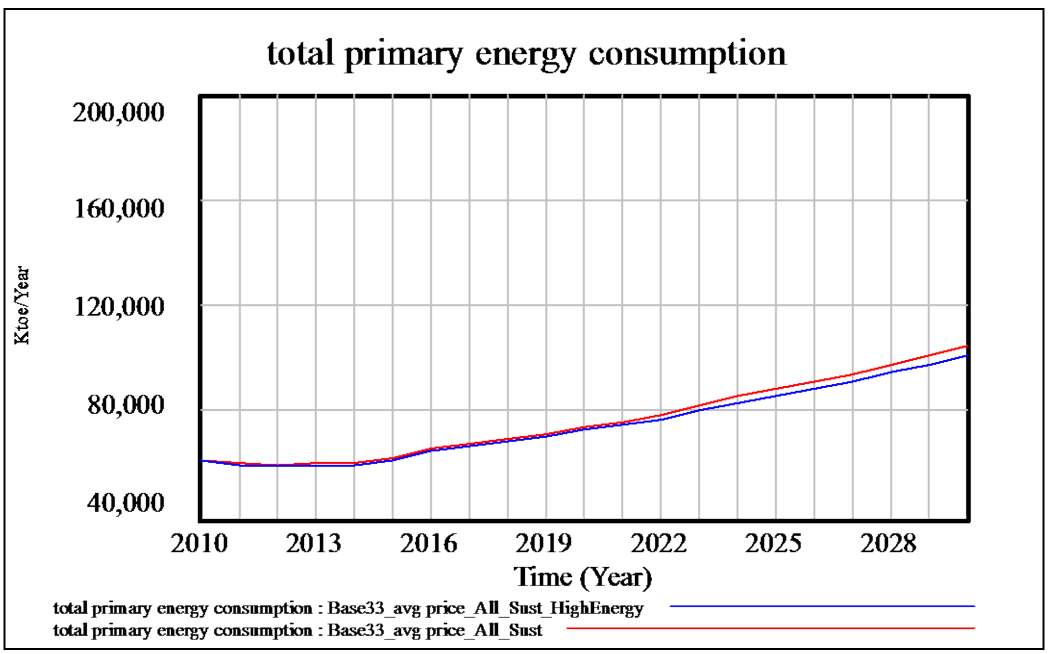


- High world energy prices. It is assumed that energy prices would grow beyond BAU assumptions and projections in two distinct manners: (1) a slow and incremental increase, and (2) a stronger and sudden increase in the short term to adjust with the incremental increase in the longer term.
    - Incremental oil and gas price increase: in this scenario prices will increase linearly from 2011 to 2030, reaching a 20% increase by 2020 and a 30% increase relative to BAU by 2030 in the case of gas, and a 10% increase by 2020 and a 22% increase relative to BAU by 2030 in the case of oil (see **Figure 32**).
    - Short term energy price peak and long term incremental increase: in this scenario prices will increase by approximately 50% and 60% by 2015 for gas and oil respectively, declining to +13% and +22% relative to BAU in 2020.

Results of the simulation of higher energy prices show consequences in the energy sector and beyond, with more marked impacts in the case of a short-term peak and longer term increase. Energy consumption is projected be on average 6% and 10%

lower than the "All & Sustainability" and BAU scenarios respectively between 2011 and 2020. The decline in energy demand reduces power supply investment only slightly, but has a more marked impact on emissions, reducing the annual flow by 5% on average between 2011 and 2020. The impacts on the economy would also be marked, especially in the short term. The average growth rate is projected to reduce annual growth by 0.2% per year until 2014, but the early removal of subsidies and efforts in energy efficiency would make so that GDP would bounce back more strongly after 2014 and remain above the "All & Sustainability" case until 2023. These results indicate that higher energy prices would create stress on the economy only during the ascending phase. If policies and interventions are coherently planned to counter this negative impact, medium and longer-term economic performance will be stronger than with lower, but ever increasing prices.

Figure 32: Total energy consumption and GDP growth rate



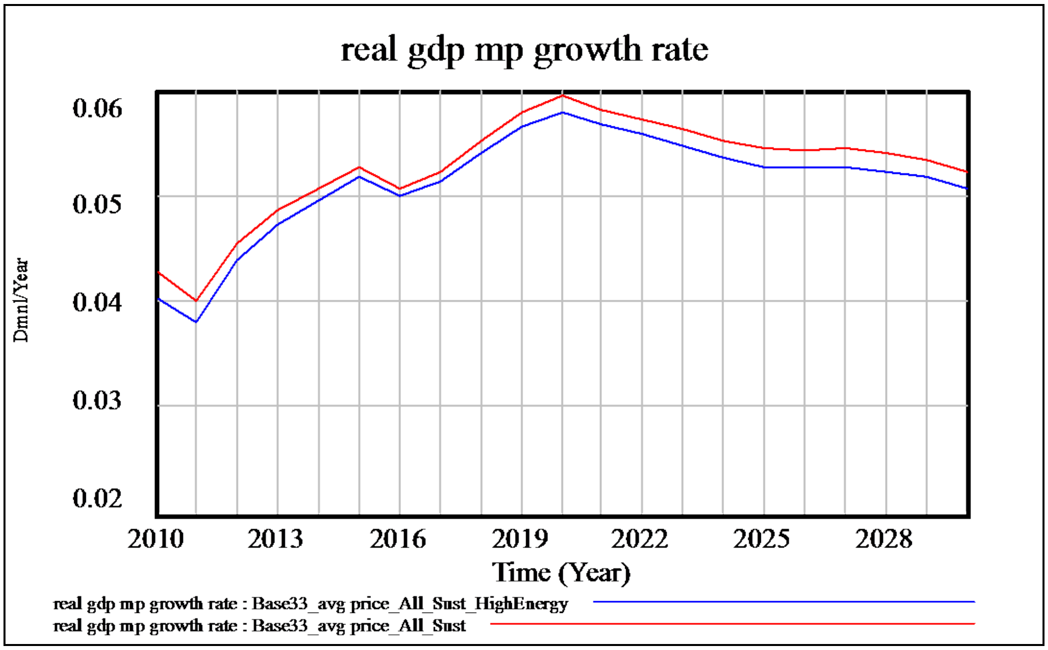

real gdp mp growth rate
0.06
0.05
0.04
0.03
0.02
Dmnl/Year
2010
2013
2016
2019
2022
2025
2028
Time (Year)
real gdp mp growth rate : Base33_avg price_All_Sust_HighEnergy
real gdp mp growth rate : Base33_avg price_All_Sust

Table 15: Key indicators under "All sustainable" scenario along with the cases of economic crisis (All sust. crisis) and high energy prices (All sust. high energy), selected years[11]

	Unit	2010	2015			2020			2030		
		BAU	All sust.	All sust. crisis	All sust. high energy	All sust.	All sust. crisis	All sust. high energy	All sust.	All sust. crisis	All sust. high energy
Economic Sphere											
Real GDP	Billion RM/Year	576	733	664	724	968	906	949	1,668	1,521	1,610
Agriculture production	Billion RM/Year	53	54	54	53	56	56	56	61	61	61
Industry production	Billion RM/Year	246	327	294	323	445	414	436	828	748	797
Services production	Billion RM/Year	289	367	330	363	487	455	477	814	743	785
Resources balance	Billion RM/Year	61	33	15	31	47	43	43	245	214	225
Total export	Billion RM/Year	854	1,437	1,290	1,412	2,380	2,214	2,318	6,728	6,065	6,394
Total import	Billion RM/Year	794	1,404	1,275	1,380	2,333	2,171	2,274	6,483	5,851	6,169
Social Sphere											
Total population	Billion people	28	31	31	31	33	33	33	38	38	38
Tertiary enrollment rate	%	39%	44%	47%	47%	49%	55%	56%	59%	62%	62%
Total employment	Million people	13,173	14,787	14,787	14,785	16,262	16,258	16,260	18,894	18,886	18,891
Environmental Sphere											
Fossil fuel GHG emissions	Million tons/Year	196	189	177	186	220	207	216	312	284	300
Primary energy demand	Mtoe/Year	61	62	57	61	74	70	73	105	96	101
Coal production	Mtoe/Year	37	36	36	36	36	36	36	29	29	30
Oil production	Mtoe/Year	1	2	2	2	2	2	2	1	1	1
Gas production	Mtoe/Year	59	42	41	41	26	26	26	7	7	7
Total electricity generation	Mtoe/Year	105	109	105	108	143	133	140	224	203	216
RE power penetration	%	1.4%	7.4%	7.6%	7.4%	21.3%	21.3%	21.4%	23.7%	23.7%	23.7%
Total energy expenditure	Billion RM/Year	9.6	12.6	11.7	13.1	15.4	14.6	16.7	22.2	20.8	26.0

[11] Note that projections of this report are highly dependent on the assumptions used to simulate the model. There might be variations relative to other models and existing projections due to different structural and numerical assumptions or due to methodological differences.

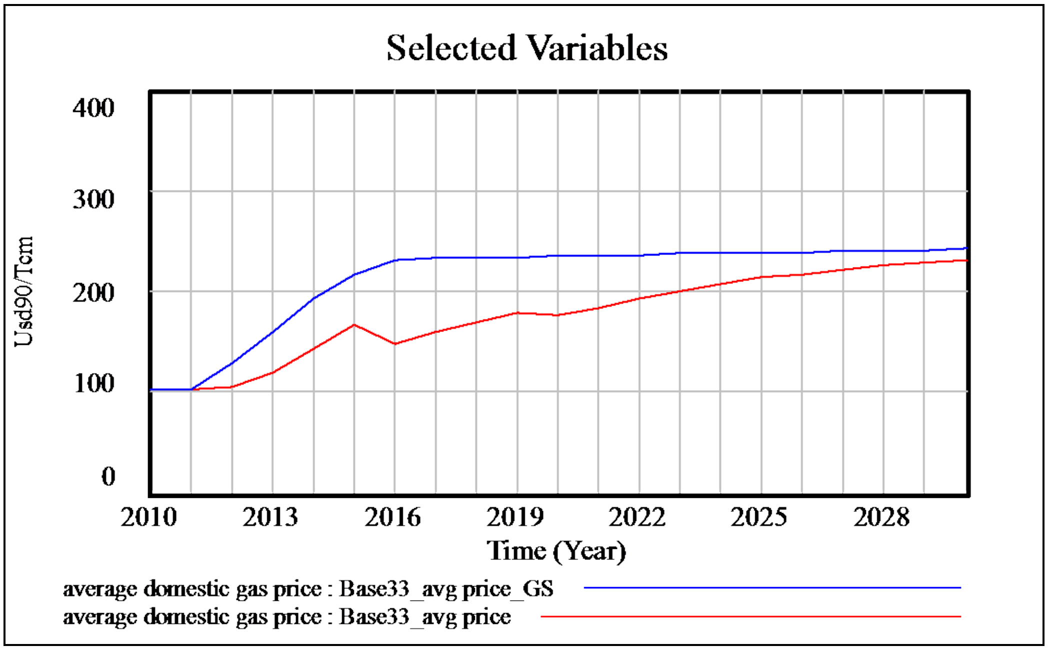
4.3.3.Analysis of the Impacts of Each Intervention Simulated

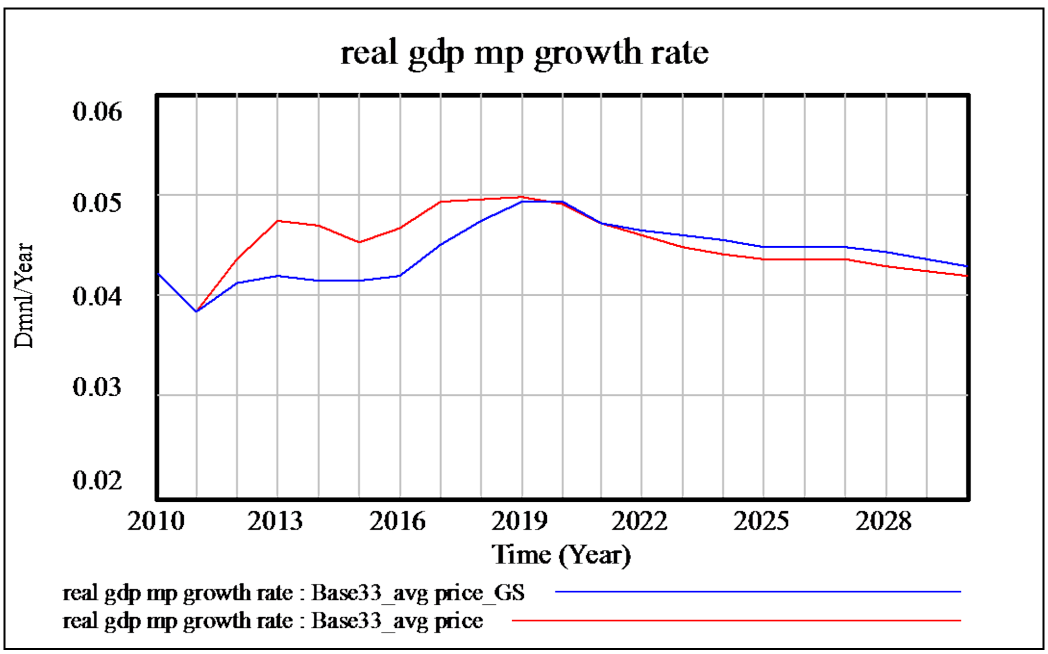
Having presented the overall impact so fall the interventions simulated in the previous sections of the report, the text below introduces and explains the impact of each provision analyzed independently from all the others. Results are presented separately for energy and trade, focusing on cumulative impacts, and an indication of synergies is presented at the end of this overview.

4.3.3.1. Interventions: Energy Sector

- Gas subsidy removal: the removal of gas subsidies by 2016 generates an increase in domestic prices. This increase is more marked when assuming that prices remain subsidized going forward, and only anticipates the market if energy imports are not subsidized. It has to be noted that, as opposed to oil subsidies, the price increase will impact only a few, but relatively large customers. Overall, higher gas prices (30% above BAU by 2015 and 2020 and 4% higher by 2030) reduce demand and consumption 4% below BAU directly and indirectly (through a reduction in GDP) (see **Figure 33**). Interestingly, GDP growth is on average 0.3% less than BAU by 2020 but 0.1% higher between 2020 and 2030. This is due to an earlier and more sudden adjustment of the economy to prices, which eases longer-term pressure on productivity. The removal of gas subsidies allows to save on average $50,000 per ktoe each year until 2020, or RM5 billion per year, summing up to RM43 billion by 2020 and RM73 billion by 2030.

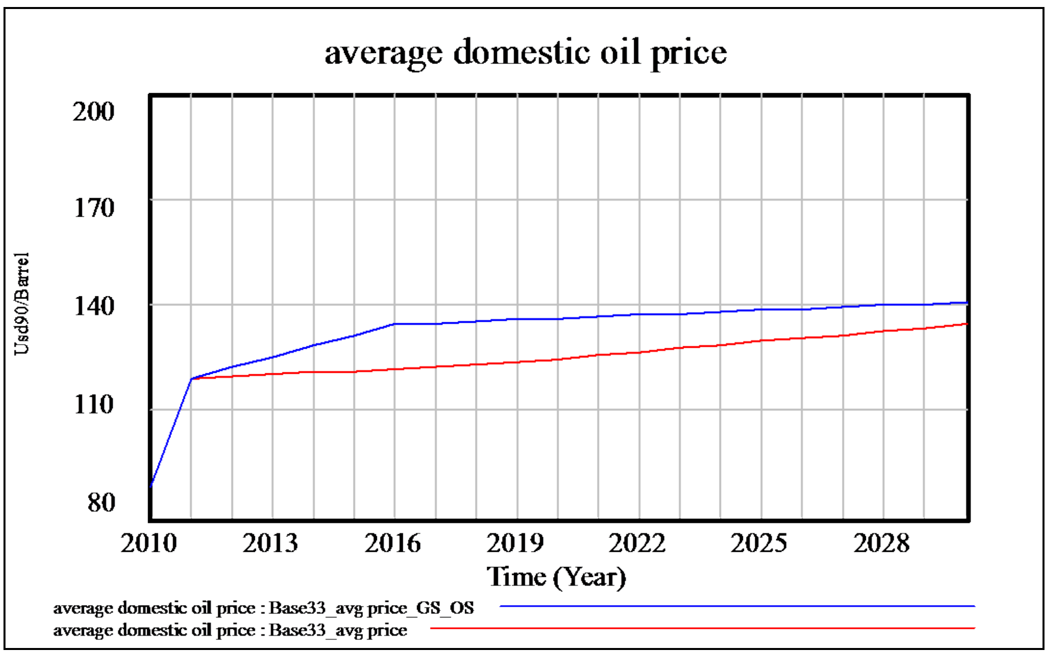
Figure 33: Average domestic gas price and GDP growth rate

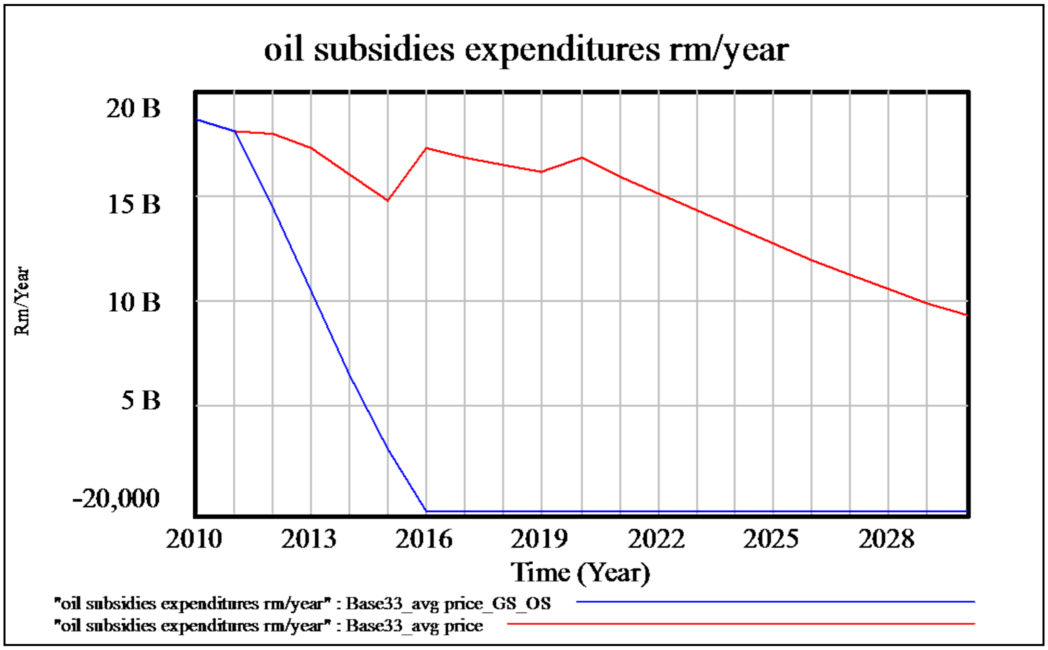




- Oil subsidy removal: the removal of oil subsidies by 2016 generates a comparatively smaller increase in domestic prices relative to natural gas, and is distributed across a much higher number of customers. As a consequence, despite the higher absolute amount of oil subsidies, the impact of subsidies removal will be felt by many but in a contained (or mitigated) manner. Overall, higher oil prices (approximately 8% above BAU by 2015 and 2020 and 4% higher by 2030) reduce demand and consumption only 2% below BAU directly and indirectly (through a reduction in GDP) (see **Figure 34**). GDP growth in this case does not change meaningfully, due to a contained increase in oil prices, which is smaller than what observed historically due to market forces. More importantly, the removal of oil subsidies allows to save on average $70,000 per ktoe each year until 2020 (for a total, considering gas of $120,000 per ktoe), or RM7 billion per year, summing up to RM70 billion by 2020 and RM170 billion by 2030.

Figure 34: Average domestic oil price and oil and gas subsidies expenditure RM/year



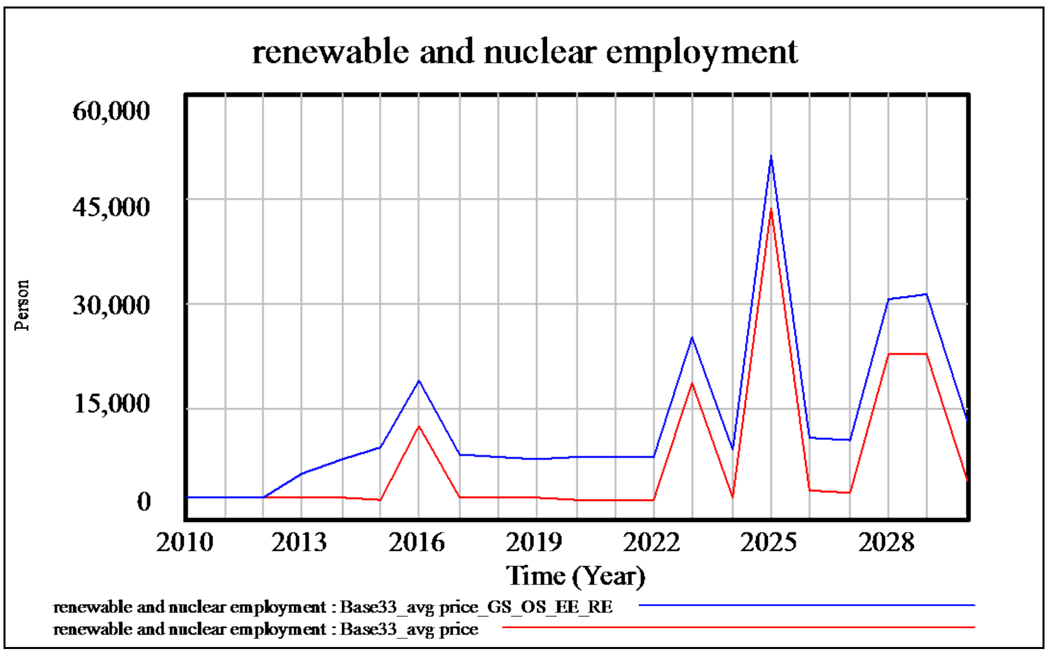


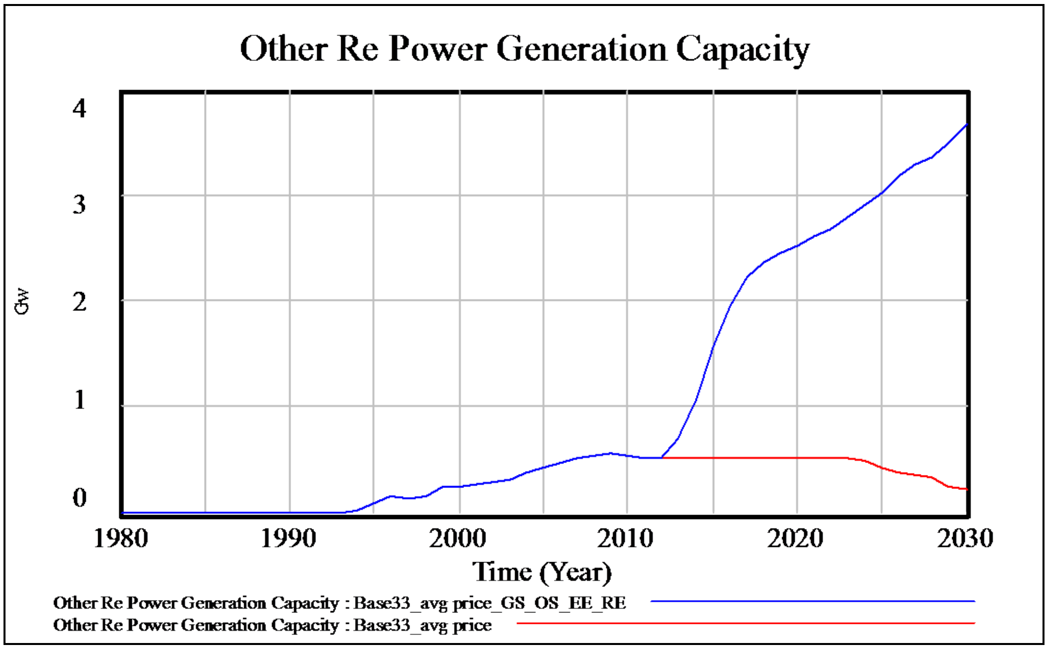
- Energy efficiency improvement: interventions in energy efficiency as simulated so as to reach savings of 4,000 ktoe by 2015. These improvements are allocated across residential and commercial, industrial and transport energy demand, respectively for achievements in the range of 8%, 10% and 7% above BAU by 2015. These interventions reduce pressure on demand and prices, making so that total primary energy consumption remains constant through 2015, as so do fossil fuel emissions. As the overall cost reduction, especially in the short term, is minimal, it is expected that savings, rather than consumption, would grow to offset higher expenses on energy due to the removal of subsidies. While not directly supporting GDP growth, energy efficiency measures increase income and savings. When not considering the removal of subsidies, energy efficiency improvements may instead effectively increase consumption and investments, and GDP as a consequence.

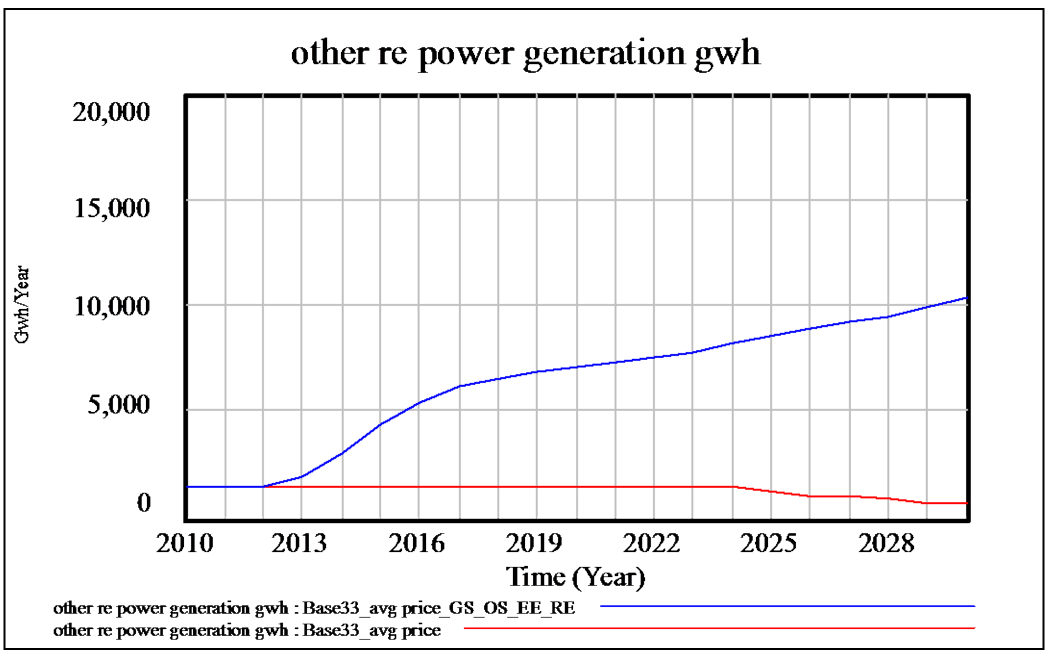
- Renewable energy (power generation): an increase in renewable energy power generation as two main purposes, namely (1) lower the carbon footprint of energy supply, and (2) improve the diversification of the supply mix, reducing reliance on more and more expensive fuels such as oil and gas. The intervention simulated, to increase the share of power generation to 5.5% by 2015 (see

Figure 35), reduces gas use (5% on average, throughout the simulation) and its import (750 ktoe/year on average until 2020 and 1,500 until 2030), and limits the growth of emissions from power. Further, by reaching a total installed capacity of 1.5 GW, 2.5 GW and 3.7 GW in 2015, 2020 and 2030 respectively, it slightly improves GDP also through the creation of new and additional jobs (about 5,000 in manufacturing, installation and operations).

Figure 35: Renewable and nuclear employment, and other RE power generation capacity and other RE power generation in GWh per year



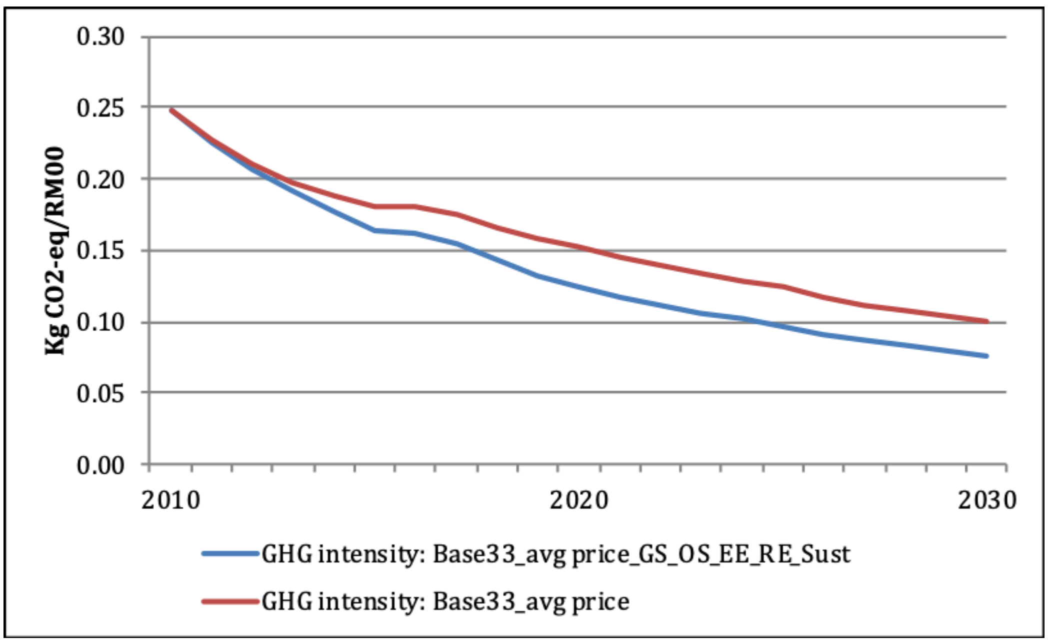


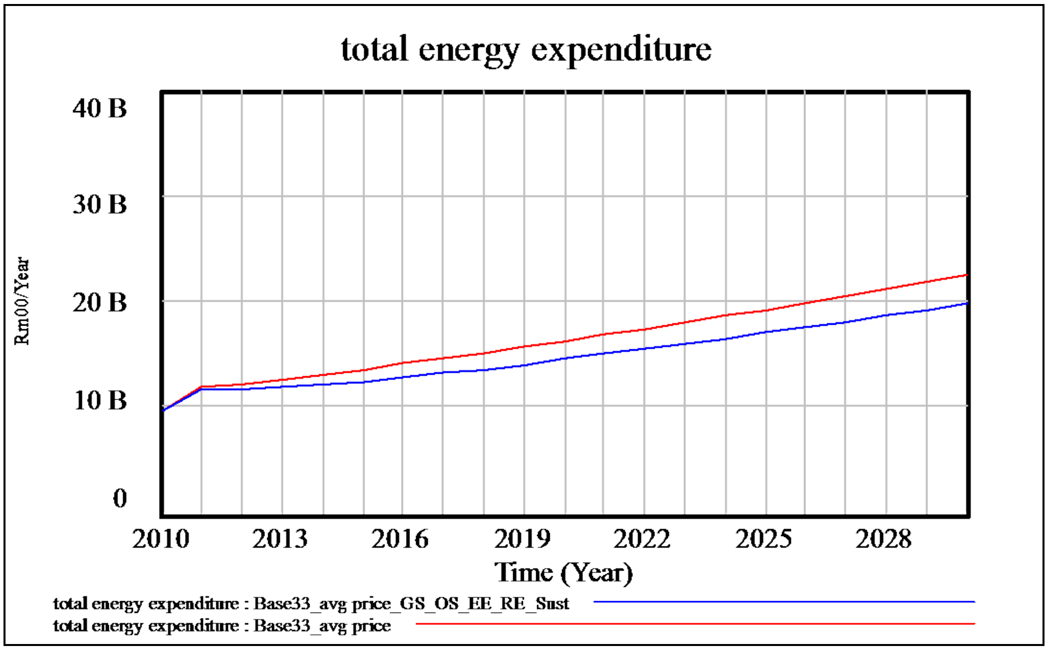


- Sustainability: a scenario that further reduces emissions is simulated to test economy-wide impacts of increasing efforts in energy efficiency improvements (30% by 2030), renewable energy for power generation (25% by 2020), while maintaining the complete removal of oil and gas subsidies by 2016. Results of the simulation of this scenario confirm the analysis of the impacts of each intervention analyzed in isolation: emissions are reduced (10% by 2105, 20% by

2020 and 25% by 2030 relative to BAU), GDP grows faster after 2018 (0.23% per year above BAU, due to the implementation of investments, complete utilization of capital, employment generation and energy savings), fossil fuel consumption is avoided (13% relative to BAU, or 10% savings on energy expenditure totaling RM1.6 billion per year or RM33 billion between 2011 and 2030) and imports are reduced (see **Figure 36**). On the other hand, the decline in GDP growth due to the removal of subsidies in the short term remains, and will be more than offset by economic development initiatives that have synergetic impacts with energy interventions.

Figure 36: GHG intensity of GDP and total energy expenditure

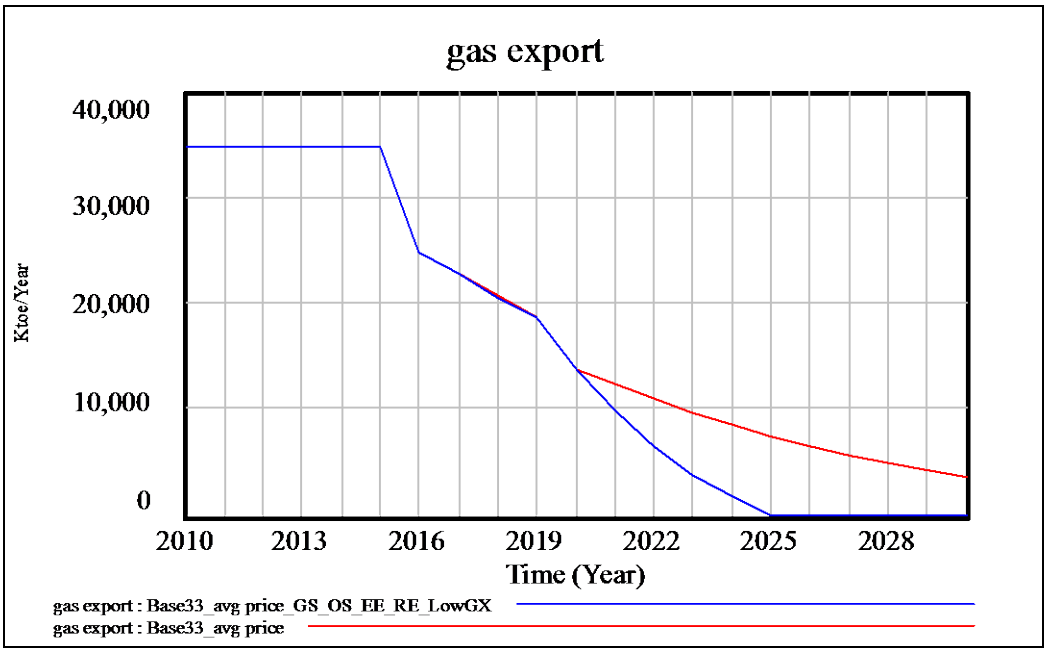


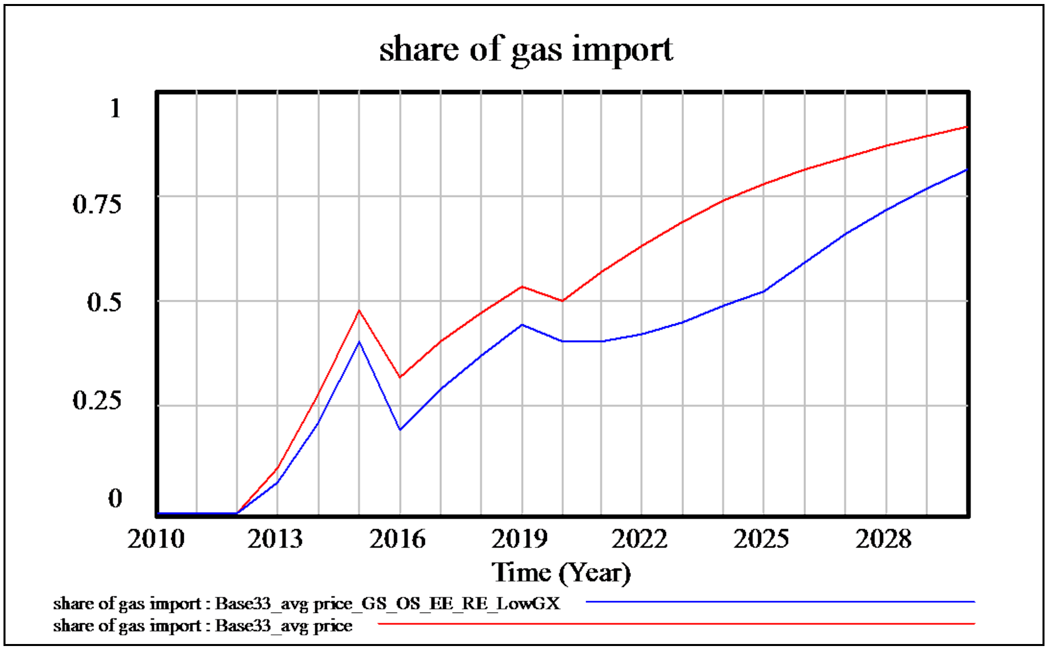


- No nuclear power investment: a scenario is simulated to remove the assumption that nuclear power capacity will be built in Malaysia after 2020. In the BAU case nuclear power is projection to become available before 2025 and reach a total capacity of 4 GW by 2030. Removing the investment in nuclear power is going to have several ramifications: (1) lower investment in power generating capacity (close to RM40 billion); (2) lower power employment (76,000 jobs, of which only 2,000 would be permanent operations and management jobs); (3) higher power cost in the longer term (5% higher, offsetting the decline brought about by renewables); (4) slightly higher emissions due to higher gas use (2.2% in 2030), and hence more consumption and imports.

- Low gas exports: a scenario analyzing the impact of full utilization of domestic gas production for domestic use, by 2025, was analyzed. Acknowledging that terminal investments and costs for transporting/importing gas (or LNG) would be the same, the analysis focuses on gas availability and imports and impacts on prices. With respect to prices, a full phase out of subsidies would make so that importing or using domestically produces gas would have no impact on consumption or domestic prices. If the amount produced is sold at market price, also the profitability of production would be the same. On the other hand, in the case of partial, or no removal of subsidies, the utilization of domestically produced gas could reduce domestic prices, while, on the other hand, reduce profits for PETRONAS and consequently dividends to the government. Aside from subsidies and pricing policies, reducing gas exports to zero by 2025 would only temporarily lower gas imports, with the share of imports reaching 50% by 2025 instead of 75% in BAU and other scenarios (see **Figure 37**). While costs are not likely to change, energy security would benefit from the availability of "extra" domestic supply.

Figure 37: Gas export and share of gas import



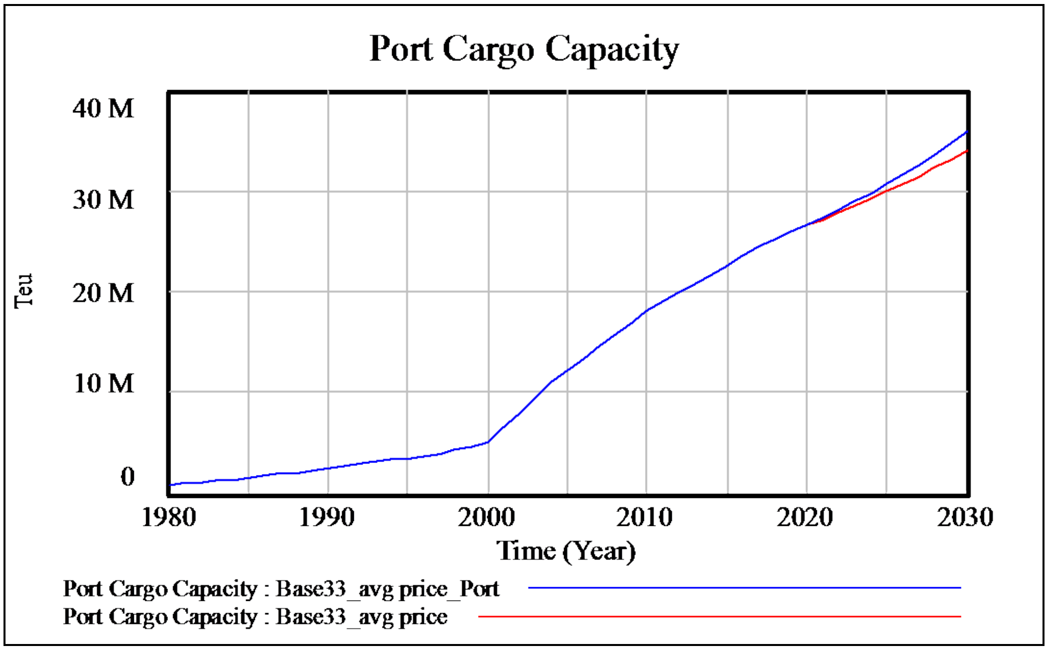


4.3.3.2. Interventions: Trade Sector

Several interventions were tested in the trade sector, in the context of national development, both to support reaching stated macroeconomic goals and to mitigate the short-term negative impacts of policies in the energy sector. Some interventions target infrastructure, to improve domestic competitiveness, reduce costs and prosper internationally. Other interventions target access to markets and the leverage of investments (e.g., stimulating more domestic investments to support the growth of endogenous drivers for economic resilience and prosperity). The specific interventions, and their cross-sectoral repercussions are discussed below.

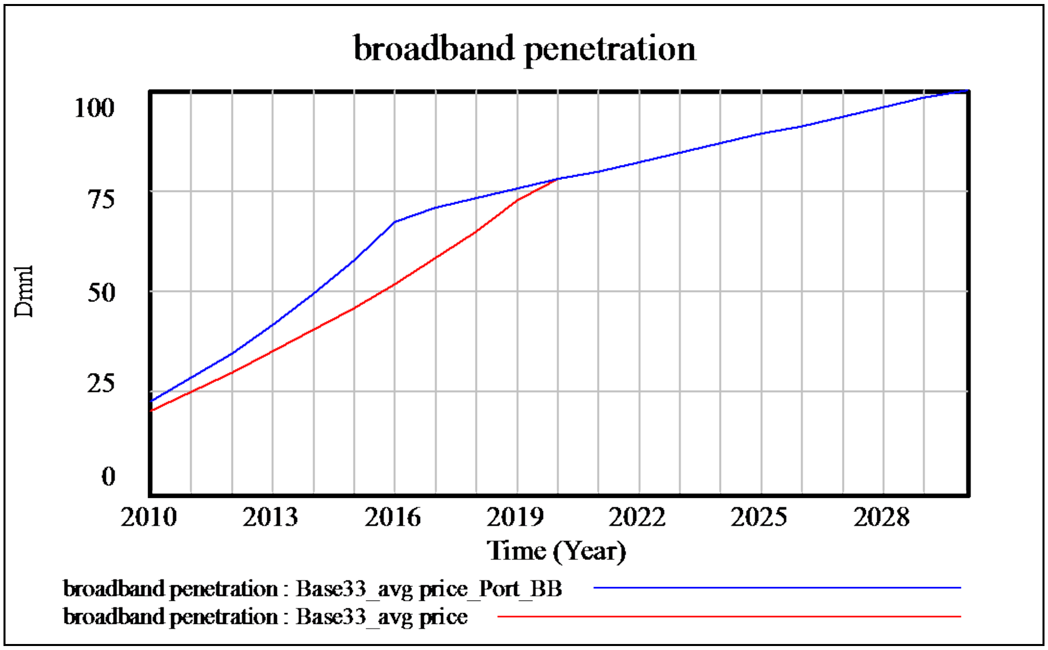
- Port cargo investment: investments in port cargo infrastructure as assumed to increase after 2015, for an average annual amount of RM11.25 billion (nominal, or current terms). The private sector is assumed to finance this investment, through a reallocation of funding across sectors. The impact of this additional investment is felt over the longer term, primarily after 2020, leading to the average growth of port capacity and operations of 3.5% between 2011 and 2030, as opposed to 3.2% in the BAU case (see **Figure 38**). This increase in port capacity is projected to have positive, but contained (from an economy-wide perspective) impacts on industrial TFP and on the export of goods.

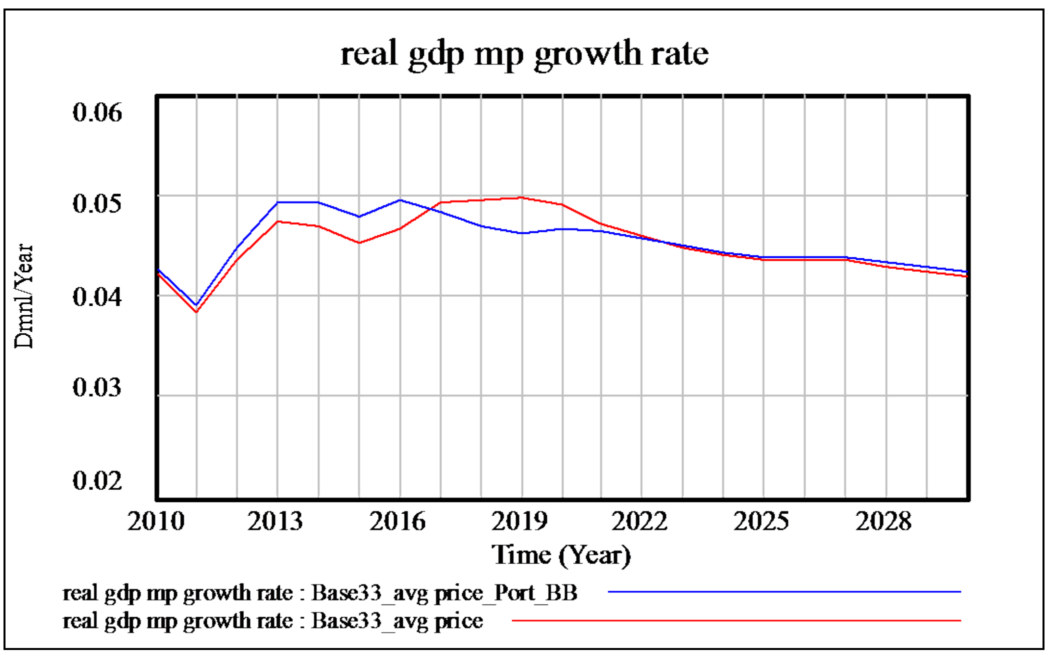
Figure 38: Port cargo capacity



- Broadband investment: as in the case of port cargo investments, the expansion of broadband connectivity is tested to further support the growth of industrial and services TFP and the export of services. The total additional investment relative to BAU average RM2.8 billion per year (nominal, or current terms) and near to full access to broadband connectivity is projected to be reached by 2017 rather than 2020, with about 75% of the population effectively being connected by 2020 (see **Figure 39**). It worth noting that this additional investment allows reaching higher broadband penetration levels earlier, practically pushing the expansion of advanced infrastructure to support the growth of productivity and exports in the short term. This effect stimulates GDP growth until about 2020, countering the negative effect of the removal of energy subsidies on economic growth.

Figure 39: Fraction of population served by broadband and GDP growth rate





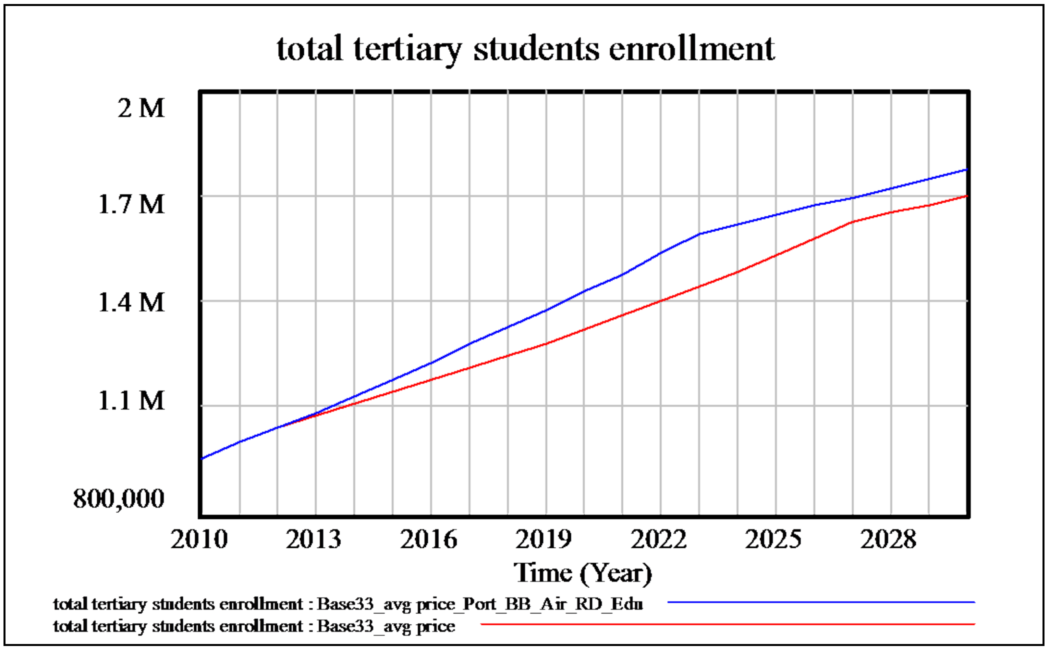
- Air cargo and passenger investment: investments in additional air cargo and passenger capacity, on top of the BAU expansion are projected to average RM850 million per year (nominal, or current terms). As a result, airline freight capacity is expected to growth 0.5% per higher than BAU at 5% in the period

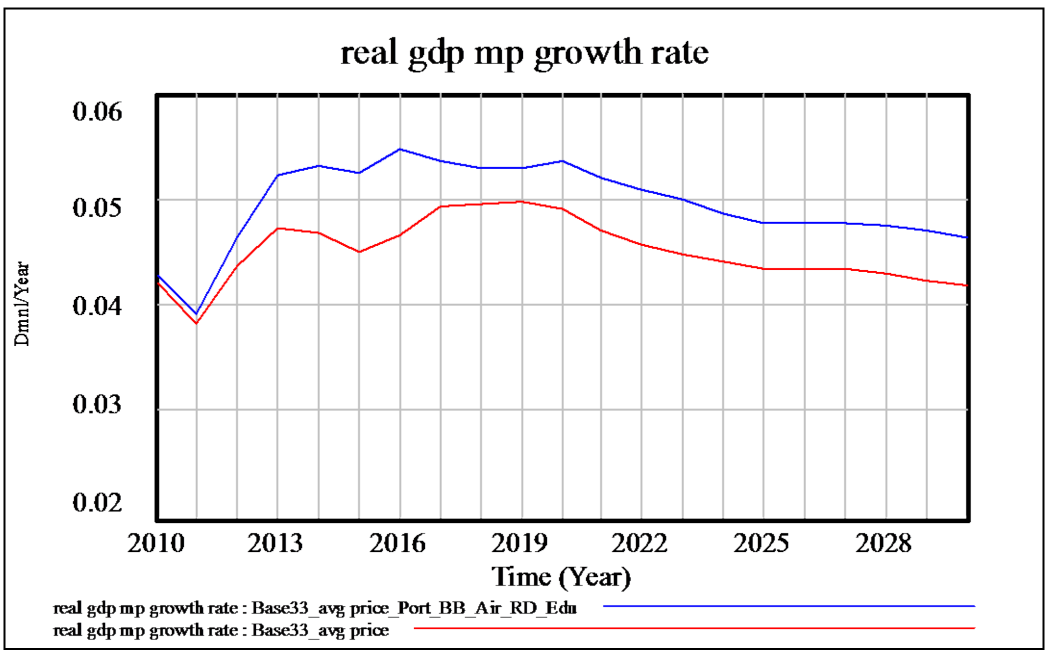
2011 – 2030. While the expansion of freight capacity is projected to improve productivity in the industrial sector and exports of goods, the growth in passenger capacity and travel is projected to support services TFP and exports. As in the case of port cargo investment, and complementing efforts in broadband connectivity, the expansion of air cargo and passenger capacity will support GDP primarily in the medium and longer term.

- Research and Development investment: an increase in overall R&D investment is simulated, in the range of 20% on top of BAU, to support productivity improvements in the secondary and tertiary sectors. This investment should be evaluate in concert with additional efforts in the education sector to support the absorption of local talents and stimulate the transition to higher value, and tech-intensive services sectors. While investments in specific processes and technologies could not be modeled, projections show permanent improvements in economy-wide TFP and GDP growth, especially in the medium and longer term.

- Education (investment and management): the interventions simulated in the education sector primarily focus on tertiary education, both on infrastructure and on procedures, to fully support targeted specialty studies that would support the economic transformation (i.e., STEM, science, technology, engineering and mathematics). On average, this scenario simulates the allocation of RM4.5 billion per year (nominal, or current terms) to tertiary education and, as mentioned for broadband, anticipates longer-term trends by pushing enrollment (5%) and graduation beyond BAU in the short and medium term (see **Figure 40**). Advances in the education sector allow fully reaching and going beyond stated goals for the participation of highly skilled workforce in the economy, and support economic growth.

Figure 40: Tertiary students enrollment and GDP growth rate





- Taxation: a scenario is simulated to test the impact of a reduction in income and profit taxation, with the explicit goal to stimulate short-term private investments. Specifically, the scenario assumes a reduction in income and profit tax as a share of GDP from 3.17% in 2009 to 2.5% by 2015. The main impact of such intervention includes a reduction in government revenues and an increase in disposable income that, though marginal, would create synergies with education spending and overall investments in the country.

- Propensity to save (assumption): with a reduction in taxation, overall higher income to reach the status of developed economy in 2015 and progressively improving level of social services and their effective utilization, a scenario assumes that the propensity to save would increase after 2015. This is due to the fact that, with income rising, and with more opportunities arising, subsistence costs would progressively be lower (as a share of disposable income) going forward. As a consequence, an increase in savings would lead to more investments (as if part of the extra disposable income would go to consumption, but mostly is allocated to savings and investment). In this scenario, the propensity to save would be more “sensitive” to income after 2015, reaching close to 56% in 2020 (54% in BAU) and 63% by 2030 (57 in BAU). Private investments would grow, as a consequence, on average 5% above BAU between 2011 and 2030, being 12.5% above reference level in 2030, stimulating GDP growth as well.

- FTA (access to market): the implementation of a broad FTA is simulated in form of increased access to market. This would be achieved not through additional growth in GDP of foreign trade partners, but through an FTA designed to support exports in light of expanded high value production and better competitiveness through reduction of costs and facilitation of business. Without having the possibility to fully disaggregate production sectors due to data availability, the FTA is applied to the broad industrial and services sectors. Synergies are noticed with investments in infrastructure, which increase domestic (internal) competitiveness relative to other foreign producers. Further, on the demand side, with stronger economic performance, and imports slightly prevailing the growth of exports going forward, a well-designed FTA would allow supporting the balance of payment remain positive through 2030. The FTA is assumed to be designed in 2012 and implemented in 2013 to make the best use of other sectoral investments and also to mitigate some of the potential negative impacts of the removal of energy subsidies. The level of access to market simulated, to put results into perspective, is of 5% the current volume of trade. As a result, also through the interaction of several feedback loops and improvements on the supply side, exports and imports would generally grow by 5% and 4.3% respectively and the resource balance would improve by 8% on average between 2011 and 2030, with peaks in the short term (+16% until 2016).

- Foreign Direct Investment (FDI): with better economic performance, increased domestic investments and an effective transition to a higher-value economy, it is assumed that private factor income and FDI would grow from 2% to 4% of GDP. This increase would further stimulate investments, and improve the overall stability of government and households accounts.

- Borrowing (increasing deficit to support short term growth): as a final measure to fully offset the negative impacts of the removal of energy subsidies on GDP and strongly support the transition to a high value economy, a scenario is simulated to test the impact of increasing public spending to reach 5% of GDP in annual deficit (as opposed to 3% in the BAU case) between 2012 and 2020. The extra expenditure is assumed to be allocated across sectors, as a general stimulus to the economy. Results of the simulation indicate that the annual deficit would be, on average, 35% above BAU between 2011 and 2030 (being about 70% above BAU until 2020). In absolute terms, the additional deficit would average RM26 billion (in nominal, or current terms), for a total amount of about RM240 billion between 2012 and 2020. The overall impacts of such measure can be clearly observed on GDP and its growth rate. The simulated increase in public spending is projected to have considerable short term impacts, adding 0.2% per year to GDP growth between 2012 and 2020, and 0.16% until 2030 (indicating that positive returns remain even after the investment is scaled back to BAU). Comparing GDP and the additional expenditure, positive economy-wide return on investment would be reached in 2026 (break even point), and by 2030 over 65% of the total expenditure would have been collected back by the government in form of revenues from taxation (due to higher economic growth). This analysis should also be put in the context of the relevant (and growing) amount of international reserves being accumulated at the national level.

4.3.3.3. Interventions: Combining Energy and Trade

Combining the analysis of the interventions simulated in the energy and trade sector it becomes evident that there are synergies and potential bottlenecks within and across sectors. Considering the overall and sectoral targets set by the government certain interventions were designed to mitigate negative impacts or to exploit potential synergies. The result is a strategy that would allow to move towards stated goals and reach most of them, while ensuring a coherent and coordinated action across sectors of interest.

Worth mentioning, it has to be noted that a few key feedbacks, also highlighted in the CLDs, have important impacts on the progress toward reaching several sectoral goals. It is clear that removing energy price subsidies would generate negative impacts on productivity if the policy-driven additional costs are not mitigated. Existing energy efficiency plans and the projected increasing use of renewables support the transition, but do not seem to be aggressive enough to fully offset costs. In this context, an important role is played by international energy prices, as the price oscillations observed in past go well beyond the price changes driven by a short term removal of subsidies. While economic development policies, especially those targeting competitiveness and trade would generate additional income to offset the negative economic impacts of energy price increases, more emphasis should be put on efficiency going forward. A removal of subsidies would in fact support such transition, which would bode very well with the economic transformation strategy. In fact, while trade measures can support growth in the short term (it is difficult to forecast long term trade dynamics without having integrated cross-national models), improving competitiveness domestically (including energy efficiency) would certainly support both medium and longer-term success at the international level -especially under a high energy price scenario-.

It has to be noted that the current analysis would profit from a more detailed and as a result broader representation of key industrial sectors. Currently, economic development policies are designed to have a macro impact, and offset the economy-wide repercussions that higher energy prices would have on all key actors in the economy. As it is often the case, certain industries would be more affected than others, and investments should be targeted to account for sectoral differences, being leveraged by specifically designed policies.

5. Policy Recommendations

A variety of interventions are simulated to evaluate impacts on socio-economic development and define strategies to move towards stated goals and support an effective economic transformation. The interventions simulated represent a broad range of policies across sectors aimed at reaching specific targets, and the key value of this analysis consists in the integrated, cross-sectoral estimation of potential synergies and unexpected side effects.

The definition of a strategy for the energy and trade sector of Malaysia, in the context of national development (and therefore considering existing cross-sectoral targets), starts from the analysis of the relevant dynamics that are going to shape the energy sector in the next few years. With a growing volume of imports primarily for oil and gas in the years to come, maintaining energy price subsidies would have a relevant impact on government accounts. On the other hand, with the gradual removal of subsidies until 2015, energy prices are expected to increase faster than in the BAU case. It is in fact projected that oil and gas prices will be aligned with market prices by 2017 and will entirely follow market dynamics after then. It is therefore expected that negative impacts can be seen both for actions (higher energy prices) and inaction (worsening of government accounts). As a consequence, an integrated approach is needed to mitigate short-term negative impacts and maintain positive synergies in the longer term.

In light of these challenges, and to reach stated goals and ensure a coherent cross-sectoral development, the following steps and actions are proposed:

Energy Sector:

- Oil and gas subsidy removal: while energy price subsidies support cost reductions and improve short term competitiveness (positive effect), in the medium and longer term subsidies reduce the incentive to invest in energy efficiency and innovation (negative effect). Further, in the case of Malaysia, with the current economic structure being largely based on low cost manufacturing, a lock-in effect has been created, making it more difficult for producers to profits from improvements in infrastructure and education. As a result, a mismatch across sectors is becoming more evident, exposing the country to a critical risk at a juncture in which domestic energy supply has likely reached its peak.

- Energy efficiency improvement: energy efficiency should be improved with a dual goal: to reduce the impact of increasing energy prices (especially in the case of the removal of subsidies), and to improve longer-term competitiveness for manufacturers and reduce energy costs for households. Energy efficiency creates a win-win situation and several “low hanging fruits”, low cost investments that can yield short-term economic benefits, can be identified across sectors. Concerning competitiveness, efforts should be put on industrial sectors (with incentives to invest in energy efficiency for process improvements); regarding households, options are available in lighting, cooling and transport.

- Renewable energy power generation: the penetration of renewables in power generation should be increased to diversify the energy supply mix, reducing exposure to fossil fuels and creating cost reduction opportunities in the medium and longer term. Also, renewable energy, when the power generating capacity is manufactured locally, creates a considerable amount of additional jobs when compared to thermal power generation. Several policies exist to stimulate demand (incentives, such as feed-in tariffs, tax rebates, mandates and targets), and supply –although supply is already present in Malaysia.

- Low carbon power generation: given the existing plans defined by TNB, it seems that was majority of power generating capacity coming on stream by 2025 will be thermal-based. A more marked switch to low carbon sources, as indicated for renewables, would be advised if challenging targets to reduce emissions (such as reducing the emission intensity by 40% within the next 10 years) are confirmed and turned into law. Alternatively, as a preferred choice, considering the challenges posed by nuclear power, a stronger effort to reduce demand (through energy efficiency) would avoid the construction of power capacity.

- Flexible agreements for gas exports: acknowledging that terminal investments and costs for transporting/importing gas (or LNG) would be the same, a full phase out of subsidies would make so that importing or using domestically produced gas would have no impact on consumption or domestic prices. If the amount produced is sold at market price, also the profitability of production would be the same. On the other hand, concerning energy security, it would be preferred to reduce exports according to the overall trend of decline of national output, to potentially maintain reserves until the early 2020s and reduce the economic risk related to imports.

The forecasted impacts of the interventions listed above indicate progress towards the transition to a more efficient and productive economy, with investment costs being offset by avoided consumption and income generated by higher employment in the power sector. On the other hand, a large part of the population is likely to suffer from the policy-driven increase in energy prices, to an extent that varies depending on future market (world) energy prices.

Trade Sector:

As a consequence of the expected impacts of the energy interventions across the economy, and in light of the targets set for trade and economic development, the trade interventions recommended below are designed to maximize synergies and an effective allocation of funds to promote a coherent economic development leading to the desired economic transformation.

- Infrastructure investment: port cargo, air cargo and passenger and broadband connectivity are important investments aimed at supporting an improvement in industrial and services productivity, on top of creating employment. Interventions in these areas will both support domestic production, as well as increase international competitiveness, supporting the integration of local talents in the economy. The expansion of infrastructure, especially when aimed at energy efficiency (e.g., switch to low carbon transport modes) and technological development, may need to be adjusted over time, to make use of several policies that would leverage private as well as public investment.

- Research and Development: investments in R&D are critical to support the transition to higher value production and services, and to make use of the investments made in the education sector and retain local talents. These investments will have to target sectors that hold promise to deliver of the economic transformation strategy, or support sectors (such energy intensive manufacturing sectors) that would particularly suffer from higher energy prices, having an impact on profit margins and competitiveness.

- Education (investment and practices): investments in tertiary education should be planned to increase the intake rate and graduation especially in science, technology, engineering and mathematics (STEM) to support the economic transformation. If other investments are successful, and the economy grows as projected, highly skilled workforce will needed in a variety of sectors. Higher emphasis on education, in the context of national development, also indicates a transition to higher value manufacturing and services, with employment generation being more concentrated in specialty areas where Malaysians already excel, but do not find suitable domestic employment opportunities.

- Taxation: a reduction in selected brackets of taxation on income and profits are advised to increase households' disposable income in the short term and encourage private investments. Specific manufacturing and service sectors may also be selected, to encourage expansion and economies of scale. Higher household revenues from higher production and employment, combined with lower taxation should increase the savings and investment rate, further stimulating the economy and creating a positive feedback loop.

- FTA: the definition of an FTA targeting access to market is advised to create synergies with investments in infrastructure and education, effectively making use of improvements in competitiveness from the supply (domestic) side. An FTA should be tailored around specific needs and opportunities related to the sectors that can promote the economic transformation, with emphasis on technology transfer. Existing sectors, in which Malaysia already excels in low cost and effective production, could also be included in the agreement, as public and private investments would likely soon be shifted towards new sectors, making access to market a good factor supporting traditional sectors. An FTA, in concert with improved competitiveness and strong growth is also very likely to increase FDI.

- Borrowing: in order to support short-term economic growth (in case energy prices and regional economic growth do not support the transition as expected) a higher deficit could be approved -but limited to the short term- to support economic growth as done in the 2008-2010 period. With the economic transformation being crucial to Malaysia's development for the decades to come, such measure could be evaluated.

Analyzing more in detail the projected GDP growth rate it can be noted that the combination of interventions simulated, both on energy and trade, yield a similar growth rate as BAU until 2013, to then show higher growth throughout 2030. The short term, due to the removal of energy subsidies is the most critical period analyzed, and specific interventions, especially on economic development -although possibly not necessary if regional growth exceeds expectations and energy (market) prices are below current projections- have been suggested to offset the negative impacts of higher energy prices. Reduced pressure from energy prices and more coordinated economic development make so that GDP growth remains constantly above BAU in the medium and longer term, when the advantages of short-term investments come to fruition.

Finally, key risks to be considered include:

- The future rate of change of energy prices: the timing for the removal of subsidies, and future trend in prices, could possibly lead to very small -or considerable impacts- on consumption and households.
- The future economic growth of the region: higher (lower) than expected growth could push production beyond (below) BAU making the removal of energy subsidies less (more) relevant and synergies on economic development and trade stronger (weaker).
- The rebound effect, with its impacts on energy costs: the projected increase in energy prices and efforts in energy efficiency are likely to have a negative impact on energy demand and productivity. While a reduction in demand is welcome, it is important that the rebound effect does not fully offset the gains made in efficiency. In such a case costs would be higher than BAU, despite investments -and progress- in energy efficiency.

6. Potential Model Improvements

The T21-Malaysia model v.3.3, the final version developed for this project, is highly focused on energy and trade but accounts for several sectors across social, economic and environmental spheres. Several expansions and improvements can be contemplated going forward, to both add detail and cross-sectoral representation to the model. More specifically:

- T21-Malaysia could be expanded to analyze additional sectors, and policies in more (integrated) detail. For instance, a finer disaggregation of manufacturing sectors could be carried out to improve the analysis of energy and trade interventions on energy intensive and trade exposed sectors. This exercise has been carried out for several countries already, but lack of data limits the additional of disaggregated manufacturing sectors (representing, among others, production output, employment, as well as energy inputs - direct and feedstock use-, capital and labor costs).

- A second area of expansion could be the analysis of the goods and services tax (GST). In order to analyze the impact of such change to taxation, despite being envisaged as a mechanism that does not generate net revenues for the government, the national accounts would need to be expanded and analyzed in more detail.

- A third area of expansion, adding detail to the representation of energy consumers and producers, could regard the estimation of gains and losses for each of the main actors in the energy sector under different policy scenarios (which could also be added to evaluate specific strategies worth considering, such as capital investment, targets and subsidies).

- A fourth area of analysis, possible through the addition of detail to the current version of the model, is the education sector. In this case the quality (rather than the capacity) of the Malaysian education system could be analyzed.

- On top of expanding the structure of the model, a geographical disaggregation could be added to evaluate the specific structural characteristics (from a causal -CLD- perspective) and policy costs, as well as impacts of selected geographical areas.

- The model could also be improved to carry out specific analyses that would target sectors of interest. Two examples could be (1) a transport sector analysis, where modules of T21 exist that account for several transport modes, vehicle and engine types, as well as energy sources; and (2) the computation of competitiveness indicators using outputs from T21-Malaysia to directly evaluate areas of strength and weaknesses of Malaysia’s economy.

Overall, it is envisaged that potential areas of improvement will be selected in concert with the needs and requirements of selected stakeholders, to make the best use of the cross-sectoral nature of the model, have access to the best available information to further customize the model, and carry out a thorough validation.

7. Conclusions

In light of the profound and challenging evolution facing Malaysia in the next decade, the project titled *"Comprehensive National Development Planning -with emphasis on energy and trade- using Threshold 21 (T21)"* was undertaken by the Economic Planning Unit in collaboration with the Millennium Institute (MI) in June 2011. The main objective of the project is to provide the Government of Malaysia (Government) with a dynamic integrated tool -"T21-Malaysia"- able to support policy formulation and evaluation in key trade and energy sectors, as linked to broader economic, social and environmental ones. T21-Malaysia has been customized with the support of local teams working on energy and trade, and has been used to simulate a wide variety of interventions and scenarios.

Project and Model Overview

The project consists of three main phases, namely, (1) training, (2) model creation, (3) analysis and dissemination of the results. The project developed over 7 months, between June and December 2011. Key milestones were set, and achieved, for data collection (month 1) and model development (month 2 through 4). The finalization of the model and the preparation of the final report were completed in October and December respectively.

T21 is a System Dynamics based model designed to support national development planning. T21 is structured to analyze medium-long term development issues at the national level. The model integrates in a single framework, the economic, the social, and the environmental aspects of development. Its comprehensiveness and level of aggregation make it ideally suited to support comprehensive analysis of different governmental strategies. T21 can also serve as a complement to budgetary models and other short-medium term planning tools by providing a comprehensive and long-term perspective on development. As a result of the variety of issues considered, T21-Malaysia is a relatively large size model accounting for 87 stock variables and several thousand feedback loops. Given the size and the level of complexity of the model, its structure has been reorganized into smaller logical units, labeled as modules. The 45 modules comprising T21-Malaysia are grouped into 18 sectors: 6 social, 5 economic and 7 environmental sectors.

Interventions and Scenarios

Several interventions are analyzed in this study with T21-Malaysia, most of which are based on the 10th Malaysia Plan (EPU), the New Economic Model (NEAC) and the Economic Transformation Programme (PEMANDU, 2010). Certain interventions observed in recent history were also tested, to strengthen the transition to a transformed economy, based on high value products and services and focused on efficiency improvements to drive international competitiveness.

The interventions listed below are analyzed both independently (in isolation) and combined, to improve the understanding of specific contributions to reaching stated goals and eventual synergies and bottlenecks created within and across sectors.

- The Business as Usual (BAU) scenario assumes a continuation of existing trends, with no changes in policy ad no reaction to eventual improvements of worsening of the economic performance of the country. Two BAU scenarios are simulated and analyzed (1) subsidized energy prices, (2) subsidized energy prices, adjusting for imports at market price.

- For the alternative scenarios, a variety of interventions are analyzed, for both energy and trade, as listed below:

    - Oil and gas subsidy removal; energy efficiency improvement; renewable energy (power generation) expansion; avoided nuclear power generation; limited gas exports.

    - Port cargo, air cargo and passenger and broadband connectivity investments; R&D investments; education investment; reduction in the taxation of income and profits; implementation of an FTA aimed at increasing access to markets; increased public deficit; and assumptions related to increased propensity to save and higher FDI.

A few additional scenarios were considered to analyze the adequacy of policies and interventions currently being discussed under varying assumption on key macroeconomic themes, such as a potential economic crisis in 2015 (with two cases of different duration and strength) and higher energy prices (with two cases of a peak and steady increase).

Main Results

The key results of the "All & Sustainability" scenario, the most comprehensive set of interventions simulated, are presented below:

- The real GDP growth rate averages 5.3% per year and results to be higher than BAU by 0.8% per year on average, reaching its highest value of 1.2% per year above BAU after 2020. Thanks to an increase in productivity, investment and market access, GDP will reach close to RM970 billion in 2020 and RM1,670 billion in 2030, 5.5% and 18% above BAU respectively.

- Comparing cumulative values by 2030 for additional GDP (approximately RM1,700 billion), the additional investment simulated (both public and private, approximately RM1,000 billion), as well as avoided costs (RM255 billion), positive economy-wide return on investment would be reached before 2030 (but certain economic actors would certainly see a net benefit well before 2030). This analysis should also be put in the context of the relevant (and growing) amount of international reserves being accumulated at the national level.

- Per capita income is projected to reach close to RM50,700 per capita (nominal, or current) and surpass the national target of RM49,500 in 2020.

These projections are 8% and 20% above BAU in 2020 and 2030 respectively.

- Total employment is projected to reach close to 16.3 million people by 2020, reaching the target employment level and pushing a transition to high skill employment going forward.

- Matching the existing targets, imports are projected to reach close to 111% and 120% of GDP by 2015 in the BAU and "All & Sustainability" scenarios respectively. Exports are expected to reach 117% and 124% of GDP by 2015 in the BAU and "All & Sustainability" scenarios respectively.

- Energy demand is projected to grow at a much lower rate than BAU throughout the simulation, averaging 0.08% until 2015, 1.9% until 2020 and 2.7% between 2011 and 2030.

- Despite slightly lower power demand, the increasing use of renewables requires higher total installed capacity: 3 GW by 2020 and close to 10 GW by 2030 (or 16% above BAU). Higher capacity generates more employment, twice as much as in the BAU case, and requires higher investment.

- Power generation costs, and prices are projected to increase above BAU in the short term (RM0.8 per kWh in 2017), due to the removal of subsidies and investments in renewable energy, and will remain about constant after 2015 (RM0.76 per kWh in 2030) and below BAU shortly after 2020.

- Fossil fuel GHG emissions intensity (calculated as emissions over GDP) declines by 10%, 18% and 25% relative to BAU by 2015, 2020 and 2030 respectively, or 35% below its 2005 value.

Energy and Trade Strategy

The definition of a strategy for the energy and trade sector of Malaysia, in the context of national development (and therefore considering existing cross-sectoral targets), starts from the analysis of the relevant dynamics that are going to shape the energy sector in the next few years. In light of these challenges, and to reach stated goals and ensure a coherent cross-sectoral development, the following steps and actions are proposed:

Energy sector: oil and gas subsidy removal; enhanced energy efficiency improvement; higher renewable energy power generation (and emphasis on low carbon power generation); flexible agreements for gas exports.

Trade sector: higher infrastructure investment; more targeted and higher research and development investment; reduced taxation on income and profits; definition of on FTA targeting access to market; increase public borrowing (primarily form foreign sources).

Key risks to be considered include (1) the future rate of change of energy prices, (2) the future economic growth of the region, and (3) the rebound effect linking energy and economy.

Institutionalization

The adoption of the Threshold 21 Model by the Government of Malaysia is a significant effort aimed at long-term capacity and institutional development and should be considered an ongoing activity for the long term. To assure institutionalization of the model, MI recommends (1) defining an institutional home -and core team- for the model ahead of the completion of the MI project; (2) utilizing the model on a continuous basis; (3) ensuring multi-stakeholder participation; (4) guaranteeing continuous capacity development; (5) allocating funding to support continuous development and use of the model.

Annexes

Annex I: Conversion of Energy Units

Energy quantities can be expressed by a variety of units. In this analysis and T21-Malaysia model, the energy unit "ktoe" (thousand tons of oil equivalent) is the main unit used to measure energy flows. The **Table 19** below shows how major energy units are converted into ktoe.

Table 16: Conversion of energy units to ktoe

From:	To ktoe, multiply by:
General Conversion	
Million Btu (Mbtu)	2.52 E-05
GWh	8.60 E-02
Terajoule (TJ)	2.39 E-02
Specific Energy Source	
Barrel of oil	1.46 E-04
Tcm of natural gas*	9.14 E+05

* Tcm: Trillion cubic meter.

Sources:

- U.S. Energy Information Administration (EIA), Energy Conversion Calculators (http://www.eia.gov/energyexplained/index.cfm?page=about_energy_conversion_calculator)
- International Energy Agency (IEA), Unit Converter (http://www.iea.org/stats/unit.asp)

Annex II: Sensitivity Analysis

A series of sensitivity analyses has been carried out to show the range of possible results of key indicators when by simulating different assumptions. For each sensitivity analysis a random uniform distribution is used for the simulation of 200 scenarios (i.e. Monte Carlo Simulation) where the value of a selected parameter changes within a specific range, so as to provide insights on the impacts of the underlying assumption. A total of six parameters have been selected, as follows:

1. Elasticity of services TFP to broadband connectivity
2. Elasticity of industry TFP to R&D investment
3. Oil resources
4. Renewable power generation operations and maintenance labor intensity
5. World crisis magnitude
6. Effect of FTA market access on export

The scenarios of altering these six parameters and the corresponding assumptions, and their effects on the key indicators are described below.

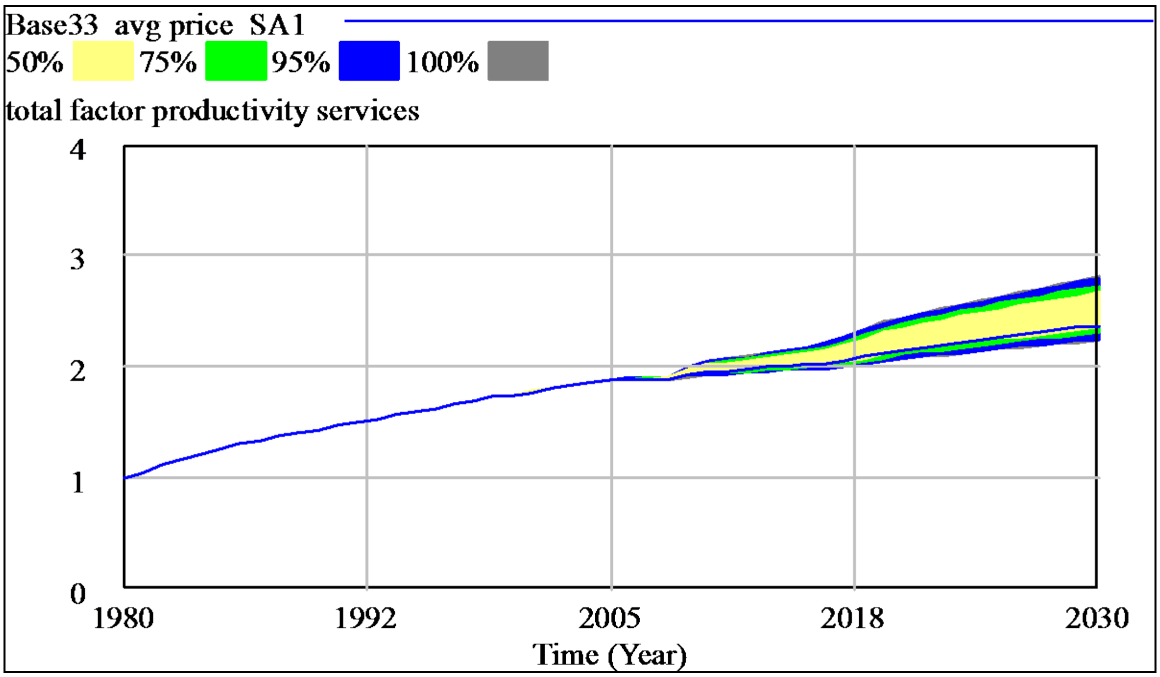
1. Elasticity of services TFP to broadband connectivity

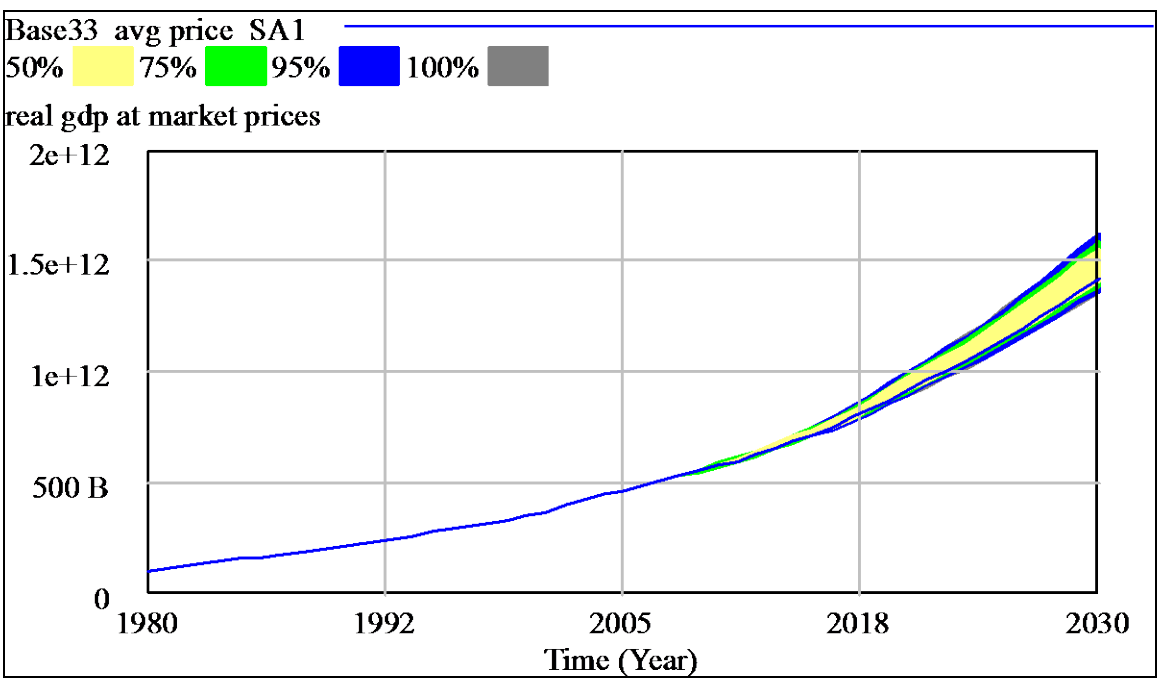
To evaluate the degree of impacts of broadband connectivity on productivity and the economy, we simulated 200 different scenarios, in relation to the BAU case, with the elasticity of services TFP to broadband connectivity ranging from 0.1 to 0.9 (respectively 1/3 and 3 times of the BAU value of 0.3).

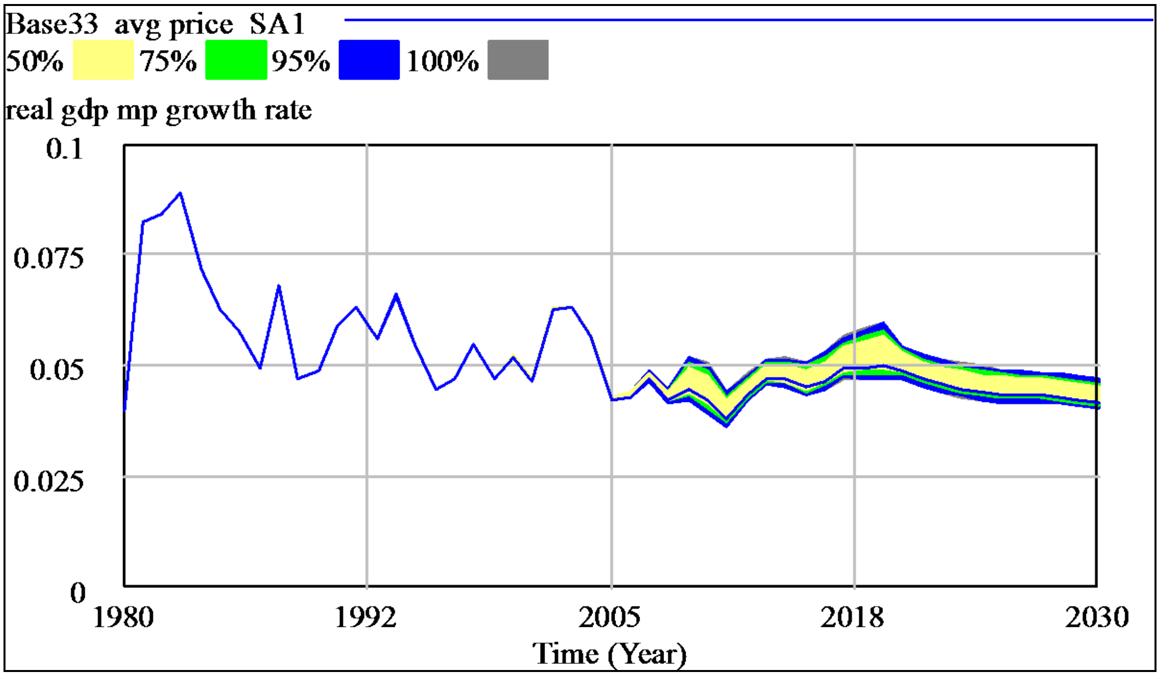
These simulations show that with the expected expansion of broadband, a higher effectiveness for broadband connectivity of services TFP to would increase services productivity, real GDP and GDP growth rate (See **Figure 46**). Among the simulated scenarios, services TFP falls in the range of between around 2.2 and 2.8 in 2030 (compared to 2.4 in BAU), driving GDP to reach between above RM1.3 trillion and

RM1.6 trillion (RM1.4 trillion in BAU). Along the same line, GDP growth per annum ranges from slightly above 4% in BAU to almost 5%.

Figure 41: Results of sensitivity analysis for services TFP, real GDP and GDP growth rate





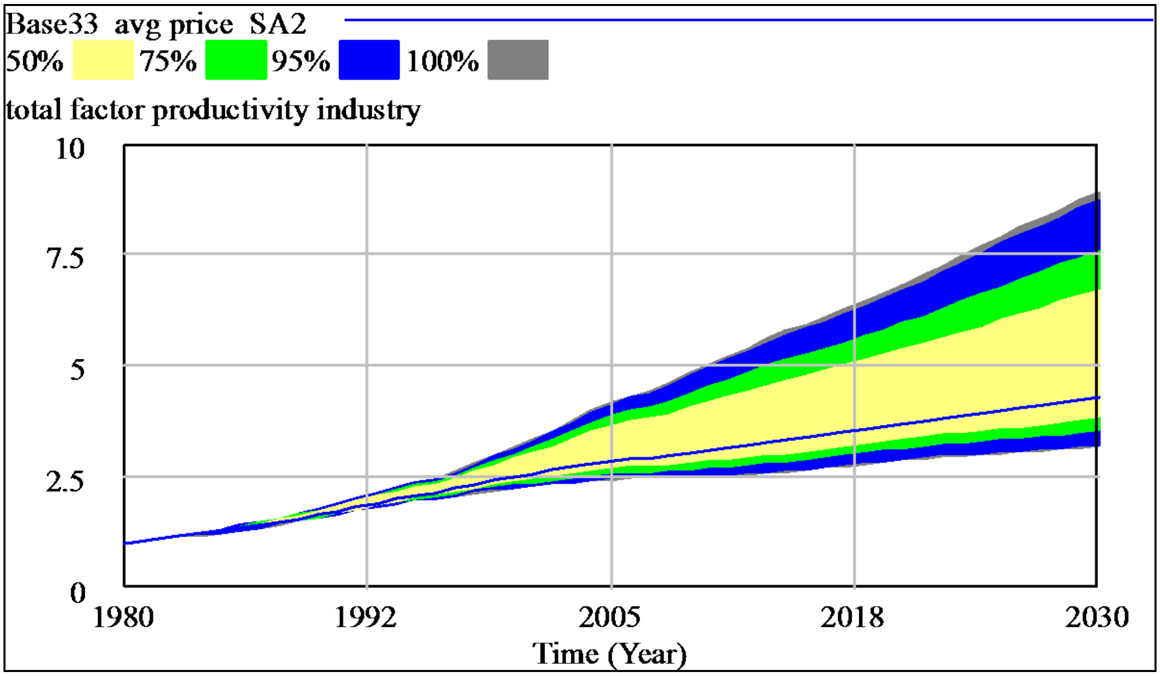


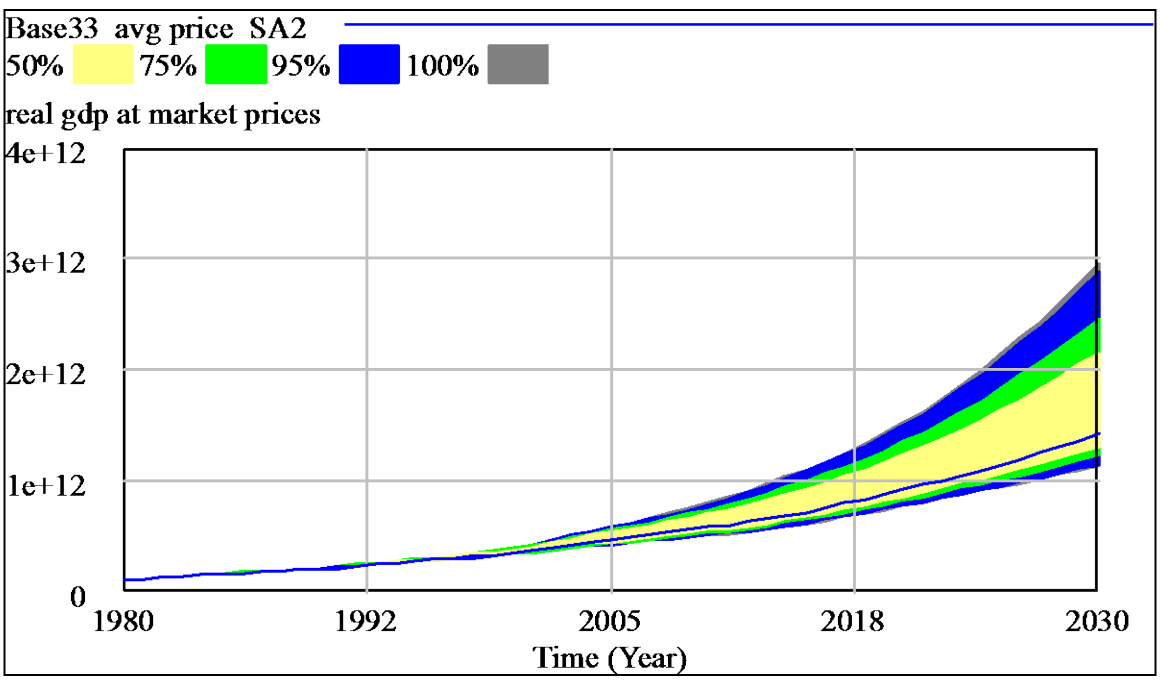
2. Elasticity of industry TFP to R&D investment

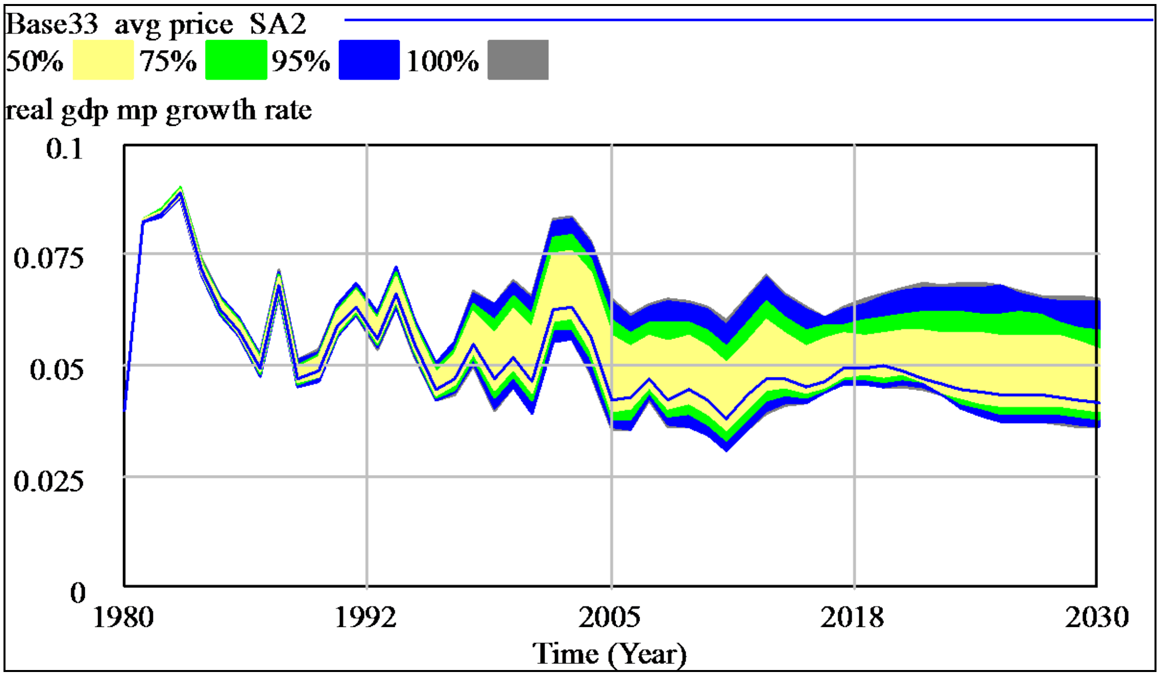
Similarly, with the projected strong increase in R&D investment under the BAU case, industry productivity improves rapidly if R&D investment becomes more effective (higher elasticity), leading to significantly higher GDP value and annual growth rate.

As is illustrated in **Figure 47** below, in the case that the elasticity of industry TFP to R&D investment subject to the range of between 0.075 and 0.3 (compared to 0.15 in BAU), industry TFP varies between around 3 and above 8 in 2030, with the highest value doubling the BAU level of 4.3. Consequently, real GDP ranges from above RM1 trillion up to close to RM3 trillion (RM1.4 trillion in BAU), and GDP growth rate from around 3% to 6% per annum (4% in BAU).

Figure 42: Results of sensitivity analysis for industry TFP, real GDP and GDP growth rate







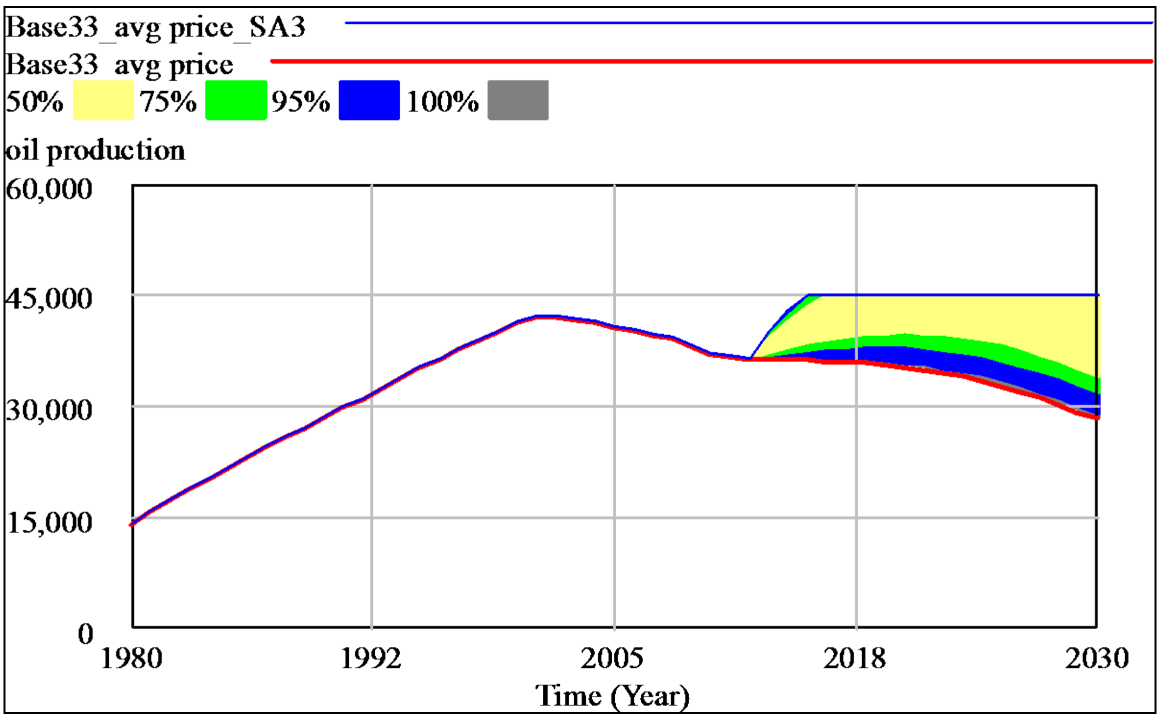
3. Oil resources

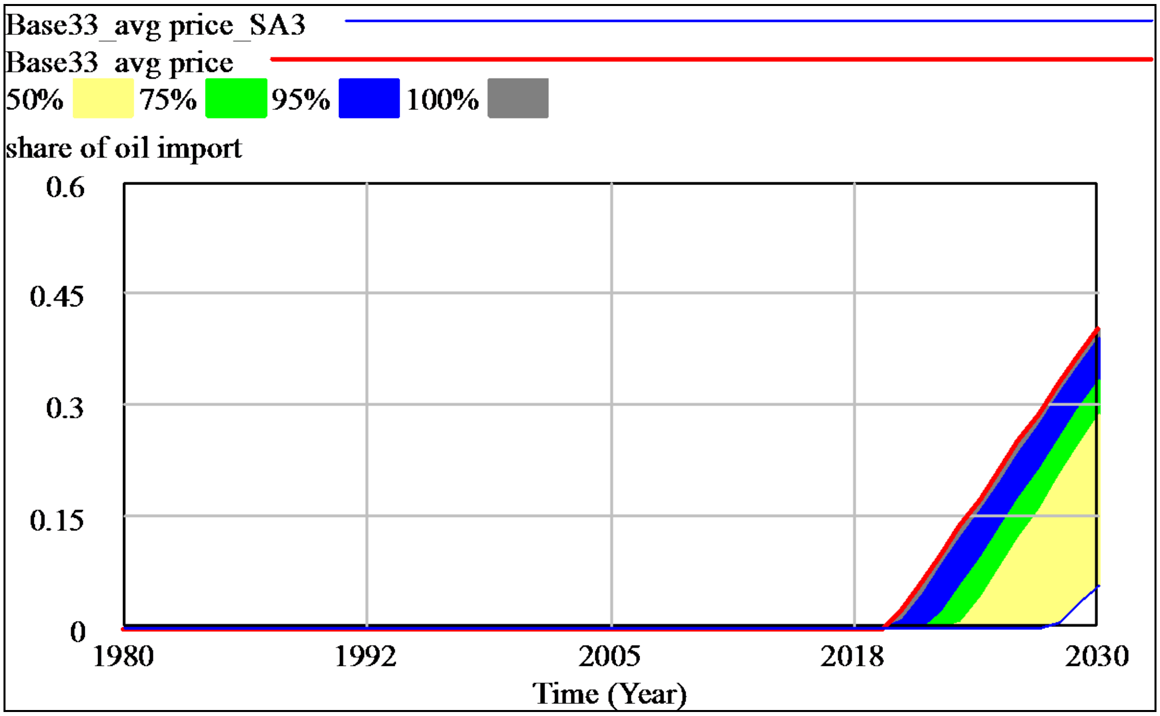
The following sensitivity analysis investigates the potential impacts of additional oil reserves (from discovery of new fields or extra exploration of existing ones). A series of scenarios are simulated where the incremental oil discovery (on top of BAU) ranges between 0 and the baseline volume (from 30,000 ktoe per year in 2012 to around 18,000 in 2030, meaning that total oil discovery ranges between the same amount and twice the baseline from 2012.

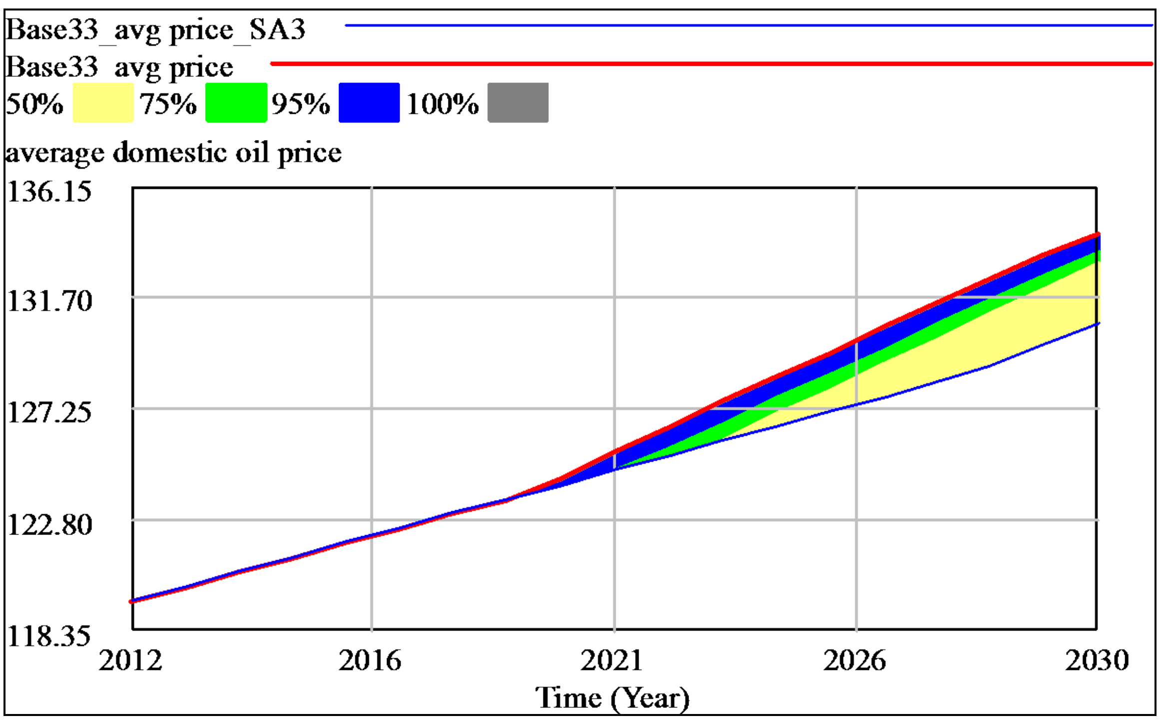
In the extreme scenario of doubling oil discovery per year from 2012, total oil reserve reverses the downward trend in BAU, and instead increases significantly from 300,000 in 2012 to the peak of close to 400,000 in 2025, which then declines to around 370,000 in 2030 (See **Figure 48**). The higher reserves allow annual production to increase again, reaching the production limit from 2015 through to 2030. This contributes to a delay for the country to become a pure oil import till close to 2030, from 2018 in BAU case. The share of import is also reduced to around 6% from as high as 40% in the BAU.

Moreover, the combined effect of a relatively adequate oil supply and larger share in utilization of the expensive domestically produced sources (due to smaller imports) allows a slower pace in the increase of oil prices. That is, Malaysia average domestic oil price follows the domestic subsidized price until 2028 when the increasing imports pushing the price up to closer to the market level.

Figure 43: Results of sensitivity analysis for oil production, share of oil import and oil price




Base33_avg price_SA3
Base33_avg price
50%
75%
95%
100%
share of oil import
0.6
0.45
0.3
0.15
0
1980
1992
2005
2018
2030
Time (Year)

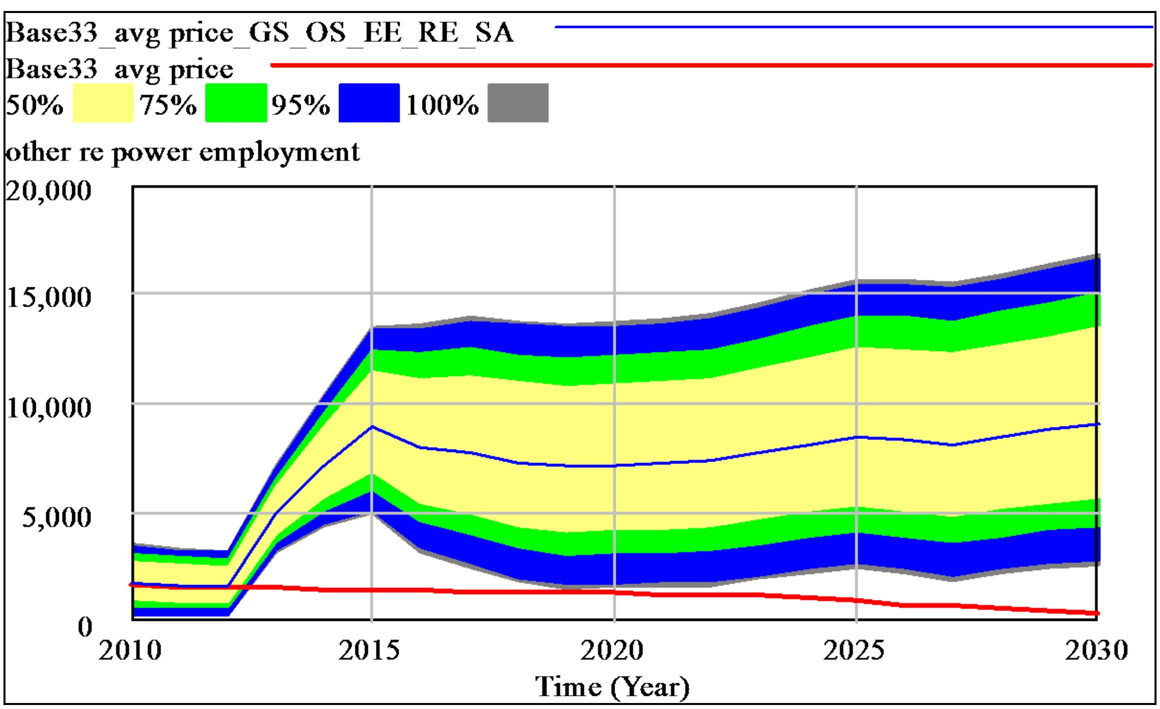

Base33_avg price_SA3
Base33_avg price
50%
75%
95%
100%
average domestic oil price
136.15
131.70
127.25
122.80
118.35
2012
2016
2021
2026
2030
Time (Year)

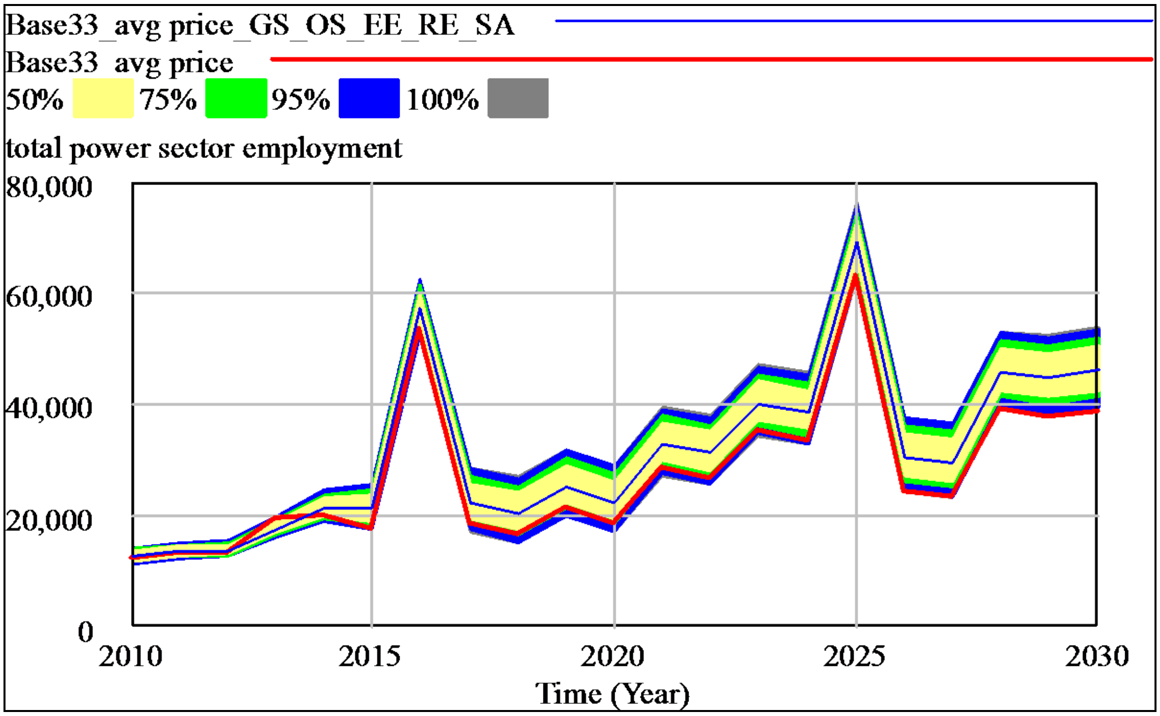
4. Renewable (RE) power generation operations and maintenance labor intensity

An analysis has been conducted to evaluate the possible employment created by the expansion of RE power generation capacity. On top of the scenario that promotes RE power generation from 2013 ("Base33_avg price_GS_OS_EE_RE.vdf"), we have simulated a variety of scenarios where each MW of RE power capacity requires between 0.3125 employees (same as for oil and gas power plants) and 4.25 employees (doubling the BAU level of 2.123) in plant operations and maintenance.

Simulation results show that even in the extreme case that RE power labor intensity is reduced to the value of oil and gas power (around 1/7 of BAU), the intervention of ambitious RE expansion starting from 2013 always results in gains in both RE and overall power sector employment (**Figure 49**). By 2030, power generation sector will potentially create 2,000-16,000 jobs in renewable energy and around 40,000-52,000 jobs in total (compared to 9,000 and 46,000 respectively in BAU).

Figure 44: Results of sensitivity analysis for power generation employment from renewables and total power sector employment



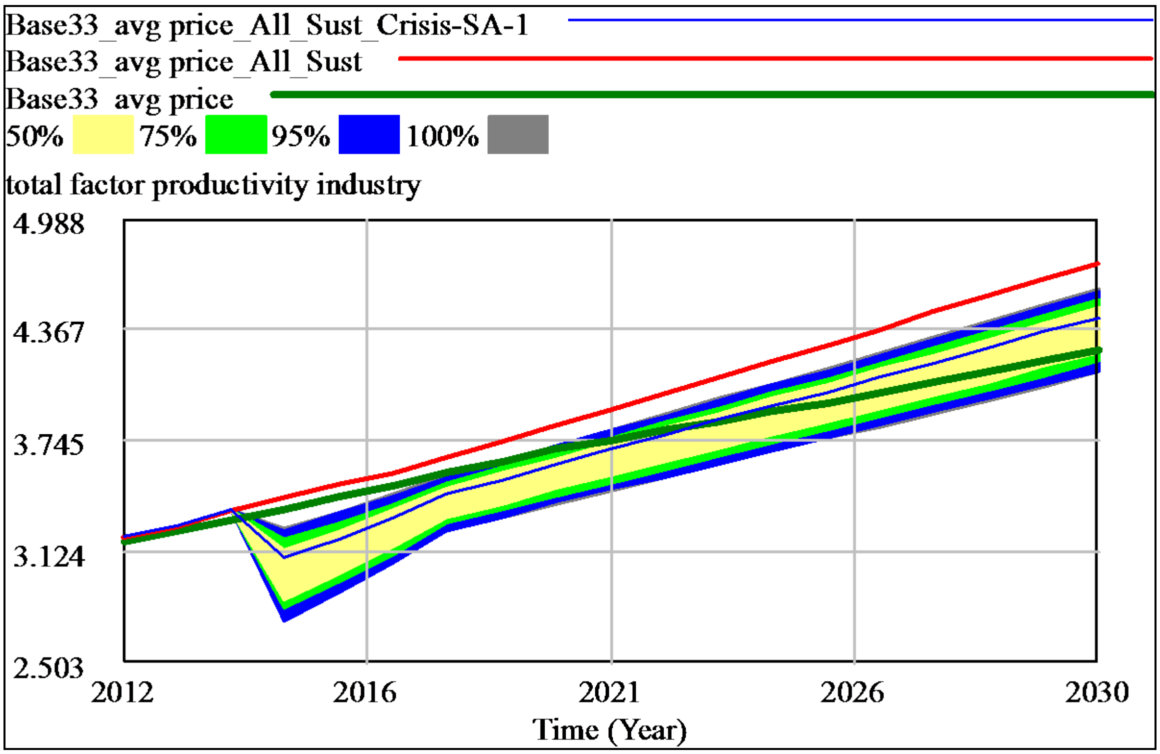


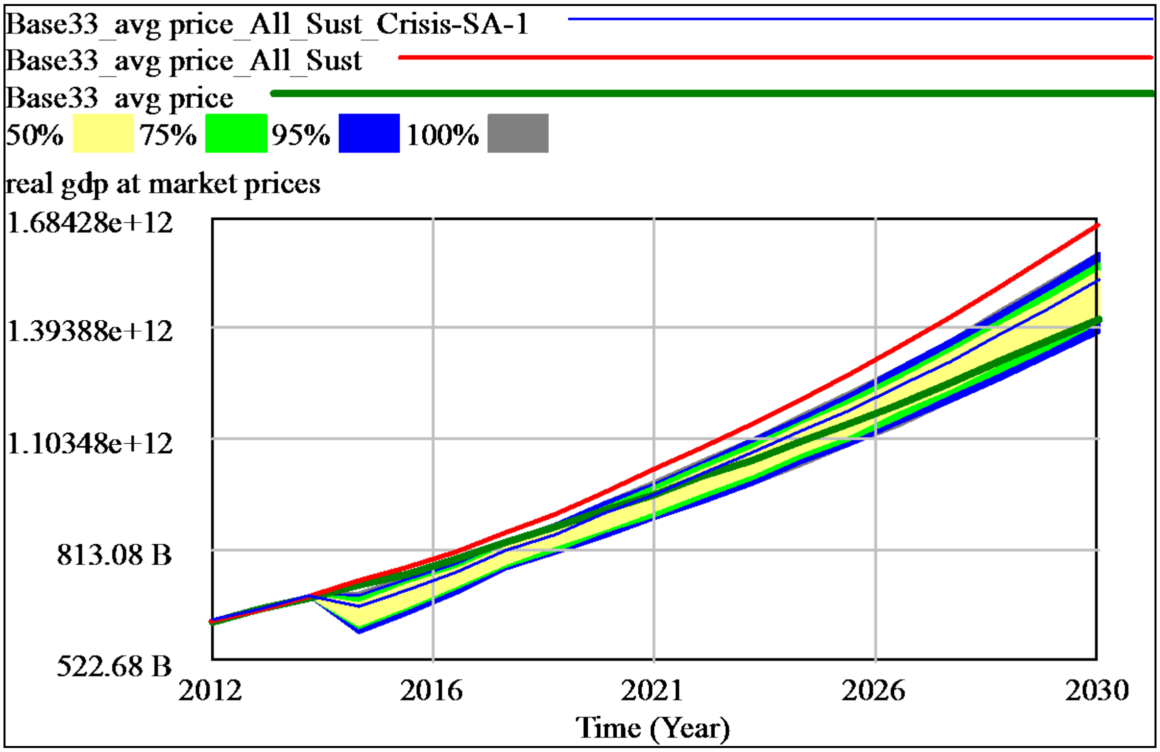
5. World crisis magnitude

In section 5.3.1 above, the scenario of a potential 2015 worldwide economic crisis like the one in 2008-2009 ("All & Sustainability - Crisis" scenario) is presented. Considering the uncertainty of the magnitude of such an event, a range of scenarios has been simulated to evaluate possible impacts of different crisis sizes, ranging from half to twice the BAU-Crisis level.

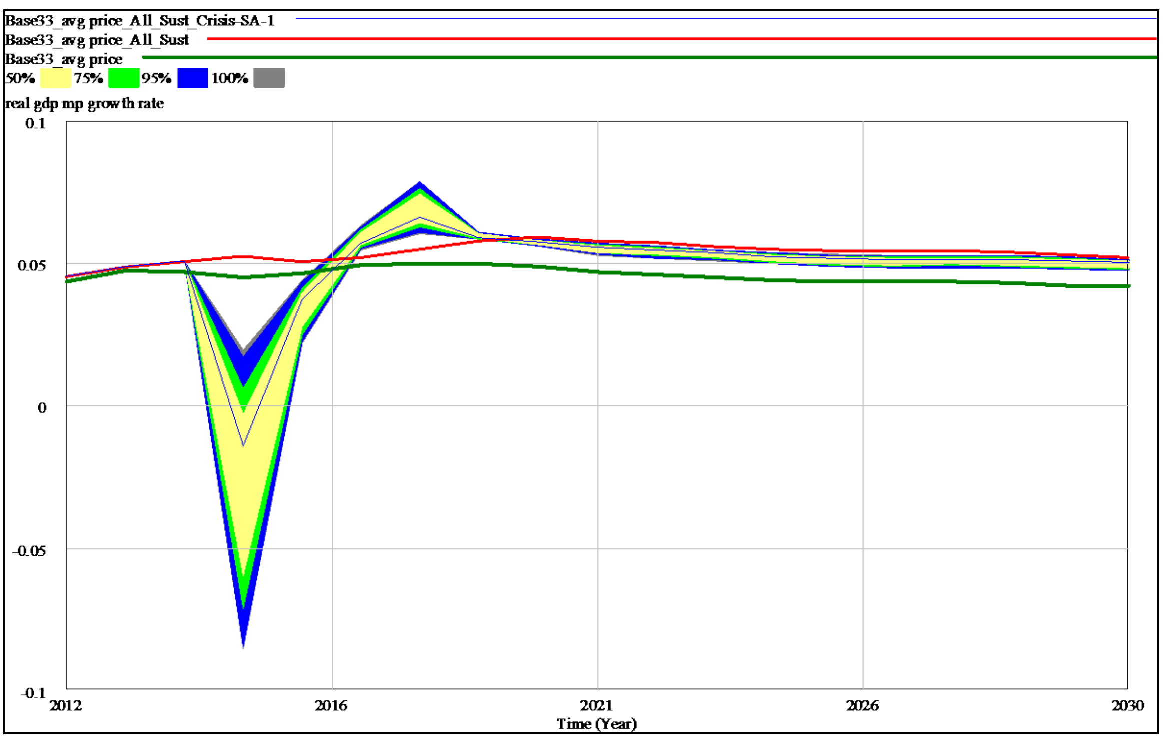
In the two extreme cases, the capacity utilization is reduced by 5% and 20% in the period 2014-2015, and recovering to 2.5% and 10% by 2018 respectively. Results of these simulations indicate that, when magnitude of recession is halved, the recovery is faster and stronger: industry TFP and consequently GDP will exceed the BAU by 2019 thanks to the combined interventions, which is 3-4 years ahead of the All & Sustainability - Crisis scenario (**Figure 50**). On the other hand, doubling the recession size would cause industry productivity and GDP to remain below the BAU level through to 2030 despite the implementation of all interventions, while the damage shrinks over time. Along the same line, the GDP growth rate is reduced to -8% - 2% as the crisis strikes in 2015, which then rises to the peak of 6% - 8% when entering the recovery phase in 2018. In the longer term, it gradually declines to slightly below the "All & Sustainability" scenario.

Figure 45: Results of sensitivity analysis for industry TFP, real GDP and GDP growth rate





Base33_avg price_All_Sust_Crisis-SA-1
Base33_avg price_All_Sust
Base33_avg price
50% 75% 95% 100%
real gdp at market prices
1.68428e+12
1.39388e+12
1.10348e+12
813.08 B
522.68 B
2012
2016
2021
2026
2030
Time (Year)

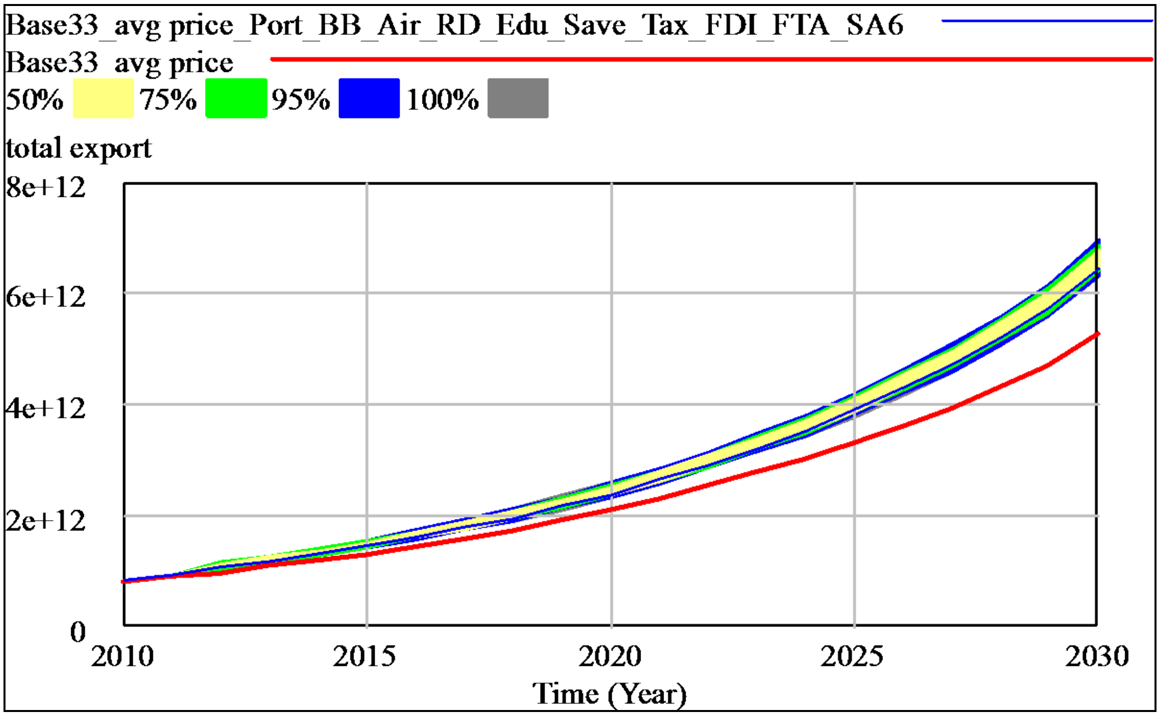


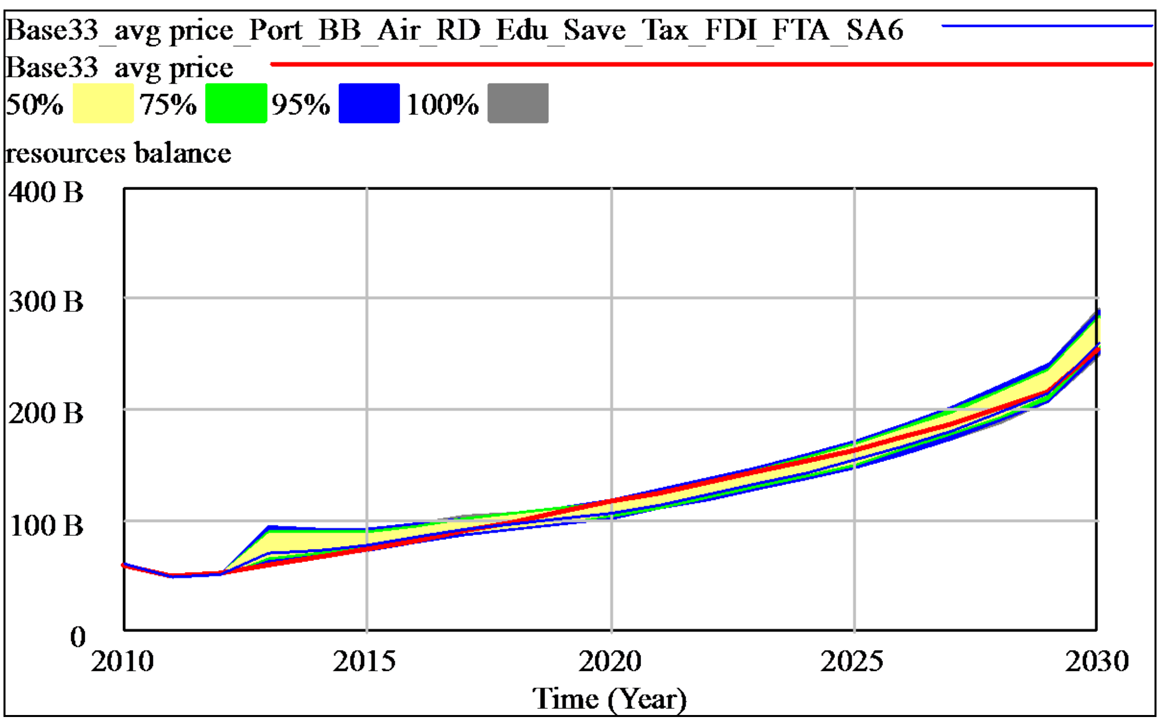
Base33_avg price_All_Sust_Crisis-SA-1
Base33_avg price_All_Sust
Base33_avg price
50% 75% 95% 100%
real gdp mp growth rate
0.1
0.05
0
-0.05
-0.1
2012
2016
2021
2026
2030
Time (Year)

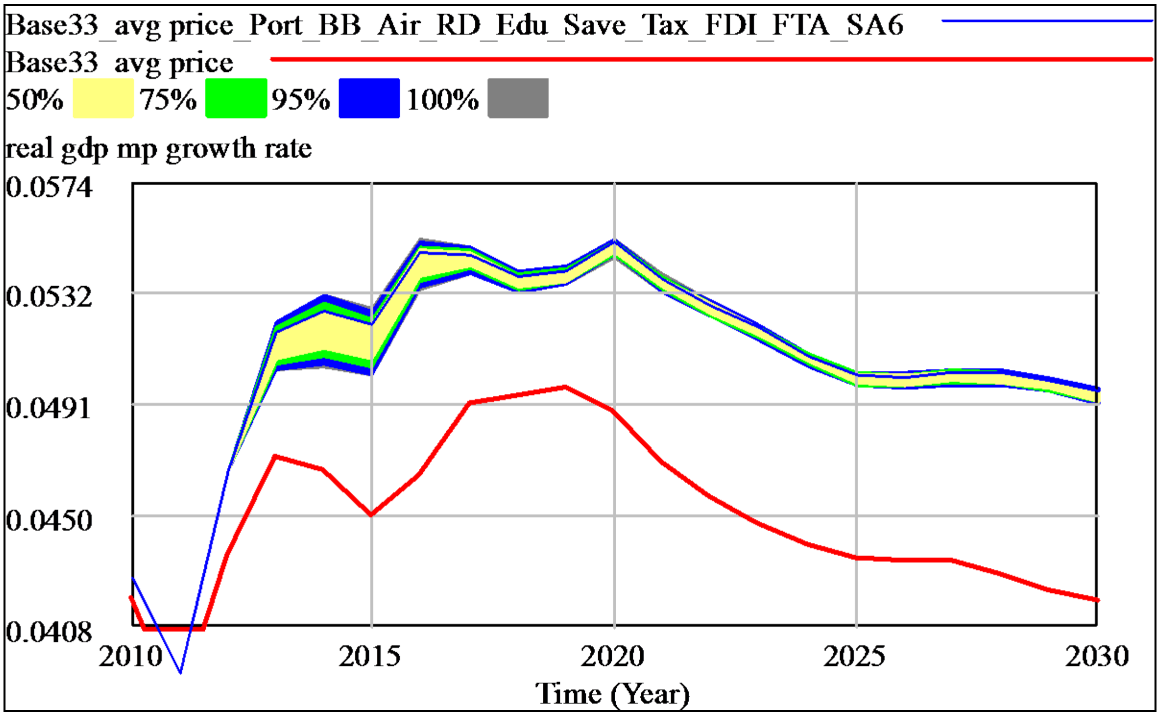
6. Effect of FTA market access on export

Finally, we evaluate the effectiveness of FTA interventions after 2012 by simulating a number of scenarios where the increase in market access supported by FTA implementation boosts trade volume by 2.5%-10% (compared to 5% in the FTA intervention scenario) (see **Figure 51**). As a result, total export ranges from RM5.6 trillion to RM6.2 trillion in 2030 (compared to RM5.6 trillion and RM4.7 trillion in the scenario of FTA interventions and the BAU respectively). The implementation of FTA in 2013 leads to immediate gains in the resources balance. However, as total import is also gradually boosted in the context of better economic performance, resource balance falls below the BAU with the difference shrinking after 2020 in the case of smaller effect of FTA. On the other hand, the resource balance remains above the BAU level through to 2030, meaning that the higher increase in market access permits the additional export volume to prevail imports throughout the simulation period. The higher competitiveness would also stimulate economic development above the baseline. In 2030, GDP will reach RM1.58-1.61 trillion, close to the RM1.6 trillion in the FTA scenario. While the GDP growth rate upsurges in 2013 to different extents in the two extreme cases, it converges after 2020 to around 5% in 2030.

Figure 46: Results of sensitivity analysis for total export, real GDP and GDP growth rate







Base33_avg price_Port_BB_Air_RD_Edu_Save_Tax_FDI_FTA_SA6
Base33_avg price
50%
75%
95%
100%
real gdp mp growth rate
0.0574
0.0532
0.0491
0.0450
0.0408
2010
2015
2020
2025
2030
Time (Year)

Annex III: Model Documentation

Social Sectors

1. Population module

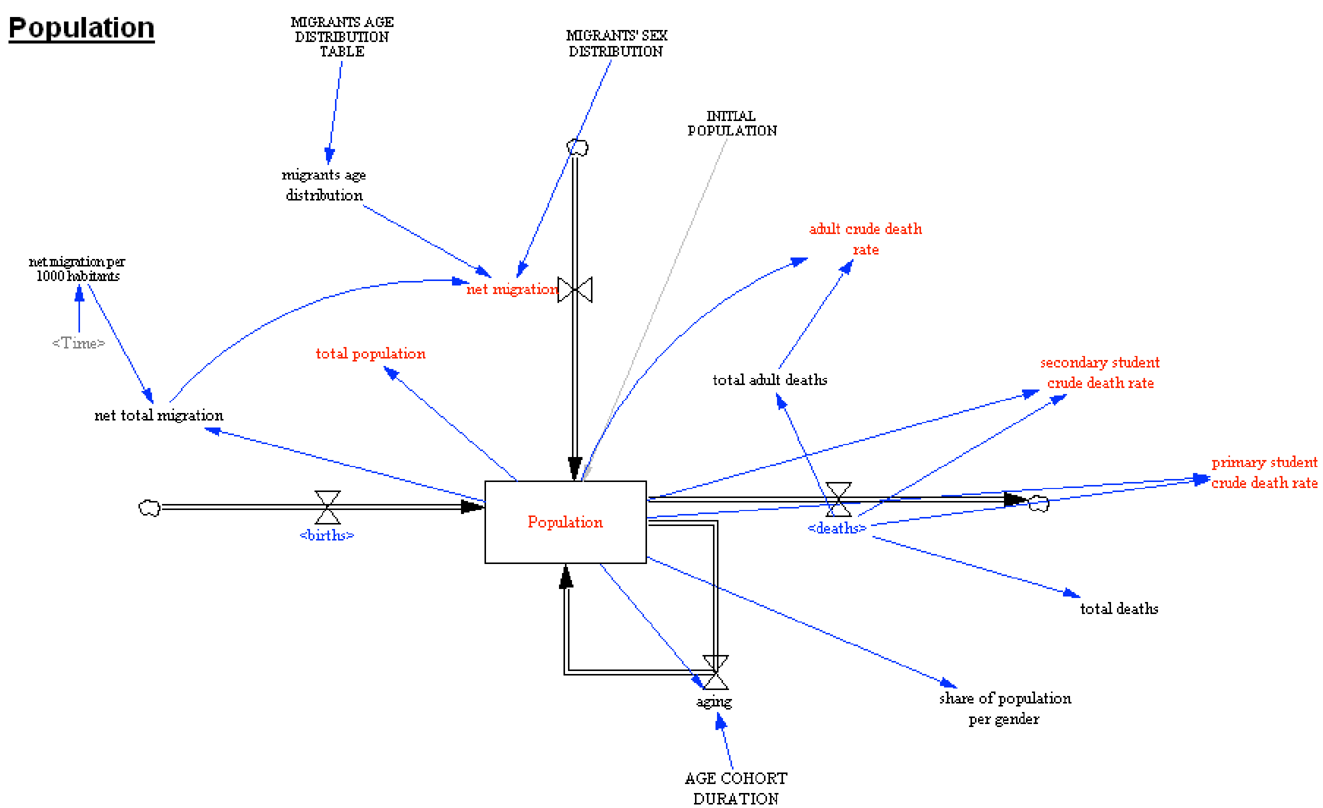


Figure 47: Sketch of the Population module

Purpose and Perspective

Since population levels and growth rates have a major influence on development, a long-term model of the development process requires an endogenous treatment of both fertility and mortality. The model needs to capture the dynamics of major factors that influence fertility and mortality and also the major ways in which population and growth rates influence development.

The T21 Population module (see **Figure 52**) simulates total population and population age-distribution based on endogenous fertility and mortality. The endogenous formulations are presented below in the sections on Fertility and Mortality modules.

In the T21 Population module, the population stock is an accumulation of three flows: births, deaths and net migration. The Population module is a coherent component model with 82 age cohorts (new born, age 0 to 80 and over) for both genders.

While population data from the best available source (the UN) comes in five-year age cohorts, we use a one-year age cohort structure because it gives us greater flexibility and accuracy. This flexibility is especially important for handling age-specific matters in other sectors of the model. For example, countries and organizations use different definitions of the ages covered by “infant mortality rate”. Also, the age at which children enter school varies by country. The flexibility of using one-year age cohorts in T21 makes for easy application of the model in any country and does not significantly complicate the programming or data input.

Explanation

Major Assumptions

- All births happen at the first of the year
- The aging process (the shift of individuals from one age cohort to the next) happens only at the first of each year
- Net migration is exogenously determined
- Immigrants have the same fertility and mortality behavior as the rest of the population

Table 17: Input variables: Population module

Variable Name	Module of Origin
Births	Fertility
Deaths	Mortality

Table 18: Output variables: Population module

	Destination Module		
Variable Name	**Same Sector**	**Other Social Sectors**	**Other Sectors**
Adult female population share		Secondary Education, Tertiary Education	
Age cohort duration		Secondary Education, Tertiary Education	
Initial total population			Husbandry, Fishery and Forestry, Land
Net migration		Primary Education, Secondary Education, Tertiary Education	
Population	Fertility, Mortality	Primary Education, Secondary Education, Tertiary Education, Labor availability and unemployment	Aggregate production and income, MDGs, HDI and GDI
Primary student crude death rate		Primary Education	
Relative population			Energy demand
Secondary student crude death rate		Secondary Education, Tertiary Education	
Share of population per gender	Mortality		HDI and GDI
Total adult population		Primary Education	
Total population	Mortality	Healthcare, Income Distribution, Nutrition, Roads, Port cargo, Labor availability and unemployment, Income distribution	Husbandry-Fishery-Forestry, Public investment and consumption, Households, Government Expenditure, Relative Prices, Investment, Land, Agriculture, Water Demand, Water

			supply, Fossil Fuel GHG emissions, Ecological Footprint, HDI and GDI

Table 19: Constants and table functions: Population module

Variable Name	Type of Variable	Source for Estimation
Initial Population	Constant	UN Population Data
Migrants' sex distribution	Constant	Local Experts
Migrants' age distribution	Constant	Wils (1996)
Net migration per 1000 habitants	Time Series	UN Population Data

Functional Explanation

The T21 Population module has one stock variable, the *population* stock, which is affected by three flows: *births*, *deaths*, and *net migration*.

The population stock

The *population* stock is disaggregated into 2 genders and 81 age-cohorts. Modeling the age-cohort system and aging process are conceptually straightforward, as illustrated in **Figure 53**. In T21, a flow of *aging* is used to shift the population in each age cohort (minus cohort deaths) to the next age cohort at the end of the year, except the cohort over 80. For this cohort, deaths are subtracted and last year's age 79 cohort is added.

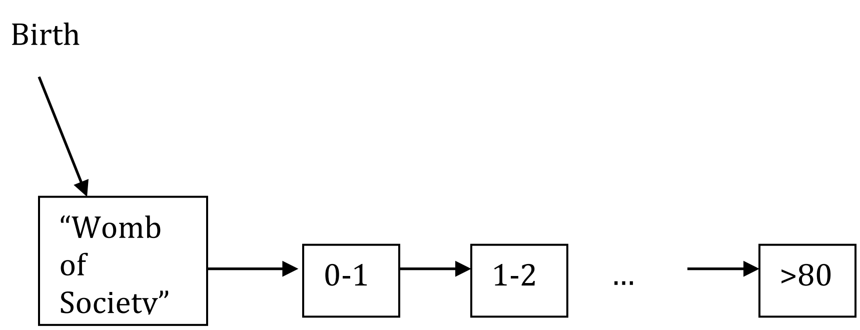


Figure 48: Illustration of the modeling of the ageing process

At the end of each year, the surviving population in each age cohort is moved to the next age cohort, except for the last age cohort. Since the last age cohort does not have a "next" cohort to move to, the population in the last cohort either dies or remains in the last cohort. And since the first age cohort does not have a "previous" cohort, it receives its population from births.

Annual population change is modeled using two equations. The first equation is for the infants born within the year. This first-year population is determined by the addition of births:

Population[sex, AGE 0] = INTEG(births[sex]-aging[sex, AGE 0] -deaths[sex, AGE 0], INITIAL POPULATION[sex, AGE 0])

The function INTEG performs the mathematical process of integration (accumulation), and the subscript *AGE 0* refers to the first age cohort, or the cohort of infants born within that year ("society's womb").

Since no one is born directly into any of the other age cohorts, the second equation (which applies to all other age cohorts) is as follows:

Population[sex, all but youngest] = INTEG(-deaths[sex,all but youngest] +net migration[sex,all but youngest] +aging[sex,all but eldest] -aging[sex,all but youngest], INITIAL POPULATION[sex,all but youngest])

in which "all but youngest" refers to the categories "age 1" to "age over 80".

The variable *initial population* specifies the value for the stock of population for both males and females in each of the 81 age cohorts when the simulation begins, such as 1980 or 1990. The first "age cohort" is initialized at zero at the beginning of the simulation. It is like the "womb of society" and is used to accumulate new births each year.

The flows

As is indicated above, the population stock depends on the flows of *net migration*, *births*, *deaths* and *aging* per year.

Net migration (immigration less emigration) is calculated as an exogenous input and is disaggregated by gender and age. *Net migration* may be set to zero in an actual application if net migration is insignificant for that country.

Details about the calculation of *births* are in the Fertility module section.

Details about the calculation of *deaths* are in the Mortality module section.

The equation of the age-shifting variable aging is as follows:

aging[sex,age] = Population[sex,age]/AGE COHORT DURATION

Other components

In the top right corner of the sketch, crude death rates for adults, primary and secondary students are calculated. These three variables are calculated in a similar way; the sum of deaths for a certain age group divided by the total number of individuals in that group. For example, the *adult crude death rate* is calculated as:

Adult crude death rate = total adult deaths/SUM(Population[sex!,adult age!])

Here the SUM function calculates the total population of both genders and at all adult ages.

These three crude death rates are an important indicator of demographic development and are used in the Production (adult crude death rate) and Education sectors (primary and secondary student crude death rates).

References.

Shorter, F.C., R. Sendek, and Y. Bayoumy, *Computational Methods for Population Projections*, New York: The Population Council, 1995.

Hughes, B., *International Futures (IFS) Documentation*, Working Draft 1, 1997.

Sehgal, J., *An Introduction to Techniques of Population and Labor Force Projections*, International Labor Office, Geneva, 1989.

US Immigration and Naturalization Service, *1993 Statistical Yearbook of the Immigration and Naturalization Service, Washington: US Government Printing Office, 1993*.

A. Wils, 1996, PDE-Cape Verde: *A Systems Study of Population, Development, and Environment, Laxenburg, Austria*: IIASA, WP-96-009.

2. Fertility module

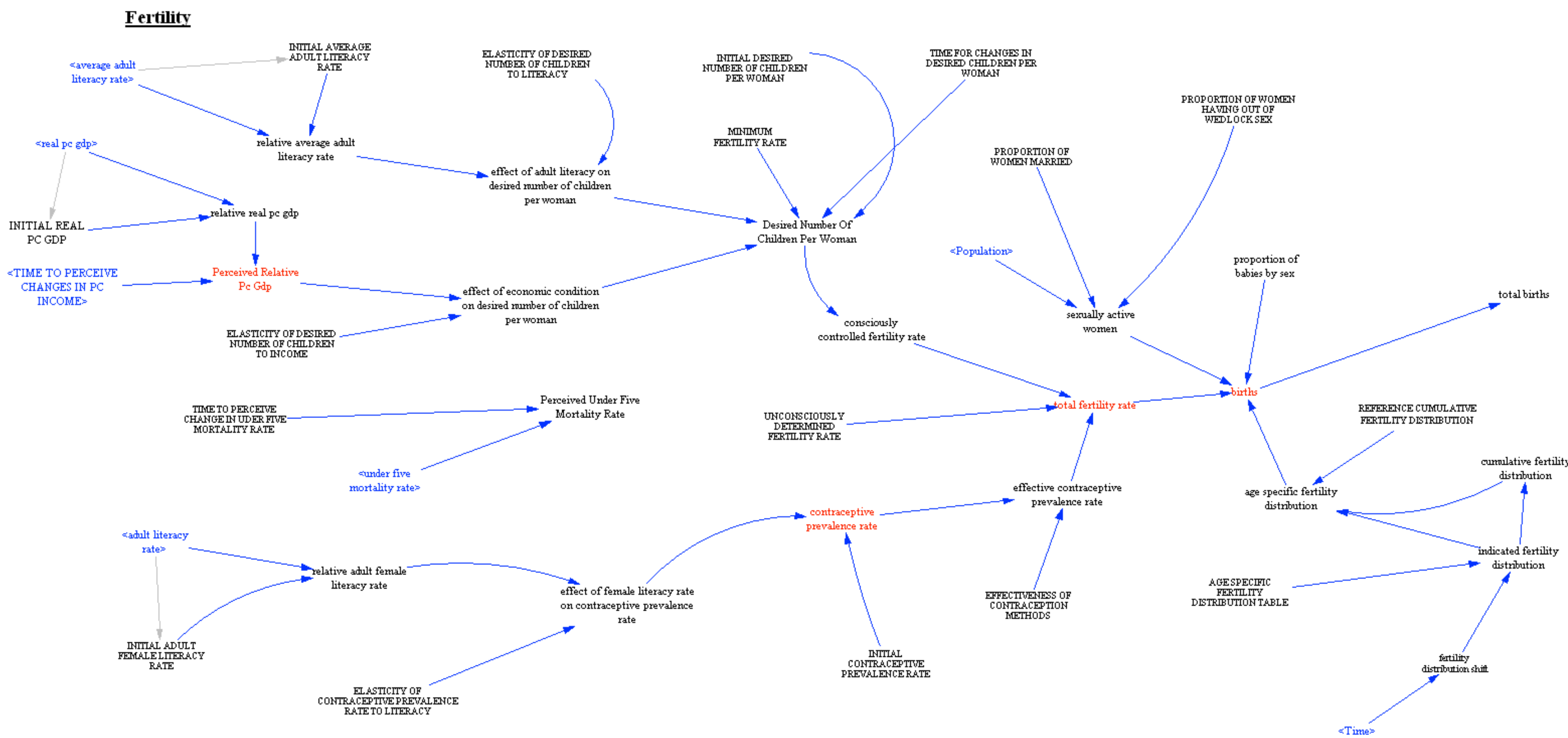


Figure 49: Sketch of the Fertility module

Purpose and Perspective

Because T21 is a long-term development model, it must represent the Total Fertility Rate (TFR) endogenously. And because the various factors that influence TFR have age-specific impacts, it is necessary to calculate age-specific fertility endogenously.

The Fertility module (**Figure 54**) is based on an extensive review and synthesis of demographic literature and the findings of the 1994 International Conference on Population and Development as they relate to fertility modeling (Appendix A). Births, the final output from the module, are calculated on the basis of the number of sexually active women in the fertile age cohorts (15 to 49), the total fertility rate (TFR), and the age-specific fertility distribution.

Explanation

Major Assumptions

- That Total Fertility Rate (TFR) has two components: (1) a consciously controlled part related to education level, desired family size, and contraceptive use and availability and (2) an unconsciously controlled part related to cultural factors;
- Fertile females can be classified into two types, each with its own fertility rate: (1) those who practice conscious birth control, and (2) those who do not;
- The proportion of females who practice conscious birth control changes over time, affected by female adult literacy rates;
- The fertility rate for females who do not use birth control is the natural fertility rate which changes with female life expectancy; the fertility rate for those who practice conscious birth control changes primarily in response to the trend of society's desired family size. The variables that affect desired family size are per capita real GDP and male and female adult literacy rates;
- The probability distribution underlining the age specific fertility rates is constant over time;
- The fraction of women using conscious birth control is considered the same across all age cohorts.

Table 20: Input variables: Fertility module

Variable name	Module of Origin
Population	Population
Under-five mortality rate	Mortality
Adult literacy rate	Primary Education
Average adult literacy rate	Primary Education
Real pc GDP	Aggregate Production and Income
Time to perceive changes in pc income	Households

Table 21: Output variables: Fertility module

	Destination Module		
Variable Name	**Same Sector**	**Other Social Sectors**	**Other Sectors**
Births	Population, Mortality		
Contraceptive prevalence rate			MDGs

Table 22: Constants and table functions: Fertility module

Variable Name	Type	Source for Estimation
Age specific fertility distribution table	Table function	FIVFIV
Effectiveness of contraception methods	Constant	Data on fertility rate (UN Population Division)
Elasticity of contraceptive prevalence rate to literacy	Constant	Data on literacy rate (Malaysian Economy in Figures 2011) and fertility rate (UN Population Division)
Elasticity of desired number of children to income	Constant	Data on income (Malaysian Economy in Figures 2011) and total fertility rate (UN Population Division)
Elasticity of desired number of children to literacy	Constant	Data on literacy rate (Malaysian Economy in Figures 2011) and total fertility rate (UN Population Division)
Fertility distribution shift	Constant	Data on births (UN Population Division)
Initial adult female literacy rate	Constant	Malaysian Economy in Figures 2011
Initial contraceptive prevalence rate	Constant	Calibrated based on fertility rate data (UN Population Division)
Initial desired number of children per woman	Constant	Data on births (UN Population Division)
Minimum fertility rate	Constant	Data on fertility rate (UN Population Division)
Proportion of babies by sex	Constant	Data on births (UN Population Division)
Proportion of women having out of wedlock sex	Constant	Local Experts
Proportion of women married	Constant	Local Experts
Time for changes in desired children per woman	Constant	Data on total fertility rate (UN Population Division)
Unconsciously determined fertility rate table	Constant	Data on total fertility rate (UN Population Division)

The T21 model distinguishes between two types of fertile females, those who use birth control and those who do not. The size of each group is determined by the size of female population cohorts and by the proportion using conscious control, both changing over time. Those who use birth control have a *consciously controlled fertility rate*, and those who do not use birth control have an *unconsciously determined fertility rate.*

The equation for the *total fertility rate* (TFR) follows from the causal relationships in **Figure 54**. The equation, which is the weighted sum of controlled and natural fertility rates, is as follows:

Total fertility rate= consciously controlled fertility rate*effective contraceptive prevalence rate+ unconsciously determined fertility rate*(1-effective contraceptive prevalence rate)

In the T21 model, controlled fertility rate is further affected by direct birth control factors (contraceptive effectiveness) and indirect birth control factors (economic conditions and education). In particular:

- Economic conditions (r*eal pc GDP*) and education (*adult literacy rate*) are all used to determine the *consciously controlled fertility rate*;
- Education also affects the proportion using conscious control. From the literature, the decision whether to use conscious control is primarily made by the female, while decisions regarding family size involve both sexes. Consequently, female literacy rate is used to affect the proportion using conscious control (*contraceptive prevalence rate*), and average literacy rate is used to affect *desired number of children per woman;*
- Contraceptive effectiveness (*effectiveness of contraception methods*) is used to determine the *effective contraceptive prevalence rate;*
- Contraceptive usage (*contraceptive prevalence rate*) is finally used to calculate the *total fertility rate.*

The variable *contraceptive prevalence rate* has a numeric value at any point in time—such as 0.35—, which means at that time 35% of females are using conscious control. This percentage is the overall average for all females between the ages 15 and 49. Actual values of *contraceptive prevalence rate* for different age cohorts can be different for different age groups, such as 50% for age 30 and 10% for age 15. In this model, a simplifying assumption was made, namely that the fraction of women using conscious birth control is constant over all age cohorts. This means that a single value of *contraceptive prevalence rate* can be applied to all female childbearing cohorts.

The proportion of the fertile population using conscious control (*effective contraceptive prevalence rate)* depends on the female adult literacy. The equations are as follows:

effective contraceptive prevalence rate = contraceptive prevalence rate *effectiveness of contraception methods

contraceptive prevalence rate = MIN(1, initial contraceptive prevalence rate*effect of female literacy rate on contraceptive prevalence rate)

The consciously controlled fertility rate is determined by the *desired number of children per women*, which is further related to economic conditions and general levels of education:

desired number of children per woman = INITIAL DESIRED NUMBER OF CHILDREN PER WOMAN * effect of economic condition on desired number of children per woman * effect of adult literacy on desired number of children per woman

The effect of economic conditions is calculated as a function of average per capita GDP:

effect of economic condition on desired number of children per woman = Perceived Relative PC Gdp ^ELASTICITY OF DESIRED NUMBER OF CHILDREN TO INCOME

SMOOTH N(relative real pc GDP ,TIME TO PERCEIVE CHANGES IN PC INCOME , 1 , 1)

Note that a SMOOTH function is used in the equation above to represent the time lag for economic conditions to affect desired number of children per woman.
Similarly, the effect of economic conditions is a function of the male and female adult literacy rate:

effect of adult literacy on desired number of children per woman = relative average adult literacy rate ^ELASTICITY OF DESIRED NUMBER OF CHILDREN TO LITERACY

The fertile female population is made up of all women married or sexually active outside of wedlock, as described in the following equation:

sexually active women [ag childbearing] = Population[FEMALE,ag childbearing] *(PROPORTION OF WOMEN MARRIED+PROPORTION OF WOMEN HAVING OUT OF WEDLOCK SEX)

The proportion of babies per sex is a gender-based function. It is represented as an auxiliary variable in the model because the value for male is determined based on the value for female:

proportion of babies per sex[female] = 0.485

proportion of babies per sex [male] = 1-proportion of babies per sex[female]

To convert TFR into births, we use the variable *age specific fertility distribution*.[12] This distribution is actually the probability density function indicating the distribution of births over the population of fertile women. Thus, births are equal to the total fertility rate multiplied by the fertility distribution multiplied by the total number of

[12] This approach is based on Shorter, et al., Op Cit.

females of child bearing age, multiplied by the proportion of babies per sex, as shown in the following equation:

births[sex] = total fertility rate*SUM(sexually active women[ag childbearing!]*age specific fertility distribution[ag childbearing!])*proportion of babies per sex[sex]

Births accumulate in the population stock in the Population module.

References.

Shorter, F.C., R. Sendek, and Y. Bayoumy, *Computational Methods for Population Projections*, New York: The Population Council, 1995.

3. Mortality module

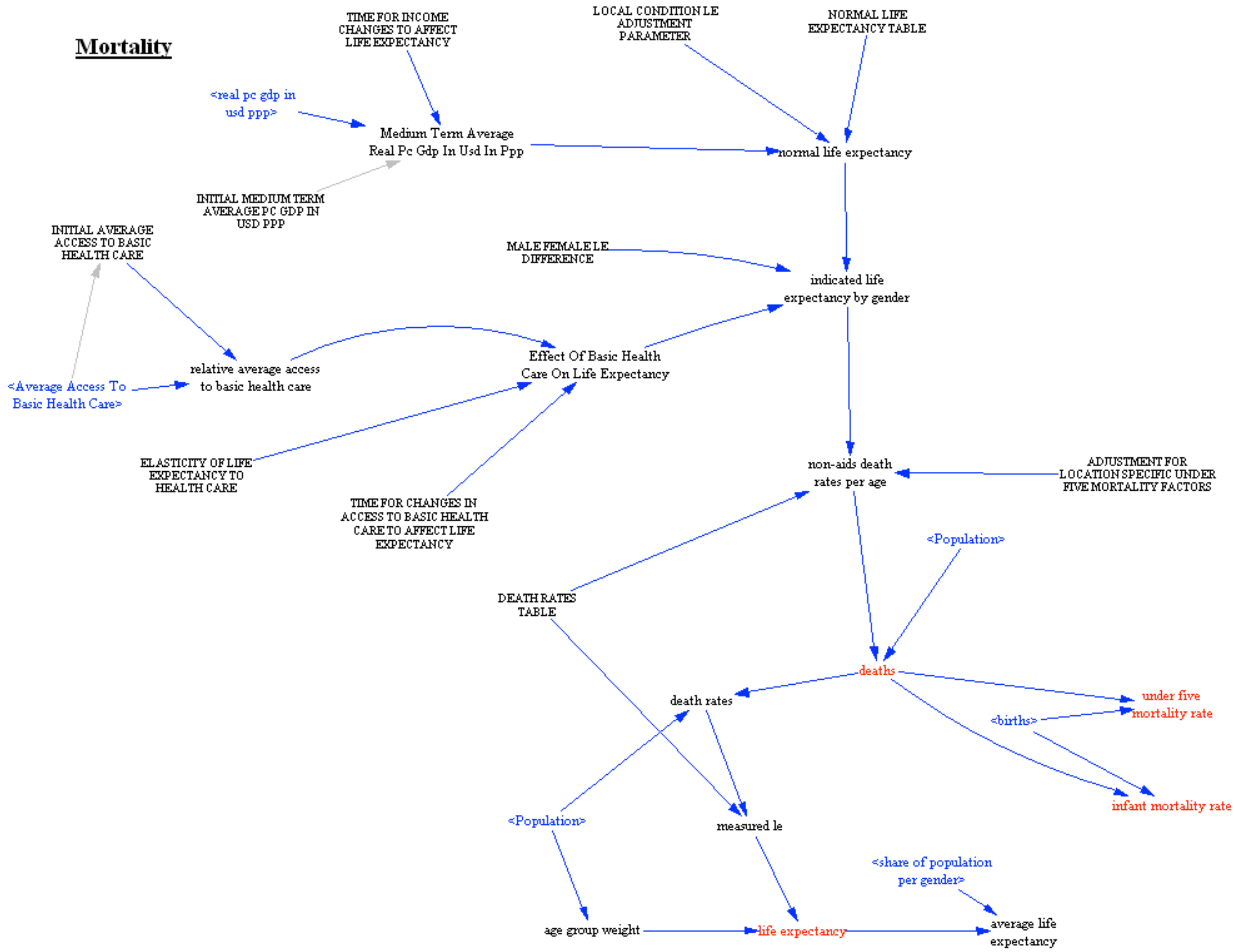


Figure 50: Sketch of the Mortality module

Purpose and Perspective

Because it is a model created to analyze long-term socio-economic development, T21 must represent deaths endogenously. Further, because the various factors that influence deaths have age-specific impacts, it is necessary to model age-specific death rates endogenously.

To compute the age-specific death rates endogenously, we calculate life expectancy at birth and then use life expectancy to look up age specific death rates from “life” tables. Demographers have tabulated the numeric relationship found empirically between life-expectancy-at-birth and the age- and gender-specific-death-rates in various countries. Further, they found that the relationship is largely independent of the country within specific regions.[13]

The life tables included in T21 were developed at the Population Council.[14] The tables have proven highly accurate for several country applications of T21 (for example, China, USA, Mexico, Italy, and Malawi) when life-table-based projections were compared with historic data for the period 1980 to 2000.

Explanation

Assumptions

- Variations in GDP per capita in PPP can explain major changes in life expectancy at birth;
- Variations in the level of health care also effect life expectancy;
- Cohort death rates can be determined by *indicated life expectancy by gender* using a *death rates table*;

Table 23: Input variables: Mortality module

Variable Name	Module of Origin
Real pc GDP in USD PPP	HDI and GDI
Births	Fertility
Share of population per gender	Population
Population	Population
Average access to basic health care	Healthcare

[13] Demographers at the Population Council found that the pattern of age specific death rates vary slightly in different regions of the world. Specifically, they found that there are four patterns: (a) West (base); (b) East (higher infant mortality rates than in west, increasingly high rates over age 50, and lower for other ages, relative to West); (c) North (lower infant mortality rates, low rates beyond 45 or 50, and higher for other ages, relative to West); and (d) South (higher mortality rates for ages under 5, lower mortality between 40-65, and higher over 65, relative to West). We have tested these four life tables in ten countries, and they have proven to be extremely accurate.

[14] Coale, A.J., and Demeny, P., Regional Model Life Tables and Stable Population, second edition, Academic Press, 1983.

Table 24: Output variables: Mortality module

	Destination Module		
Variable Name	**Same Sector**	**Other Social Sectors**	**Other Sectors**
Deaths	Population	Primary Education, Secondary Education, Tertiary Education	
Death rates		Primary Education	
Infant mortality rate			MDGs
Under five mortality rate	Fertility		MDGs
Life expectancy		Primary Education, HDI and GDI	
Relative average life expectancy		Industry, Services	
Average life expectancy		Agriculture	

Table 25: Constants and table functions: Mortality module

Variable Name	Type of Variable	Source for Estimation
Elasticity of life expectancy to health care	Constant	Data on access to basic health care (WDI) and life expectancy (UN Population Division)
Time for changes in access to basic health care to affect life expectancy	Constant	Data on access to basic health care (WDI) and life expectancy (UN Population Division)
Time for income changes to affect life expectancy	Constant	Data on income (Malaysian Economy in Figures 2011) and life expectancy (UN Population Division)
Initial medium term average pc income in USD in PPP	Constant	Malaysian Economy in Figures 2011
Male female le difference	Constant	UN Population Division data
Local condition le adjustment parameter	Constant	Data on income (Malaysian Economy in Figures 2011) and life expectancy (UN Population Division)
Death rates table	Table function	Population Council
Normal life expectancy table	Table function	World Development Indicators 1997
Adjustment for location specific	Constant	Data on deaths (UN

under five mortality factors		Population Division)

Functional Explanation

The method of computing age-specific death rates endogenously proceeds in three steps. The first step is to calculate indicated life expectancy at birth endogenously based on four basic factors: health care, availability of water, nutrition, and income. The second step involves using the life tables to obtain age-specific death rates. Finally, key indicators of this sector such as mortality rates, life expectancy and deaths are calculated.

Modeling life expectancy

In T21-Malaysia, we assume that income level plays a crucial role in the determination of life expectancy. In addition, improvements in access to health care would contribute to reducing life expectancy.

One way to represent the effect of income on life expectancy is through Gross National Product (GNP). There are many published correlations between life expectancy and GNP. A good example is the smooth plot of national average life expectancy against GNP at purchasing power parity published in 1997 by the World Bank (**Figure 56**). The WB graph shows a rapid rise in life expectancy with increasing GNP per capita at low GDP, a slowing of the increase after $5,000 per capita (1991 dollars, PPP), and a saturation (flattening out) beyond $20,000 per capita. In other words, there is little gain in life expectancy from growth in GNP beyond $20,000 per capita. The graph also suggests a 90% "confidence band" (interval) of about ten years of life expectancy, meaning that, at each income level, 90% of the national life expectancy values for all countries are within 10 years of each other.

A curve like the one in **Figure 56** suggests that differences in per capita GNP can explain a big part of the differences in life expectancy in different countries[15].

In T21, the variable *normal life expectancy* is calculated using the relationship shown in **Figure 57**. This relationship is related to lower "confidence bound" in the WDI graph. Implicit in the curve in **Figure 57** is the assumption that GDP per capita determines life expectancy at birth up to a GNP per capita of $20,000 (1991 dollars, PPP).

[15] While there is a correlation between GNP and life expectancy, GNP does not directly cause life expectancy to change. GNP is an aggregate measure of goods and services produced per year, and it is the effect of the consumption of specific goods and services—not aggregate GDP—that cause increases or decreases in life expectancy.

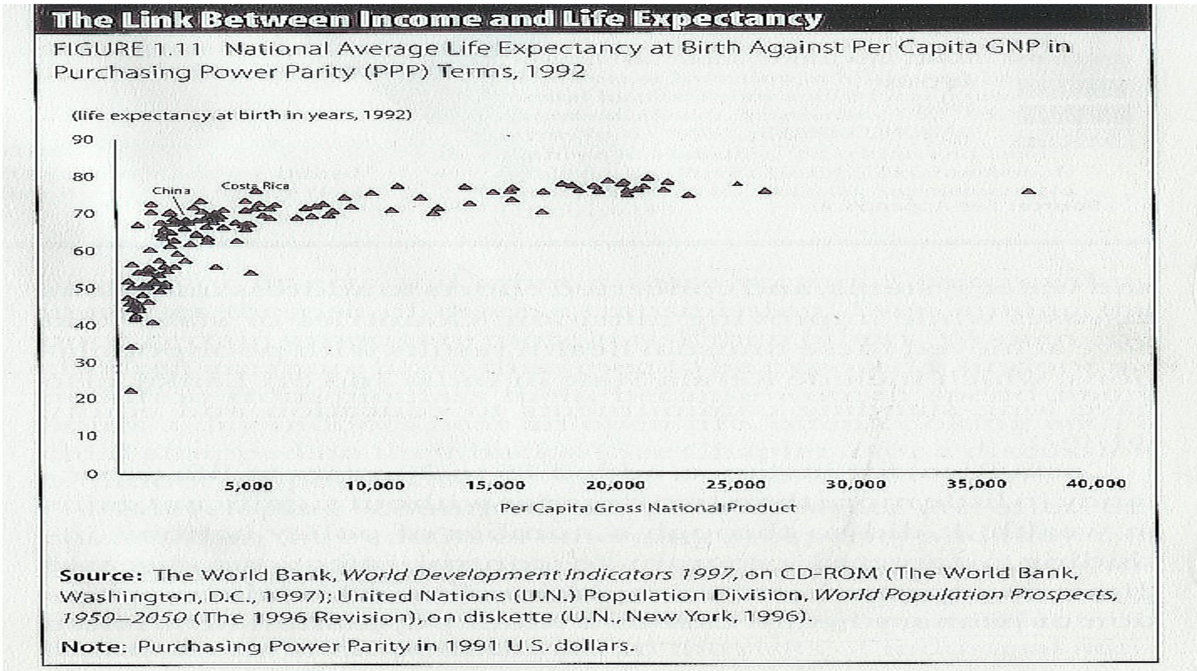


Figure 51: The correlation between life expectancy and GNP

Source: The World Bank, ***World Development Indicators 1997***, Washington D.C., 1997

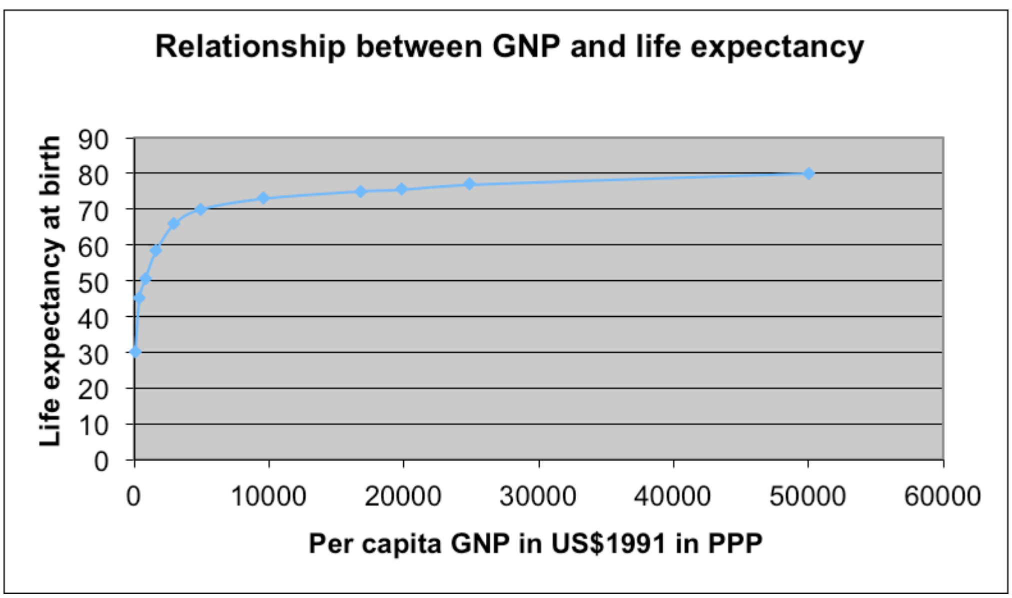


Figure 52: Relationship between life expectancy and GNP assumed in T21

As discussed before, changes in life expectancy may also come from health care, nutrition, water availability and other country-specific elements. Starting from *normal life expectancy,* which is calculated based on GNP, the effect of these additional elements is considered when calculating *indicated life expectancy*. In T21, the effects of health care, water availability and nutrition on life expectancy include assumptions (in the form of a table function) that relate the variable (such as access to basic health care) to life expectancy. An example is provided in **Figure 58**. The estimation of these table functions is based on country-specific data on life expectancy, health care, water availability and nutrition, as well as on expert opinions of local technicians.

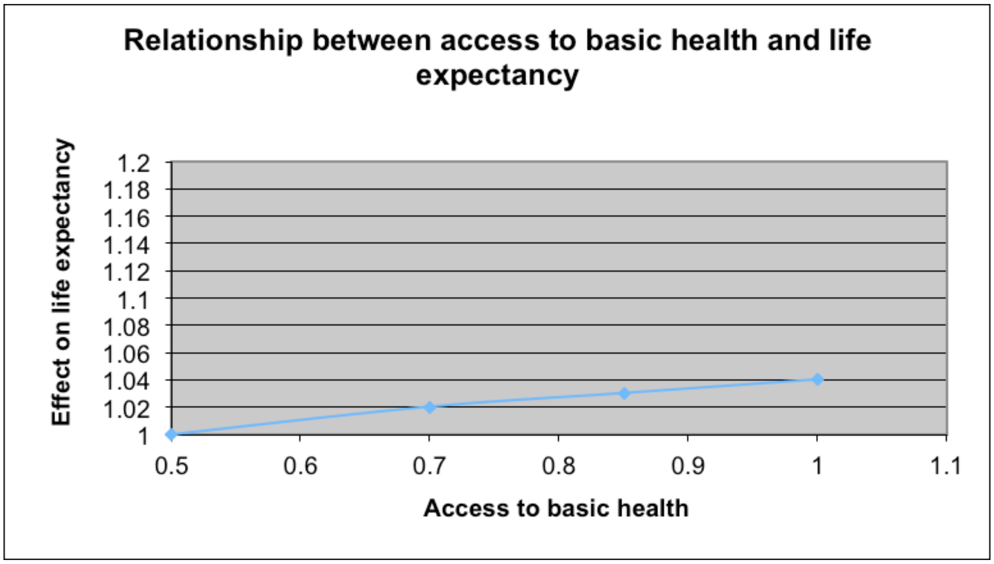


Figure 53: Assumed relationship between access to basic health care (%) and the effect on life expectancy

The *indicated life expectancy* is calculated separately for each sex: the difference between the two is represented by the parameter *male female le difference*. The equation is as follows:

Indicated life expectancy by gender [female]= normal life expectancy*Effect Of Basic Health Care On Life Expectancy +MALE FEMALE LE DIFFERENCE/2

Indicated life expectancy by gender [male]= indicated life expectancy[FEMALE]-MALE FEMALE LE DIFFERENCE/2

Normal life expectancy, as explained above, is a function of per capita GDP in PPP values. The other terms in the equation introduce a degree of influence in basic health care on life expectancy.

Death rates

In T21, the *death rates table* is used to link *indicated life expectancy* with age-specific death rates. The relationship inherent in the *death rates table* for males is illustrated in **Table 29**. The first column is age, and the first row is life expectancy at birth. All the other cells are age specific death rates. For instance, when male life expectancy at birth is 39.695 years (about 40 years), male infant mortality rate (death rate for age 0, or the first year of life) is 0.18951, or 189.51 per thousand live births, and the death rate of a 40-year-old male is 0.01584.

Table 26: Illustration of life table (west) for males

Age	20.4	30.1	39.7	49.5	61.2	76.6
0	0.38386	0.27135	0.18951	0.12513	0.06334	0.00711
1	0.06514	0.04294	0.02772	0.01548	0.00537	0.00015
5	0.01264	0.00872	0.00591	0.00366	0.00163	0.00012
10	0.00901	0.00625	0.00427	0.00267	0.00125	0.00011
20	0.01751	0.01227	0.00853	0.00567	0.00291	0.00035
30	0.02291	0.01589	0.01090	0.00710	0.00346	0.00037
40	0.03247	0.02271	0.01584	0.01067	0.00577	0.00090
50	0.04695	0.03401	0.02501	0.01833	0.01208	0.00364
60	0.07680	0.05798	0.04518	0.03593	0.02723	0.01248
70	0.13999	0.10954	0.08976	0.07600	0.06315	0.03794
80	0.36141	0.31181	0.27628	0.24998	0.22414	0.16595

In the Mortality module, three fundamental variables are calculated: *under-five mortality, infant mortality,* and *life expectancy*.

The first two variables are calculated per the World Bank definition:

Under five mortality rate = SUM (deaths [sex!,under 5!]) /SUM (births[sex!])

Infant mortality = SUM (deaths [sex!, AGE 0]) /SUM(births[sex!])

Life expectancy is calculated from deaths rates per age group *(age group weight)*, by applying the inverted *death rates table* used to calculate *deaths* in the Mortality module. As *death rates* is also affected by health care –in addition to *indicated life expectancy*-, then this effect is reflected in the difference between *life expectancy* and *indicated life expectancy*.

measured le [sex, age group]= LOOKUP INVERT(DEATH RATES TABLE[sex,age], death rates[sex,age])

life expectancy[sex]= SUM(measured le[sex,age group!]*age group weight[sex,age group!])

References

World Resources Institute, World Resources 1998-99: *A Guide to the Global Environment*, Oxford: Oxford University Press, 1998.

Coale, A.J., and Demeny, P., *Regional Model Life Tables and Stable Population*, second edition, New York: Academic Press, 1983.

Sehgal, J., *An Introduction to Techniques of Population and Labor Force Projections*, International Labor Office, Geneva, 1989.

Shorter, F.C., R. Sendek, and Y. Bayoumy, *Computational Methods for Population Projections*, New York: The Population Council, 1995.

UN Population Division, *Sex and Age Annual, 1950-2050 (The 1994 revision)* (on disks)

The World Bank, *World Development Indicators 1997*, Washington D.C., 1997

4. Healthcare module

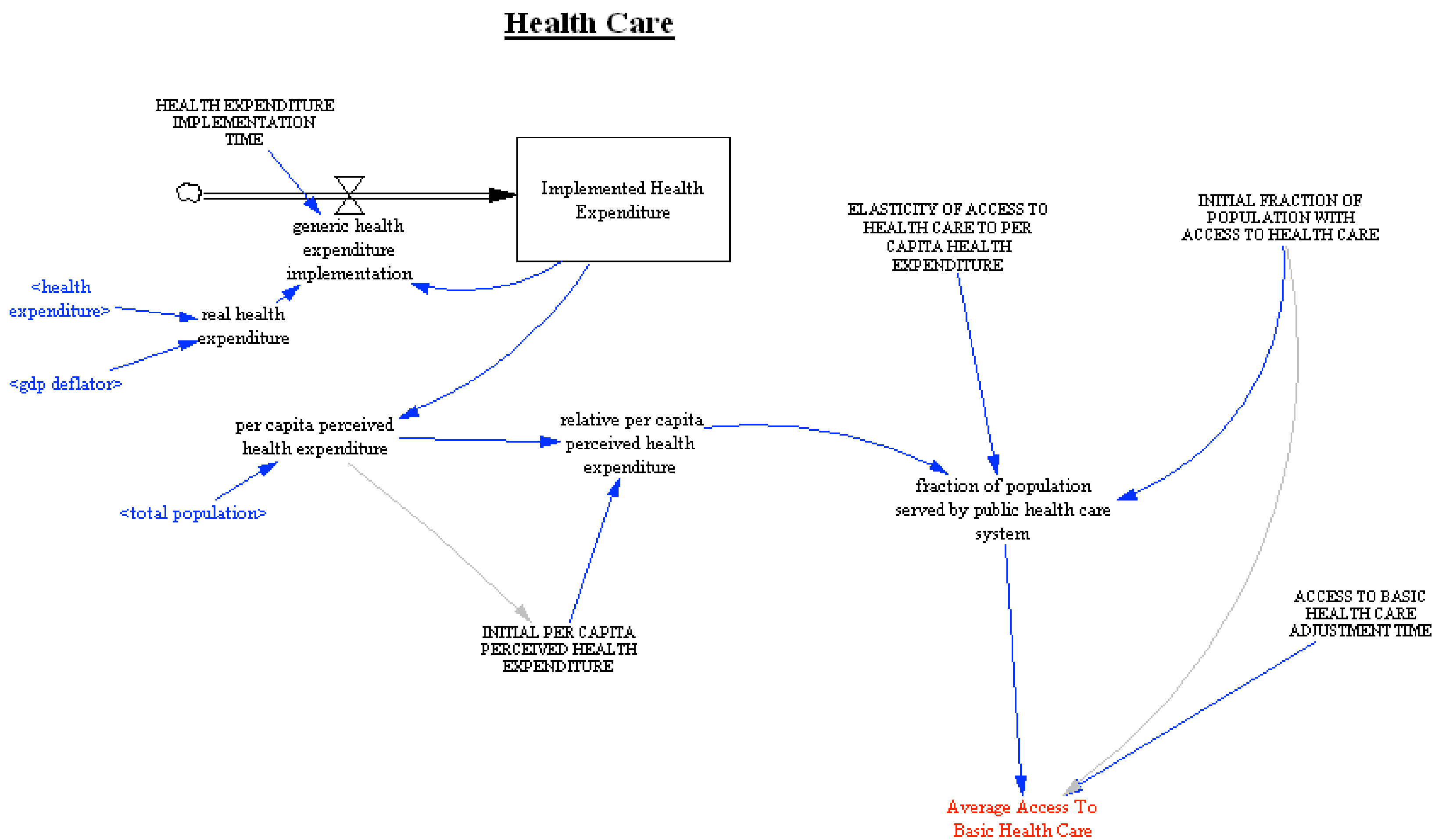


Figure 54: Sketch of the Healthcare module

Purpose and Perspective

The HealthCare module (**Figure 59**) computes access to basic health care, driven by government expenditure on health care per capita. It is assumed that the level of service offered by the government affects access to basic health care. The average access to basic health care is a major factor in determining life expectancy in the Population Sector, as well as a frequently used indicator.

Explanation

Major Assumptions

- Access to basic health care is related to government expenditure on health care per capita;

Table 27: Input variables: HealthCare module

Variable Name	Module of Origin
Total population	Population
GDP deflator	Relative prices
Health expenditure	Government expenditure

Table 28: Output variables: HealthCare module

	Destination Module		
Variable Name	**Same Sector**	**Other Social Sectors**	**Other Sectors**
Average access to basic health care		Mortality	MDGs

Table 29: Constants and table functions: HealthCare module

Variable Name	Type of Variable	Source for Estimation
Initial fraction of population with access to health care	Constant	WDI
Access to basic health care adjustment time	Constant	Data on health expenditure (Malaysian Economy in Figures 2011) and on access to health care (WDI)
Elasticity of access to health care to per capita health expenditure	Constant	Data on health expenditure (Malaysian Economy in Figures 2011) and on access to health care (WDI)
Health expenditure implementation time	Constant	Data on health expenditure (Malaysian Economy in

		Figures 2011) and on access to health care (WDI)

Functional Explanation

To estimate access to basic health care, the first step is to calculate per capita level of health infrastructure and personnel put in place by the government, which is the *per capita perceived health expenditure*. To do this, *perceived health expenditure* is divided by *total population*:

Per capita perceived health expenditure = Implemented Health Expenditure /total population

The *Implemented Health Expenditure* is determined by government *health expenditure*. The implementation of expenditure is realized over a five-year period (represented by *health expenditure implementation time*). The formulation is as follows:

Implemented Health Expenditure = INTEG (generic health expenditure implementation, 5e+007)

Here, the generic health expenditure implementation is calculated as the difference between *real health expenditure* (if positive) and *Implemented Health Expenditure*, divided by implementation time:

Generic health expenditure implementation = (MAX(0,real health expenditure)-Implemented Health Expenditure) /health expenditure implementation time

Then second step is to calculate *fraction of population served by public health care system,* which is determined as a function of *relative per capita perceived health expenditure.*

Fraction of population served by public health care system = MIN(1, INITIAL FRACTION OF POPULATION WITH ACCESS TO HEALTH CARE *relative per capita perceived health expenditure ^ELASTICITY OF ACCESS TO HEALTH CARE TO PER CAPITA HEALTH EXPENDITURE)

The *relative per capita perceived health expenditure* represents the ratio between the current and *initial per capita perceived health expenditure* (in 1990).

Finally, the access to basic health care, calculated as the exponential average of *fraction of population served by public health care system* over a period of time for the health care level to change (*access to basic health care adjustment time*). A SMOOTH N function is used to represent the exponential average:

Average Access To Basic Health Care = SMOOTH N (fraction of population served by public health care system, access to basic health care adjustment time, initial fraction of population with access to health care, 1)

References

Gerald Barney, W. Brian Kreutzer, and Martha J. Garrentt, *Managing a Nation: the Microcomputer Software Catalog*, pp. 182-3, (the Peru 21st Century Model), Institute for 21st Century Studies and Westview Press, 1991.

International Monetary Fund, IMF Country Report No. 04/182, *Mali: Poverty Reduction Strategy Paper Annual Progress Report*, June 2004

World Bank, World Development Indicators 2000, on CD-ROM.

5. Primary Education module

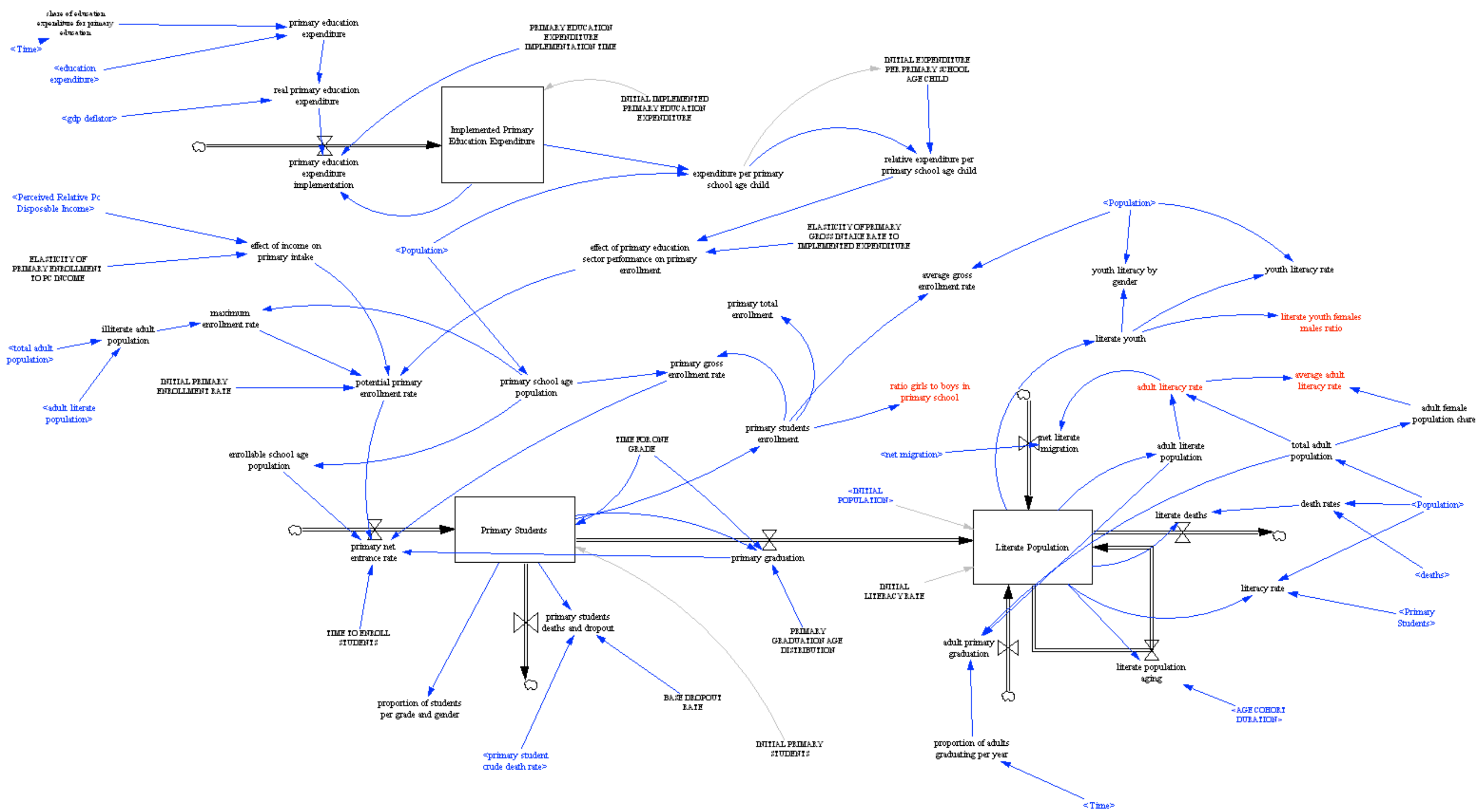


Figure 55: Sketch of the Primary Education module

Purpose and Perspective

The Primary Education module (see **Figure 60**) represents the progression of children through primary school to becoming part of the literate population. Students are disaggregated by both year and gender so that gender-related education issues are addressed. The major output of the module is the adult literacy rate (both male and female), which affects many other sectors including Population and Production sectors. The Primary Education module is based on the Peru 21st Century Model and a UNESCO model.

Explanation

Major Assumptions

- Entrance rate depends on government education expenditure per student;
- Primary school lasts for 6 years;
- Graduates from primary schools are literate;
- All new entrants enter primary school at grade one;
- Primary dropout fraction is the same for all grades;
- The children in school have the same life expectancy as the children who do not go to school; migration of children in school is not considered;
- The literate population has the same life expectancy and migration behavior as the rest of the population.

Table 30: Input variables: Primary Education module

Variable Name	Module of Origin
Population	Population
Net migration	Population
Total adult population	Population
Deaths	Mortality
Life expectancy	Mortality
GDP deflator	Relative prices
Education expenditure	Government expenditure
Perceived relative pc disposable income	Households
Primary student crude death rate	Population

Table 31: Output variables: Primary Education module

	Destination Module		
Variable Name	**Same Sector**	**Other Social Sectors**	**Other Sectors**
Adult literacy rate	Secondary education	Fertility	HDI and GDI
Average adult literacy rate	Secondary education, Tertiary education	Fertility	Industry, Water demand
Average gross enrollment rate			MDGs
Literate population	Secondary education		
Literate youth females males ratio			MDGs
Perceived education expenditure	Secondary education		
Primary gross enrollment rate			HDI and GDI
Primary students			MDGs
Ratio girls to boys in primary school			MDGs
Share of education expenditure for primary education	Secondary education, Tertiary education		
Time to enroll students	Secondary education, Tertiary education		
Youth literacy rate			MDGs

Table 32: Constants and table functions: Primary Education module

Variable Name	Type of Variable	Source for Estimation
Share of education expenditure for primary education	Constant	Data on education expenditure (Malaysian Economy in Figures 2011) and entrance rate (Malaysian Economy in Figures 2011)
Primary education expenditure implementation time	Constant	Data on education expenditure (Malaysian Economy in Figures 2011) and entrance rate (Malaysian Economy in Figures 2011)
Initial implemented primary education expenditure	Constant	Data on education expenditure (Malaysian Economy in Figures 2011) and population (UN Population Division)
Elasticity of primary enrollment to pc income	Constant	Data on education expenditure (Malaysian Economy in Figures 2011) and enrollment rate (Malaysian Economy in Figures 2011)
Elasticity of primary gross entrance rate to implemented expenditure	Constant	Data on education expenditure (Malaysian Economy in Figures 2011) and enrollment rate (Malaysian Economy in Figures 2011)
Initial primary enrollment rate	Constant	Data on primary student (Malaysian Economy in Figures 2011)
Time to enroll students	Constant	Local experts
Base dropout rate	Constant	Data on primary student (Malaysian Economy in Figures 2011)
Primary graduation age distribution	Constant	Data on primary student and literacy rate (Malaysian Economy in Figures 2011)
Time for one grade	Constant	Malaysian Economy in Figures 2011
Initial primary students	Constant	Malaysian Economy in Figures 2011
Initial literacy rate	Constant	Malaysian Economy in Figures 2011
Proportion of adults graduating per year	Time series	Data on adult literacy rate and gross enrollment rate (Malaysian Economy in Figures 2011)

Functional Explanation

The calculation of the adult literacy rate is divided into three parts. First, the level of education offered by the government is calculated; then the flows affecting the stock of students are calculated (the enrollment, graduation and dropout and death flows); and finally the literate population is calculated.

The level of education services

As an indicator of the level of education services available, we use expenditures per primary school age child (age 7 to 12). To calculate this, the *Implemented Primary Education Expenditure* (driven by government *education expenditure* and the share implemented in primary education) is divided by the number of age 7-to-12 children:

expenditure per primary school age child = Implemented Primary Education Expenditure/SUM(Population[sex!, primary school age!])

Note that the subscript *primary school age* represents children at the age of age 7 to 12.

Primary students and entrance rate

Expenditures per student is then compared to its initial value (determining the *relative expenditure per primary school age child*) and used to calculate *potential primary enrollment rate.* The *potential primary enrollment rate* is further affected by income per capita and limited by *maximum enrollment rate*, as explained below:

potential primary enrollment rate [sex] = MIN(INITIAL PRIMARY ENROLLMENT RATE[sex]*effect of income on primary intake[sex]*effect of primary education sector performance on primary enrollment[sex], maximum enrollment rate[sex])

maximum gross entrance rate[sex]= (primary school age population[sex]+illiterate adult population[sex])/primary school age population[sex]

Once children enter school, they must complete six grades before they are considered literate. The subscript [grades] (including Grade 1 to 6) is used to model the *primary students* stock on six levels: students enter the stock at grade 1 and graduate at grade 6 (unless they drop out of school and do not become literate):

Primary Students[sex,GRADE 1] = INTEG (primary net entrance rate[sex] - primary students deaths and dropout[sex,GRADE 1] - Primary Students[sex,GRADE 1] /TIME FOR ONE GRADE, INITIAL PRIMARY STUDENTS[sex, GRADE 1])

Primary Students[sex,GRADE 2] = INTEG (Primary Students[sex,GRADE 1]/TIME FOR ONE GRADE- primary students deaths and dropout[sex,GRADE 2] - Primary Students[sex,GRADE 2]/TIME FOR ONE GRADE, INITIAL PRIMARY STUDENTS[sex, GRADE 2])

Primary Students[sex,GRADE 6] = INTEG (Primary Students[sex,GRADE 5]/TIME FOR ONE GRADE- primary students deaths and dropout[sex,GRADE 6] - SUM(primary graduation[sex, age!]), INITIAL PRIMARY STUDENTS[sex, GRADE 6])

Note that the calculation of primary students at grade 2 to grade 5 follow the same logic.
The graduation flow is calculated as the number of primary students at grade 6 divided by *time for one grade,* multiplied by primary graduation age distribution. The variable *time for one grade* represents the time required to complete one grade: this is set to a value higher than 1 to take into consideration the students repeating one grade.
The flow of *primary students deaths and dropout* for each grade is calculated as the sum of primary student crude death rate (estimated in Population module) and dropout rate, multiplied by the number primary students at that grade.

The primary gross enrollment rate is then calculated by dividing the total number of primary school students of all grades by age 7-to-12 population:

primary students enrollment[sex]= SUM(Primary Students[sex,grades!])

primary gross enrollment rate[sex]= (primary students enrollment[sex])/primary school age population[sex]

This variable represents the actual primary school enrollment rate, which is used to obtain the primary entrance rate by comparing with the potential entrance rate.

The literate population
As students graduate and leave primary school (*primary graduation*), they enter the *literate population* stock. This stock is also influenced by migration and death flows, according to the same rules used in the Population module. In addition, the *literate population* stock can increase because adults can become literate (e.g. due to an adult literacy program).

The adult literacy rate is then calculated by dividing the adult literate population (the part of literate population over 15 years) by the total adult population:

Adult literacy rate [sex] = MIN(1,adult literate population[sex]/ total adult population[sex])

References

Gerald Barney, *Managing a Nation: the Microcomputer Software Catalog*, pp. 182-3, (the Peru 21st Century Model), Institute for 21st Century Studies and Westview Press, 1991.

World Bank, *World Development Indicators 2000,* on CD-ROM.

6. Secondary Education module

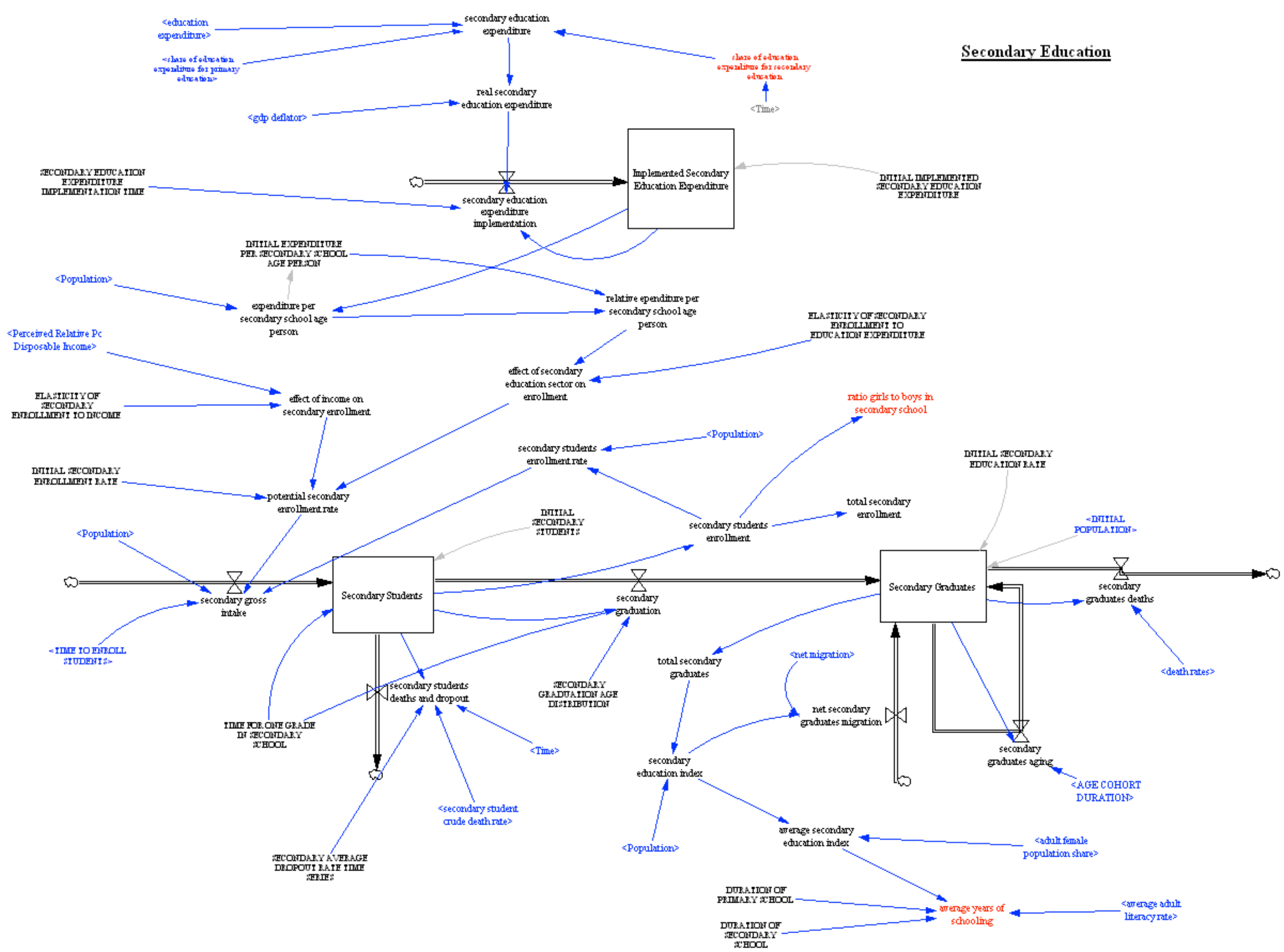


Figure 56: Sketch of the Secondary Education module

Purpose and Perspective

Built on the same basic structure of the Primary Education module, the Secondary Education module (see **Figure 61**) represents the process of students going through secondary school and eventually becoming a part of the population with a secondary degree. Students are disaggregated by both year and gender so that gender-related education issues could be addressed. The major outputs of the module are *total secondary graduates* and *secondary students enrollment* (for both sexes). The Secondary Education module is also based on the Peru 21st Century Model and a UNESCO model.

Explanation

Major Assumptions

- Entrance and dropout rates depend on government per student expenditures for education
- Secondary school lasts for 4 years
- All new entrants enter secondary school at grade one
- Secondary dropout fraction is the same for all grades
- The children in school have the same life expectancy as the children who do not go to school; the migration of children in school is not considered
- The population of secondary school graduates have the same life expectancy and migration behavior as the rest of the population

Table 33: Input variables: Secondary Education module

Variable Name	Module of Origin
Population	Population
Net migration	Population
Death rates	Mortality
Age cohort duration	Population
Secondary student crude death rate	Population
Adult female population share	Population
Average adult literacy rate	Primary education
Education expenditure	Government expenditure
Share of education expenditure for primary education	Primary education
Time to enroll students	Primary education

Table 34: Output variables: Secondary Education module

	Destination Module		
Variable Name	**Same Sector**	**Other Social Sectors**	**Other Sectors**
Ratio girls to boys in secondary school			MDGs
Secondary students enrollment rate			HDI and GDI
Share of education expenditure for secondary education	Tertiary education		
Relative average years of schooling		Employment	Industry, Services
Average years of schooling			Agriculture

Table 35: Constants and table functions: Secondary Education module

Variable Name	Type of Variable	Source for Estimation
Share of education expenditure for secondary education	Time Series	Data on education expenditure (Malaysian Economy in Figures 2011) and entrance rate (Malaysian Economy in Figures 2011)
Secondary education expenditure implementation time	Constant	Data on education expenditure (Malaysian Economy in Figures 2011) and entrance rate (Malaysian Economy in Figures 2011)
Initial implemented secondary education expenditure	Constant	Data on education expenditure (Malaysian Economy in Figures 2011) and population (UN Population Division)
Elasticity of secondary enrollment to pc income	Constant	Data on education expenditure (Malaysian Economy in Figures 2011) and enrollment rate (Malaysian Economy in Figures 2011)
Elasticity of secondary gross entrance rate to implemented expenditure	Constant	Data on education expenditure (Malaysian Economy in Figures 2011)

		and enrollment rate (Malaysian Economy in Figures 2011)
Initial secondary enrollment rate	Constant	Data on secondary student (Malaysian Economy in Figures 2011)
Secondary average dropout rate time series	Time Series	Data on secondary student (Malaysian Economy in Figures 2011)
Secondary graduation age distribution	Constant	Data on secondary student (Malaysian Economy in Figures 2011)
Time for one grade in secondary school	Constant	Data on secondary student (Malaysian Economy in Figures 2011)
Initial secondary students	Constant	Malaysian Economy in Figures 2011

Functional Explanation

The structure of the Secondary Education module can be divided into three parts, according to the function of each part. The structure represented in the top part of the sketch in **Figure 61** is functional to determine the level of the educational services offered by the government. In the bottom left part of the sketch the stock of students and the entrance, graduation, dropout and deaths flows are determined. In the bottom right part of the sketch the stock of secondary graduates and relative flows are calculated.

The level of education services

As an indicator of the level of education services available, we use expenditures per secondary school age child. To calculate this, the *Implemented Secondary Education Expenditure* (driven by government *education expenditure* and the share implemented in secondary education) is divided by the number of secondary school age children:

expenditure per secondary school age child = Implemented Secondary Education Expenditure/SUM(Population[sex!, secondary school age!])

Note that the subscript *secondary school age* represents children at secondary school age.

Secondary education expenditure by the government is calculated as a share of government education expenditure. It is also limited by the share in primary education, represented by a MIN function:

secondary education expenditure = education expenditure*MIN(share of education expenditure for secondary education, (1-share of education expenditure for primary education))

Secondary students and enrollment rate

Expenditures per student is then compared to its initial value (determining the *relative expenditure per secondary school age child*) and used to calculate *potential secondary enrollment rate.* The *potential secondary enrollment rate* is further affected by income per capita, as explained below:

potential secondary enrollment rate [sex] = INITIAL SECONDARY ENROLLMENT RATE[sex]*effect of income on secondary enrollment [sex]*effect of secondary education sector on secondary enrollment[sex]

Once children enter school, they must complete four grades before they become *secondary graduates*. The subscript [grades] (including Grade 1 to 4 for secondary education) is used to model the *secondary students* stock on four levels: students enter the stock at grade 1 and graduate at grade 4 (unless they drop out of school and do not become literate):

Secondary Students[sex,GRADE 1] = INTEG (secondary gross intake [sex] - secondary students deaths and dropout[sex,GRADE 1] - Secondary Students[sex,GRADE 1] /TIME FOR ONE GRADE in secondary school, INITIAL SECONDARY STUDENTS[sex, GRADE 1])

Secondary Students[sex,GRADE 2] = INTEG (Secondary Students[sex,GRADE 1]/TIME FOR ONE GRADE- secondary students deaths and dropout[sex,GRADE 2] - Secondary Students[sex,GRADE 2]/TIME FOR ONE GRADE in secondary school, INITIAL SECONDARY STUDENTS[sex, GRADE 2])

Secondary Students[sex,GRADE 4] = INTEG (Secondary Students[sex,GRADE 3]/TIME FOR ONE GRADE in secondary school - secondary students deaths and dropout[sex,GRADE 4] - SUM(secondary graduation[sex, age!]), INITIAL SECONDARY STUDENTS[sex, GRADE 4])

Note that the calculation of secondary students at grade 2 and 3 follow the same logic.

The graduation flow is calculated as the number of secondary students at grade 4 divided by *time for one grade in secondary school,* multiplied by secondary graduation age distribution. The variable *time for one grade in secondary school* represents the time required to complete one grade: this is set to a value higher than 1 to take into consideration the students repeating one grade.

The flow of *secondary students deaths and dropout* for each grade is calculated as the sum of secondary student crude death rate (estimated in Population module) and dropout rate, multiplied by the number secondary students at that grade.

The secondary gross enrollment rate is then calculated by dividing the total number of secondary school students of all grades by secondary-school-age population:

secondary students enrollment[sex]= SUM(Secondary Students[sex,grades!])

secondary gross enrollment rate[sex]= (secondary students enrollment[sex])/secondary school age population[sex]

This variable represents the actual secondary school enrollment rate, which is used to obtain the *secondary gross intake* by comparing with the *potential secondary enrollment rate*.

The secondary graduates

As students graduate and exit secondary school, they enter *secondary graduates* stock. This stock is also influenced by migration and death flows, accordingly to the same rules used in the Population module.

The *average years of schooling* is calculated based on the duration of primary and secondary school, and the proportion of adults with secondary education. This is a main output of this sector, which is assumed to affect productivity and employment in other sectors.

References

Gerald Barney, *Managing a Nation: the Microcomputer Software Catalog*, pp. 182-3, (the Peru 21st Century Model), Institute for 21st Century Studies and Westview Press, 1991.

World Bank, *World Development Indicators 2000,* on CD-ROM.

7. Tertiary Education module

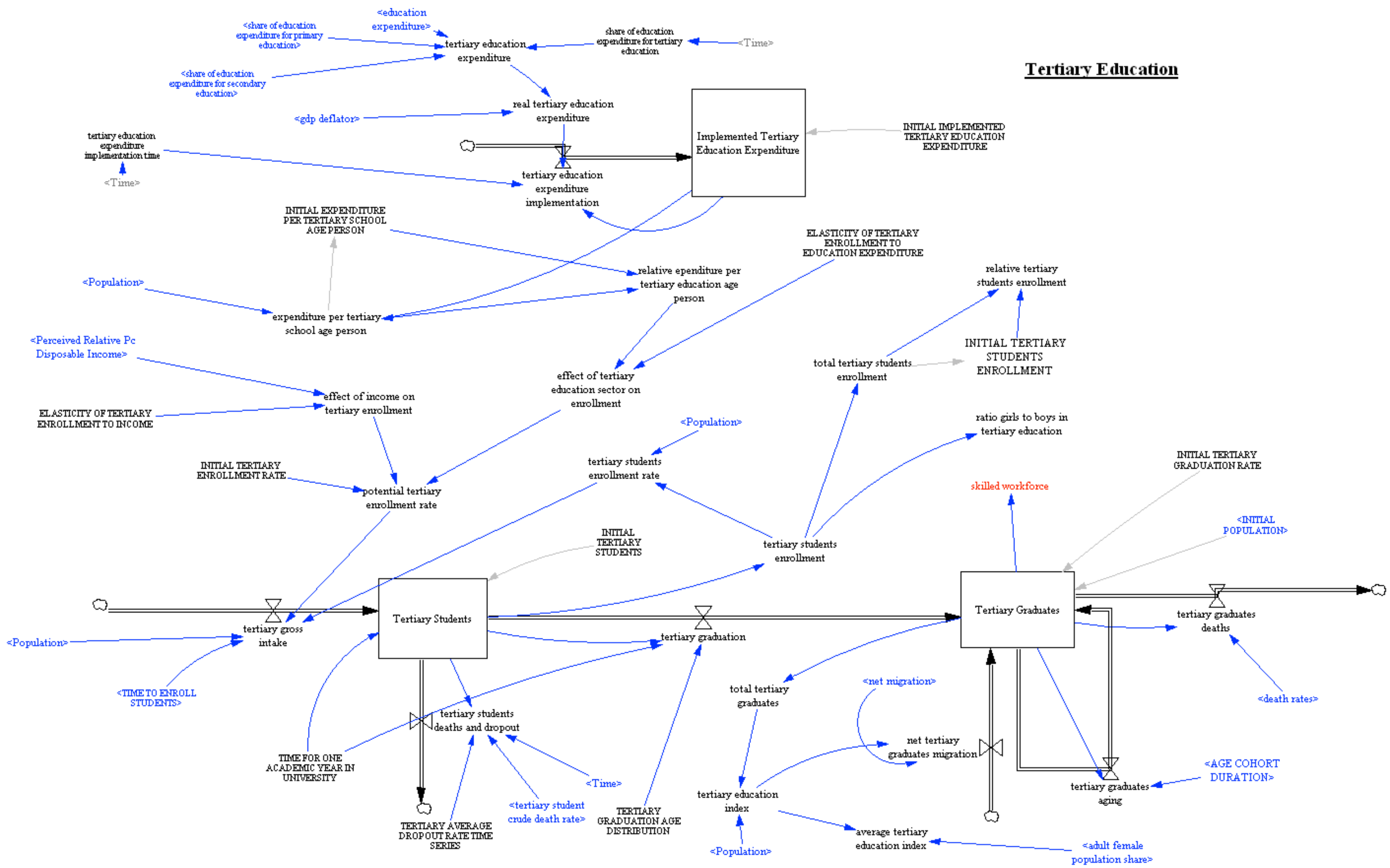


Figure 57: Sketch of the Tertiary Education module

Purpose and Perspective

Built on the same basic structure of the Primary and Secondary Education module, the Tertiary Education module (see **Figure 62**) represents the process of students going through university and eventually becoming a part of the population with a university degree. Students are disaggregated by both year and gender so that gender-related education issues could be addressed. The major output of the module is *relative tertiary students enrollment*, which affects other sectors, including the Labor and Services production sectors. The Tertiary Education module is also based on the Peru 21st Century Model and a UNESCO model.

Explanation

Major Assumptions

- Entrance and dropout rates depend on government per student expenditures for education
- University lasts for 5 years
- All new entrants enter the university at grade one
- Tertiary dropout fraction is the same for all grades
- The children in school have the same life expectancy as the children who do not go to school; the migration of children in school is not considered
- The population of university graduates have the same life expectancy and migration behavior as the rest of the population

Table 36: Input variables: Tertiary Education module

Variable Name	Module of Origin
Population	Population
Net migration	Population
Death rates	Mortality
Age cohort duration	Population
Secondary student crude death rate	Population
Adult female population share	Population
Average adult literacy rate	Primary education
Education expenditure	Government expenditure
Share of education expenditure for primary education	Primary education
Share of education expenditure for secondary education	Primary education
Time to enroll students	Primary education

Table 37: Output variables: Tertiary Education module

	Destination Module		
Variable Name	**Same Sector**	**Other Social Sectors**	**Other Sectors**
Tertiary gross enrollment rate			HDI and GDI
Relative tertiary students enrollment			Services
Skilled workforce		Labor Availability and Unemployment	

Table 38: Constants and table functions: Tertiary Education module

Variable Name	Type of Variable	Source for Estimation
Share of education expenditure for tertiary education	Time Series	Data on education expenditure (Malaysian Economy in Figures 2011) and entrance rate (Malaysian Economy in Figures 2011)
Tertiary education expenditure implementation time	Constant	Data on education expenditure (Malaysian Economy in Figures 2011) and entrance rate (Malaysian Economy in Figures 2011)
Initial implemented tertiary education expenditure	Constant	Data on education expenditure (Malaysian Economy in Figures 2011) and population (UN Population Division)
Elasticity of tertiary enrollment to pc income	Constant	Data on education expenditure (Malaysian Economy in Figures 2011) and enrollment rate (Malaysian Economy in Figures 2011)
Elasticity of tertiary gross entrance rate to implemented expenditure	Constant	Data on education expenditure (Malaysian Economy in Figures 2011) and enrollment rate (Malaysian Economy in Figures 2011)
Initial tertiary enrollment rate	Constant	Data on tertiary student (Malaysian Economy in

		Figures 2011)
Tertiary average dropout rate time series	Time Series	Data on tertiary student (Malaysian Economy in Figures 2011)
Tertiary graduation age distribution	Constant	Data on tertiary student (Malaysian Economy in Figures 2011)
Time for one academic year in university	Constant	Data on tertiary student (Malaysian Economy in Figures 2011)
Initial tertiary students	Constant	Malaysian Economy in Figures 2011

Functional Explanation

The structure of the Tertiary Education module can be divided into three parts, according to the function of each part. The structure represented in the top part of the sketch in **Figure 62** is functional to determine the level of the educational services offered by the government. In the bottom left part of the sketch the stock of students and the entrance, graduation, dropout and deaths flows are determined. In the bottom right part of the sketch the stock of tertiary graduates and relative flows are calculated.

The level of education services

As indicators of the level of education services available, we use expenditures per student and per tertiary school age child. To calculate this, the *Implemented Tertiary Education Expenditure* (driven by government *education expenditure* and the share implemented in tertiary education) is divided by the number of tertiary school age children:

expenditure per tertiary school age child = Implemented Tertiary Education Expenditure/SUM(Population[sex!, tertiary school age!])

Note that the subscript *tertiary school age* represents children at tertiary school age. *Tertiary education expenditure* by the government is calculated as a share of government education expenditure. It is also limited by the shares in primary and secondary education, represented by a MIN function:

tertiary education expenditure = education expenditure*MIN(share of education expenditure for secondary education, (1-share of education expenditure for primary education -share of education expenditure for secondary education))

Tertiary students and enrollment rate

Expenditures per student is then compared to its initial value (determining the *relative expenditure per tertiary school age child*) and used to calculate *potential tertiary* *enrollment rate.* The *potential tertiary enrollment rate* is further affected by income per capita, as explained below:

potential tertiary enrollment rate [sex] = INITIAL TERTIARY ENROLLMENT RATE[sex]*effect of income on tertiary enrollment [sex]*effect of tertiary education sector on tertiary enrollment[sex]

Once children enter school, they must complete four grades before they become *tertiary graduates*. The subscript [grades] (including Grade 1 to 5 for universities) is used to model the *tertiary students* stock on five levels: students enter the stock at grade 1 and graduate at grade 4 (unless they drop out of school and do not become literate):

Tertiary Students[sex,GRADE 1] = INTEG (+tertiary gross intake[sex]-tertiary students deaths and dropout[sex,GRADE 1]-Tertiary Students[sex,GRADE 1]/TIME FOR ONE ACADEMIC YEAR IN UNIVERSITY, INITIAL TERTIARY STUDENTS[sex, GRADE 1])

Tertiary Students[sex,GRADE 2] = INTEG (Tertiary Students[sex,GRADE 1]/TIME FOR ONE GRADE- tertiary students deaths and dropout[sex,GRADE 2] - Tertiary Students[sex,GRADE 2]/TIME FOR ONE GRADE, INITIAL TERTIARY STUDENTS[sex, GRADE 2])

Tertiary Students[sex,GRADE 5] = INTEG (Tertiary Students[sex,GRADE 4]/TIME FOR ONE GRADE- tertiary students deaths and dropout[sex,GRADE 5] - SUM(tertiary graduation[sex, age!]), INITIAL TERTIARY STUDENTS[sex, GRADE 5])

Note that the calculation of tertiary students at grade 2 to 4 follow the same logic.
The graduation flow is calculated as the number of tertiary students at grade 6 divided by *time for one academic year in university,* multiplied by tertiary graduation age distribution. The variable *time for one academic year in university* represents the time required to complete one grade: this is set to a value higher than 1 to take into consideration the students repeating one grade.
The flow of *tertiary students deaths and dropout* for each grade is calculated as the sum of tertiary student crude death rate (estimated in Population module) and dropout rate, multiplied by the number tertiary students at that grade.

The tertiary gross enrollment rate is then calculated by dividing the total number of tertiary school students of all grades by age 19-to-23 population:

tertiary students enrollment[sex]= SUM(Tertiary Students[sex,grades!])

tertiary gross enrollment rate[sex]= (tertiary students enrollment[sex])/tertiary school age population[sex]

This variable represents the actual tertiary school enrollment rate, which is used to obtain the *tertiary gross intake* by comparing with the *potential tertiary enrollment rate*.

The tertiary graduates

As students graduate and exit tertiary school, they enter *tertiary graduates* stock. This stock is also influenced by migration and death flows, accordingly to the same rules used in the Population module.

References

Gerald Barney, *Managing a Nation: the Microcomputer Software Catalog*, pp. 182-3, (the Peru 21st Century Model), Institute for 21st Century Studies and Westview Press, 1991.

World Bank, *World Development Indicators 2000,* on CD-ROM.

8. Nutrition module

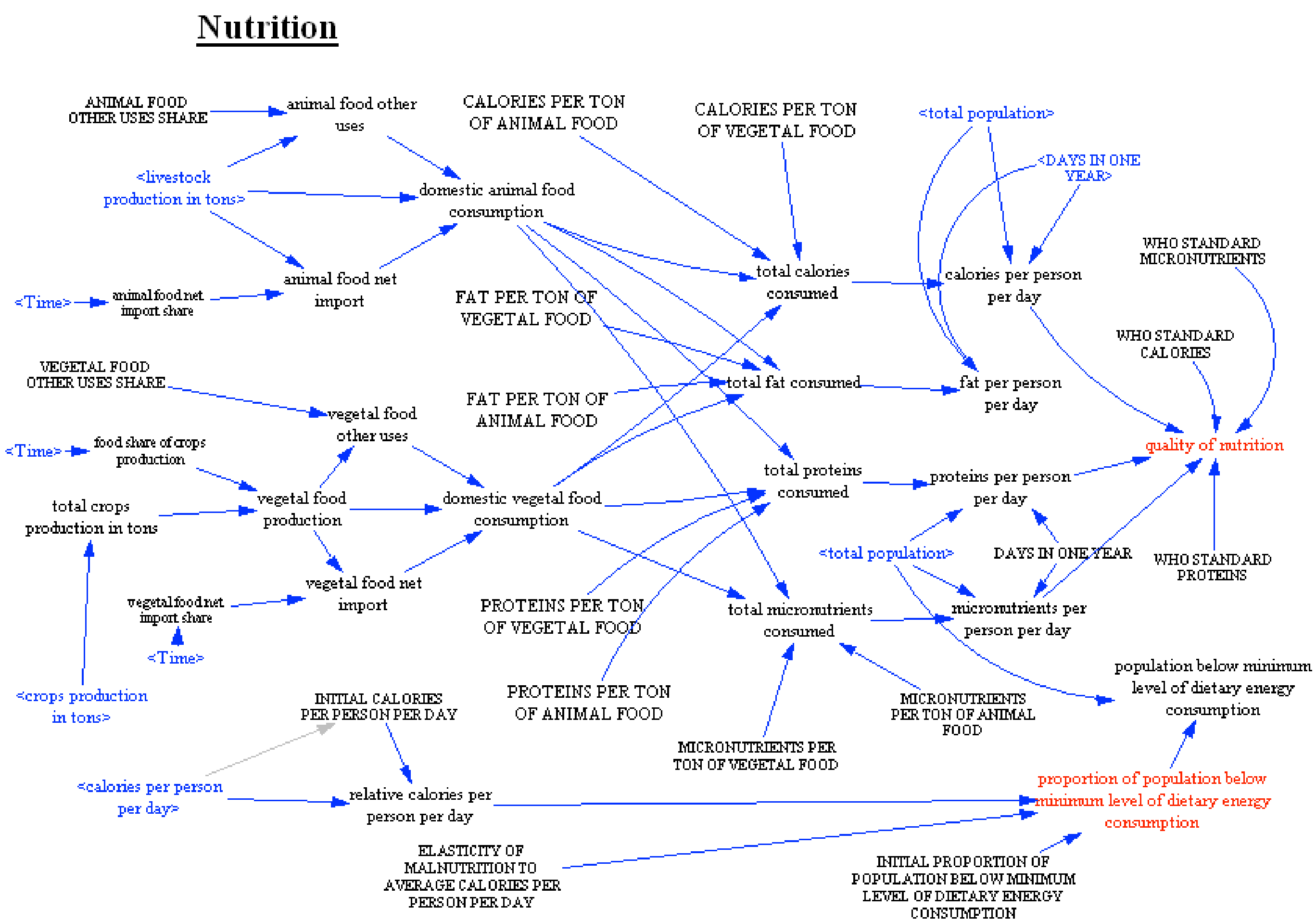


Figure 58: Sketch of the Nutrition module

Purpose and Perspective

The purpose the Nutrition module (see **Figure 63**) is to simulate food supply and consumption relative to World Health Organization standards for food entrance. Food products are divided into vegetables and animal products. The model calculates average per capita food consumption in calories, fat, micronutrients and protein contents. The daily entrance of calories, proteins and micronutrients are used to calculate a “quality of nutrition” measurement based on international standards.

Explanation

Major Assumptions

- Food produced and not exported is locally consumed;
- The mix of the types of vegetable produced is constant;
- The mix of the types of meat produced is constant.

Table 39: Input variables: Nutrition module

Variable Name	Module of Origin
Total population	Population
Crops production in tons	Agriculture
Agriculture crops value added per ton	Agriculture
Livestock production in tons	Husbandry, fishery and forestry

Table 40: Output variables: Nutrition module

	Destination Module		
Variable Name	**Same Sector**	**Other Social Sectors**	**Other Sectors**
Proportion of population below minimum level of dietary energy consumption			MDGs

Table 41: Constants and table functions: Nutrition module

Variable Name	Type of Variable	Source for Estimation
Fat per ton of meat	Constant	FAO
Fat per ton of food vegetables	Constant	FAO
Calories per ton of meat	Constant	FAO
Calorie per ton of food vegetables	Constant	FAO
Proteins per ton of meat	Constant	FAO
Proteins per ton of food vegetables	Constant	FAO
Micronutrients per ton of food vegetables	Constant	N.A.
Micronutrients per ton of meat	Constant	N.A.
Days in one year	Constant	Gregorian calendar
WHO standard calories	Constant	WHO
WHO standard proteins	Constant	WHO
WHO standard micronutrients	Constant	WHO

Functional Explanation

T21 uses the domestic supply of animals, vegetables and total population to calculate per capita consumption of proteins, fat calories and micronutrients. Proteins, calories and micronutrients are compared to international standards from WHO (World Health Organization) to derive an aggregate measure of the quality of nutrition.

Domestic animal and vegetable consumption

The domestic consumption of animal food is calculated as the sum of the livestock production and imports, less the amount for other uses:

Domestic animal food consumption = livestock production in tons +animal food net import-animal food other uses

Similarly, the domestic consumption of vegetables is calculated as the sum of the crops production and net imports, less the amount for other uses:

Domestic vegetal food consumption = vegetal food production +vegetal food net import-vegetal food other uses

Domestic consumption of vegetables and animal food are then used to calculate the total consumption in terms of calories, proteins, fat and micronutrients. As an example, the total consumption of calories is calculated as follows:

Total calories consumed = domestic animal food consumption*CALORIES PER TON OF ANIMAL FOOD +domestic vegetal food consumption*CALORIES PER TON OF VEGETAL FOOD

Consumption of fat, proteins and micronutrients are calculated accordingly to the same logic.

The total amount of nutrients consumed is divided by the total population and by the number of days in one year to obtain the daily per capita consumption of fat, calories, proteins and micronutrients. These last three variables are then weighted to derive a *quality of nutrition* index:

Quality of nutrition = 0.625* Calories Per Person Per Day/WHO STANDARD CALORIES + 0.375*Proteins Per Person Per Day/WHO STANDARD PROTEINS + 0*Micronutrients Per Person Per Day/WHO STANDARD MICRONUTRIENTS

The weight given to the different nutrients is arbitrarily chosen. Note that in this case a weight of 0 is given to the consumption of micronutrients, because data on micronutrients was not available.

References

Hunter Colby, Mark Giordano, and Kim Hjort, The ERS China CPPA Model: Documentation, 1997

US Department of Agriculture, International Agricultural Baseline Projections to 2005, AER-750, USDA/ERS.

US Department of Agriculture, World Agriculture, Trends and Indicators, 1970-91, USDA, 1993

World Bank, World Data 1995, on CD-ROM.

9. Roads module

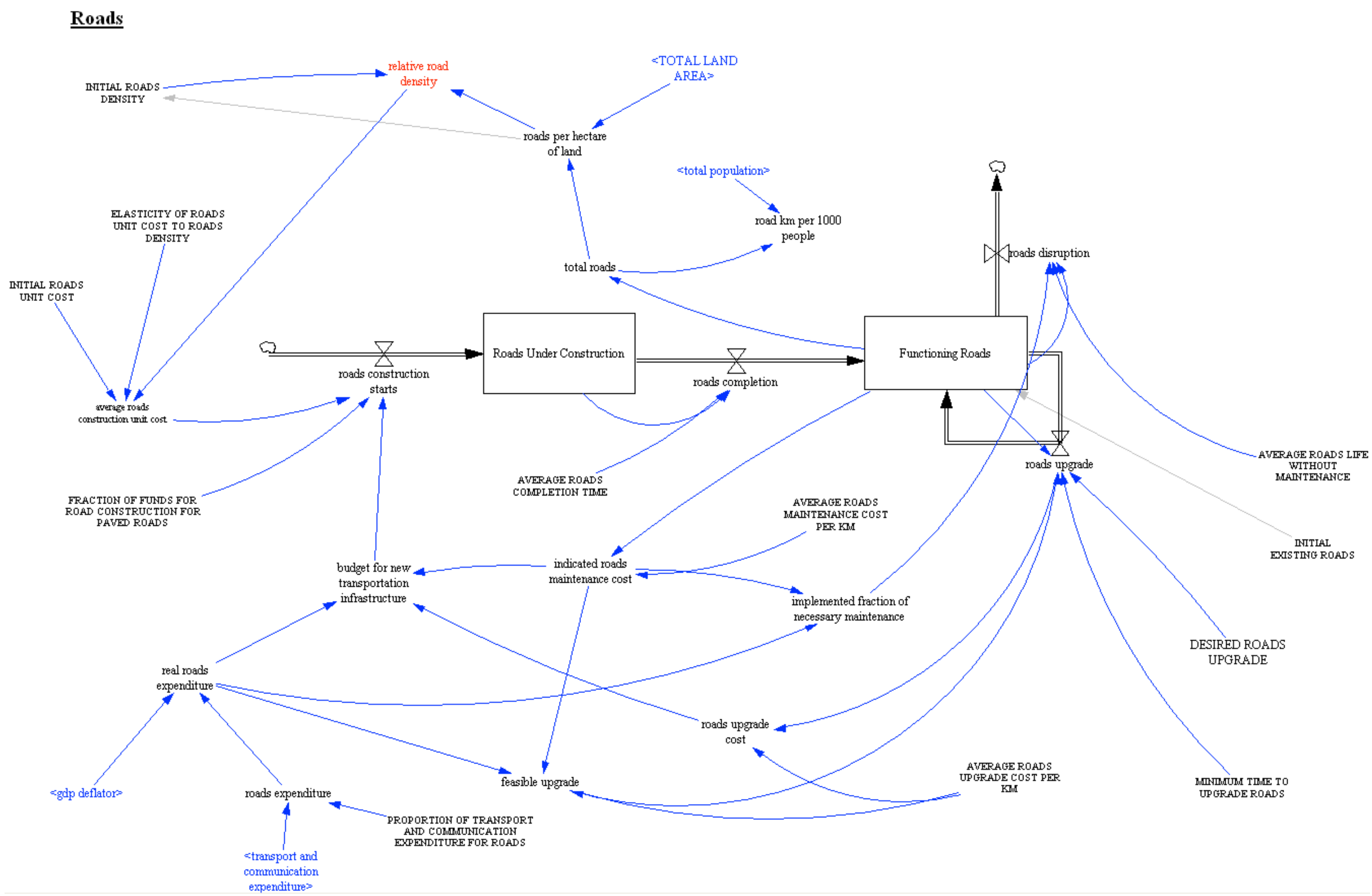


Figure 59: Sketch of the Roads module

Purpose and Perspective

The Infrastructure sector of the T21-Malaysia model includes the main types of infrastructure for the country, including roads, port cargo, air transport and broadband.

The Roads module represents the process of road construction, disruption and upgrade on a countrywide level. Roads are a fundamental piece of infrastructure, which stimulates or limits economic development. The Roads module in T21 allows users to monitor the development of the road network from a national, aggregate perspective, and to simulate various types of related policies.

Explanation

Major Assumptions

- Roads are of two types: paved and unpaved;
- Unpaved roads can be upgraded to paved roads;
- Road maintenance and upgrade has priority over road construction when budgets are limited;
- The density of roads has an important effect on agricultural, industrial and services productivity.

Table 42: Input variables: Roads module

Variable Name	Module of Origin
Total population	Population
Total land area	Land
Transport and communication expenditure	Government expenditure
GDP deflator	Relative prices

Table 43: Output variables: Roads module

	Destination Module		
Variable Name	**Same Sector**	**Other Social Sectors**	**Other Sectors**
Relative road density			Agriculture, Industry, Services

Table 44: Constants and table functions: Roads module

Variable Name	Type of Variable	Source for Estimation
Average roads completion time	Constant	Data on road density (Malaysian Economy in Figures 2011)
Average roads life without maintenance	Constant	Data on road density (Malaysian Economy in Figures 2011)
Average roads maintenance cost per km	Constant	Data on road density and expenditure (Malaysian Economy in Figures 2011)
Average roads upgrade cost per km	Constant	Data on road density and expenditure (Malaysian Economy in Figures 2011)
Desired road upgrade	Time series	Data on road density (Malaysian Economy in Figures 2011)
Elasticity of roads unit cost to roads density	Constant	Data on road density and expenditure (Malaysian Economy in Figures 2011)
Fraction of funds for road construction for paved roads	Constant	Data on road density (Malaysian Economy in Figures 2011)
Initial existing roads		Malaysian Economy in Figures 2011
Initial roads unit cost	Constant	Data on road density and expenditure (Malaysian Economy in Figures 2011)
Minimum time to upgrade roads	Constant	Data on road density (Malaysian Economy in Figures 2011)
Proportion of transport and communication expenditure for roads	Constant	Data on road expenditure (Malaysian Economy in Figures 2011)

Functional Explanation

The structure of the Roads module can be divided into two sub-structures: (1) the budget for road construction, maintenance and upgrade; (2) the physical flows of road construction, maintenance and upgrade.

Budgets for road construction, maintenance and upgrades

The government expenditure for roads is calculated as a share of government transport and communication expenditure. This is then deflated by the GDP deflator to obtain the *real roads expenditure*:

Roads expenditure = transport and communication expenditure*PROPORTION OF TRANSPORT AND COMMUNICATION EXPENDITURE FOR ROADS

Real roads expenditure = roads expenditure/GDP deflator

This budget is allocated with priority to the maintenance and upgrade of the existing structures, with respect to building new infrastructures. The budget for the construction of new roads is calculated as:

budget for new transportation infrastructure = MAX(0,(government real expenditure for transport infrastructure-indicated roads maintenance cost-roads upgrade cost))

The budget for the upgrade of existing structures (roads upgrade cost) is determined by the km of roads upgrade from unpaved to paved and average unit upgrade cost, while the indicated budget for road maintenance (the expenditure that the government should sustain to keep the existing roads in good order) is calculated as the sum of existing roads times the average maintenance cost per km for both paved and unpaved roads:

Indicated roads maintenance cost = SUM(AVERAGE ROADS MAINTENANCE COST PER KM[roads type!]*Functioning Roads[roads type!])

Here the subscript [roads type] refers to unpaved or paved roads.

Roads construction, upgrade and maintenance

The budget for the construction of new roads is allocated with the construction of paved or unpaved roads, depending on the parameter *fraction of funds for road construction for paved roads*. The funds allocated to the construction of each type of road are then divided by the average cost per km to determine how many km of road the government starts building every year:

Roads construction starts [unpaved] = budget for new transportation infrastructure*(1-FRACTION OF FUNDS FOR ROAD CONSTRUCTION FOR PAVED ROADS) /average roads construction unit cost [UNPAVED]

Roads construction starts [paved] = budget for new transportation infrastructure*(FRACTION OF FUNDS FOR ROAD CONSTRUCTION FOR PAVED ROADS) /average roads construction unit cost [PAVED]

It is assumed in the model that *average roads construction unit cost* increases as road density becomes higher:

average roads construction unit cost [roads type] = INITIAL ROADS UNIT COST[roads type] *relative road density ^ELASTICITY OF ROADS UNIT COST TO ROADS DENSITY

The *road construction starts* accumulates in the stock of *roads under construction*, before becoming *functioning roads* after a certain average construction time. *Functioning roads* are disrupted when proper maintenance is not implemented:

Roads disruption [road type] = Functioning Roads [roads type]*(1-implemented fraction of necessary maintenance)/AVERAGE ROADS LIFE WITHOUT MAINTENANCE[roads type]

The percentage of properly maintained roads (*implemented fraction of necessary maintenance*) depends on the ratio of allocated roads expenditure over the required amount for maintenance:

implemented fraction of necessary maintenance = MIN(1,real roads expenditure/indicated roads maintenance cost)

Functioning unpaved roads can be upgraded to paved roads, depending on the road upgrade sought by the government and available funds:

Roads upgrade [unpaved] = MIN(feasible upgrade, MIN(desired road upgrade, Functioning Roads[UNPAVED]/MINIMUM TIME TO UPGRADE ROADS))

The road density (*roads per hectare of land*) is calculated as:

roads per hectare of land = total roads/TOTAL LAND AREA

The current *roads per hectare of land* is then compared to its initial amount to obtain the *relative road density*, which is a main output of this sector that drives agricultural, industrial and services productivity.

References

Stifel D, B. Minten, and P. Dorosh. 2003. "Transaction Costs and Agricultural Productivity: Implications of Isolation for Rural Poverty in Madagascar." IFPRI MSSD Discussion Paper No. 56. IFPRI, Washington D.C.

10. Port cargo module

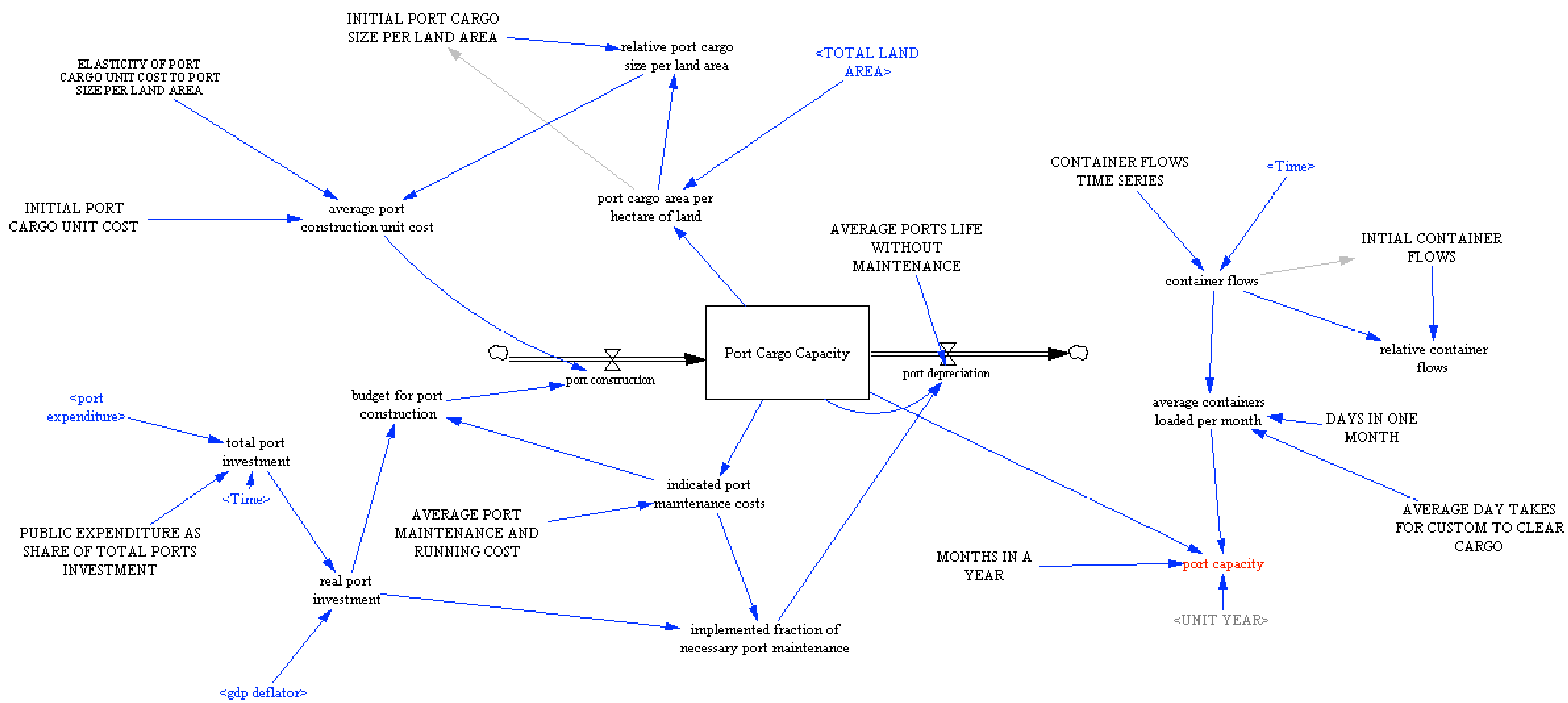


Figure 60: Sketch of the Port Cargo module

Purpose and Perspective

Apart from roads, the T21-Malaysia model also computes the capacity of port cargo infrastructure. The Port Cargo module represents the process of port cargo construction and disruption on a countrywide level.

As one of the crucial types of infrastructure in Malaysia, the port capacity is a main driver for productivity and exports of industrial products, and thus economic development.

Explanation

Major Assumptions

- Port cargo construction depends on the amount of public and private investment in ports;
- Port cargo maintenance has priority over port cargo construction when budgets are limited;
- The port capacity has an important effect on industrial productivity and exports.

Table 45: Input variables: Port cargo module

Variable Name	Module of Origin
Total population	Population
Total land area	Land
Port expenditure	Government expenditure
GDP deflator	Relative prices

Table 46: Output variables: Port cargo module

	Destination Module		
Variable Name	**Same Sector**	**Other Social Sectors**	**Other Sectors**
Port capacity			Industry, International Trade
Initial port capacity			International Trade

Table 47: Constants and table functions: Port cargo module

Variable Name	Type of Variable	Source for Estimation
Average day takes for custom to clear cargo	Constant	Data on port capacity (Malaysian Economy in Figures 2011)
Average Port maintenance and running cost	Constant	Data on port capacity and expenditure (Malaysian Economy in Figures 2011)
Average ports life without maintenance	Constant	Data on port capacity (Malaysian Economy in Figures 2011)
Container flows time series	Time Series	Data on port transport (Malaysian Economy in Figures 2011)
Elasticity of port cargo unit cost to port size per land area	Constant	Data on port capacity and expenditure (Malaysian Economy in Figures 2011)
Initial port cargo unit cost	Constant	Data on port capacity and expenditure (Malaysian Economy in Figures 2011)
Months in a year	Constant	Gregorian calendar
Public expenditure as share of total ports investment	Time Series	Data on port investment (Malaysian Economy in Figures 2011)

Functional Explanation

Similar to the Roads module, the structure of the Port Cargo module can be divided into two sub-structures: (1) the budget for port construction and maintenance; (2) the physical flows of port construction and maintenance.

Budgets for port cargo construction, maintenance and upgrades

The total investment in ports is calculated as government expenditure for ports divided by the public share of investment in ports. This is then deflated by the GDP deflator to obtain the *real port investment*:

Total port investment = port expenditure/PUBLIC EXPENDITURE AS SHARE OF TOTAL PORTS INVESTMENT(Time)

Real port investment = total port investment /GDP deflator

This budget is allocated with priority to the maintenance of the existing structures, with respect to building new infrastructures. The budget for the construction of new ports is calculated as:

Budget for port construction = MAX(0,(real port investment-indicated port maintenance costs))

The indicated budget for port maintenance (the expenditure that the government should sustain to keep the existing ports in good order) is calculated by multiplying existing port capacity and the average maintenance cost:

Indicated port maintenance costs = AVERAGE PORT MAINTENANCE AND RUNNING COST*Port Cargo Capacity

Port cargo construction and maintenance

The fund allocated to port construction then determines how ports are constructed each year:

port construction = budget for port construction/average port construction unit cost

It is assumed in the model that *average port construction unit cost* increases as port density becomes higher:

average port construction unit cost = INITIAL PORT CARGO UNIT COST*relative port cargo size per land area ^ELASTICITY OF PORT CARGO UNIT COST TO PORT SIZE PER LAND AREA

The *port construction starts* accumulates in the stock of *Port Cargo Capacity*. The capacity is reduced after a certain period of time when proper maintenance is not implemented:

port depreciation = Port Cargo Capacity*(1-implemented fraction of necessary port maintenance)/AVERAGE PORTS LIFE WITHOUT MAINTENANCE

The percentage of properly maintained ports (*implemented fraction of necessary port maintenance*) depends on the ratio of allocated port investment over the required amount for maintenance:

implemented fraction of necessary port maintenance = MIN(1,real port investment/indicated port maintenance costs)

The *port capacity* per year is calculated as the minimum of the capacity and exogenous flows of containers at ports:

port capacity = MIN(Port Cargo Capacity, average containers loaded per month*MONTHS IN A YEAR)

The *port capacity* is a main output of this sector that drives productivity and exports of industrial products.

11. Air Transport module

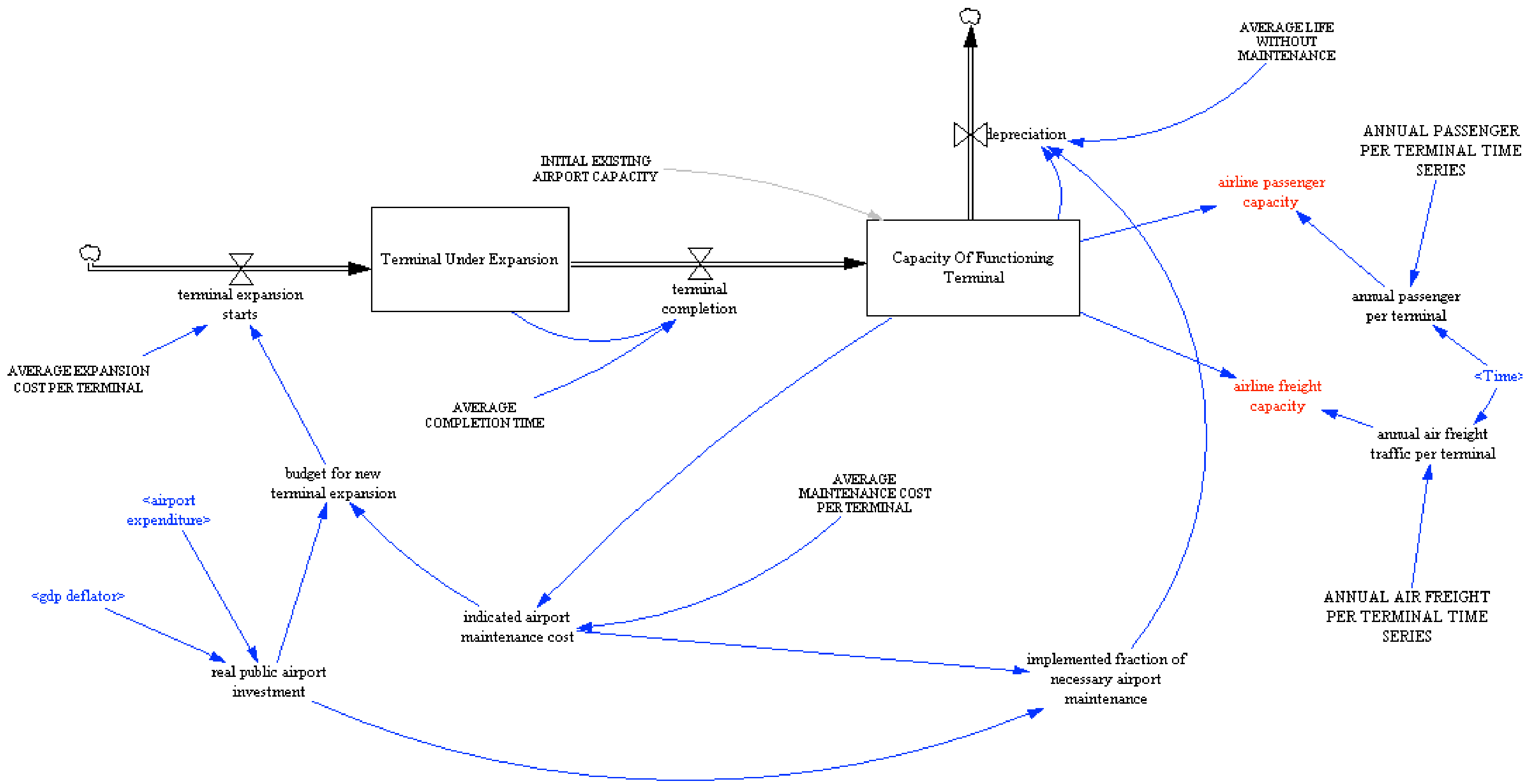


Figure 61: Sketch of the Air Transport module

Purpose and Perspective

The Infrastructure sector of the T21-Malaysia model also includes the Air Transport module that represents the process of airport expansion, completion and disruption on a countrywide level.

The air transport capacity of passengers and freight are computed in this module, which are used in other sector to drive the services and industrial development respectively.

Explanation

Major Assumptions

- Airport maintenance has priority over airport construction when budgets are limited;
- The capacity of passengers air transport has an important impact on services productivity and exports, while capacity of freight air transport affects industrial productivity and exports

Table 48: Input variables: Air Transport module

Variable Name	Module of Origin
Airport expenditure	Government expenditure
GDP deflator	Relative prices

Table 49: Output variables: Air Transport module

	Destination Module		
Variable Name	**Same Sector**	**Other Social Sectors**	**Other Sectors**
Airline passenger capacity			Services, International trade
Airline freight capacity			Industry, International trade
Initial airline passenger capacity			International trade
Initial airline freight capacity			International trade

Table 50: Constants and table functions: Air Transport module

Variable Name	Type of Variable	Source for Estimation
Annual air freight per terminal time series	Constant	Data on air transport and capacity (Malaysian Economy in Figures 2011)
Annual passenger per terminal time series	Time series	Data on air transport and capacity (Malaysian Economy in Figures 2011)
Average completion time	Constant	Data on airport capacity (Malaysian Economy in Figures 2011)
Average expansion cost per terminal	Constant	Data on airport capacity and expenditure (Malaysian Economy in Figures 2011)
Average life without maintenance	Constant	Data on airport capacity (Malaysian Economy in Figures 2011)
Average maintenance cost per terminal	Constant	Data on airport capacity and expenditure (Malaysian Economy in Figures 2011)
Initial existing airport capacity	Constant	Data on airport capacity (Malaysian Economy in Figures 2011)

Functional Explanation

Similar to the Roads module, the structure of the Air Transport module can be divided into two sub-structures: (1) the budget for airport construction and maintenance; (2) the physical flows of airport construction and maintenance.

Budgets for airport expansion and maintenance

The real government expenditure for airports is calculated as a the deflated amount of the *airports expenditure* by the GDP deflator:

real public airport investment = airport expenditure/GDP deflator

This budget is allocated with priority to the maintenance of the existing airports, with respect to expanding new infrastructures. The budget for the expansion of new terminals is calculated as:

budget for new terminal expansion = MAX(0,(real public airport investment-indicated airport maintenance cost))

The indicated budget for airport maintenance (the expenditure that the government should sustain to keep the existing airports in good order) is calculated by multiplying existing terminals and the average maintenance cost:

Indicated airports maintenance cost = AVERAGE MAINTENANCE COST PER TERMINAL*Capacity Of Functioning Terminal

Airports expansion, completion and maintenance

The fund allocated to airport expansion then determines how terminals are expanded each year:

terminal expansion starts = budget for new terminal expansion/AVERAGE EXPANSION COST PER TERMINAL

The *port construction starts* accumulates in the stock of *Terminal Under Expansion*, before becoming functioning terminals after a certain average completion time. *Capacity of functioning terminal* is reduced when proper maintenance is not implemented:

depreciation = Capacity Of Functioning Terminal*(1-implemented fraction of necessary airport maintenance)/AVERAGE LIFE WITHOUT MAINTENANCE

The percentage of properly maintained terminals (*implemented fraction of necessary airport maintenance*) depends on the ratio of allocated airport investment over the required amount for maintenance:

implemented fraction of necessary airport maintenance = MIN(1,real public airport investment/indicated airport maintenance cost)

The *airline passenger capacity* per year is calculated by multiplying *Capacity of functioning terminal* and the average number of passenger transport of each terminal:

airline passenger capacity = annual passenger per terminal*Capacity Of Functioning Terminal

This is a main output of this sector that has impacts on productivity and exports of services.
Following the same logic, *airline freight capacity* per year is obtained in this sector, driving industrial productivity and exports.

12. Broadband module

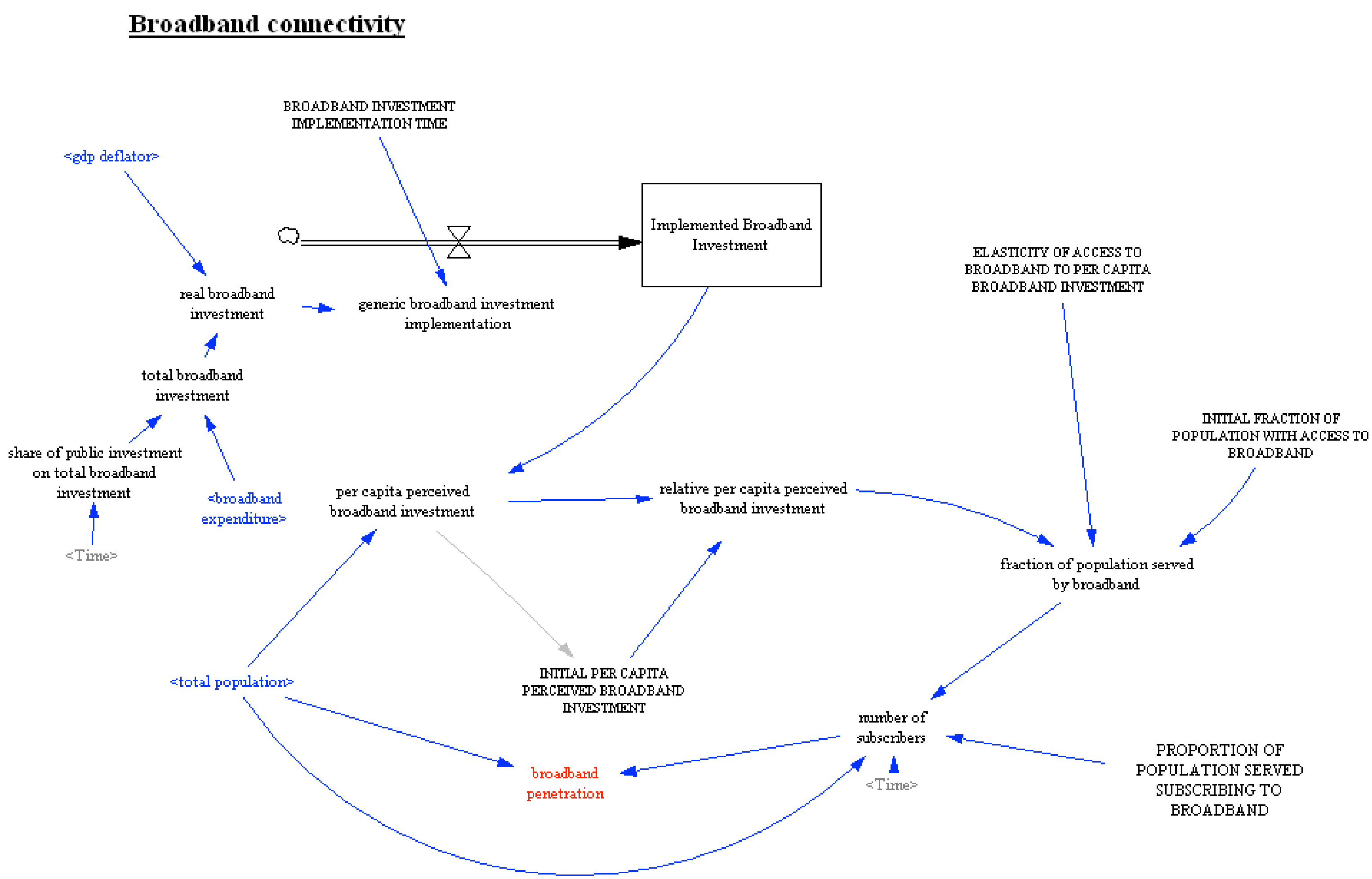


Figure 62: Sketch of the Broadband module

The Broadband module estimates the connectivity of broadband driven by the per capita level of infrastructure put in place by both the government and private sectors.

As one of the crucial types of infrastructure in Malaysia, the broadband penetration rate is a main driver for economic growth through productivity and exports of industrial and services products.

Explanation

Major Assumptions

- Broadband connectivity depends on the amount of public and private investment for broadband;
- Broadband penetration has an important effect on industrial and services productivity and exports.

Table 51: Input variables: Broadband module

Variable Name	Module of Origin
Broadband expenditure	Government expenditure
GDP deflator	Relative prices

Table 52: Output variables: Broadband module

	Destination Module		
Variable Name	**Same Sector**	**Other Social Sectors**	**Other Sectors**
Broadband penetration			Industry, Services, International trade

Table 53: Constants and table functions: Broadband module

Variable Name	Type of Variable	Source for Estimation
Broadband investment implementation time	Constant	Data on broadband penetration and investment (Malaysian Economy in Figures 2011)
Initial fraction of population with access to broadband	Constant	Data on broadband penetration (Malaysian Economy in Figures 2011)
Elasticity of access to broadband to per capita broadband investment	Constant	Data on broadband penetration and investment (Malaysian Economy in Figures 2011)
Proportion of population served subscribing to broadband	Constant	Data on broadband penetration (Malaysian Economy in Figures 2011)
Share of public investment on total broadband investment	Time Series	Data on broadband investment (Malaysian Economy in Figures 2011)

Functional Explanation

Similar to the structure of Healthcare module, broadband penetration in this module, is related to per capita level of government expenditure per capita in broadband infrastructure, which is the *per capita perceived broadband expenditure*. To calculate this, *Implemented Broadband Investment* is divided by *total population*:

per capita perceived broadband investment = Implemented Broadband Investment/total population

The *Implemented Broadband Investment* is determined by the total public and private investment in broadband (*total broadband investment*), which is calculated as government expenditure for broadband divided by the public share of investment in broadband. This is then deflated by the GDP deflator to obtain the *real broadband investment*:

Total broadband investment = broadband expenditure/share of public investment on total broadband investment

Real broadband investment = total broadband investment /GDP deflator

The *per capita perceived broadband expenditure* is compared to its initial value to obtain the *relative per capita perceived broadband expenditure*. This is then used to calculate *fraction of population served by broadband:*

Fraction of population served by broadband = MIN(1,INITIAL FRACTION OF POPULATION WITH ACCESS TO BROADBAND*relative per capita perceived broadband investment ^ELASTICITY OF ACCESS TO BROADBAND TO PER CAPITA BROADBAND INVESTMENT)

This fraction is then multiplied by the *total population* and the *proportion of population served subscribing to broadband* to obtain the total *number of subscribers:*

number of subscribers = (fraction of population served by broadband*total population)*PROPORTION OF POPULATION SERVED SUBSCRIBING TO BROADBAND(Time)

Therefore, as a main output of this sector driving industrial and services productivity and exports, the *broadband penetration* can be estimated by comparing the *number of subscribers* to *total population:*

broadband penetration = number of subscribers/total population*100

13. Employment module

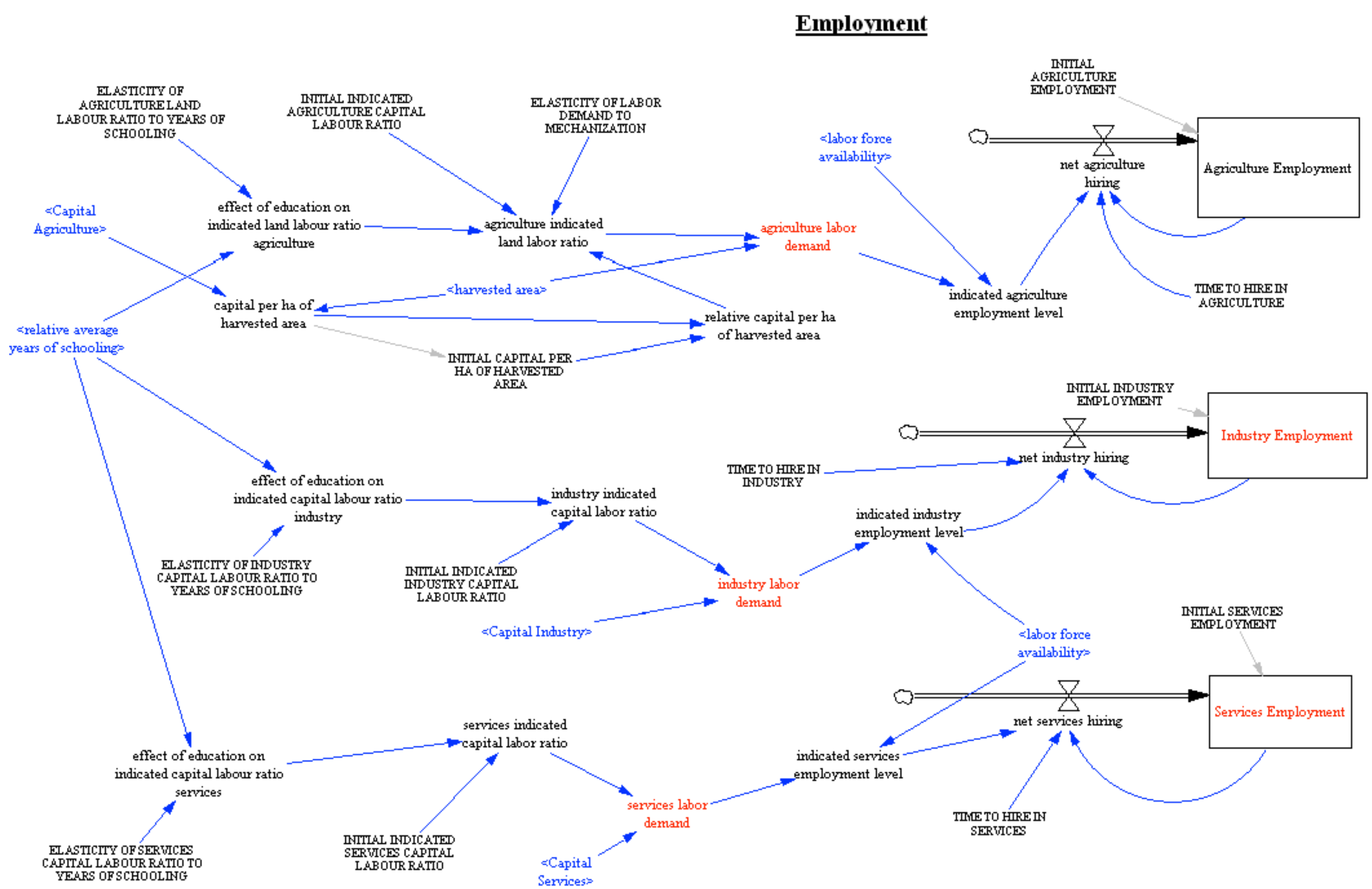


Figure 63: Sketch of the Employment module

Purpose and Perspective

The Employment module represents how economic activity creates employment (**Figure 68**). Capital accumulation for agriculture, industry and services production is considered the major force for driving the growth labor demand. The main driver for agricultural labor demand is the amount of harvested area, while it is also related to capital availability. Education improvements, on the contrary, tend to decrease labor demand, assuming that with better education level less labor is required for each unit of capital. Eventually, employment levels tend to adjust over time to labor demand, unless the labor supply is insufficient to satisfy demand. Future long-term employment trends will likely be captured to links to capital and education, while short-term fluctuations of employment are likely to be captured through the effect of changes in wages. Since T21 is long-term oriented (rather than short-term), the employment algorithm used is driven by capital and education.

Explanation

Major Assumptions

- Employment levels depend on the amount of productive capital and current levels of education;
- Agricultural employment is also driven by harvested area;
- Employment levels cannot be higher than the available labor force.

Table 54: Input variables: Employment module

Variable Name	**Module of Origin**
Capital agriculture	Agriculture
Harvested area	Agriculture
Capital industry	Industry
Capital services	Services
Labor force availability	Labor availability and unemployment
Relative average years of schooling	Secondary Education

Table 55: Output variables: Employment module

	Destination Module		
Variable Name	**Same Sector**	**Other Social Sectors**	**Other Sectors**
Agriculture employment	Labor availability and unemployment		Agriculture
Industry employment	Labor availability and unemployment		Industry
Services employment	Labor availability and unemployment		Services
Agriculture labor demand	Labor availability and unemployment		
Industry labor demand	Labor availability and unemployment		
Services labor demand	Labor availability and unemployment		
Relative agriculture employment			Agriculture
Relative industry employment			Industry
Relative services employment			Services

Table 56: Constants and table functions: Employment module

Variable Name	Type of Variable	Source for Estimation
Initial agriculture employment	Constant	Malaysian Economy in Figures 2011
Time to hire in agriculture	Constant	Data on employment and investment (Malaysian Economy in Figures 2011)
Initial industry employment	Constant	Malaysian Economy in Figures 2011
Time to hire in industry	Constant	Data on employment and investment (Malaysian Economy in Figures 2011)
Initial services employment	Constant	Malaysian Economy in Figures 2011
Time to hire in services	Constant	Data on employment and investment (Malaysian Economy in Figures 2011)
Elasticity of agriculture land labour ratio to years of schooling	Constant	Data on employment, education (Malaysian Economy in Figures 2011) and land (FAO)
Initial indicated agriculture capital labour ratio	Constant	Data on employment and investment (Malaysian Economy in Figures 2011)
Elasticity of labor demand to mechanization	Constant	Data on employment, investment (Malaysian Economy in Figures 2011) and land (FAO)
Elasticity of industry capital labour ratio to years of schooling	Constant	Data on employment, investment and education (Malaysian Economy in Figures 2011) and land (FAO)
Initial indicated industry capital labour ratio	Constant	Data on employment and investment (Malaysian Economy in Figures 2011)
Elasticity of services capital labour ratio to years of schooling	Constant	Data on employment, investment and education (Malaysian Economy in Figures 2011) and land (FAO)
Initial indicated services capital labour ratio	Constant	Data on employment and investment (Malaysian Economy in Figures 2011)

The calculation of employment levels for the three production activities (agriculture, industry and services) follow a very similar approach, so only the description of the calculation for industry employment appears here. Users can understand the formulations used to calculate employment for the other two types of production activity by analogy.

To determine employment levels, labor demand from the Industry module is calculated first, and then it is assumed employment is adjusted to labor demand, unless labor supply is insufficient to cover demand.

Labor demand

To determine labor demand, the desired capital labor ratio is determined first, that is the optimal capital labor ratio sought by producers.

For industry and services sectors, the desired capital labor ratio increases as education level improves. The industry sector, for instance:

Industry indicated capital labor ratio = INITIAL INDICATED INDUSTRY CAPITAL LABOUR RATIO*effect of education on indicated capital labour ratio industry

effect of education on indicated capital labour ratio industry = relative average years of schooling ^ELASTICITY OF INDUSTRY CAPITAL LABOUR RATIO TO YEARS OF SCHOOLING

Then, labor demand is calculated as the capital stock, divided by the desired capital labor ratio.

Industry labor demand = (Capital Industry/industry desired capital labor ratio)

The services sector labor demand is calculated according to the same logic.

In terms of agriculture sector, *harvested area* is considered as the main driver for labor demand, while the land-labor ratio depends on capital per ha of land and education level of the labor:

agriculture indicated land labor ratio[crop type] = INITIAL INDICATED AGRICULTURE CAPITAL LABOUR RATIO[crop type]*relative capital per ha of harvested area[crop type]^ELASTICITY OF LABOR DEMAND TO MECHANIZATION[crop type]*effect of education on indicated land labour ratio agriculture

effect of education on indicated land labour ratio agriculture = relative average years of schooling ^ELASTICITY OF AGRICULTURE LAND LABOUR RATIO TO YEARS OF SCHOOLING

Here, the subscript [crop type] refers to rice paddy, oil palm and the rest crop types in the agriculture sector.

Then agriculture labor demand is calculated by dividing harvested area by land-labor ratio, then summed over all crop types:

agriculture labor demand = SUM(harvested area[crop type!]/agriculture indicated land labor ratio[crop type!])

Employment

Employment is represented as a stock variable in T21, and it adjusts toward labor demand, unless the labor supply is insufficient to meet the demand.
As the same approach is used for the three sectors, only the calculation for industry employment is described here. The formulations for agriculture and services employment can be understood by analogy.

The only flow accumulating in the stock of employment is net hiring:

Net industry hiring = (indicated industry employment level-Industry Employment)/TIME TO HIRE IN INDUSTRY

Indicated employment levels represent feasible employment levels, when considering the demand of producers and the available labor force:

Indicated industry employment level = industry labor demand * labor force availability

Labor force availability represents the fraction of labor demand that can be satisfied by the current labor supply, and is calculated in the Labor availability and unemployment module.

14. Labor Availability and Unemployment module

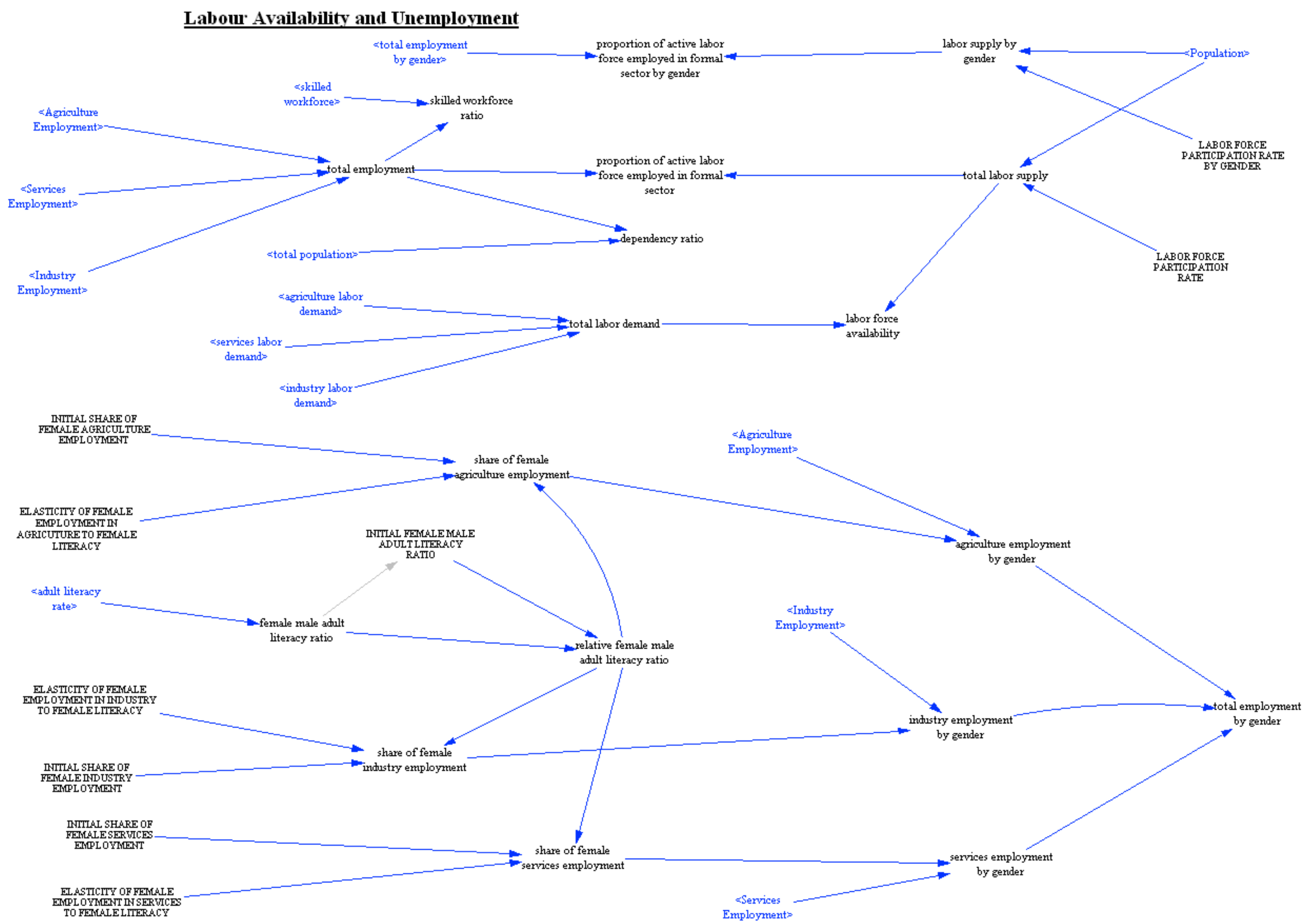


Figure 64: Sketch of the Labor Availability and Unemployment module

Purpose and Perspective

This module represents the mechanisms that, over time, cause the availability of skilled and unskilled labor (**Figure 69**). Labor supply and demand is compared to derive availability of labor force, which is used in the Labor sector to determine employment. Skilled labor supply (defined as graduates from universities) is compared with total employment to determine the share of skilled labor. Male and female employment is computed in this module.

Explanation

Major Assumptions

- Labor supply covers the age from 15 to 65;
- Skilled labor supply corresponds to the stock of graduates from universities;

Table 57: Input variables: Labor Availability and Unemployment module

Variable Name	Module of Origin
Population	Population
Total population	Population
Agriculture labor demand	Employment
Industry labor demand	Employment
Services labor demand	Employment
Agriculture employment	Employment
Industry employment	Employment
Services employment	Employment
Skilled workforce	Tertiary education
Adult literacy rate	Primary education

Table 58: Output variables: Labor Availability and Unemployment module

	Destination Module		
Variable Name	**Same Sector**	**Other Social Sectors**	**Other Sectors**
Labor force availability	Employment		
Total employment by gender			HDI and GDI
Industry employment by gender			MDGs
Industry employment by gender			MDGs
Relative skilled labor availability			Agriculture

Table 59: Constants and table functions: Labor Availability and Unemployment module

Variable Name	Type of Variable	Source for Estimation
Labor force participation rate by gender	Constant	Data on employment (Malaysian Economy in Figures 2011) and population (UN POP)
Labor force participation rate	Constant	Data on employment (Malaysian Economy in Figures 2011) and population (UN POP)

Functional Explanation

The Labor Availability and Unemployment module describes the mechanism that estimates the availability of labor, which is used to determine actual employment. In addition, a number of indicators relevant to labor and employment are calculated.

Availability of labor

The availability of the labor force is calculated as the ratio of labor supply and demand. Labor supply is calculated as a fraction of the population in the productive age:

Total labor supply = SUM(Population[sex!,labor age!])*labor force participation rate

Total labor demand is calculated as the sum of labor demand for each type of production activity calculated in the Employment module:

Total labor demand = agriculture labor demand+industry labor demand+services labor demand

Labor availability is determined as below:

Labor force availability = IF THEN ELSE (total labor demand>total labor supply, total labor supply/total labor demand, 1)

Note that the formulation “if then else” is used to make sure that when labor supply exceeds labor demand, labor availability is equal to 100%.

Other indicators

In this module, a number of indicators are calculated that compares employment, labor supply, skilled labor and total population:

dependency ratio = total population/total employment

proportion of active labor force employed in formal sector = total employment/total labor supply

skilled workforce ratio = skilled workforce/total employment

15. Income Distribution module

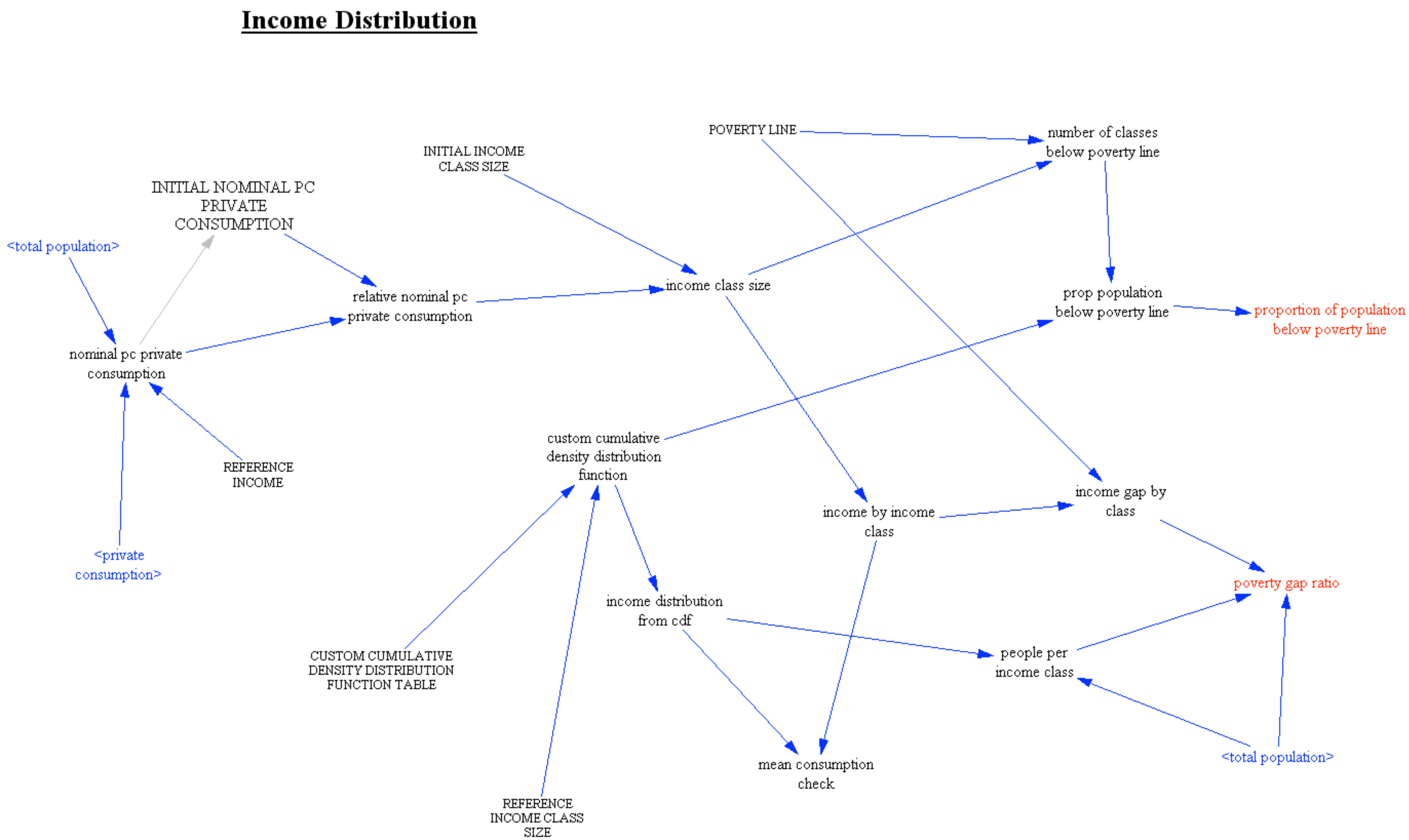


Figure 65: Sketch of the Income Distribution module

Purpose and Perspective

The Income Distribution module in a development model is important because much of the discussion of development focuses on reducing poverty. A model supporting development policies must discuss the implications of specific policies on income for the poorest in society, and on the overall income distribution for the country. It is also true there is no well-formed consensus of how to model income distribution, the processes that change it or its effects on growth processes.

The Income Distribution module is illustrated in **Figure 70**. It assumes a log normal distribution of income to model income distribution for rural and urban areas of a country. There are three main reasons we choose this approach to model income distribution. First, the log normal distribution is described in many economic publications as very similar to income distribution in a wide range of countries (c.f. p. 71 of Greene and p.254 of Pearce in References). Second, empirical tests show that the difference between real income distribution and that obtained by using a log normal distribution are relatively small (test run on Brazil, China, and India, and found that the differences between the calculated and empirical data sets were less than 10%). Finally, the log normal distribution is easy to implement, since it can be specified with only two parameters—the mean and the variance (or standard deviation).

Explanation

Major Assumptions

- Income is log normally distributed

Table 60: Input variables: Income Distribution module

Variable Name	Module of Origin
Total population	Population
Disposable income	Households account
Private consumption	Households
GDP deflator	Relative prices

Table 61: Output variables: Income Distribution module

	Destination Module		
Variable Name	**Same Sector**	**Other Social Sectors**	**Other Sectors**
Proportion of population below poverty line			MDGs
Poverty gap ratio			MDGs

Table 62: Constants and table functions: Income Distribution module

Variable Name	Type of Variable	Source for Estimation
Custom cumulative density distribution function table	Table function	Data on poverty (Malaysian Economy in Figures 2011)
Initial income class size	Constant	Data on poverty (Malaysian Economy in Figures 2011)
Reference income class size	Constant	Data on poverty (Malaysian Economy in Figures 2011)
Poverty line	Constant	Malaysian Economy in Figures 2011

Functional Explanation

From a mathematical perspective, the Income Distribution module is probably the most complex part of the T21 model. Assuming a log normal distribution of income, two parameters must be determined to calculate income distribution: the mean and standard deviation of income. The Households module of T21 generates disposable income, from which we can compute mean income. The standard deviation of income can be computed from the Gini coefficient and the mean of income, as seen in the next section. The next section describes the general characteristics of a log normal distribution, while the subsequent sections describe the method used to calculate income distribution and other indicators.

Characteristics of the log normal distribution

If X is log normally distributed as LN(θ, λ^2), and Y = log X, then Y is normally distributed as N(μ, δ^2), i.e., the log of a log normal variable becomes a normal variable. (In other words, if Y is normal, then X=EXP(Y) is log normal)

The relationship between the parameters θ, λ and μ, δ are:

$$\mu = LN(\theta^2) - 0.5 * LN(\theta^2 + \lambda^2) \quad (1)$$

$$\delta^2 = LN(1 + \lambda^2/\theta^2) \quad (2)$$

$$\theta = EXP(\mu + \delta^2/2) \quad (3)$$

$$\lambda^2 = EXP(2*\mu + \delta^2) * (EXP(\delta^2) - 1) \quad (4)$$

The log normal distribution has the following density function, in which x is the income level:

$$f(x) = 1/(SQRT(2*\pi)*\delta*x) * EXP(-((\ln x - \mu)\hat{}2)/(2*\delta\hat{}2) \quad (5)$$

From the density function we see that, once we know the mean (θ) and standard deviation (λ) of the log normal (or income) distribution, we need to compute the mean (μ) and the standard deviation (δ) of the corresponding normal distribution before we arrive at the density function.

The cumulative function of the log normal distribution cannot be written in an analytically closed form.

The income distribution

In this model, the density function of income distribution for the first and the rest income classes can now be computed separately from the cumulative distribution function *custom cumulative density distribution function table* (obtained from the exogenous CDF table) as:

income distribution from cdf[INCCLASS 1] = custom cumulative density distribution function[INCCLASS 1]

income distribution from cdf[incclass not first] = custom cumulative density distribution function[incclass not first]-VECTOR ELM MAP(custom cumulative density distribution function[incclass not first], -1)

Notice that [IncClass] is an array, so that the density function values at all the income levels can be computed with a single equation.

Indicators

With income distribution and its mean and standard deviations, a variety of indicators are calculated. Two common indicators are the *proportion of population below poverty line* and the *poverty gap ratio*. The *proportion of population below poverty line* is calculated as:

proportion of population below poverty line = SUM(prop population below poverty line[incclass!])*100

prop population below poverty line[incclass] = IF THEN ELSE(incclass=INTEGER (number of classes below poverty line), custom cumulative density distribution function[incclass]+MODULO(number of classes below poverty line,1)*(VECTOR ELM MAP(custom cumulative density distribution function[incclass], +1)-custom cumulative density distribution function[incclass]),0)

Note that the LNNORMAL distribution of income is endogenously included in this module.

The *poverty gap ratio* is calculated from income distribution.

Poverty gap ratio = SUM(income gap by class[incclass!]*people per income class[incclass!])/total population

people per income class[incclass] = income distribution from cdf[incclass]*total population

income gap by class[incclass] = IF THEN ELSE(POVERTY LINE-income by income class[incclass]>0, (POVERTY LINE-income by income class[incclass])/POVERTY LINE,0)

References

William H. Greene, *Econometric Analysis, 3rd Edition*, Prentice Hall 1993 (p.71)

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Economic Sectors

16. Aggregate Production and Income module

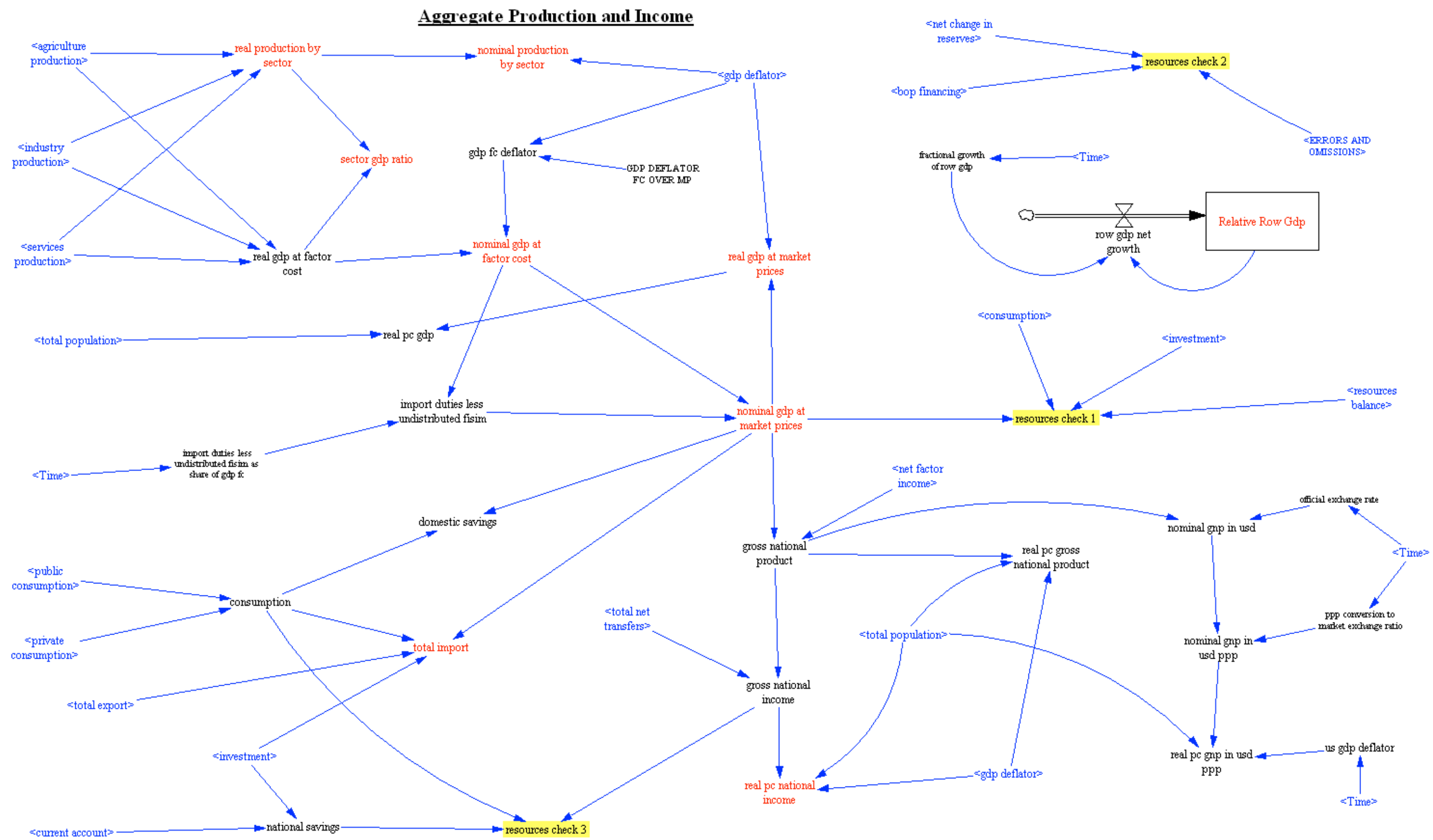

Figure 66: Sketch of the Aggregate Production and Income module

Purpose and Perspective

The Aggregate Production and Income module represents the economic accounting of complex economic activities and the interaction between different economic agents in the economy. This module national account model shows how income is determined and the distribution of the income and uses by economic agents. The main purpose of this module is to summarize and represent the aggregate indicators that evaluate the country's overall economic performance. Some key indicators of national economic accounts are calculated in this module, such as gross domestic product (at market prices and factor cost) and per capita GDP, gross national income, national saving, among others. The GDP identity is also represented in this module. Three check variables (highlighted) are included in this sketch, which are used to monitor the consistency of national accounts.

Explanation

Table 63: Input variables: Aggregate Production and Income module

Variable Name	Module of Origin
Public consumption	Public investment and consumption
Private consumption	Public investment and consumption
Investment	Investment
Resources balance	Balance of payments
Current account	Balance of payments
Total net transfers	Balance of payments
Net factor income	Balance of payments
Bop financing	Balance of payments
Errors and omissions	Balance of payments
Total export	International trade
Net change in reserves	Households
GDP deflator	Relative prices
Industry production	Industry
Services production	Services
Agriculture production	Agriculture
Total population	Population

Table 64: Output variables: Aggregate Production and Income module

	Module of Destination		
Variable Name	**In the Same Sector**	**In Other Economic Sectors**	**In Other Sectors**
Nominal sectoral production		Government revenue, relative prices	
Nominal GDP at factor cost		Government revenue	
Nominal GDP at market prices		Government Balance and Financing, Government Debt, Households, International Trade, Balance of Payments	HDI and GDI
Nominal production by sector		Relative prices	
Official exchange rate		Public Investment and Consumption, International Trade	Energy Prices, HDI and GDI
Perceived relative prices		International trade	
PPP conversion to market exchange ratio			HDI and GDI
US GDP deflator			HDI and GDI
Real GDP at market prices		Households, Industry, Services	Fossil fuel and GHG emissions, Energy demand, Energy supply
Real pc GDP			Fertility
Real pc national income		Relative prices	
Real production by sector		Relative prices, International trade	
Relative row GDP		International trade	
Sector GDP ratio		Investment	
Total import		International trade	

Table 65: Constants and table functions: Aggregate Production and Income module

Variable Name	Type of Variable	Source for Estimation
Import Duties less Undistributed FISIM as share of GDP fc	Time series	Data on production (Malaysian Economy in Figures 2011)
GDP deflator fc over mp	Constant	Data on production (Malaysian Economy in Figures 2011)
Official exchange rate	Time series	Malaysian Economy in Figures 2011
US GDP deflator	Time series	WDI
PPP conversion to market exchange ratio	Time series	Malaysian Economy in Figures 2011
Fractional growth of row GDP	Time series	WDI

Functional Explanation

The major function of this module is to calculate gross value of production activity (GDP): agriculture, industry and services. On top of this, a number of key aggregate indicators of the national economic account are calculated.

Gross domestic product

The real and nominal GDP at factors cost or market prices are calculated based on the production value of agriculture, industry and services sectors. The GDP per capita is also computed:

Real GDP at factor cost = agriculture production +industry production +services production

Nominal GDP at factor cost = real GDP at factor cost* GDP fc deflator

Nominal GDP at market prices = nominal GDP at factor cost +import duties less undistributed fisim

Real GDP at market prices = nominal GDP at market prices / GDP deflator

The GDP per capita and sectoral GDP ratio (relative contribution of each type of production activity to GDP) are also computed:

Real PC GDP = real GDP at market prices/total population

Sector GDP ratio [sectors] = real production by sector[sectors]/real GDP at factor cost

Other indicators

The total import is calculated by using the GDP identity (GDP=C+I+IM-EX):

total import = consumption + investment+ total export - nominal GDP at market prices

The nominal gross national income and real gross national income per capita are calculated on top of GDP:

gross national income = gross national product + total net transfers

gross national product = nominal GDP at market prices+net factor income

real pc national income = (gross national income/GDP deflator)/total population

Finally, this module contains three *check* variables (*resources check 1, 2, 3*), which are used to test at any time the internal consistency of the system of national accounts of T21.

17. Agriculture module

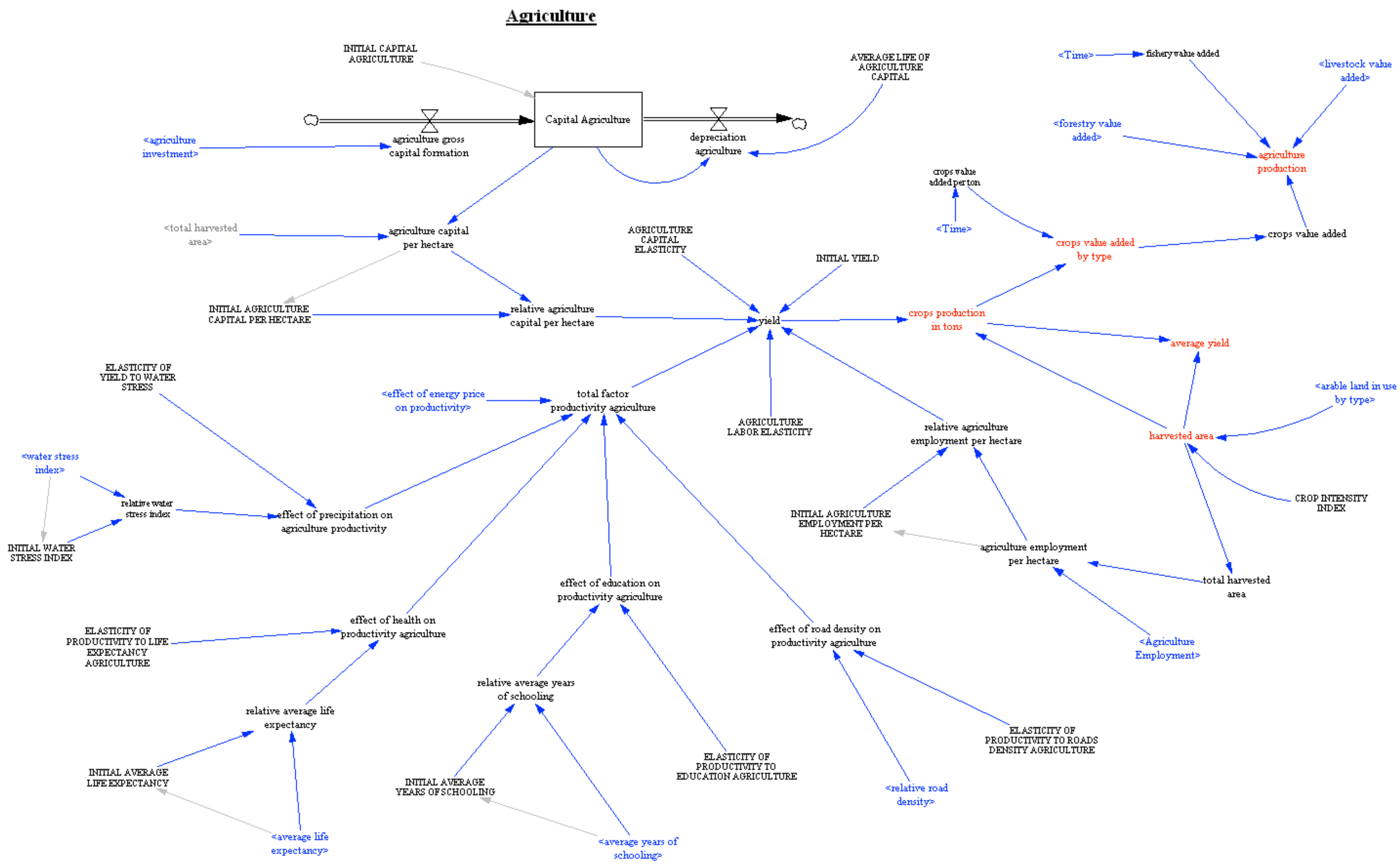

Figure 67: Sketch of the Agriculture module

Purpose and Perspective

The Agriculture module (**Figure 72**) calculates agriculture production, including crops production, livestock production and forestry production. The Agriculture module only considers crops production, while the other types of agricultural production are taken into account in the Husbandry, Fishery and Forestry module.

The production function used in the Agriculture module is based on the Cobb-Douglas production function. Capital, Land and the availability of water, energy prices, labor amount, health and education level, and roads are the factors of production included.

In the CD production function, growth in production is driven by the increase in availability of the necessary production factors. This implies that demand factors are not considered in the calculation of production, and that the quantities produced are always consumed. These characteristics of the CD production function make it unsuitable to represent short-term fluctuations in production, which are generally caused by the accumulation of inventories of finished goods. Since T21 is geared toward long-term analysis and not short-term fluctuations, these limitations do not affect the validity of the model. On the other hand, the CD production function can adequately represent the long-term pattern of production growth, and is therefore well suited to calculate production in T21.

Explanation

Major Assumptions

- Agriculture production is calculated using a Cobb-Douglas production form;
- Productivity depends on capital and land, and on the availability of a healthy labor force and their education level, water, roads, and energy prices;

Table 66: Input variables: Agriculture module

Variable Name	Module of Origin
Agriculture investment	Investment
Effect of energy price on productivity	Energy Prices
Average life expectancy	Mortality
Average years of schooling	Secondary Education
Water stress index	Water Supply
Relative road density	Roads
Relative skilled labor availability	Labor Availability and Cost
Agriculture employment	Employment
Arable land in use by type	Land
Total harvested area	Land
Forestry value added	Husbandry-fishery- forestry
Livestock value added	Husbandry -fishery-forestry

Table 67: Output variables: Agriculture module

	Module of Destination		
Variable Name	**Same Sector**	**Other Economic Sectors**	**Other Sectors**
Crops production in tons			Nutrition
Agriculture crops value added per ton			Nutrition
Agriculture production		Aggregate Production and Income, Investment	
Crops production		Investment	
Capital agriculture			Employment
Average yield			Land
Harvested area		Water demand	Employment
Relative average yield		Husbandry, Fishery and Forestry	

Table 68: Constants and table functions: Agriculture module

Variable Name	Type of Variable	Source for Estimation
Agriculture capital elasticity	Constant	Data on investment (Malaysian Economy in Figures 2011) and yield (FAO)
Agriculture labor elasticity	Constant	Data on education (Malaysian Economy in Figures 2011) and yield (FAO)
Average life of agriculture capital	Constant	Data on investment (Malaysian Economy in Figures 2011) and yield (FAO)
Crop intensity index	Time series	Data on production per crop (FAO)
Crops value added per ton	Time series	Data on value added per crop (IMF)
Elasticity of productivity to education agriculture	Constant	Data on education (Malaysian Economy in Figures 2011) and yield (FAO)
Elasticity of productivity to life expectancy agriculture		Data on life expectancy (Malaysian Economy in Figures 2011) and yield (FAO)
Elasticity of productivity to roads density agriculture	Constant	Data on roads (Malaysian Economy in Figures 2011) and yield (FAO)
Elasticity of yield to water stress	Constant	Data on yield (FAO) and precipitations (local statistical office)
Fishery value added	Time series	FAO
Initial capital agriculture	Constant	Data on investment (Malaysian Economy in Figures 2011)
Initial yield	Constant	FAO

The major output of the Agriculture module (see **Figure 72**) is agriculture production. Mere agriculture production is modeled using a Cobb-Douglas (CD) production function with main inputs land, capital, and technology. Productivity is also determined by the availability of water, roads, oil and healthy labor force (basic and educated). Mere agriculture production is calculated for two types of crops separately: cotton and rest. The type of crops considered in the agriculture production function should be determined based on the characteristics of agriculture production in the country being modeled.

In the top right of the sketch, mere agriculture production is added to fishery, forestry and livestock productions to determine total agriculture production. The following paragraphs describe how the Cobb-Douglas production function is applied to the agriculture production in T21, and how eventually total agriculture production is determined.

Note that values for agriculture production are measured in physical quantities or at constant prices.

The Cobb-Douglas production function in T21

The classic form of the CD production function is expressed as following:

$$Y = A * K^\alpha * L^(1-\alpha)$$

Where A represents the total factor productivity (TFP), K represents the stock of capital, and L represents labor or, as in the case of the agriculture production in T21, the stock of land used for agriculture. The constant α represents the elasticity of output to capital: the ratio between the percentage change of output and the percentage change of an input. The elasticity of output to labor is set to 1-α, assuming that there are constant returns to scale (the production function is thus first order, homogeneous).

In T21 the standard CD production function is transformed into a more transparent algebraic form, and TFP is expanded to include several different elements. To explain the final form of production function used in T21, we have to proceed in steps.

First, in T21 the CD production function is implemented using the values for capital and land relative to their initial values, or normalized. In the original CD function, capital and land are used directly to determine production: this leads to inconsistency in the units of measure used (capital is measured in currency units, land in hectares and production in currency per year). Normalizing K and L (dividing them by their initial value) avoids unit errors, does not modify the results of the production function and conforms to good System Dynamics practice[16] (see Sterman, 2000). In the following paragraphs we will consider the terms Y, K and L as normalized.

Second, in T21 the CD production function is written in an extended way in order to identify more clearly the contribution of each factor to production. Using the classic economic nomenclature for variables (which is different from the nomenclature chosen for T21, later explained) the CD function is written as:

Y = A * K*K^(α-1) *L* L^(-α)

In this case, K^(α-1) represents the average productivity of K, that is the factor that in a multiplicative formulation transforms K into production. Similarly, L^(-α) represents the average productivity of L. It is important to notice that as K and L increase, their average productivity tends to decrease. This is consistent with the hypothesis of diminishing marginal returns.

Third, the TFP includes several different elements affecting the productivity of factors. In the T21 agriculture production function we explicitly considered technology, a healthy labor force (uneducated and educated) and the availability of water, roads and oil. The T21 formulation for TFP for agriculture in T21 can be written as:

A = relative technology level*effect of energy price on productivity*effect of draughts on agriculture productivity* effect of water stress on agriculture productivity*effect of education on agriculture productivity*effect of road proximity on agriculture productivity*effect of labor force availability on agriculture productivity*Effect Of Hiv On Labor Productivity

These effects are separately represented in the agriculture production function used in T21, and they are applied in a multiplicative form to the average productivity of K and L. For example, the average productivity of L is calculated as:

Average productivity of land = L^(-α)*effect of draughts on agriculture productivity* effect of water stress on agriculture productivity*effect of education on agriculture productivity*effect of road proximity on agriculture productivity*effect of labor force availability on agriculture productivity*Effect Of Hiv On Labor Productivity

And the average productivity of K is calculated as:

Average productivity of K = K^(α-1) * relative technology level*effect of energy price on productivity

Note that since all the elements composing the TFP are used in a multiplicative form, it is algebraically indifferent whether a specific effect is assumed to affect the productivity of K or L. We chose whether to use the various elements composing TFP to calculate capital or land productivity based on common sense, and to make the CD production function as transparent as possible. For example, we used

[16] From a System Dynamics perspective, K ^α and L^(1-α) represent the effects of capital and land on production, and are used in a multiplicative form in the production function

technology to calculate the productivity of capital, assuming that technology is more strictly related to capital than land. However, one can use technology to determine the productivity of land and not capital, and the result would not change.

The actual equations used in T21 to calculate the agriculture production reflect exactly the logic described above, but use more transparent variable names to identify the various factors and effects. The capital per ha of land is calculated by dividing agriculture capital by total harvested area. Similarly, employment per ha of land is calculated by dividing agriculture capital by total harvested area. Both are divided by their initial value to obtain the relative (normalized) levels, which are used to determine crops yield.
The formulation of crops *yield* is:

yield [crop type] = INITIAL YIELD[crop type] *relative agriculture capital per hectare[crop type]^AGRICULTURE CAPITAL ELASTICITY[crop type]*total factor productivity agriculture[crop type] *relative agriculture employment per hectare^AGRICULTURE LABOR ELASTICITY

Note that the subscript [crop type] is used to distinguish among the land used for the different crops.

Crops production in tons is calculated as the product of yield and harvested area:

Crops production in tons [crop type] = yield[crop type]*harvested area[crop type]

To obtain *crops value added* in monetary values for each crop type, production in tons is multiplied by the value added per ton of crop, and production from all crops is summed up:

crops value added by type[crop type] = crops production in tons[crop type]*crops value added per ton[crop type]

crops value added = SUM(crops value added by type[crop type!])

Finally, total *agriculture production* is calculated as the sum of *mere agriculture production*, forestry, fishery and livestock productions:

Agriculture production = crops value added +livestock value added +forestry value added +fishery value added

Cobb-Douglas alternative transformations

The particular transformation of the Cobb-Douglas production function presented above is one of many possible forms in which the CD production function can be used. Depending on the type of audience to which the model is directed, different CD forms can be adopted.

For example, another commonly used transformation of the CD production function is:

$$Y = A * (K/L)^\alpha * L$$

In this case, production is obtained by multiplying the land L times the average productivity of land $(K/L)^\alpha$, and by the total factor productivity A. Note that the average productivity of land is a function of the capital intensity per unit of land (K/L), and it increases at decreasing rate as K/L increases.

Agriculture capital

Agriculture Capital is accumulated through investment and reduced by depreciation, as described in the following equation:

Capital Agriculture = INTEG(investment mere agriculture - depreciation agriculture, INITIAL CAPITAL AGRICULTURE)

Initial capital can be estimated in several ways, depending on the data available. When direct estimation of capital stock does not exist, a commonly used approach is the perpetual inventory method[17].

Agricultural total factor productivity

Agricultural total factor productivity is a key driver for crops yield. As mentioned above, in T21 many elements affect total factor productivity (TFP), including the health (represented by average life expectancy) and education (average years of schooling) level of labor, the availability of water (water stress index) and road density, and energy prices, all endogenously determined in the model. The *total factor productivity (agriculture)* for each crop type is calculated as the product of all these drivers:

Total factor productivity agriculture[crop type] = effect of education on productivity agriculture*effect of energy price on productivity *effect of precipitation on agriculture productivity[crop type]*effect of road density on productivity agriculture *effect of health on productivity agriculture

While the effect of energy price on productivity is calculated in the Energy sector, the effects of other factors on TFP are calculated in this module, following similar approaches. Hence, the calculation of the effects of water availability (represented by water stress index, calculated in the Water sector) is explained as an example. Assuming a non-linear relationship between water stress index and agriculture productivity, the effect for each crop type is formulated as the relative water stress index (the ratio between current and initial levels) to the power of an elasticity:

effect of precipitation on agriculture productivity[crop type] = relative water stress index ^ELASTICITY OF YIELD TO WATER STRESS[crop type]

The effect of other factors on TFP can be understood by analogy.

References

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Donald O. Mitchell, and Merlinda D. Ingco, The World Food Outlook, The World Bank, November 1993

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[17] The perpetual inventory method (PIM) is a method of constructing estimates of capital stock and consumption of fixed capital from time series of gross fixed capital formation.

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18. Husbandry, Fishing and Forestry module

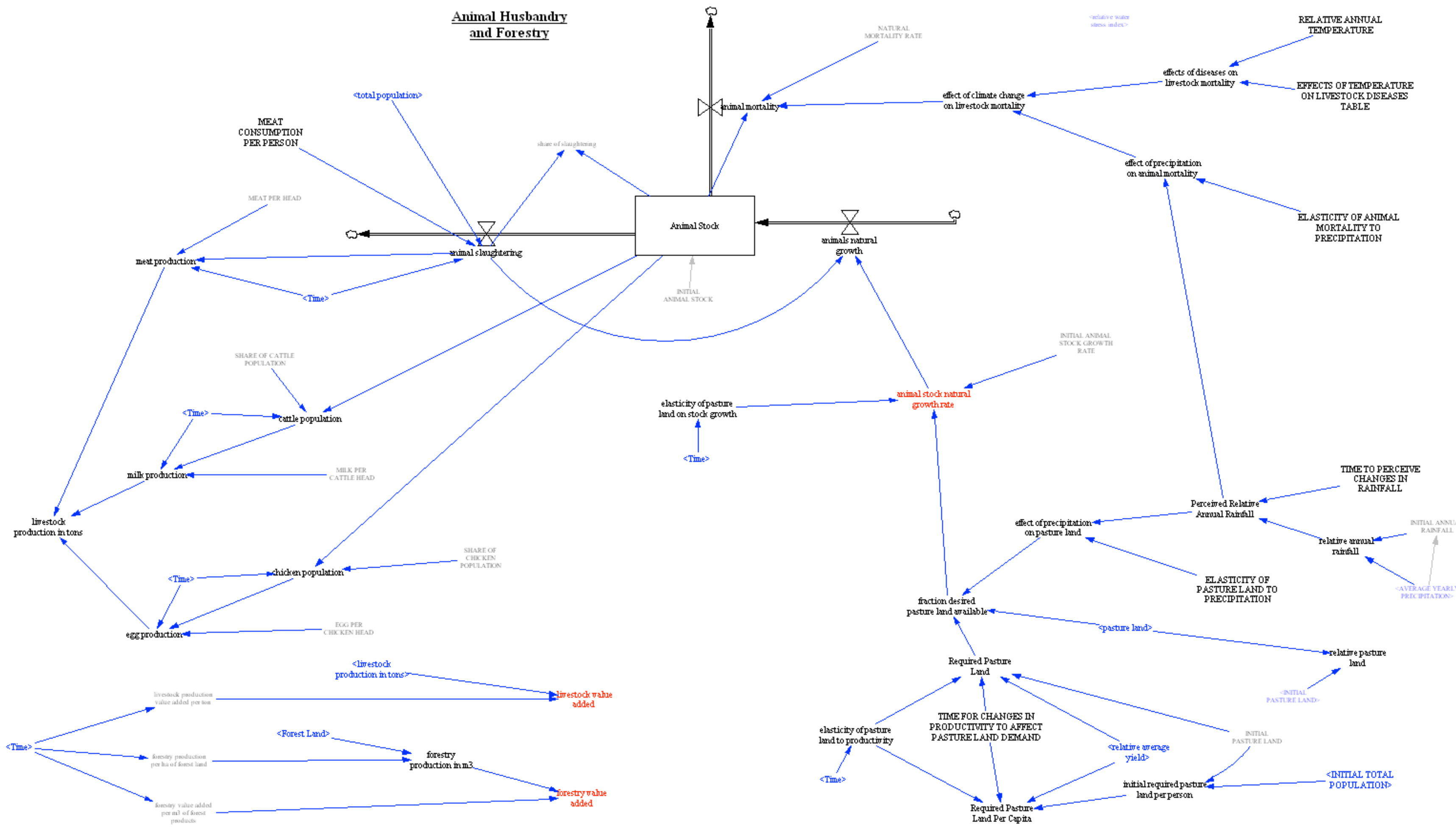

Figure 68: Sketch of the Husbandry, Fishing and Forestry module

Purpose and Perspective

The Husbandry, Fishing and Forestry (see **Figure 73**) module calculates two important elements in agriculture production, livestock and forestry value added. Unlike other types of production in the model, the livestock value added is calculated as a function of the stock, along with annual growth, deaths and slaughtering of animals, based on environmental and economic factors. The forestry value added is based on the area of forestland obtained in the Land module.

Explanation

Major Assumptions

- Animal growth depends on slaughtering and natural growth rate, which is further affected by the availability of pasture land;
- Animal mortality is affected by climate changes such as rainfall;
- The amount of animal slaughtering is determined by human meat consumption;
- Supply meets demand for livestock and forestry products;
- Forestry means wood production;

Table 69: Input variables: Husbandry, Fishing and Forestry module

Variable Name	Module of Origin
Pasture land	Land
Forest land	Land
Relative average yield	Agriculture
Total population	Population
Initial total population	Population

Table 70: Output variables: Husbandry, Fishing and Forestry module

	Module of Destination		
Variable Name	**Same Sector**	**Other Economic Sectors**	**Other Sectors**
Livestock value added	Agriculture		
Forestry value added	Agriculture		
Livestock production in tons			Nutrition

Table 71: Constants and table functions: Husbandry, Fishing and Forestry module

Variable Name	Type of Variable	Source for Estimation
Meat consumption per person	Time series	Data on meat consumption (FAO) and population (UNPOP)
Meat per head	Time series	Data on meat consumption and animals (FAO)
Share of cattle population	Time series	Data on animals (FAO)
Milk per cattle head	Time series	Data on milk consumption and animals (FAO)
Share of chicken population	Time series	Data on animals (FAO)
Egg per chicken head	Time series	Data on egg consumption and animals (FAO)
Livestock production value added per ton	Time series	Data on livestock production (FAO)
Forestry production per ha of forest land	Time series	Data on forestry production and land (FAO)
Forestry value added per m3 of forest products	Time series	Data on forestry production (FAO)
Natural mortality rate	Constant	Data on animals (FAO)
Effects of temperature on livestock diseases table	Time series	Data on animals (FAO)
Elasticity of animal mortality to precipitation	Constant	Data on animals (FAO)
Initial animal stock growth rate	Constant	Data on animals (FAO)
Elasticity of pasture land on stock growth	Constant	Data on animals (FAO)
Time to perceive changes in rainfall	Constant	Data on animals (FAO)
Elasticity of pasture land to precipitation	Constant	Data on animals (FAO)
Elasticity of pasture land to productivity	Constant	Data on animals (FAO)
Initial pasture land	Constant	Data on land (FAO)
Time for changes in productivity to affect pasture land demand	Constant	Data on animals (FAO)

Functional explanation

The sketch in **Error! Reference source not found.** estimates animal stock, along with annual growth, deaths and slaughtering of animals, and based on which the value-added from livestock. The forestry value-added is also calculated in this module. Both are important components of the agriculture production.

Note that values for production in this module are measured in physical quantities or at constant prices.

Animal stock

The stock of animals is accumulated by annual growth, and reduced by deaths and slaughtering.

The amount of *animal slaughtering* per year is decided by human demand for meet, calculated as total population times the exogenous meat consumption per capita:

animal slaughtering = total population*MEAT CONSUMPTION PER PERSON(Time)

Animal mortality (deaths) per year depends on total animal stock, natural mortality rate and the effect of diseases caused by climate changes (represented by rainfall):

animal mortality = MAX(0,Animal Stock*(NATURAL MORTALITY RATE*effect of climate change on livestock mortality))

The annual growth of animals is determined by the amount of *animal slaughtering* and *natural growth rate*, so as to assure enough supply for human demand of livestock products.

animals natural growth = MAX(0, animal slaughtering*(1+animal stock natural growth rate/100))

The natural growth rate of animal stock is affected by the availability of pasture land (measured by *fraction desired pasture land available*), while the latter is further a function of current and required pasture land and the effect of precipitation:

animal stock natural growth rate= INITIAL ANIMAL STOCK GROWTH RATE * fraction desired pasture land available ^elasticity of pasture land on stock growth

fraction desired pasture land available = (pasture land*effect of precipitation on pasture land)/Required Pasture Land

The *required pasture land*, before considering precipitation, is calculated as an exponential average (represented by a SMOOTH N function) of *initial pasture land* and the effect of land productivity (represented by *relative average yield*):

Required Pasture Land = SMOOTH N(INITIAL PASTURE LAND* relative average yield ^elasticity of pasture land to productivity, TIME FOR CHANGES IN PRODUCTIVITY TO AFFECT PASTURE LAND DEMAND, INITIAL PASTURE LAND,1)

This formulation as an exponential average takes into consideration that land demand responds gradually over time (*time for changes in productivity to affect pasture land demand*) to productivity changes.

Agricultural production also includes meat production. Meat includes seven categories: pork, beef, lamb, poultry, egg, fish, and milk. T21 uses a general "meat" to represent the sum of demand of the seven meat categories.

To calculate meat production, first *per capita meat demand* is determined. *Per capita meat demand* is assumed to adjust over time as per capita income changes. The non-linear relationship binding income and per capita meat demand is described in **Error! Reference source not found.**[18]. More specifically, per capita meat demand is calculated as following:
Note that a first order delay formulation is used to consider that meat demand responds gradually over time to income changes. Also, the *local conditions meat adjustment factor* is used to consider aspects of the dietary habits in a country that are not related to income (e.g. cultural aspects).

Livestock Production and Value-added

Based on the estimation of animal stock, the production quantities of milk and egg products are calculated as fraction of cattle and chicken population. Total livestock production quantity is then equal to the sum of meat, milk and egg production. This is multiplied by an exogenous average price to obtain the *livestock value added*.

Forestry Value-added

Forestry value added is determined as forestry production in cubic meters, multiplied by the value added per cubic meter of wood, while the former is equal to *forest land* area times production per ha of forests:

forestry value added = forestry production in m3*forestry value added per m3 of forest products

forestry production in m3 = FORESTRY PRODUCTION IN CUBIC METERS TABLE(Time)* Forest Land*forestry production per ha of forest land

References

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19. Industry module

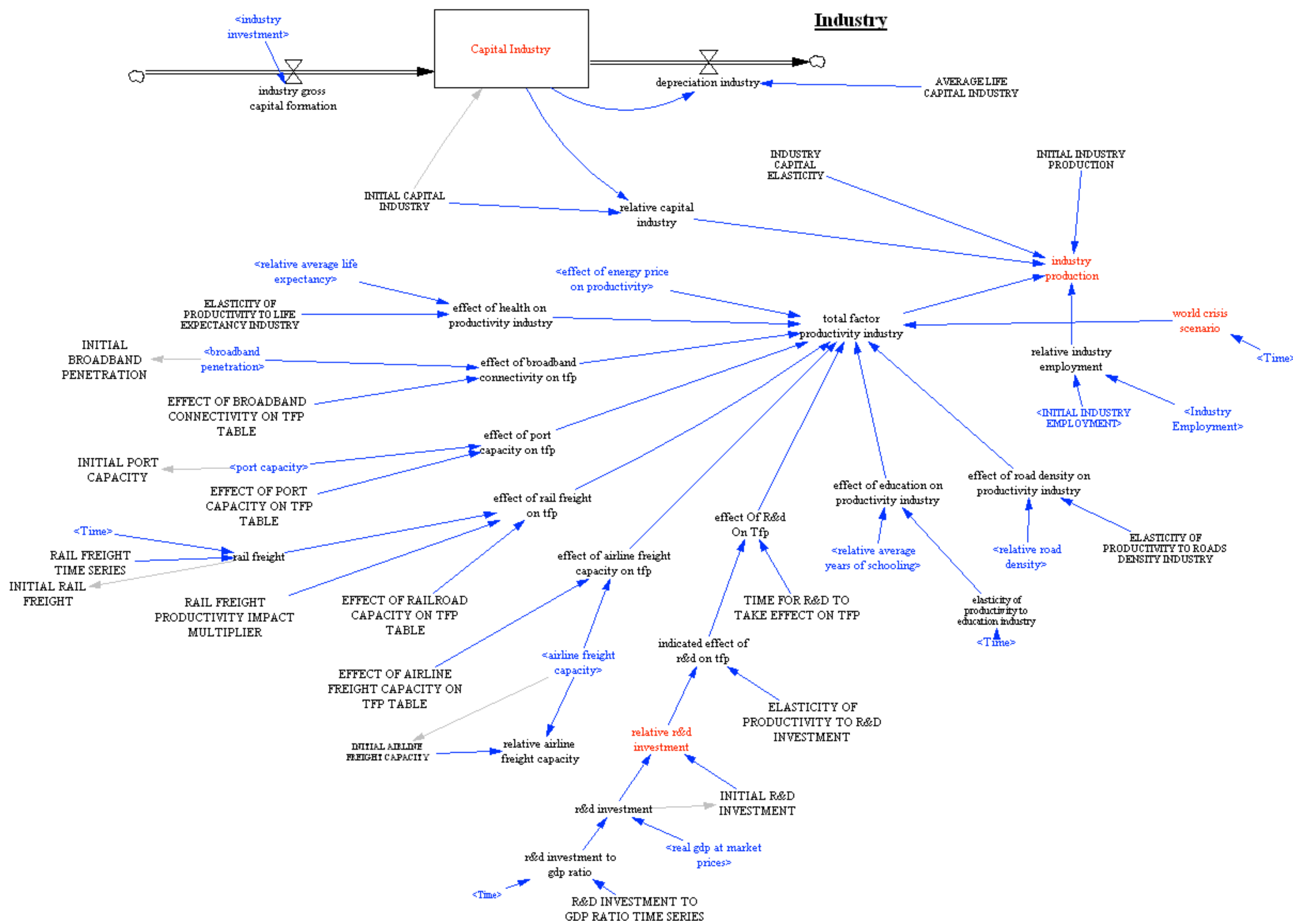

Figure 69: Sketch of the Industry module

Purpose and Perspective

The Industry module (see **Figure 74**) employs a Cobb-Douglas (CD) production function to represent industrial production. Inputs to the CD production function include capital, labor, and TFP, which is further driven by the availability, heath and education of labor, R&D investment, energy prices and infrastructure capacity of roads, ports, airline and railway freight transport and broadband connectivity. The impact of world crisis is further considered.

For more details about the appropriateness of using a CD production function in T21, see the “Purpose and Perspective” section of the documentation for the Agriculture module.

Explanation

Major Assumptions

- Industrial production follows a Cobb-Douglas form, with main production factors including labor and capital;
- The availability, heath and education of labor, R&D investment, energy prices and infrastructure capacity of roads, ports, airline freight transport and broadband connectivity also affect productivity.

Table 72: Input variables: Industry module

Variable Name	Module of Origin
Industry investment	Investment
Relative average life expectancy	Mortality
Relative average years of schooling	Primary education
Relative road density	Roads
Broadband penetration	Broadband
Port capacity	Port cargo
Airline freight capacity	Air transport
Industry employment	Employment
Relative industry employment	Employment
Effect of energy price on productivity	Energy Supply
Real GDP at market prices	Aggregate Production and Income

Table 73: Output variables: Industry module

	Module of Destination		
Variable Name	**Same Sector**	**Other Economic Sectors**	**Other Sectors**
Industry production		Aggregate Production and Income, Investment	Water demand
Initial capital industry			Fossil Fuels Production
Capital industry			Employment
Relative R&D investment	Services		
World crisis scenario	Services		
Relative R&D investment	Industry		

Table 74: Constants and table functions: Industry module

Variable Name	Type of Variable	Source for Estimation
Industry capital elasticity	Constant	Data on investment and industry production (Malaysian Economy in Figures 2011)
Industry labor elasticity	Constant	Data on education and industry production (Malaysian Economy in Figures 2011)
Industry life agriculture capital	Constant	Data on investment and industry production (Malaysian Economy in Figures 2011)
Elasticity of productivity to education industry	Time Series	Data on education and industry production (Malaysian Economy in Figures 2011)
Elasticity of productivity to life expectancy industry	Constant	Data on life expectancy and industry production (Malaysian Economy in Figures 2011)
Elasticity of productivity to roads density industry	Constant	Data on roads and industry production (Malaysian Economy in Figures 2011)
Effect of broadband connectivity on TFP table	Constant	Data on broadband and industry production

		(Malaysian Economy in Figures 2011)
Effect of port capacity on TFP table	Constant	Data on ports and industry production (Malaysian Economy in Figures 2011)
Effect of railroad capacity on TFP table	Constant	Data on railroad and industry production (Malaysian Economy in Figures 2011)
Rail freight productivity impact multiplier	Time Series	Data on rail freight transport and industry production (Malaysian Economy in Figures 2011)
Effect of airline freight capacity on TFP table	Constant	Data on airline freight and industry production (Malaysian Economy in Figures 2011)
Elasticity of productivity to R&D investment	Constant	Data on R&D investment and industry production (Malaysian Economy in Figures 2011)
Time for R&D to take effect on TFP	Constant	Data on R&D investment and industry production (Malaysian Economy in Figures 2011)
Rail freight time series	Time Series	Data on rail freight transport (Malaysian Economy in Figures 2011)
R&d investment to GDP ratio time series	Time Series	Data on R&D investment and industry production (Malaysian Economy in Figures 2011)
Initial capital industry	Constant	Data on investment (Malaysian Economy in Figures 2011)
INITIAL INDUSTRY PRODUCTION	Constant	Malaysian Economy in Figures 2011

Functional Explanation

The industry production function

In T21, non-mining industry production is calculated using a Cobb-Douglas (CD) production function. For an explanation of how the CD production function is implemented in the Production sector of T21, refer to the section "The Cobb-Douglas production function in T21", in the documentation for the Agriculture module. Note that production in this module is intended at constant prices.

The actual equations used to calculate industry production are based on those explained in the section “The Cobb-Douglas production function in T21”, but use more transparent variable names to identify the various factors and effects. The relative (normalized) levels of capital and land are calculated as:

Relative capital industry = Capital Industry/INITIAL CAPITAL INDUSTRY

Relative industry employment = Industry employment/INITIAL industry employment

The *industry production* is calculated as a function of initial industry production and the relative capital and employment levels:

industry production = INITIAL INDUSTRY PRODUCTION*relative capital industry^INDUSTRY CAPITAL ELASTICITY*relative industry employment^(1-INDUSTRY CAPITAL ELASTICITY)*total factor productivity industry

Capital in Industry

Capital Industry is a stock that accumulates via investment and reduces by depreciation:

Capital industry = INTEG (investment non mining industry - depreciation industry, INITIAL CAPITAL INDUSTRY)

Initial capital can be estimated in several ways, depending on available data. If direct estimations of capital stock do not exist, a common technique is the perpetual inventory method.

Industrial total factor productivity

In T21, we assume that various elements affect productivity factors of production in industry. These include: The heath and education of labor, R&D investment, energy prices and infrastructure capacity of roads, ports, airline and rail freight transport and broadband connectivity, while the effect of energy price on productivity is calculated in the Energy sector, the other effects on TFP are calculated in this sector.

In terms of health, education and roads, their effects on industrial TFP are calculated according to the same logic as on agricultural TFP (see explanation in the Agricultural module): the relative level of the driver to the power of an elasticity. For each of these factors, different elasticity values are used for industry and agricultural sectors, showing different degree of effect.

In estimating the impact of R&D, a delay effect is considered between R&D investment and productivity improvements, using a SMOOTH N function in the model. The time lag is represented by a variable TIME FOR R&D TO TAKE EFFECT ON TFP:

effect Of R&d On Tfp = SMOOTH N("indicated effect of r&d on tfp", "TIME FOR R&D TO TAKE EFFECT ON TFP", 1, 1)

indicated effect of r&d on tfp= "relative r&d investment" ^"ELASTICITY OF PRODUCTIVITY TO R&D INVESTMENT"

The effects of ports, airline and rail freight transport and broadband connectivity on industrial productivity are calculated through distinct table functions. Take rail freight transport as an example. To calculate the effect of rail freight, a table function is used. In addition, an elasticity of 0.3 is used to represent the high historical growth in rail freight transport capacity and to prevent future effect from increasing too much. Hence the formulation is:

effect of broadband connectivity on tfp= EFFECT OF BROADBAND CONNECTIVITY ON TFP TABLE(broadband penetration)^0.3

The table function that represents the relationship between broadband penetration and its effect on TFP is shown in **Figure 75** below. It used

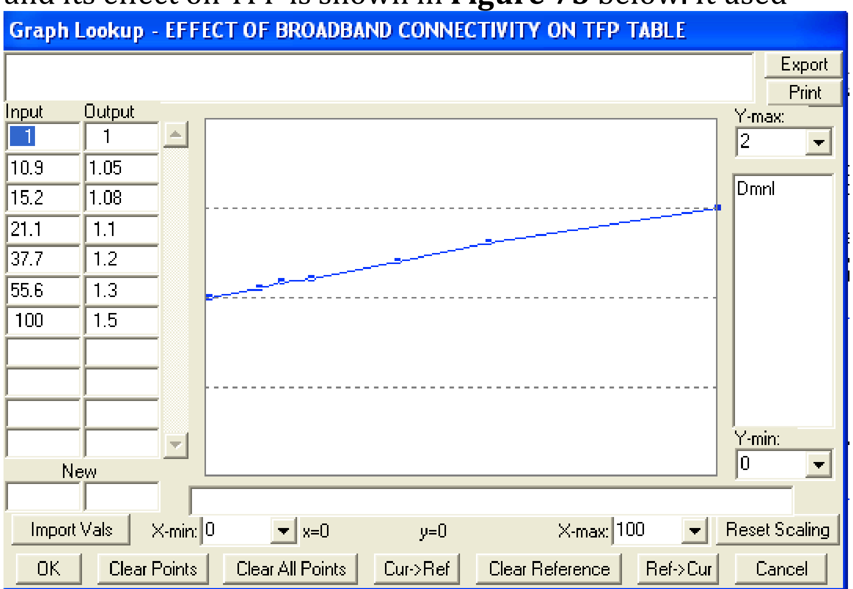

Figure 70: Assumed relationship between broadband penetration (%) and TFP

The table function is estimated based on industry productivity and broadband. It uses the broadband penetration as input and produces as output a multiplicative effect that is then applied to industrial productivity. We assume that as broadband penetration increases, industrial TFP increases but the growth rate decreases.

The same logic is used for the other three infrastructure factors above.

While all other factors are endogenously determined in the model, the amount of rail freight transport is exogenously decided due to lack of data.

Note that the potential impacts of world crisis on industry TFP is considered under the world crisis scenario. This is represented by an exogenous variable world crisis scenario. In regular cases, this variable is always equal to 1, indicating no effect on the TFP. In the case of a world crisis, the values for this variable is:

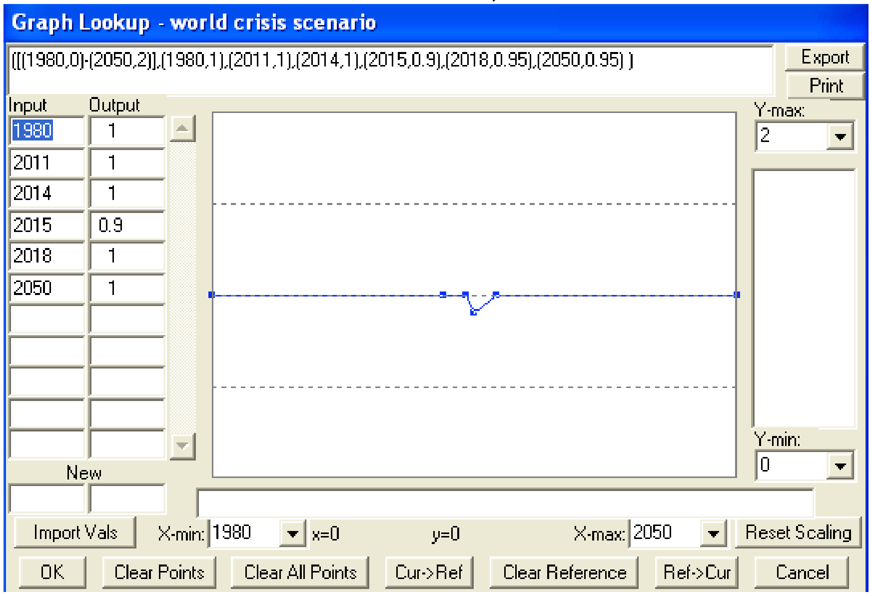

Figure 71: Assumed time series for impact of a world crisis on TFP

As is shown in the figure, we assume that starting from year 2015, the TFP is reduced by global economic meltdown by 10%. The reduction reduces in the following years and will fully recover from 2018.

Thus total factor production of industry sector is calculates as the product of all these effects and the world crisis scenario factor:

total factor productivity industry = effect of education on productivity industry*effect of health on productivity industry*effect of road density on productivity industry *effect of energy price on productivity*effect of airline freight capacity on tfp*effect of broadband connectivity on tfp*effect of port capacity on tfp*"effect Of R&d On Tfp"*effect of rail freight on tfp*world crisis scenario

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20. Services module

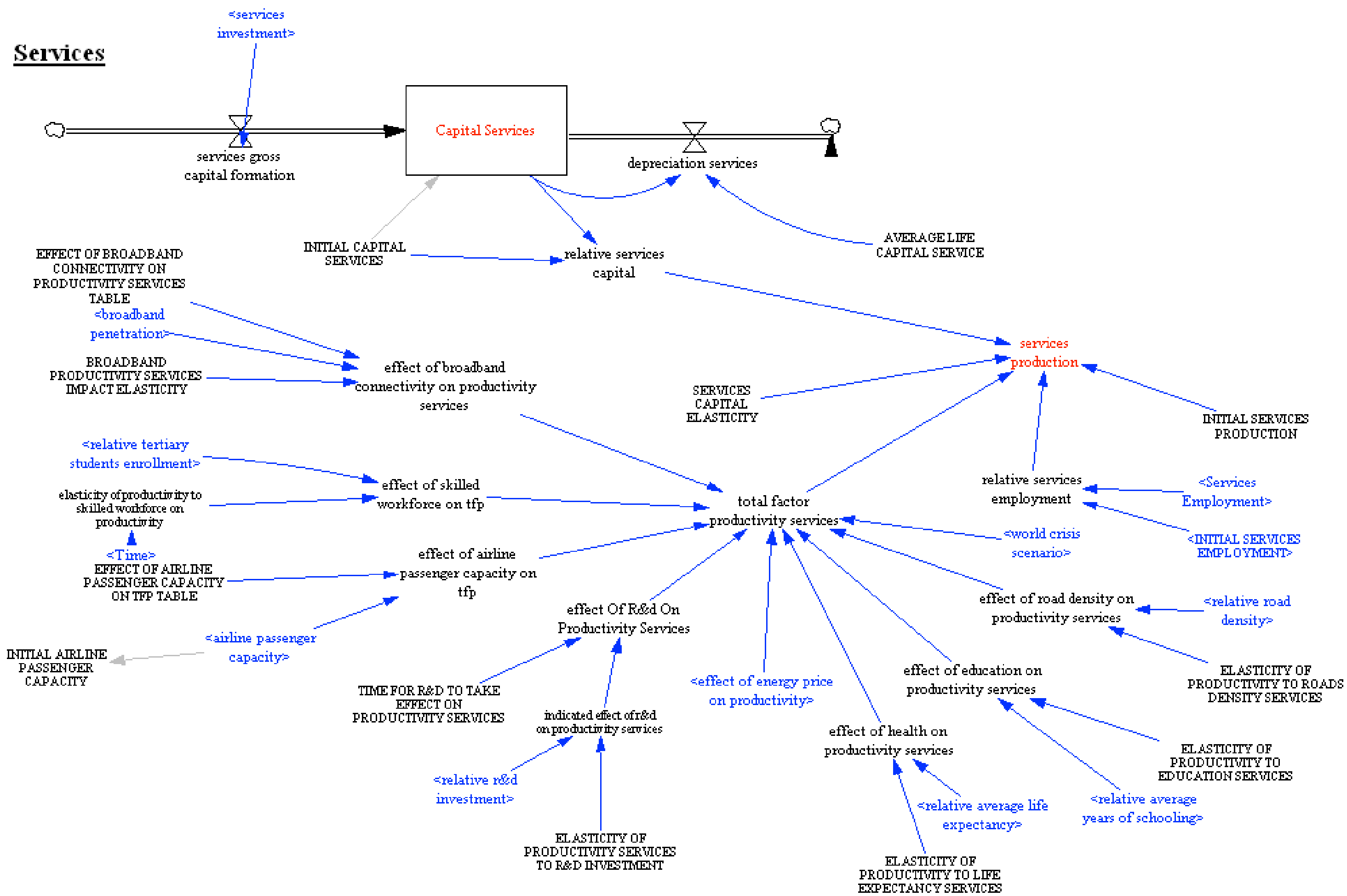

Figure 72: Sketch of the Services module

Purpose and Perspective

The Services module (see **Figure 77**) employs a Cobb-Douglas (CD) production function to represent service production. Inputs to the CD production function include capital, labor, and TFP which is further driven by the availability of healthy labor (skilled or non-skilled), R&D investment, energy prices and infrastructure capacity of roads, ports, airline passenger transport and broadband connectivity.

For more details about the appropriateness of using a CD production function in T21, see the "Purpose and Perspective" section of the documentation for the Agriculture module.

Explanation

Major Assumptions

- Services production follows a Cobb-Douglas form, with main production factors including labor and capital;
- The availability of healthy labor (skilled or non-skilled), R&D investment, energy prices and infrastructure capacity of roads, ports, airline passenger transport and broadband also affect productivity.

Table 75: Input variables: Services module

Variable Name	Module of Origin
Services investment	Investment
Relative average life expectancy	Mortality
Relative average years of schooling	Primary education
Relative road density	Roads
Broadband penetration	Broadband
Airline passenger capacity	Air transport
Industry employment	Employment
Relative industry employment	Employment
Effect of energy price on productivity	Energy Supply
Real GDP at market prices	Aggregate Production and Income
Relative R&D investment	Industry

Table 76: Output variables: Services module

	Module of Destination		
Variable Name	**Same Sector**	**Other Economic Sectors**	**Other Sectors**
Services production		Investment, Aggregate Production and Income	
Capital services			Employment
Relative skilled workforce		International Trade	

Table 77: Constants and table functions: Services module

Variable Name	**Type of Variable**	**Source for Estimation**
Services capital elasticity	Constant	Data on investment and services production (Malaysian Economy in Figures 2011)
Services labor elasticity	Constant	Data on education and services production (Malaysian Economy in Figures 2011)
Services life agriculture capital	Constant	Data on investment and services production (Malaysian Economy in Figures 2011)
Elasticity of productivity to education services	Time Series	Data on education and services production (Malaysian Economy in Figures 2011)
Elasticity of productivity to life expectancy services	Constant	Data on life expectancy and services production (Malaysian Economy in Figures 2011)
Elasticity of productivity to roads density services	Constant	Data on roads and services production (Malaysian Economy in Figures 2011)
Effect of broadband connectivity on TFP table	Constant	Data on broadband and services production (Malaysian Economy in Figures 2011)
elasticity of productivity to skilled workforce on	Time Series	Data on tertiary education and services production

productivity		(Malaysian Economy in Figures 2011)
Effect of airline passenger capacity on TFP table	Constant	Data on airline passenger and services production (Malaysian Economy in Figures 2011)
Elasticity of productivity to R&D investment	Constant	Data on R&D investment and services production (Malaysian Economy in Figures 2011)
Time for R&D to take effect on TFP	Constant	Data on R&D investment and services production (Malaysian Economy in Figures 2011)
Initial capital services	Constant	Data on investment (Malaysian Economy in Figures 2011)
Initial services production	Constant	Malaysian Economy in Figures 2011

Functional Explanation

The services production function

In T21, non-mining services production is calculated using a Cobb-Douglas (CD) production function. For an explanation of how the CD production function is implemented in the Production sector of T21, refer to the section "The Cobb-Douglas production function in T21", in the documentation for the Agriculture module. Note that production in this module is intended at constant prices.

The actual equations used to calculate services production are based on those explained in the section "The Cobb-Douglas production function in T21", but use more transparent variable names to identify the various factors and effects. The relative (normalized) levels of capital and land are calculated as:

Relative capital services = Capital Services/INITIAL CAPITAL SERVICES

Relative services employment = Services employment/INITIAL services employment

The *services production* is calculated as a function of initial services production and the relative capital and employment levels:

services production = INITIAL SERVICES PRODUCTION*relative capital services^SERVICES CAPITAL ELASTICITY*relative services employment^(1-SERVICES CAPITAL ELASTICITY)*total factor productivity services

Capital in Services

Capital Services is a stock that accumulates via investment and reduces by depreciation:

Capital services = INTEG (investment non mining services - depreciation services, INITIAL CAPITAL SERVICES)

Initial capital can be estimated in several ways, depending on available data. As direct estimations of capital stock do not exist, a common technique is the perpetual inventory method.

Services total factor productivity

In T21, we assume that various elements affect productivity factors of production in services. These include: The labor heath, education of general and skilled labor, R&D investment, energy prices and infrastructure capacity of roads, airline passenger transport and broadband connectivity, while the effect of energy price on productivity is calculated in the Energy sector, the other effects on TFP are calculated in this sector.

The total factor production of services sector is calculates as the product of all these effects and the world crisis scenario factor:

total factor productivity services = effect of education on productivity services*effect of energy price on productivity*effect of health on productivity services *effect of road density on productivity services*effect of airline passenger capacity on tfp*effect of broadband connectivity on productivity services *"effect Of R&d On Productivity Services"*effect of skilled workforce on tfp*world crisis scenario

Among the drivers for the services TFP above, the effects of labor heath, education of general labor, R&D investment, energy prices and infrastructure capacity of roads, airline passenger transport and broadband connectivity are calculated by using the same approach as in the industry sector, while the values of elasticities and table functions for the same driver vary to show different degree of impacts on services and industrial TFP.

Considering the additional factor of skilled workforce (represented by relative tertiary students enrollment), the effect is calculated as:

effect of skilled workforce on tfp= relative tertiary students enrollment ^elasticity of productivity to skilled workforce on productivity

Here the elasticity value is slightly higher in future than in the past, assuming a higher future increase in services TFP per percentage of increase in relative tertiary students enrollment.

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21. Government Revenue module

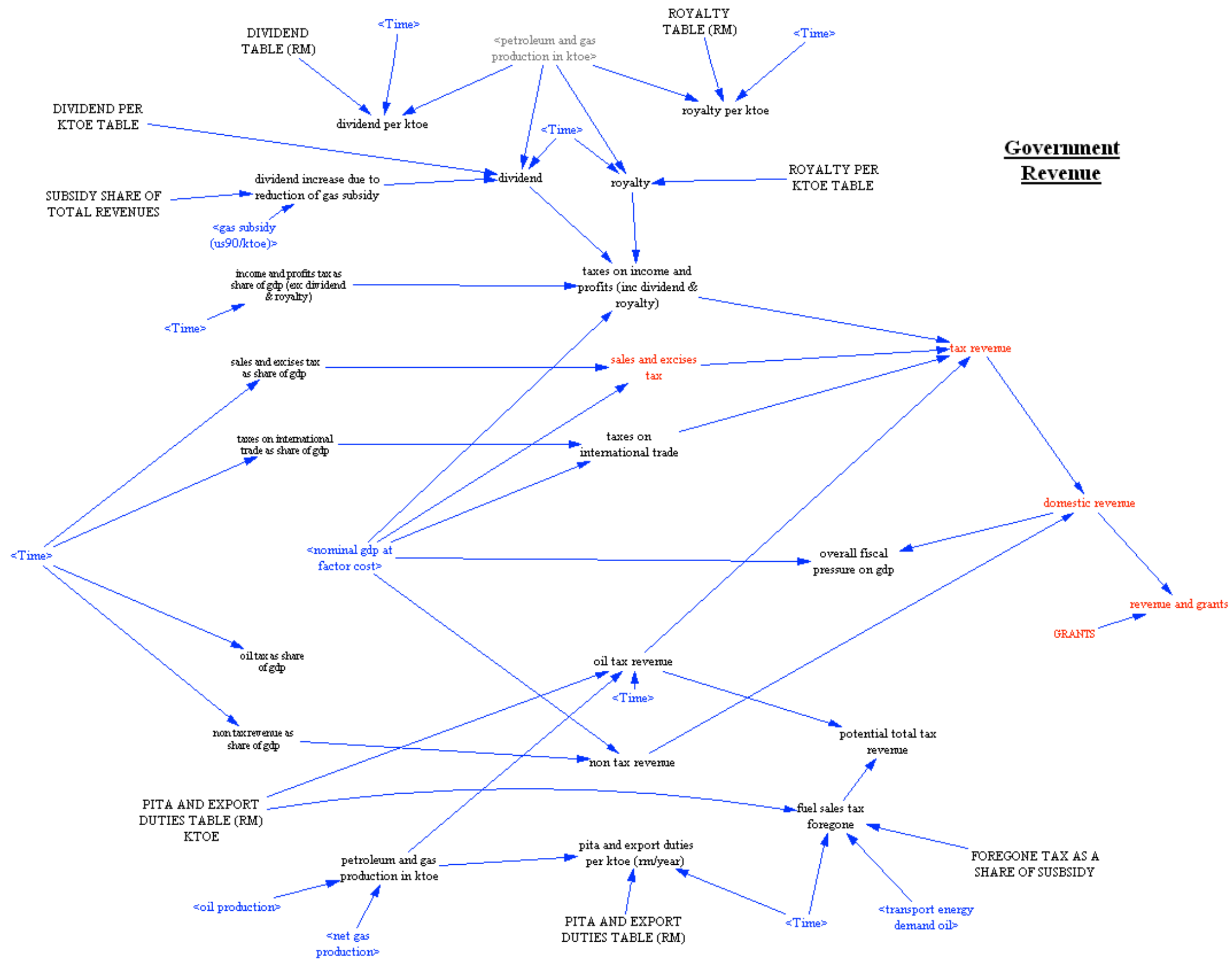

Figure 73: Sketch of the Government Revenue module

Purpose and Perspective

The Government Revenue module represents the various sources of government revenue and how these are combined in the total revenue and grants. This module contains some fundamental fiscal policy variables, such as tax rates, as well as the hypothesis regarding the amount of grants the government receives from abroad.

Note that in different countries, the sources of government revenue are likely to vary: this module should always be adapted to the nomenclature and type of accounting actually used in the country object of the analysis.

Explanation

Major Assumptions

- The efficacy of revenues collection is 100%;
- The taxes on imports and exports are calculated as shares of imports and exports;
- All the other taxes and non-taxes are calculated as share of GDP or sectoral production;
- Grants are exogenously determined.

Table 78: Input variables: Government Revenue module

Variable Name	Module of Origin
Nominal GDP at factor cost	Aggregate production and income
Gas subsidy (US90/ktoe)	Energy prices
Transport energy demand oil	Energy demand
Net gas production	Fossil Fuels Production
Oil production	Fossil Fuels Production

Table 79: Output variables: Government Revenue module

	Module of Destination		
Variable Name	**In the Same Sector**	**In Other Economic Sectors**	**In Other Sectors**
Sales and excises tax		Relative prices	
Domestic revenue	Government Balance and Financing, Households	Households	
Grants	Government Balance And Financing, Balance of Payments		
Net lending	Government Balance and Financing, Households		
Revenue and grants	Government Debt		
Subsidies and transfers	Households		

Table 80: Constants and table functions: Government Revenue module

Variable Name	Type of Variable	Source for Estimation
Sales and excises tax as share of GDP	Time series	Malaysian Economy in Figures 2011
Taxes on international trade AS SHARE OF GDP	Time series	Malaysian Economy in Figures 2011
Non tax revenue as share of GDP	Constant	Malaysian Economy in Figures 2011
Pita and export duties table (RM) ktoe	Time series	Malaysian Economy in Figures 2011
Pita and export duties table (RM)	Time series	Malaysian Economy in Figures 2011
Foregone tax as a share of subsidy	Time series	Malaysian Economy in Figures 2011
Grants	Constant	Malaysian Economy in Figures 2011
Dividend table (RM)	Time series	Malaysian Economy in Figures 2011
Dividend per ktoe table	Time series	Malaysian Economy in Figures 2011
Subsidy share of total revenues	Constant	Malaysian Economy in Figures 2011
Royalty table (RM)	Time series	Malaysian Economy in Figures 2011
Royalty per ktoe table	Time series	Malaysian Economy in Figures 2011
Income and profits tax as share of GDP (exc dividend & royalty)	Time series	Malaysian Economy in Figures 2011

Functional Explanation

The Government Revenue module has a tree-shaped structure where the various revenue items are summed together to determine the total *revenue and grants*. The following paragraphs describe how the different sources of revenue are determined. Note that economic flows in this module are considered at current prices.

Taxes on income and profits

The amount of *taxes on income and profits* is calculated as the sum of *dividend, royalty* and the remaining *income and profits tax.* While *taxes on income and profits excluding dividend and royalty* is determined as a share of GDP, *dividend* and *royalty* depend on the amount of oil and gas production. The formulations are:

> taxes on income and profits (inc dividend & royalty) = (nominal GDP at factor cost *"income and profits tax as share of GDP (exc dividend & royalty)") +dividend+royalty

> royalty = petroleum and gas production in ktoe*ROYALTY PER KTOE TABLE(Time)

> dividend = petroleum and gas production in ktoe*DIVIDEND PER KTOE TABLE(Time) *(1+dividend increase due to reduction of gas subsidy)

Note in the formulation of *dividend* above that when there is no gas subsidy the dividend increases due to reduction of gas subsidy, and the percentage of increase is equal to *SUBSIDY SHARE OF TOTAL REVENUES*, while in the case of positive gas subsidy this increase is zero. Thus *dividend increase due to reduction of gas subsidy* is calculated as:

> dividend increase due to reduction of gas subsidy = IF THEN ELSE("gas subsidy (us90/ktoe)" = 0, SUBSIDY SHARE OF TOTAL REVENUES, 0)

Other taxes

The tax revenue in this module also includes *taxes on international trade*, *sales and excises tax* and *oil tax revenue*. While the former two taxes are determined as a share of GDP, *oil tax revenue* is calculated as the amount of oil and gas production (from Energy sector) times (exogenous) duties per ktoe of oil and gas production:

> Tax revenue = "taxes on income and profits (inc dividend & royalty)"+taxes on international trade +sales and excises tax +oil tax revenue

> taxes on international trade = nominal GDP at factor cost*sales and excises tax as share of GDP

> sales and excises tax = nominal GDP at factor cost*taxes on international trade as share of GDP

> oil tax revenue = (petroleum and gas production in ktoe*"PITA AND EXPORT DUTIES TABLE (RM) KTOE"(Time))

Nontax revenue

Nontax revenue is determined as a share of GDP:

Nontax revenue = nominal GDP at factor cost * non tax revenue as share of GDP

Nontax revenue is then added to *tax revenue* to obtain *budgetary revenue*:

domestic revenue = tax revenue +non tax revenue

Finally *grants*, which are also exogenously determined, are added to *total revenue* to obtain *revenue and grants*:

Revenue and grants = domestic revenue +grants

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IMF, *Mali: Selected Issues and Statistical Annex*, IMF Staff Country Report No. 00/128, 2000 International Monetary Fund

IMF, *Mali: Selected Issues and Statistical Annex*, IMF Staff Country Report No. 04/10, 2004 International Monetary Fund

22. Government Expenditure module

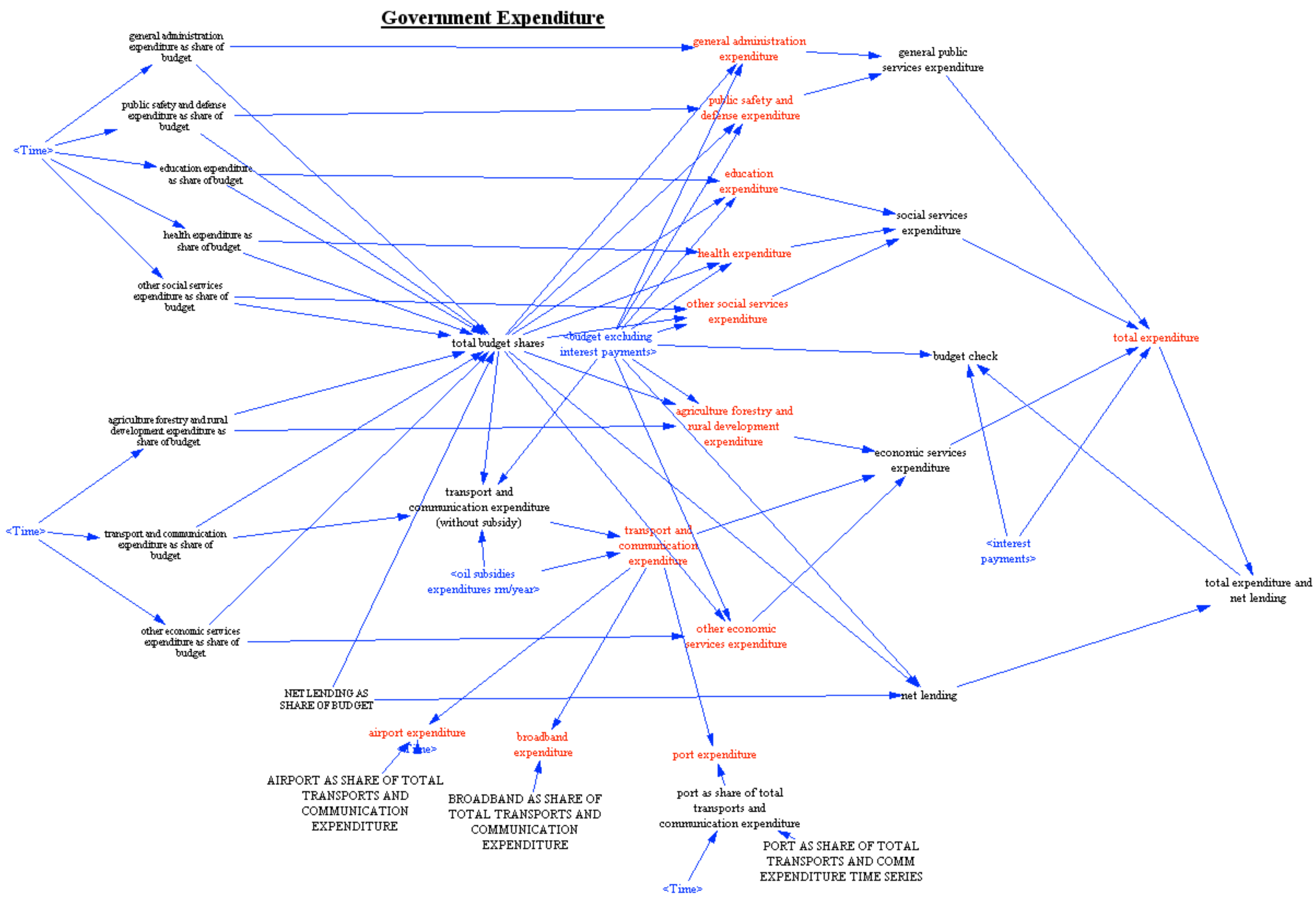

Figure 74: Sketch of the Government Expenditure module

Purpose and Perspective

The Government Expenditure module represents how total government expenditure is allocated among the various possible utilizations. Government expenditures are organized accordingly to a functional classification, i.e. based on their actual use. The share of expenditures for education, health and transport and communication (infrastructure) represent major policy variables that determine the public services of corresponding social sectors.

Funds allocated to other expenditure items only have a macroeconomic effect in the model (affect the overall level of investment and consumption), and do not have any microeconomic effect (do not affect the development of a specific sector or the level of public service).

Explanation

Major Assumptions

- The size of the each items of expenditure calculated in this module is related to the size of the government budget.

Table 81: Input variables: Government Expenditures module

Variable Name	Module of Origin
Oil subsidies expenditures RM/year	Public Investment and Consumption
Budget excluding interest payments	Government balance and financing
Interest payments	Government debt

Table 82: Output variables: Government Expenditures module

	Module of Destination		
Variable Name	**In the Same Sector**	**In Other Economic Sectors**	**In Other Sectors**
General administration expenditure	Public Investment and Consumption		
Public safety and defense expenditure	Public Investment and Consumption		
Education expenditure	Public Investment and Consumption		Primary Education, Secondary Education, Tertiary Education
Health expenditure	Public Investment and Consumption		Healthcare
Other social services expenditure	Public Investment and Consumption		
Agriculture forestry and rural development expenditure	Public Investment and Consumption		
Transport and communication expenditure	Public Investment and Consumption		Roads
Other economic services expenditure	Public Investment and Consumption		
Net lending	Public Investment and Consumption		
Airport expenditure			Air transport
Broadband expenditure			Broadband
Port expenditure			Port cargo
Total expenditure	Public Investment and Consumption		
Public investment	Government Balance and Financing	Households, Investment	

Table 83: Constants and table functions: Government Expenditures module

Variable Name	Type of Variable	Source for Estimation
General administration expenditure as share of budget	Time series	Malaysian Economy in Figures 2011
Public safety and defense expenditure as share of budget	Time series	Malaysian Economy in Figures 2011
Education expenditure as share of budget	Time series	Malaysian Economy in Figures 2011
Health expenditure as share of budget	Time series	Malaysian Economy in Figures 2011
Other social services expenditure as share of budget	Time series	Malaysian Economy in Figures 2011
Agriculture forestry and rural development expenditure as share of budget	Time series	Malaysian Economy in Figures 2011
Transport and communication expenditure as share of budget	Time series	Malaysian Economy in Figures 2011
Other economic services expenditure as share of budget	Time series	Malaysian Economy in Figures 2011
Net lending as share of budget	Time series	Malaysian Economy in Figures 2011
Airport as share of total transports and communication expenditure	Time series	Malaysian Economy in Figures 2011
Broadband as share of total transports and communication expenditure	Time series	Malaysian Economy in Figures 2011
Port as share of total transports and comm expenditure time series	Time series	Malaysian Economy in Figures 2011

Functional Explanation

In this module, expenditures are organized using a functional classification, i.e. according to the destination of the funds allocated by the government. The following paragraphs describe how the various expenditures are calculated and total expenditures are determined. Note that all the economic flows in this module are expressed in nominal terms (current prices).

Expenditure items

Each item of government expenditure is calculated as fractions of the *budget excluding interest payments*. For example, *education expenditure* is calculated as:

Education expenditure = EDUCATION EXPENDITURE AS SHARE OF BUDGET TABLE (Time)*revenue and grants

Education expenditure as share of budget table is a time series containing the actual share of past government expenditures for education and an estimate for the future.

Then the expenditures for ports, broadband and airports are determined as a share of the total amount of transport and communication expenditure excluding oil subsidies expenditures. These government infrastructure expenditures, along with private investments, determine the services levels and capacity of ports, broadband and airports.

Budgetary expenditure, expenditure and net lending

Total expenditure is determined by the sum of all items of expenditure, along with interest payments.

Finally, *net lending* (calculated as a share of the budget) is added to *total expenditure* to obtain *total expenditure and net lending*.

References

IMF, *Mali: Statistical Annex*, IMF Staff Country Report No. 98/14, 1998 International Monetary Fund

IMF, *Mali: Selected Issues and Statistical Annex*, IMF Staff Country Report No. 00/128, 2000 International Monetary Fund

IMF, *Mali:* Selected *Issues and Statistical Annex*, IMF Staff Country Report No. 04/10, 2004 International Monetary Fund

23. Government Balance and Financing module

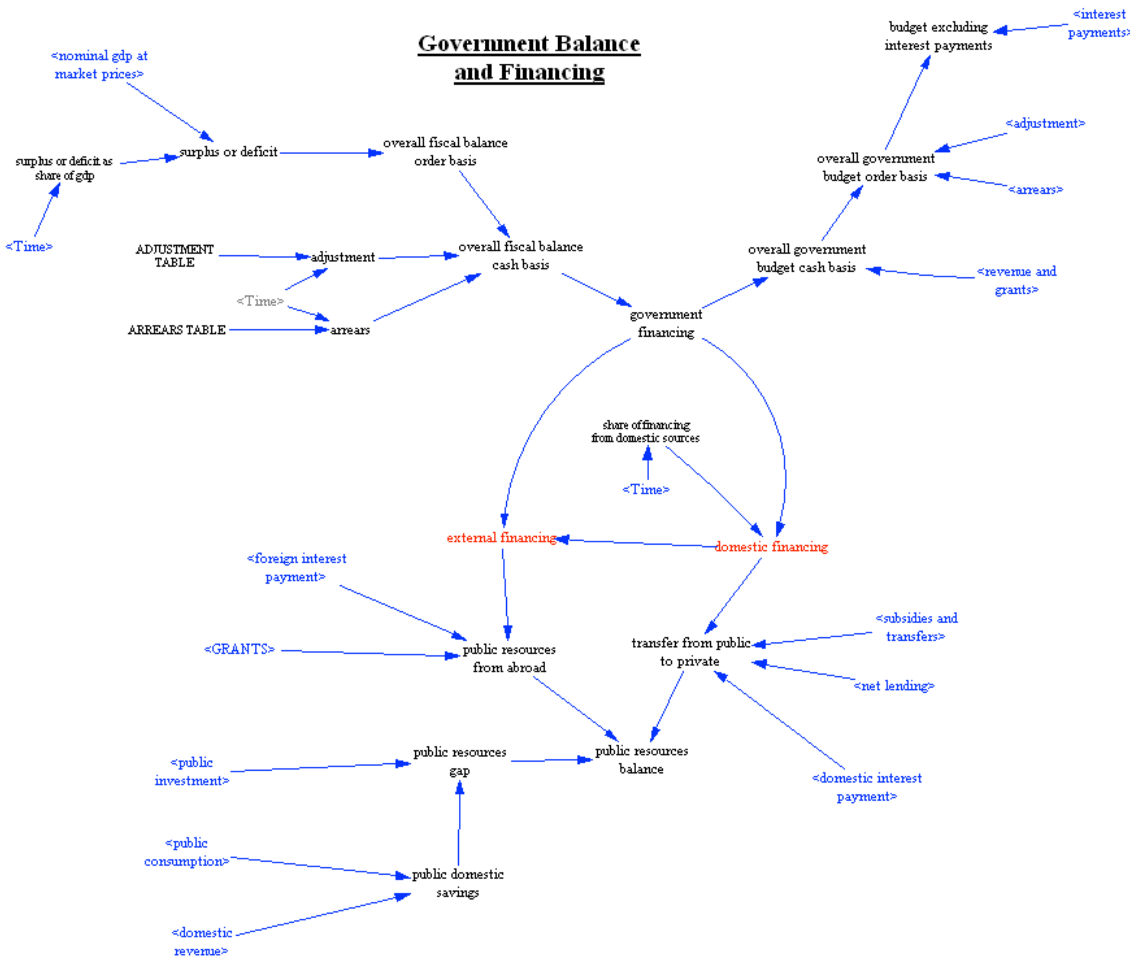

Figure 75: Sketch of the Government Balance and Financing module

Purpose and Perspective

The Government Balance and Financing module describes how the overall balance of a government budget is determined, and how domestic and foreign financing necessary to cover any eventual imbalances are calculated (top of **Figure 80**). The bottom of the sketch includes a check, the *public resources balance*, which is used to monitor the consistency of public accounts.

The *government financing* is calculated as the residual in government accounts. This means there are no explicit limits to the level of expenditure the government can sustain, and any imbalance in government accounts is always financed through domestic or foreign sources.

This leaves more freedom to the user to experiment with different levels of government expenditure, while note that the user has to continuously monitor that the level of financing and debt generated in the simulations is acceptable.

Explanation

Major Assumptions

- Government financing is the residual in the government accounts;
- Domestic and foreign sources are always available to finance the government deficit.

Table 84: Input variables: Government Balance and Financing module

Variable Name	Module of Origin
Foreign interest payment	Government debt
Grants	Government revenue
Public investment	Government expenditure
Public consumption	Public investment and consumption
Domestic revenue	Government revenue
Domestic interest payment	Government debt
Nominal GDP at market prices	Aggregate Production and Income
Subsidies and transfers	Public investment and consumption
Net lending	Government revenue

Table 85: Output variables: Government Balance and Financing module

	Module of Destination		
Variable Name	**In the Same Sector**	**In Other Economic Sectors**	**In Other Sectors**
Domestic financing	Government debt	Households	
External financing	Government debt	Balance of Payments	
Budget excluding interest payments	Government expenditure		
Arrears		Households	
Adjustment		Households	
Domestic financing		Households	

Table 86: Constants and table functions: Government Balance and Financing module

Variable Name	Type of Variable	Source for Estimation
Adjustment table	Time series	N.A.
Arrears table	Time series	N.A.
Surplus or deficit as share of GDP	Time series	Malaysian Economy in Figures 2011
Share of financing from domestic sources	Time series	Malaysian Economy in Figures 2011

Functional Explanation

The following paragraphs describe how *government financing* and *public resources balance* are determined. Note that all the economic flows in this module are expressed in nominal terms (current prices).

Government financing

To determine the required *government financing*, first *overall fiscal balance order basis* is determined as a share of GDP. The *overall fiscal balance cash basis* is then calculated as the balance order basis plus *adjustment* and *arrears*:

Overall fiscal balance cash basis = overall fiscal balance order basis +adjustment +arrears

Note that *adjustment* usually represents statistical errors in the measurement of public financial flows. *Arrears* are corrections to accounting that are used to keep track of expenditures occurring in a certain fiscal period in the order basis system. Both *arrears* and *adjustment* are set to zero in this model due to lack of data.
Government financing is subsequently set equal to the necessary resources to finance the fiscal imbalance:

Government financing = -overall fiscal balance cash basis

Government financing consists of financing from both domestic and foreign sources. The fraction of financing from foreign sources is exogenously set, and *foreign financing* is calculated as:

Foreign financing = government financing*SHARE OF FINANCING FROM FOREIGN SOURCES

Domestic financing is the residual of *government financing* minus *foreign financing*.

Public resources balance

Public resources balance is a variable used to monitor the consistency of government accounts: all resources used by the government should equal the resources absorbed from other agents. The public resources balance is defined as:

Public resources balance = public resources gap +public resources from abroad-transfer from public to private

The following paragraphs describe how the variables in the right hand side are determined.

The *public resources gap* in the equation above is defined as the *public domestic savings* minus the *public investment*:

Public resources gap = public domestic savings-public investment

The *public domestic savings* here are given by the *domestic revenue* minus the *public consumption*.

The *public resources from abroad* are given by the sum of *external financing* and *grants*, minus interest paid to foreign entities:

Public resource from abroad = external financing +grants -foreign interest payment

Finally, the *transfer from public to private* includes *domestic interest payment, domestic financing* (with a negative sign, since it represents a net flow from households to the government), subsidies and transfers and net lending:

Transfer from public to private = -domestic financing +domestic interest payment +subsidies and transfers +net lending

References

IMF, *Mali: Statistical Annex*, IMF Staff Country Report No. 98/14, 1998 International Monetary Fund

IMF, *Mali: Selected Issues and Statistical Annex*, IMF Staff Country Report No. 00/128, 2000 International Monetary Fund

IMF, *Mali: Selected Issues and Statistical Annex*, IMF Staff Country Report No. 04/10, 2004 International Monetary Fund

24. Public Investment and Consumption module

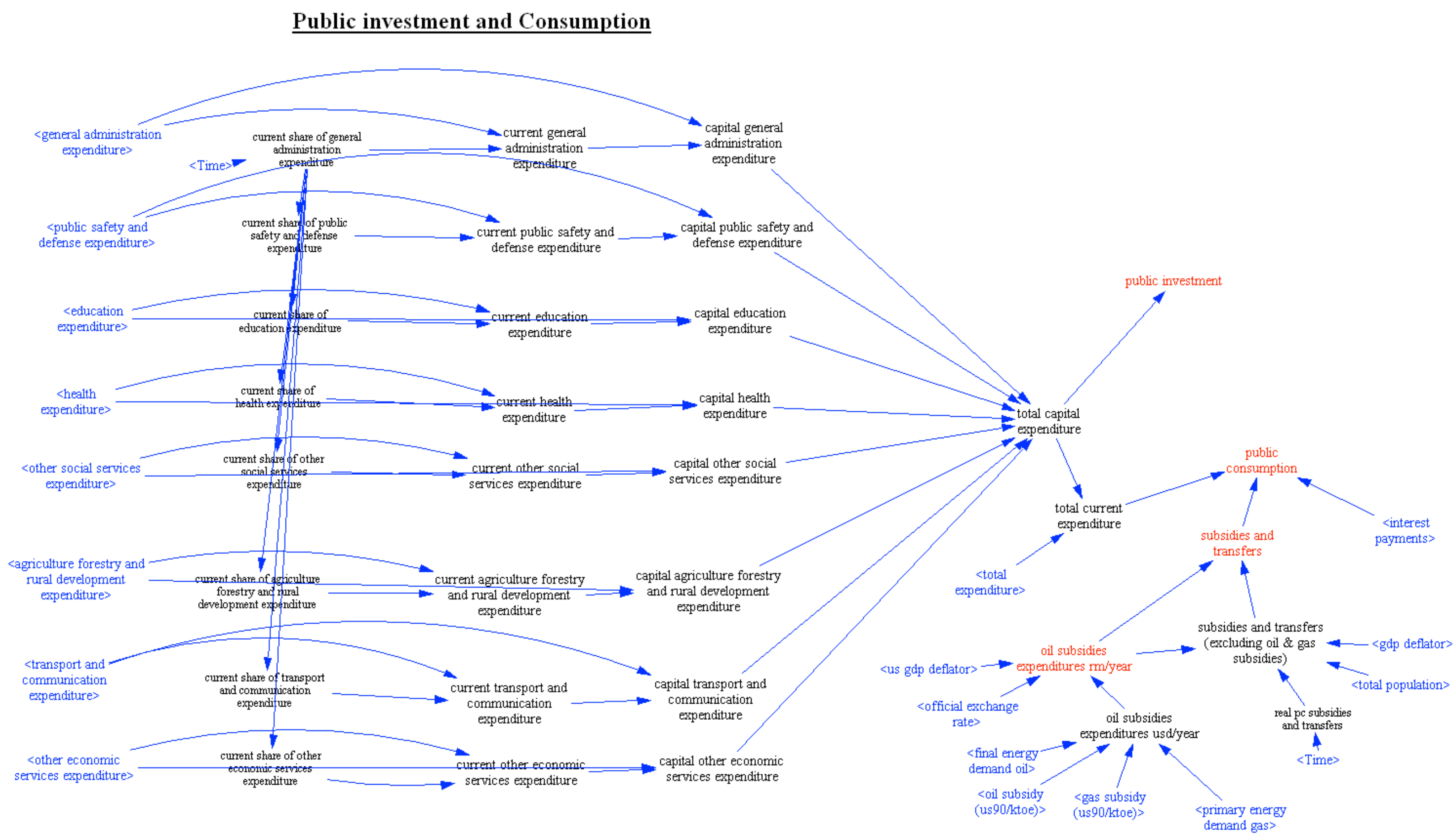

Figure 76: Sketch of the Public Investment and Consumption module

Purpose and Perspective

The Public Investment and Consumption module represents how total government expenditure is allocated between investment and consumption. The items of government expenditure (functional classification) are separated into capital and current components, which are eventually added. Public investment and consumption are fundamental components of overall investment and consumption, which are key elements in the development of the economy.

Note that in different countries, government expenditures differ: this module should always be adapted to the nomenclature and type of accounting of the country being analyzed.

Explanation

Major Assumptions

- The capital share of various items of expenditure is exogenously determined;
- Extraordinary expenditures and lending is considered consumption expenditure;
- Interest on public debt is not considered as consumption or investment, but as transfers to domestic and foreign households.

Table 87: Input variables: Public Investment and Consumption module

Variable Name	Module of Origin
General administration expenditure	Government expenditure
Public safety and defense expenditure	Government expenditure
Education expenditure	Government expenditure
Health expenditure	Government expenditure
Other social services expenditure	Government expenditure
Agriculture forestry and rural development expenditure	Government expenditure
Transport and communication expenditure	Government expenditure
Other economic services expenditure	Government expenditure
Net lending	Government expenditure
Total expenditure	Government expenditure
Interest payments	Government debt
Official exchange rate	Aggregate Production and Income
GDP deflator	Relative prices
Total population	Population
Primary energy demand gas	Energy demand
Final energy demand oil	Energy demand
Oil subsidy (US90/ktoe)	Energy prices
Gas subsidy (US90/ktoe)	Energy prices

Table 88: Output variables: Public Investment and Consumption module

	Module of Destination		
Variable Name	**In the Same Sector**	**In Other Economic Sectors**	**In Other Sectors**
Public investment		Households	
Public consumption	Government Balance and Financing	Households	
Oil subsidies expenditures RM/year	Government expenditure		
Subsidies and transfers	Government Balance and Financing		

Table 89: Constants and table functions: Public Investment and Consumption module

Variable Name	Type of Variable	Source for Estimation
Current share of general administration expenditure	Time series	Malaysian Economy in Figures 2011
Current share of public safety and defense expenditure	Time series	Malaysian Economy in Figures 2011
Current share of education expenditure	Time series	Malaysian Economy in Figures 2011
Current share of health expenditure	Time series	Malaysian Economy in Figures 2011
Current share of other social services expenditure	Time series	Malaysian Economy in Figures 2011
Current share of agriculture forestry and rural development expenditure	Time series	Malaysian Economy in Figures 2011
Current share of transport and communication expenditure	Time series	Malaysian Economy in Figures 2011
Current share of other economic services expenditure	Time series	Malaysian Economy in Figures 2011

Functional Explanation

The calculation of capital and current expenditures in the public investment and consumption module is straightforward.

Capital and current expenditures

First, each item of functional expenditure (from Government Expenditure module) is divided into current and capital expenditure, determined by the exogenous current share. For example:

Current general administration expenditure = general administration expenditure* current share of general administration expenditure capital general administration expenditure = general administration expenditure- current general administration expenditure

Then total capital expenditures is calculated as the sum of capital expenditures for all functions:

Total capital expenditure = capital agriculture forestry and rural development expenditure+capital education expenditure+capital general administration expenditure+capital health expenditure+capital other economic services expenditure+capital other social services expenditure+capital public safety and defense expenditure+capital transport and communication expenditure

Note that capital and current expenditures, as well as the other economic flows in this module, are considered at current prices.

Subsidies and transfers

Subsidies and transfers are calculated as the sum of subsidies for oil and gas and the remaining amount.

While the amount of subsidies and transfers excluding oil and gas subsidies is determined by the total population and the amount per capita, the subsidies for oil and gas is calculated by summing up the product of energy demand and unit subsidy expenditure for oil and gas:

oil subsidies expenditures usd/year = final energy demand oil*"oil subsidy (us90/ktoe)"+"gas subsidy (us90/ktoe)"*primary energy demand gas

Public investment and consumption

Public investment is set equal to total capital expenditure, and current expenditure is determined as the difference between total expenditure and total capital expenditure:

Total current expenditure = total expenditure- total capital expenditure

Finally, public consumption is calculated as current expenditure plus extraordinary expenditure (which is assumed to consist entirely of the consumption of goods and services), minus interest payments and subsidies and transfers:

Public consumption = total current expenditure-interest payments-subsidies and transfers

References

IMF, *Mali: Statistical Annex*, IMF Staff Country Report No. 98/14, 1998 International Monetary Fund

IMF, *Mali: Selected Issues and Statistical Annex*, IMF Staff Country Report No. 00/128, 2000 International Monetary Fund

IMF, *Mali: Selected Issues and Statistical Annex*, IMF Staff Country Report No. 04/10, 2004 International Monetary Fund

25. Government Debt module

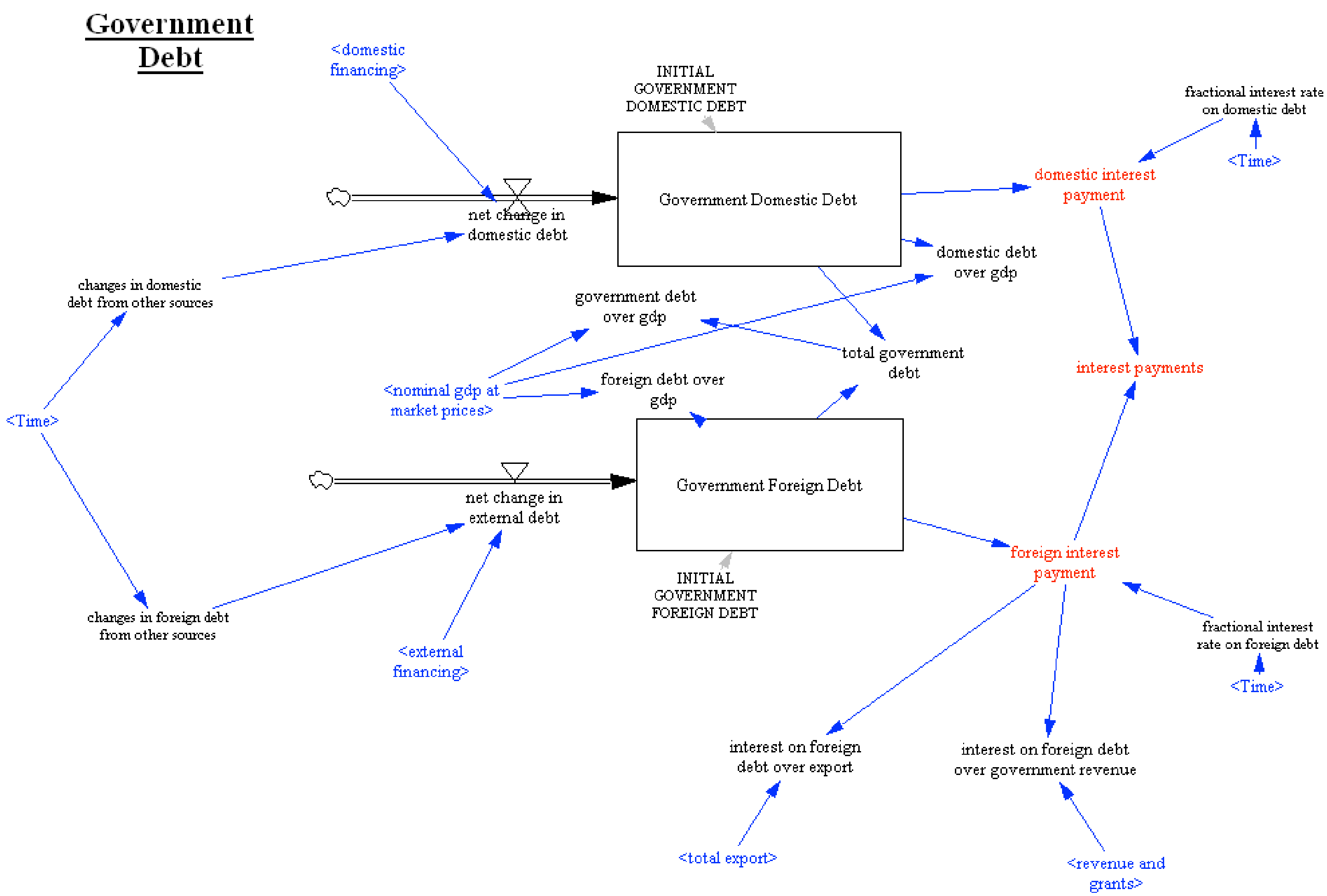

Figure 77: Sketch of the Government Debt module

Purpose and Perspective

The Government Debt module (**Figure 82**) represents the mechanisms of foreign and domestic public debt accumulation. The accumulation of public debt is often a crucial issue for developing countries. Therefore, the representation of public debt must be accurate enough to capture the fundamental dynamics of debt accumulation and support the analysis of different debt strategies.

Explanation

Major Assumptions

- Changes in debt can happen through financing or other sources;
- Other financing sources are exogenous;

Table 90: Input variables: Government Debt module

Variable Name	Module of Origin
Domestic financing	Government balance and financing
External financing	Government balance and financing
Nominal GDP at market prices	Investment
Total export	International trade
Revenue and grants	Government revenue

Table 91: Output variables: Government Debt module

	Module of Destination		
Variable Name	**In the Same Sector**	**In Other Economic Sectors**	**In Other Sectors**
Domestic interest payment	Government balance and financing	Households	
Interest payment	Government expenditure, Public investment and consumption		
Foreign interest payment	Government balance and financing	Households, Balance of payments	

Table 92: Constants and table functions: Government Debt module

Variable Name	Type of Variable	Source for Estimation
Changes in foreign debt from other sources	Time series	Malaysian Economy in Figures 2011
Changes in domestic debt from other sources	Time series	Malaysian Economy in Figures 2011
Initial Government Domestic Debt initial Government Foreign Debt	Time series	Malaysian Economy in Figures 2011
Fraction of financing from banking system from central bank table	Time series	Malaysian Economy in Figures 2011
Fractional interest rate on domestic debt	Time series	Malaysian Economy in Figures 2011
Fractional interest rate on foreign debt	Time series	Malaysian Economy in Figures 2011

Functional Explanation

The following paragraphs describe how the stocks of domestic and foreign debt are calculated and how interest paid by the government is derived. Note that all the economic variables in this module are expressed in nominal terms (current prices). The formulations of foreign and domestic debt and interest payments follow the same logic, and thus only foreign debt is explained here:

Debt

Foreign debt is represented as a stock variable. The flow that accumulates in the stock of foreign debt (*net change in external debt*) includes *external financing* and changes in debt of another nature (*changes in foreign debt from other sources*):

Net change in external debt = external financing +changes in foreign debt from other sources

External financing is calculated in the Government Balance and Financing module, while *changes in foreign debt from other sources* is determined exogenously.

Interests

The interest the government pays on debts is calculated applying an exogenous marginal interest rate to the stock of domestic and foreign debt. The *foreign interest payments* is thus calculated as:

Interest domestic interest payment = Government Domestic Debt*fractional interest rate on domestic debt

The formulation used to determine *domestic interest payments* follows the same logic.

Finally, the total interest paid by the government is calculated as the sum of interest on domestic and foreign debt:

Interest payment = foreign interest payment + domestic interest payment

Indicators

Some important indicators are also calculated in this module, including: *foreign interest payment over export*, *foreign interest payment over government revenue*, *total government debt* and *government debt over GDP*. These indicators are fundamental in monitoring the level and the sustainability of public debt, and are calculated as follows:

Total government debt = government domestic debt+ Government Foreign Debt

Domestic debt over GDP = Government Domestic Debt/nominal GDP at market prices

Foreign debt over GDP = Government Foreign Debt/nominal GDP at market prices

References

IMF, *Mali: Statistical Annex*, IMF Staff Country Report No. 98/14, 1998 International Monetary Fund

IMF, *Mali: Selected Issues and Statistical Annex*, IMF Staff Country Report No. 00/128, 2000 International Monetary Fund

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26. Households module

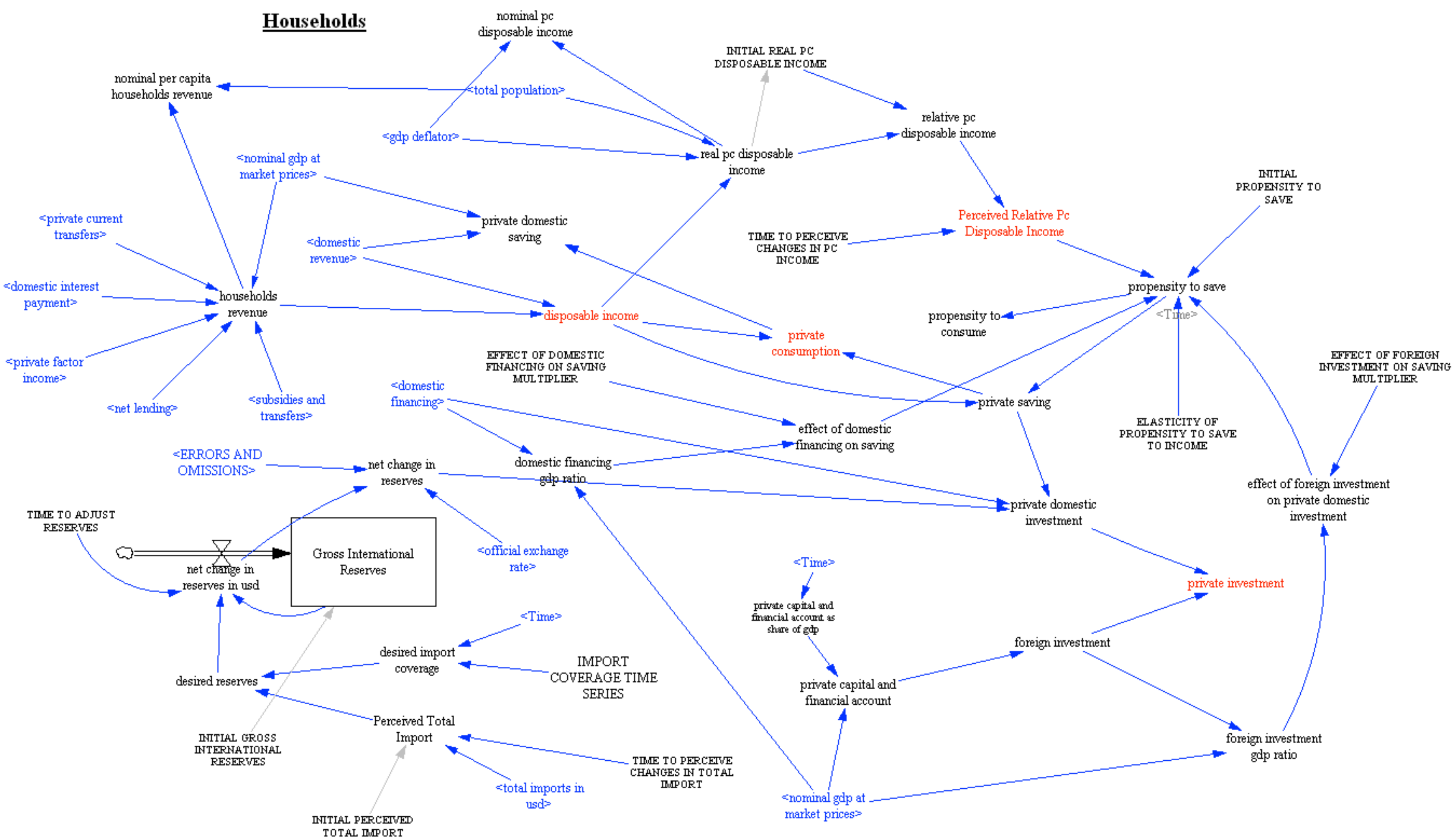

Figure 78: Sketch of the Households module

Purpose and Perspective

The Households module (see **Figure 83**) represents how various economic flows are combined to determine household income, and how this income is split into consumption and savings, part of which eventually becomes investment.

For the sake of simplification, in T21 we assume that all the value-added created by the economy is transferred to households, which pay all domestic taxes and duties. In other words, we do not separately consider that part of the value-added is retained by the firms, taxed by the government and eventually directly re-invested. Thus, the saving-investment behavior of firms is assimilated to that of households. This assumption seems to be acceptable, considering that households are in most cases the major stakeholders in a firm's activities and have therefore a strong influence on their saving-investment behavior.

In this module the role of the banking system in the allocation of savings to investment is also represented, and the stock of gross national reserves is determined.

Explanation

Major Assumptions

- All value added created in the economy is transferred to households;
- All domestic taxes and duties are paid by households;
- The propensity to consume is determined based on per capita income level (Engel's Law);
- The banking system manages the international reserves so as to maintain a given coverage in months of imports.

Table 93: Input variables: Households module

Variable Name	Module of Origin
Nominal GDP at market prices	Investment
GDP deflator	Relative prices
Foreign interest payment	Government debt
Domestic interest payment	Government debt
Private current transfers	Balance of payments
Private factor income	Balance of payments
Subsidies and transfers	Government revenue
Net lending	Government revenue
Domestic revenue	Government revenue
Total population	Population
Domestic financing	Balance of payments
Errors and omissions	Balance of payments

Arrears	Government balance and financing
Adjustment	Government balance and financing
Domestic financing	Government balance and financing
Resources balance	Balance of payments
Private capital and financial transfers	Balance of payments
Total imports in USD	International trade
Public investment	Government expenditure

Table 94: Output variables: Households module

	Module of Destination		
Variable Name	**In the Same Sector**	**In Other Economic Sectors**	**In Other Sectors**
Nominal GDP at market prices		International trade, government debt, government balance and financing, balance of payments	
Disposable income			Income distribution
Private consumption			Income distribution
Relative pc disposable income			Water demand, fertility
Consumption		International trade	
Investment		Investment, International trade, Balance of payments	
Time to perceive changes in pc income			Fertility
Perceived relative pc disposable income			Primary Education, Water demand
Net change in reserves			Aggregate Production and Income
Private capital and financial account		Balance of Payments	
Private investment		Investment	

Table 95: Constants and table functions: Households module

Variable Name	Type of Variable	Source for Estimation
Time to adjust reserves	Constant	Data on imports and gross international reserves (Malaysian Economy in Figures 2011)
Time to perceive changes in total import	Constant	Data on imports and gross international reserves (Malaysian Economy in Figures 2011)
Initial real pc disposable income	Constant	Data on disposable income (Malaysian Economy in Figures 2011) and population (UN Pop)
Initial propensity to save	Constant	Data on disposable income (Malaysian Economy in Figures 2011)
Elasticity of propensity to save to income	Constant	Data on disposable income (Malaysian Economy in Figures 2011)

Functional Explanation

The Households module contains several important elements that are functional in the determination of consumption, savings and investment. These elements are described in detail below. Note that economic flows in this module are considered at current prices, with the exception of *real pc disposable income*.

Disposable income

Household *disposable income* is determined in the upper middle part of the sketch in **Figure 83**. To calculate *disposable income*, first *households revenue* is determined as the sum of value added in the economy, net payment for factors of production lent abroad, net remittances received, interests paid by the government to households, and revenues from abroad to the households:

Total households revenue = nominal GDP at market prices +private factor income +private current transfers +domestic interest payment+ subsidies and transfers + net lending

Disposable income is then calculated as *households revenue* minus the fiscal withdraw of the government from households (the government's *domestic revenue*):

Disposable income = households revenue-domestic revenue

Propensity to consume

Disposable income is then allocated among consumption and savings based on a *propensity to save*. The *propensity to save* represents the percentage of *disposable income* that goes to savings. It is assumed the *propensity to save* is positively related to the level of per capita income (Engel's law), along with the effects of foreign investment and domestic financing:

Propensity to save = MIN(1, INITIAL PROPENSITY TO SAVE*Perceived Relative PC Disposable Income^ELASTICITY OF PROPENSITY TO SAVE TO INCOME(Time) +effect of foreign investment on private domestic investment +effect of domestic financing on saving)

Relative pc disposable income is equal to *disposable income* divided by *total population*, and normalized (divided by its initial value). The *elasticity of propensity to save to income* is a constant of positive sign. Note that the formulation MIN is used to make sure that the propensity to save can never exceed 1, by using the MIN function.

Consumption and savings

Private savings is determined as the *disposable income* times the *propensity to save*:

Private savings = disposable income*propensity to save

Private consumption are calculated as the residual in households' accounting:

Private consumption = disposable income-private savings

Gross international reserves

Gross international reserves, measured in USD, are calculated based on imports. It is assumed that the banking system will manage the reserves so as to always guarantee a certain number of months of coverage of imports. The level of reserves desired by the banking system is thus:

Desired reserves = Perceived Total Import*desired import coverage

Gross international reserves are then represented as a stock, which adjusts towards the desired level of reserves over time:

Net change in reserves in usd = (desired reserves-Gross International Reserves)/TIME TO ADJUST RESERVES

The *net change in reserves* is then calculated by converting from USD to RM and minus *errors and omissions* from the balance of payments:

Net change in reserves = net change in reserves in usd*official exchange rate-ERRORS AND OMISSIONS

Note that variable errors and omissions is set to zero in this model due to lack of data.

Investment

Private domestic investment and *private domestic saving* are determined as:

Private domestic investment = private saving-domestic financing-net change in reserves

Private domestic saving = nominal GDP at market prices-domestic revenue-private consumption

Private investment is then calculated by adding to *private domestic investment* the *foreign direct investment*:

Private investment = private domestic investment+ foreign investment

References

World Bank, Model building RMSM-X reference guide, July 1995.

World Bank, World Development Indicators 2000 on CD-ROM.

27. International Trade module

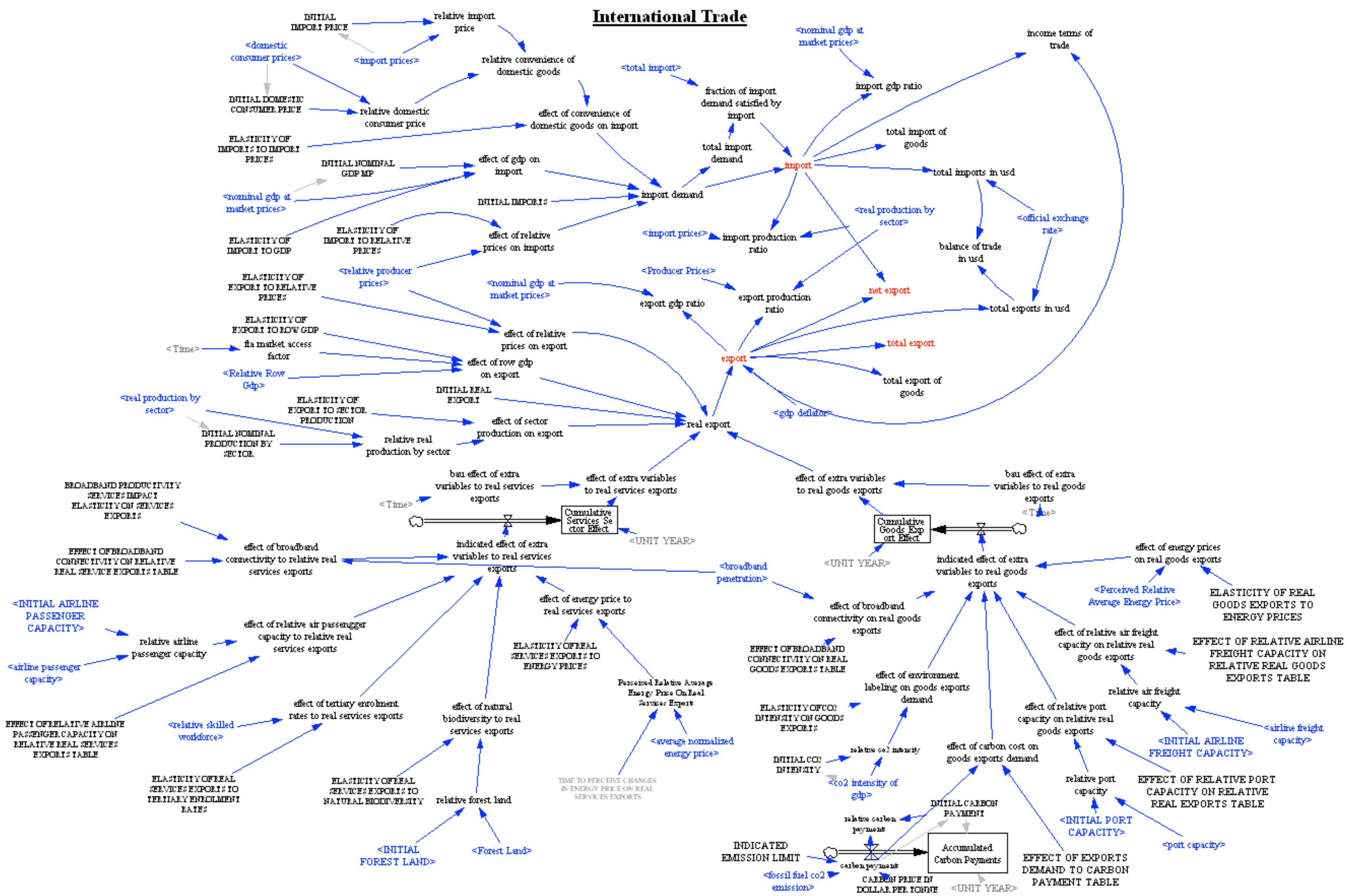

Figure 79: Sketch of the International Trade module

Purpose and Perspective

The International Trade module (see **Figure 84**) represents the mechanisms driving the development of the import and export of goods and services. The harmonic growth of imports and exports is a crucial element for the overall economic development of a country and should be carefully considered in long-term planning.

In this module, exports of goods and services are based on the influence of a number of social economic and environmental factors, including the rest of the world (ROW) and domestic production, relative price levels, energy prices and broadband connection penetration, among many others. Given that T21 endogenously determines the level of production, investment, consumption and export, total import is calculated as the residual in the GDP identity, while the import shares by sector are determined by domestic import demand for goods and services.

The structure proposed here is not well suited for analyzing short term fluctuations often observed in international trade volumes. This structure is created to analyze the medium-long term development of imports and exports as well as the impact of various governmental policies on international trade.

Explanation

Major Assumptions

- Common drivers for export of goods and services are the rest of the world (ROW) and domestic production, relative price levels, currency exchange rate, energy prices and broadband connection penetration;
- Export of goods and services are each further affected by a number of different additional factors, including:
  - Export of goods: infrastructure capacity (airline freight transport, ports), carbon payments and emission intensity;
  - Export of services: infrastructure capacity of airline passenger transport, availability of skilled labor force, forests that provides biodiversity;
- GDP identity;
- Sectoral distribution of imports depends on domestic GDP, consumer prices and import prices.

•

Table 96: Input variables: International Trade module

Variable Name	Module of Origin
Import prices	Relative prices
Domestic consumer price	Relative prices
Producer prices	Relative prices
GDP deflator	Relative prices
Relative producer prices	Relative prices
Nominal GDP at market prices	Aggregate Production and Income
Relative row GDP	Aggregate Production and Income
Official exchange rate	Aggregate Production and Income
Real production by sector	Aggregate Production and Income
Total import	Aggregate Production and Income
Broadband penetration	Broadband
Initial airline passenger capacity	Air transport
Airline passenger capacity	Air transport
Relative skilled workforce	Services
Initial forest land	Land
Forest land	Land
Average normalized energy price	Energy prices
Fossil fuel CO_2 emission	Fossil Fuel GHG emissions
CO_2 intensity of GDP	Fossil Fuel GHG emissions
Initial port capacity	Port cargo
Port capacity	Port cargo
Initial airline freight capacity	Air transport
Airline freight capacity	Air transport
Perceived relative average energy price	Energy prices

Table 97: Output variables: International Trade module

	Module of Destination		
Variable Name	**In the Same Sector**	**In Other Economic Sectors**	**In Other Sectors**
Relative real production by sector			Water demand
Total export		Aggregate Production and Income, Government debt	
Total imports in USD		Households	
Relative exchange rate with EU		Relative Prices	
Nominal exchange rate with US		Government debt	
Import	Balance of Payments	Government revenue, Relative Prices	

Export	Balance of Payments	Relative Prices	

Table 98: Constants and table functions: International Trade module

Variable Name	Type of Variable	Source for Estimation
Initial import price	Constant	Internally determined by Vensim as the first value calculated for import price
Initial domestic consumer price	Constant	Internally determined by Vensim as the first value calculated for consumer price
Elasticity of imports to import prices	Constant	Data on import and import taxes (IMF)
Elasticity of import to GDP	Constant	Data on import and GDP (IMF)
Time for GDP to affect import demand	Constant	Data on import and GDP (IMF)
Elasticity of import to relative prices	Constant	Data on import (IMF) and relative prices (WDI)
Elasticity of export to relative prices	Constant	Data on export (IMF) and relative prices (WDI)
Elasticity of export to ROW GDP	Constant	Data on ROW GDP (WDI) and export (IMF)
Share of exports to industrialized countries	Constant	Data from IMF
Relative exchange rate with developing countries	Constant	Data from IMF
Time for convenience of domestic goods to affect import	Constant	Data on tariff rates and import (IMF)
Initial import	Constant	Data from IMF
Initial export	Constant	Data from IMF
Initial nominal exchange rate with EU	Constant	Internally determined by Vensim as the first value calculated for nominal exchange rate with EU
EU inflation after 2002	Constant	Estimation based on IMF data (period average 1990-1998)
Exchange rate with EU in 2002	Constant	Data from IMF
Nominal exchange rate with EU table	Time series	Data from IMF

The following paragraphs describe the drivers for exports and imports and how are calculated. Note that all the economic variables in this module are expressed in nominal terms (current prices).

Export

Exports for each type of goods and service is primarily determined by the initial level of export, the ROW GDP growth, relative (commodity) prices, and sectoral production. On top of these drivers, export of industrial good and services products are further affected by a number of extra factors calculated in corresponding social, economic and environmental sectors. Thus the formulation of exports of agriculture, industry and services sectors are:

Real export[AGRI] = INITIAL REAL EXPORT[AGRI]* effect of row GDP on export[AGRI]* effect of relative prices on export[AGRI]*effect of sector production on export[AGRI]

Real export [ind] = INITIAL REAL EXPORT[IND]* effect of row GDP on export[IND]* effect of relative prices on export[IND]*effect of sector production on export[IND]*effect of extra variables to real goods exports

Real export [serv] = INITIAL REAL EXPORT[SERV]* effect of row GDP on export[SERV]* effect of relative prices on export[SERV]*effect of sector production on export[SERV]*effect of extra variables to real services exports

The effects of the main drivers (ROW GDP, relative prices, and sectoral production) on sectoral exports are all calculated according to the same logic, as the relative level of the drivers, raised to the power of an elasticity factor. For example, the *effect of ROW GDP on export* is determined by applying to the relative (normalized) ROW GDP the *elasticity of export to ROW GDP*:

Effect of ROW GDP on export [sectors] = Relative ROW GDP^ ELASTICITY OF EXPORT TO ROW GDP[sectors]

Note that the subscript [sectors] is used to keep track separately of the intensity of the effect on the various types of export products (agricultural, industrial and services).

In the equations of exports above, the effect of extra variables (in addition to the main drivers above) on export competitiveness of industrial and services products are summarized by the variables, which are described below.

The industrial export is further determined by energy prices, infrastructure (broadband connection penetration, capacity of airline freight transport and ports), and CO_2 emissions (payments and intensity):

indicated effect of extra variables to real goods exports = effect of relative port capacity on relative real goods exports*effect of relative air freight capacity on relative real goods exports*effect of broadband connectivity on real goods exports/(effect of carbon cost on goods exports demand*effect of energy prices on real goods exports*effect of environment labeling on goods exports demand)

Similar to the formulation of ROW GDP effect on export presented above, the effects of these extra factors are calculated very similarly, with the values of these factors obtained from other modules, except for additional steps in carbon payments calculation.

The amount of *carbon payments* is calculated in this module. It is equal to 1 when the nation's CO_2 emissions do not exceed an exogenous emission limit; otherwise it is equal to the the exceeding tonnage of emissions times carbon price per ton *effect of relative prices on export* is calculated as:

carbon payments = IF THEN ELSE (fossil fuel co2 emission > INDICATED EMISSION LIMIT , CARBON PRICE IN DOLLAR PER TONNE*(fossil fuel co2 emission-INDICATED EMISSION LIMIT), 1)

The effect of *carbon payments* on industrial goods export is represented by a table function with the carbon payments as the input:

effect of carbon cost on goods exports demand = EFFECT OF EXPORTS DEMAND TO CARBON PAYMENT TABLE(carbon payments)

Similarly, the extra factors affecting services export competitiveness include energy prices, infrastructure (broadband connection penetration, and capacity of airline passenger transport), availability of skilled labor force, and forests that provides biodiversity:

indicated effect of extra variables to real services exports = effect of relative air passenger capacity to relative real services exports*effect of broadband connectivity to relative real services exports*effect of natural biodiversity to real services exports*effect of tertiary enrolment rates to real services exports/effect of energy price to real services exports

The *effect of extra variables to real goods exports*, a component in the formulation of industrial export above, is calculated by dividing the cumulative stock of the extra effects on real goods exports by the effect under BAU:

effect of extra variables to real goods exports = Cumulative Goods Export Effect /BAU effect of extra variables to real goods exports

Cumulative Goods Export Effect = INTEG (indicated effect of extra variables to real goods exports, 1)

The formulation for services export is very similar.

Hence, total export of the country is the sum of sectoral exports:

total export = SUM(export[sectors!])

Here *total export* and *export* are in nominal terms, while *export* is calculated as the *real export* deflated by the GDP deflator.

Import

The total level of imports is determined as the residual in the GDP equation. Using the classical economic nomenclature, given the level of production (Y), investment (I), consumption (C) and export (X), import (M) is calculated as:

$$M = + I + C + X - Y$$

In T21, the equation for *total import* is:

Total import = consumption + investment+ total export - nominal GDP at market prices

The distribution of *total import* among the types of goods and services is calculated based on *initial import* and the effect of convenience of domestic goods (with respect to imported goods), the effect of relative prices, and the effect of domestic GDP.

The *effect of convenience of domestic goods on imports* is calculated elevating the relative (normalized) convenience of domestic goods to the power of the elasticity of imports to such variable:

Effect of convenience of domestic goods on imports [sectors] = DELAY N(relative convenience of domestic goods[sectors]^ELASTICITY OF IMPORTS TO IMPORT PRICES[sectors] , TIME FOR CONVENIENCE OF DOMESTIC GOODS TO AFFECT IMPORT,1,1)

Note that a first order delay formulation is used to represent the time lag between the change in the convenience of domestic goods and the change in imports.

Similarly, *effect of GDP on import* is calculated as:

Effect of GDP on import [sectors] = DELAY N((nominal GDP at market prices/INITIAL NOMINAL GDP MP)^ELASTICITY OF IMPORT TO GDP[sectors], TIME FOR GDP TO AFFECT IMPORT DEMAND , 1 , 1)

The effect or *relative prices on import* is calculated as:

Effect of relative prices on import [sectors] = Perceived Relative prices[sectors] ^ELASTICITY OF IMPORT TO RELATIVE PRICES[sectors]

Import demand, which is only used to determine the fraction of imports per type of goods and services and not the total level of import, is subsequently calculated as:

Import demand [sectors] = INITIAL IMPORTS [sectors]* Effect Of Convenience Of Domestic Goods On Import[sectors]* Effect Of Gdp On Import[sectors]* effect of relative prices on imports[sectors]

Finally, the *import* for each type of goods and services are calculated as:

Import [sectors] = import demand[sectors]*fraction of import demand satisfied by import

The *fraction of import demand satisfied by import* is determined as total imports calculated as the residual of the GDP identity, divided by total import demand.

References

Devarajan, Lewis and Robinson, *From stylized to applied models: Building multi-sector models for policy analysis*, Working paper No. 616, UC Berkeley, September 1991.

World Bank, W*orld Development Indicators 2000 on CD-ROM*.

28. Balance of Payments module

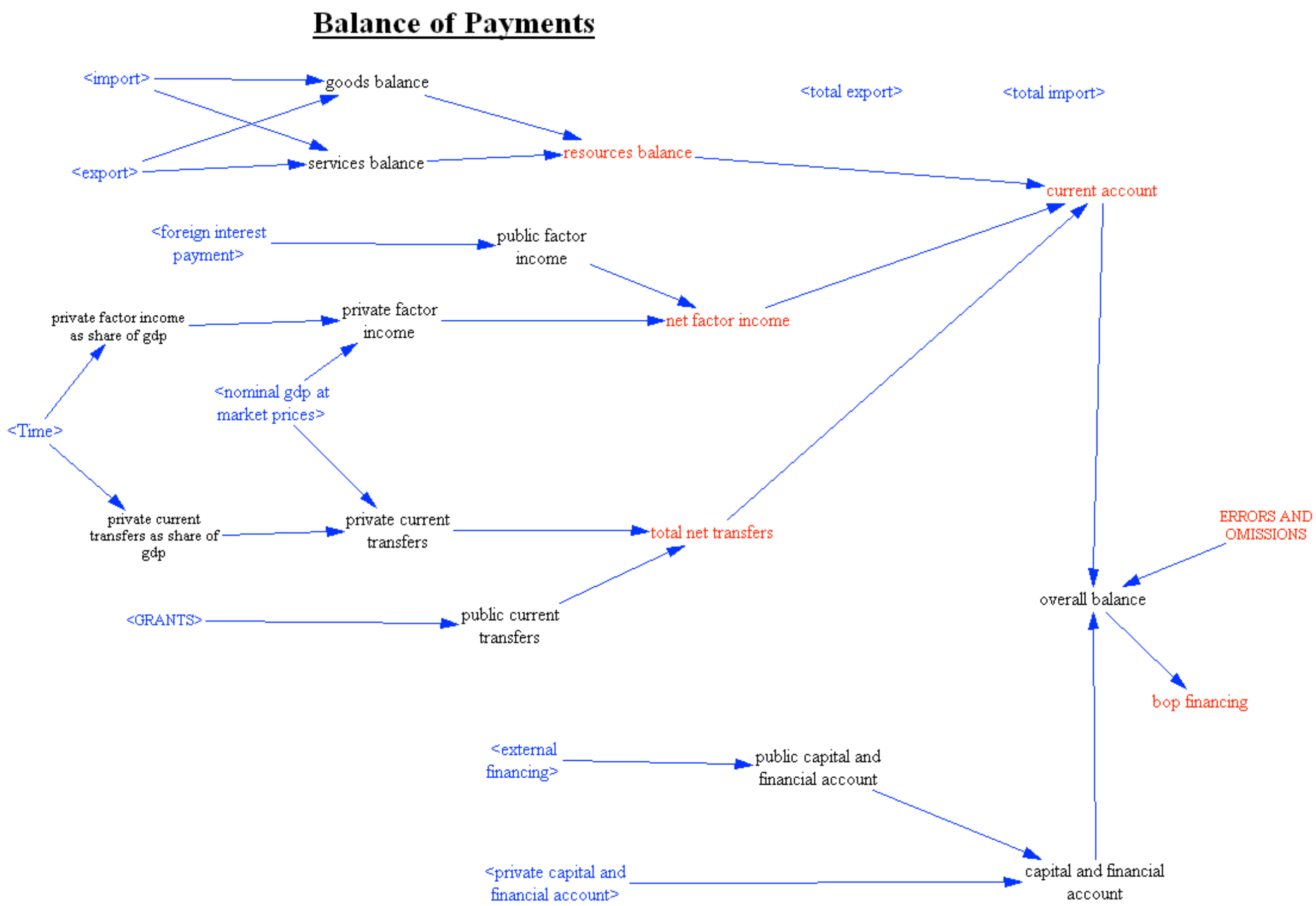

Figure 80: Sketch of the Balance of Payments module

Purpose and Perspective

The Balance of Payments module (**Figure 85**) represents a set of accounting relationships between the country object of the analysis and the rest of the world. The purpose of this module is to describe the major cross-border flows of goods, services and money and derive the overall balance of payments, which is a key economic indicator. The Balance of Payments module is based on the IMF Balance of Payments manual.

Explanation

Major Assumptions

- Private factor income and private transfers are exogenous;
- Private capital and financial transfers are affected by the level of fiscal pressure.

Table 99: Input variables: Balance of Payments module

Variable Name	Module of Origin
Export	International trade
Import	International trade
Foreign interest payment	Government debt
Grants	Government revenue
Nominal GDP at market prices	Investment
External financing	Government balance and financing
Private capital and financial account	Households

Table 100: Output variables: Balance of Payments module

	Module of Destination		
Variable Name	**In the Same Sector**	**In Other Economic Sectors**	**In Other Sectors**
Private factor income		Households	
Private current transfers		Households	
Private capital and financial transfers		Households	
Domestic financing		Households	
External financing		Government balance and financing	
Errors and omissions		Households	
Gross national product			Mortality
Gross national income		Relative prices	
Resources balance		Aggregate Production and Income, Households	
Current account		Aggregate Production and Income	
Total net transfers		Aggregate Production and Income	
Net factor income		Aggregate Production and Income	
BOP financing		Aggregate Production and Income	
Errors and omissions		Aggregate Production and Income	

Table 101: Constants and table functions: Balance of Payments module

Variable Name	Type of Variable	Source for Estimation
Private factor income as a share of GDP	Time series	Malaysian Economy in Figures 2011
Private current transfers as a share of GDP	Time series	Malaysian Economy in Figures 2011
Errors and omissions	Time series	Malaysian Economy in Figures 2011

Functional Explanation

Accounting in the Balance of Payments module has a tree-shaped structure (see **Figure 85**). On the left part of the sketch, basic cross-border economic flows are represented. The upper part of the sketch contains the flows belonging to the current account, while the lower part of the sketch contains those belonging to the capital and financial account. The two flows are added together to calculate the overall balance of payments.

Current account

In the top part of the sketch, *import* and *export* from the International Trade module are used to define the import and export of goods and services. The *resources balance* is then defined as:

resources balance = export of goods +import of goods

Just below in the sketch, the *net factor income* is determined. The *net factor income* includes the *public factor income* (assumed to be equal to the negative amount of *foreign interest payment*) and the *private factor income* (determined as a share of GDP):

Net factor income = private factor income +public factor income

Similarly, *net transfers* are determined as the sum of *private current transfers* and *public current transfers*. *Private current transfers* are determined as a share of GDP, while *official transfers* are assumed equal to net *grants* received by the government:

total net transfers = public current transfers + private current transfers

Finally, *resources balance*, *net factor income* and *net transfers* are added up to obtain *current account balance*:

Current account = net factor income +resources balance +total net transfers

Capital and financial account

Capital and financial account consists of *public capital and financial transfers* (equal to *external financing*) and *private capital and financial transfers* (from the Households module):

Capital and financial account = private capital and financial transfers +public capital and financial transfers

Finally, the overall balance of payments is calculated as the sum of current account and capital and financial account, along with errors and omissions (set to be 0 in this model due to lack of data):

overall balance= current account +capital and financial account +ERRORS AND OMISSIONS

References

International Monetary Fund, *Balance of Payments Manual*, fifth edition, available online at http://www.imf.org/external/np/sta/bop/BOPman.pdf

Barth, Richard, and William, Hemphill, *Financial Programming and Policy*, IMF Institute, 2000.

29. Relative Prices module

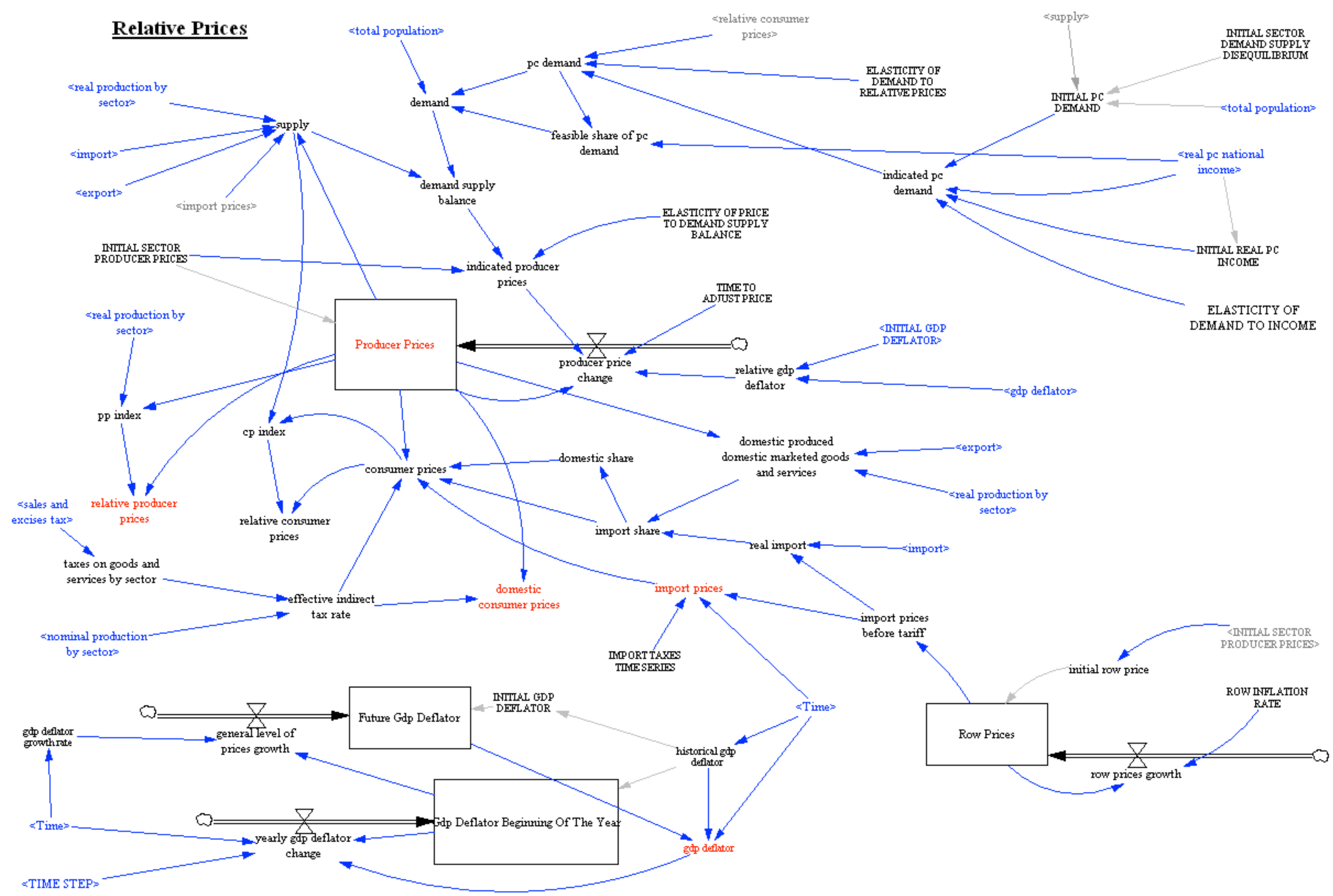

Figure 81: Sketch of the Relative Prices module

Purpose and Perspective

The Relative Prices module (see **Figure 86**) was developed based on the work of Devarajan, Lewis and Robinson (1991). The purpose of this module is to describe the mechanisms driving prices for various types of goods and services.

T21 includes three types of goods and services: agricultural goods, industrial goods, and services. As conditions change, prices per unit for goods and services change. Relative prices are a measure of how prices for the three types of goods and services change, relative to each other.

A distinction is made between producer prices (prices received by domestic producers for their output) and market prices (prices paid by consumers on the market). Producer prices are mainly a function of supply and demand balance for goods and services. Consumer prices are a function of producer prices, import prices, and indirect taxation.

Relative prices, the producer prices relative to overall level of prices in the economy, have a major influence on investment. As demand for one good/service rises with respect to demand, its price rises and, ceteris paribus, its relative price will rise. Higher relative prices for a good/service make investment in production capacity for that good/service more profitable, and therefore more attractive. This makes investment in production capacity for that good/service increase, supply consequently increases and eventually causes prices to return to normal levels. Therefore, relative prices are a vital part of a balancing mechanism between supply and demand.

Consumer prices have a balancing effect: as the demand for one good increases, consumer prices tend to increase. The higher the consumer price for one good, the lower the demand will be for that good next time around.

Explanation

Major Assumptions

- Producer prices depend on the supply/demand balance for goods and services;
- Consumer prices depend on producer prices, import prices and indirect taxation;
- Demand for goods and services is affected by relative consumer prices and real income (Engel Curves);
- Cross-product price elasticity values are all zero, which means that when, e.g., industry prices go up, it will affect the industry market, but it will not affect the price of other products (agriculture and services).

Table 102: Input variables: Relative Prices module

Variable Name	Module of Origin
Real production by sector	Aggregate Production and Income
Real pc national income	Aggregate Production and Income
Import	International trade
Export	International trade
Sales and excises tax	Government revenue
Nominal production by sector	Aggregate Production and Income
Total population	Population

Table 103: Output variables: Relative Prices module

	Module of Destination		
Variable Name	**In the Same Sector**	**In Other Economic Sectors**	**In Other Sectors**
Import prices		International Trade	
Domestic consumer price		International Trade	
Producer prices		International Trade	
GDP deflator	Investment	Aggregate Production And Income, Agriculture, Public Investment and Consumption, Households, International Trade	Healthcare, Primary Education, Roads, Port Cargo, Air Transport, Broadband, Income Distribution
Relative producer prices	Investment	International Trade	

Table 104: Constants and table functions: Relative Prices module

Variable Name	Type of Variable	Source for Estimation
Initial sector producer price	Constant	Malaysian Economy in Figures 2011
GDP deflator growth rate	Time series	Malaysian Economy in Figures 2011
Historical GDP deflator	Time series	Malaysian Economy in Figures 2011
Elasticity of demand to income	Constant	Data on income and demand (Malaysian Economy in Figures 2011)
Time to adjust price	Constant	Data on prices, demand and production (Malaysian Economy in Figures 2011)
Elasticity of demand to relative prices	Constant	Data on prices, demand and production (Malaysian Economy in Figures 2011)
Import taxes time series	Time series	Malaysian Economy in Figures 2011
Initial sectoral demand supply demand disequilibrium	Constant	Malaysian Economy in Figures 2011
Elasticity of price to demand supply balance	Constant	Data on price, production and demand (Malaysian Economy in Figures 2011)
ROW inflation rate	Constant	Malaysian Economy in Figures 2011

Functional Explanation

The Relative Prices module can be divided into four functional parts: the calculation of demand (top right of the sketch in **Figure 86**); the calculation of producer prices (middle of the sketch); the calculation of relative prices (middle left of the sketch); and the calculation of consumer prices (bottom left of the sketch). The following paragraphs describe these four parts.

Demand for goods and services

Relative prices reflects supply and demand situations for agricultural and industrial goods, and for services. Demand for goods and services responds to changes in prices and income per capita.

As per capita income increases, consumer demand does not increase for all types of goods and services in the same way. In general, demand for agricultural goods tends to be less elastic with income changes than the demand for industrial goods, which in turn is less elastic than the demand for services (a relationship know as Engel's Law[19]). This means that as income increases, consumers tend to spend a higher share of their income on services and a lower share on agricultural and industrial goods. Consequently, as a country develops demand patterns change and production tends to adapt to the new demand.

At the per capita income levels of the United States, for example, most additional income becomes a demand for services rather than agricultural or industrial goods. In other words, income elasticity of services demand at incomes per capita typical of the US is larger than that of industry demand or agriculture demand. Similarly, when people with US-income levels suffer a reduction in income, they cut their demand for services more than for industrial and agricultural goods.

In T21, *Indicated pc demand* (per capita demand before considering price levels, based on income only) of agricultural and industrial goods and services is first computed, using specific income elasticity for each type of goods and services:

Indicated pc demand [sectors] = (INITIAL PC DEMAND[sectors])*(real pc national income/INITIAL REAL PC INCOME)^ELASTICITY OF DEMAND TO INCOME[sectors]

Note that the subscript [sectors] is used to differentiate among different types of products (agricultural and industrial goods, and services).

Subsequently, *per capita demand* is determined based on *Indicated pc demand* and the *consumer prices*:

PC demand [sectors] = indicated pc demand [sectors]*relative consumer price[sectors]^ELASTICITY OF DEMAND TO RELATIVE PRICES sectors]

Demand is then computed as *per capita demand* multiplied by *total population*:

Demand = (pc demand [sectors]*feasible share of pc demand)*total population

Note that pc demand is also multiplied by the *feasible share of pc demand*, to ensure that the sum of *pc demand* for the various goods and services does not exceed the overall per capita income.

Producer prices

Producer prices are mainly a function of supply and demand balance for goods and services. The paragraphs above describe how demand is determined in T21. Supply is equal to production plus imports minus exports:

Supply[sectors] = real sectoral production [sectors] + import [sectors]/import prices [sectors] – export [sectors]/ Producer Prices [sectors]

The intensity of the change in prices that follow the change in the demand supply balance varies from country to country and among the different types of goods and

[19] This relationship is associated with Ernst Engel, a 19th century German statistician

services. In general, prices of agricultural goods tend to be more sensitive to supply and demand changes than industrial goods, which in turn are more sensitive than services. This is because agriculture production tends to be less flexible and adapts less rapidly to changes in demand than industry or services production. The intensity of price change from changes in the supply demand balance is represented by *elasticity of price to demand supply balance*. The values used in T21 for this parameter are estimated for each country depending on its historic experience. *Indicated producer prices* (producer prices before considering the time delays involved in price changes) are thus calculated as:

Indicated producer prices [sectors] = INITIAL SECTOR PRODUCER PRICES[sectors]*demand supply balance[sectors]^ELASTICITY OF PRICE TO DEMAND SUPPLY BALANCE[sectors]

Producer prices are represented as a stock variable, integrating the flow of *change in producer prices*:

Producer price change [sectors] = (indicated producer prices[sectors] *relative GDP deflator -Producer Prices[sectors]) /TIME TO ADJUST PRICE

Note from the equation above that *producer prices* are set to adjust to *indicated producer prices* times the relative (normalized) GDP deflator. This captures the overall inflationary tendency in the economy, which is not captured by the simple balance between supply and demand of goods and services.

Relative prices

Relative producer prices are producer prices divided by the *PP index* (Producer Prices index):

Relative producer prices [sectors] = Producer Prices [sectors]/pp index

The *PP index* represents the sum of *producer prices* weighted by the shares of GDP derived from the production of each different type of good and service. More precisely, the *PP index* is calculated as:

PP index = SUM (Producer Prices [sectors!]*real sectoral production [sectors!]) / SUM(real sectoral production [sectors!])

Consumer prices

Consumer prices are based on *producer prices* and indirect taxation (for domestically produced and marketed goods) and *import prices* (for imported goods). More precisely, *consumer prices* are a weighted average of *producer prices* plus the *effective indirect tax rate* and of *import prices*:

Consumer prices [sectors] = import prices[sectors]*import share[sectors]+Producer Prices[sectors]*(1+effective indirect tax rate[sectors])*domestic share[sectors]

Import prices are defined as the *import prices before tariff* plus the *effective tariff rate*:

Import prices [sectors] = import prices before tariff[sectors]*(1+IMPORT TAXES TIME SERIES[sectors](Time))

The *import prices before tariff* are assumed to equal to the overall level of prices in the rest of the world (*ROW prices*).
Using this definition for *import prices* and *consumer prices*, when the government increases taxation on certain types of goods or services, demand for that good or service tends to decrease. Consequently, *producer prices* decrease and investment in production capacity for that good or service also decreases.

Other components

The *GDP deflator* (bottom left part of the sketch in **Figure 86**) and average price levels in the rest of the world (bottom right part of the sketch) are also calculated in this module.

The *GDP deflator* is exogenously determined using an exogenous time series for the past and is determined by the growth rate for the future. More precisely, the *GDP deflator* is calculated as:

GDP deflator = IF THEN ELSE(Time>2010, Future Gdp Deflator, historical GDP deflator)

Future GDP Deflator is a stock variable that accumulates a net flow called *general level of prices growth*:

General level of prices growth = Gdp Deflator Beginning Of The Year*GDP deflator growth rate

The average level of prices in the rest of the world (*ROW prices*) is also represented as a stock variable, which accumulates the *ROW prices growth* flow:

ROW prices growth [sectors] = Row Prices [sectors]*ROW INFLATION RATE

The *ROW inflation rate* is assumed to be constant.

References

Devarajan, Lewis and Robinson, *From stylized to applied models: Building multisector models for policy analysis,* Working paper No. 616, UC Berkeley, September 1991.

Sterman, *The energy transition and the economy, A system dynamics approach*, Ph.D. Thesis, MIT, December 1981.

30. Investment module

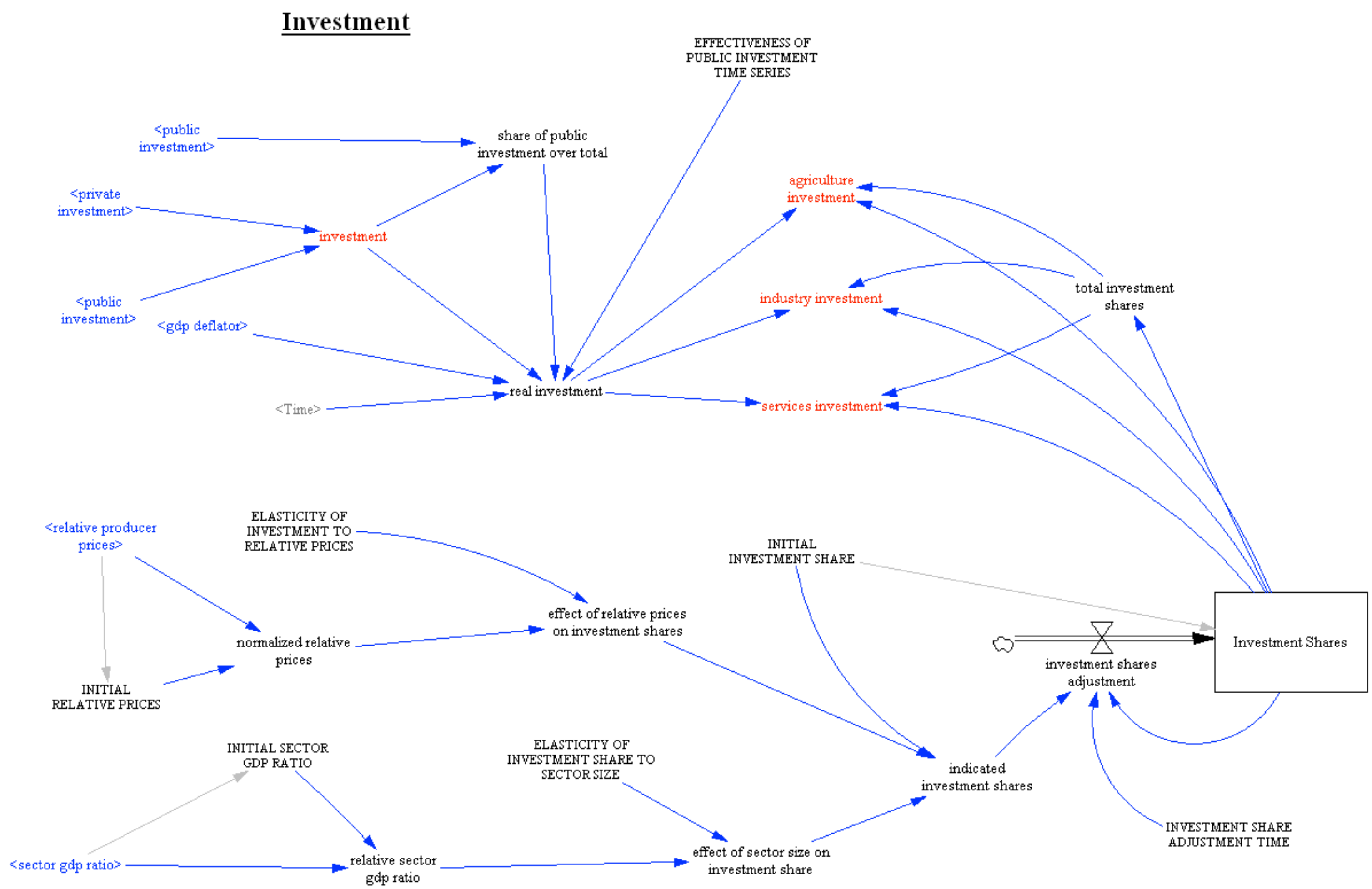

Figure 82: Sketch of the Investment module

Purpose and Perspective

Capital accumulation is one of the major sources of economic growth in developing countries. Investment from foreign and domestic sources generates capacity for the production of goods and services, and eventually stimulates employment. The Investment module (see **Figure 87**) determines the total real investment (the gross capital formation) and allocates investment funds among industry, agriculture, and services. Allocation of investment depends on two factors: the relative contribution of the three categories of production to GDP, and relative producer prices.

Some important indicators of overall economic performance are calculated in this module, such as gross domestic product (at market prices and factor cost) and per capita GDP.

Explanation

Major Assumptions

- The larger the contribution of one category of production (agriculture, industry, services) to GDP, the larger the investment for that type of production;
- The higher the relative producer prices for one type of goods or services, the larger the investment for the production of that good or services;
- The effectiveness of public investment is lower than the effectiveness of private investment.

Table 105: Input variables: Investment module

Variable Name	Module of Origin
Public investment	Government expenditure
Private investment	Households
GDP deflator	Relative prices
Relative producer prices	Relative prices
Sector GDP ratio	Aggregate Production and Income

Table 106: Output variables: Investment module

	Module of Destination		
Variable Name	**In the Same Sector**	**In Other Economic Sectors**	**In Other Sectors**
Investment		Aggregate Production and Income	
Agriculture investment		Agriculture	
Industry investment		Industry	Fossil Fuels Production
Services investment		Services	

Table 107: Constants and table functions: Investment module

Variable Name	Type of Variable	Source for Estimation
Time to perceive changes in relative prices	Constant	Data on producer prices and investment (Malaysian Economy in Figures 2011)
Elasticity of investment to relative prices	Constant	Data on producer prices and investment (Malaysian Economy in Figures 2011)
Effectiveness of public investment table	Time series	Local experts' knowledge
Initial investment share	Constant	Production data (Malaysian Economy in Figures 2011)
Investment share adjustment time	Constant	Data on production and investment (Malaysian Economy in Figures 2011)

Functional Explanation

The major function of this module is to calculate investment flow for each type of production activity: agriculture, industry and services. To do so, first *real investment* is calculated (top left of the sketch in **Figure 87**), and then *real investment* is shared based on the relative contribution of each production activity to the GDP and the effect of relative prices.

Real investment

Real investment represents the gross capital formation, i.e. the effective inflow of capital for the various production activities. *Real investment* differs from *investment* in two aspect: first it is expressed in real terms (constant prices) while *investment* is expressed in nominal terms; second, it considers that part of the *public investment* does not turn in capital formation due to inefficiencies in the public management of investment. *Real investment* is thus calculated by dividing *investment* by *GDP deflator*, and then subtracting the fraction of public investment that is lost due to inefficiencies:

Real investment = (investment/GDP deflator)*(1-share of public investment over total +share of public investment over total*EFFECTIVENESS OF PUBLIC INVESTMENT TABLE (Time))

Effects of sectoral production shares and relative prices on investment shares

The relative contribution of each type of production activity to GDP is an important element for the allocation of investment among agriculture, industry and services. In general, for example, the higher the share of GDP from industry, the higher the investment in industry. This tends to be true because activities that account for bigger shares of GDP normally have a bigger production capacity, which often coincides with a bigger capital stock. The substitution of old capital requires a bigger investment flow, and if production is to expand 10% for all activities, the activity that has a bigger capital stock will need to receive a bigger investment flow.

The sectoral production shares are compared to the initial shares to obtain the relative levels, which is used to determine the effect on investment shares:

effect of sector size on investment share[sectors] = relative sector GDP ratio[sectors]^ELASTICITY OF INVESTMENT SHARE TO SECTOR SIZE

Another important element for the allocation of investment among the various types of production activities is *relative prices*. A high relative price for one type of good or service indicates a strong demand for that good or service, and a higher than average profitability for those who produce that good or service. High profitability has a significant influence on investors who tend to direct their capital towards building capacity for the production of that good or service. This mechanism is represented in T21 through the *effect of relative prices on investment shares*. This variable is calculated by applying *elasticity of investment to relative prices* to *perceived relative prices*:

Effect of relative prices on investment shares [sectors] = normalized relative prices[sectors] ^ELASTICITY OF INVESTMENT TO RELATIVE PRICES[sectors]

Normalized relative prices are calculated as the ratio between current and initial producer prices.

Investment shares

To calculate *investment shares*, first *indicated investment shares* is determined. This variable represents the investment share that one would observe if there was no time lag between the moment market conditions change and the moment investment decisions are actually influenced. *Indicated investment shares* are calculated by combining together the effect of the size of the various production activities with respect to the GDP and the effect of relative prices:

Indicated investment shares [sectors] = MAX(0, INITIAL INVESTMENT SHARE[sectors]*effect of relative prices on investment shares[sectors]*effect of sector size on investment share[sectors])

Investment shares is then calculated as a stock that accumulates the flow of *investment shares adjustment*. This flow is calculated as the difference between the indicated and the current shares of investment, divided by the time required to implement changes in investment decisions, so that the current investment share converges to the indicated shares over time:

investment shares adjustment[sectors] = (indicated investment shares[sectors]-Investment Shares[sectors])/INVESTMENT SHARE ADJUSTMENT TIME

Investment

Investment is calculated by multiplying the *investment shares* by the *real investment*:

agriculture investment = real investment*Investment Shares [AGRI]/total investment shares industry investment = real investment*Investment Shares [IND]/total investment shares

services investment = real investment*Investment Shares [SERV]/total investment shares

Note that *investment shares* in the equations above are also divided by *total investment shares*, or normalized, to make sure that the sum of investment shares does not exceed 1.

Agriculture industry and services investment are directly used as inflow in the capital stock for production in the three sectors respectively.

References

Devarajan, Lewis and Robinson, *From stylized to applied models: Building multi-sector models for policy analysis*, Working paper No. 616, UC Berkeley, September 1991.

World Bank, W*orld Development Indicators 2000 on CD-ROM*.

Environmental Sectors

31. Land module

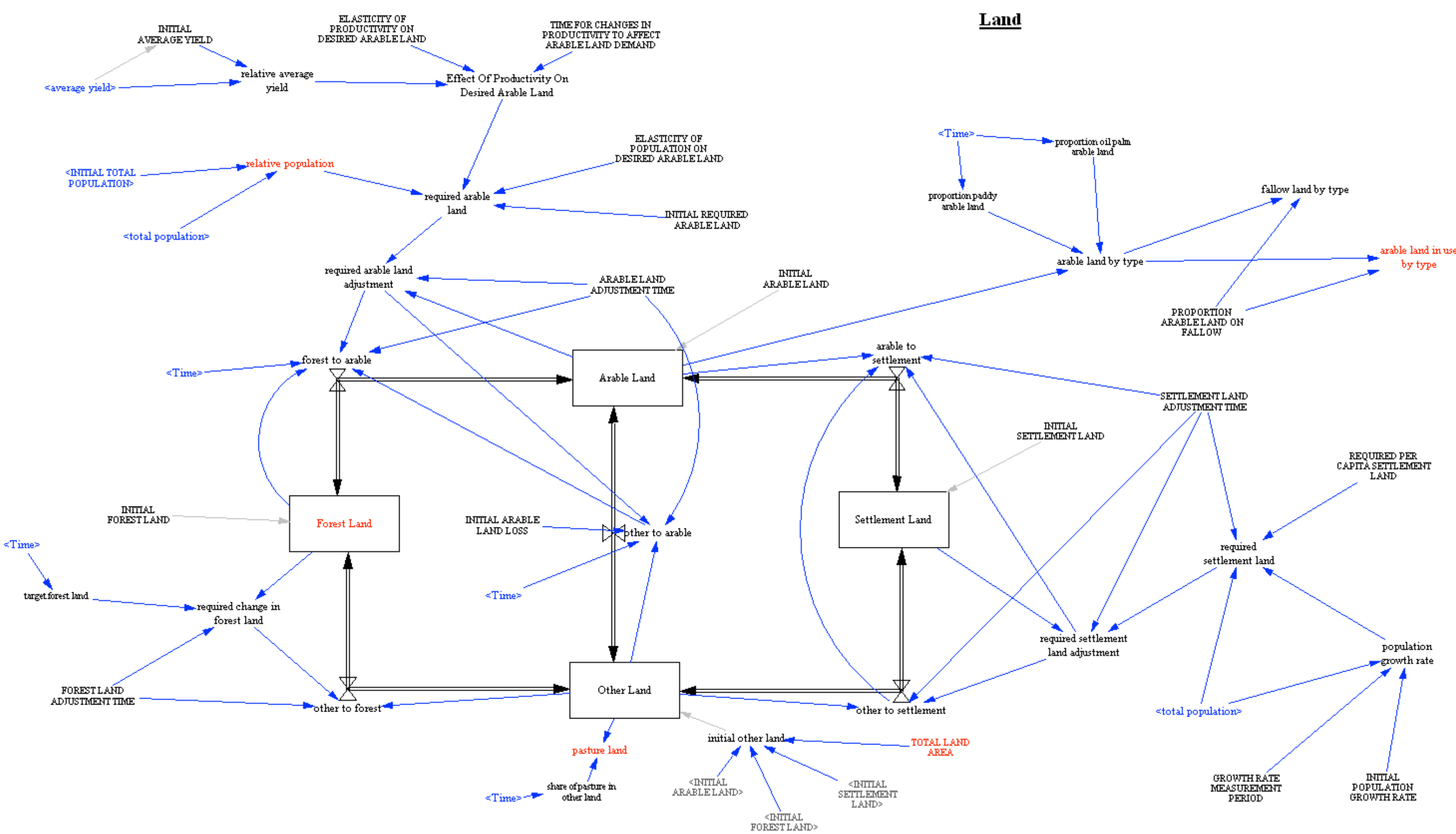

Figure 83: Sketch of the Land module

Purpose and Perspective

The purpose of the Land module (see **Figure 88**) is to track land use for different purposes. The Land module models five classifications of land including forestland, arable land, settlement land, and other land. The area of pasture land is also calculated as a share of other land. While the levels of the different types of land change, the Land module ensures that total land is always conserved. The approach is to use the FAO land definition and classification and represent the causal factors that shift land from one category to another.

Explanation

Major Assumptions

- Arable land and pasture land are utilized for crops and livestock production respectively;
- To meet the increased land demand for agricultural purposes, arable land will be converted from other land or forest land (if is other land is not sufficient);
- Other land is lost to settlement land due to increases in population, and arable land is used when other land is not sufficient;
- Other land is transformed to forest land to meet exogenous target of forest land.

Table 108: Input variables: Land module

Variable Name	Module of Origin
Total Population	Population
Initial total population	Population
Average Yield	Agriculture

Table 109: Output variables: Land module

	Module of Destination		
Variable Name	**Same Sector**	**Other Environmental Sectors**	**Other Sectors**
Arable land			Agriculture
Forest Land			International Trade, Husbandry, Fishery and Forestry, MDGs
Arable land by type			Agriculture
Pasture land			Husbandry, Fishery and Forestry
Relative population			Energy Demand
Total land area		Water supply, Fossil Fuel GHG emissions	Roads

Table 110: Constants and table functions: Land module

Variable Name	Type of Variable	Source for Estimation
Additional Demand of Arable Land Due to Cotton Price Changes	Time Series	FAO data on cotton prices and the area cultivated with cotton.
Degraded Land Recovery Time	Constant	Based on local experts opinion
Desired per Capita Agriculture Production	Constant	FAO data on agriculture land and population
Desired Time to Adjust Agriculture Land	Constant	FAO data on agriculture land and population
Effect of Agriculture Intensity on Land Exhaustion table	Table Function	FAO data on land use
Effect of Forest Cover on Desertification table	Table Function	FAO data on land use
Fallow Land Conversion Time	Constant	FAO data on land use
Initial Agricultural Area	Constant	FAO data
Initial Agricultural Land in Use	Constant	FAO data
Initial Average Yield	Constant	Internally determined by Vensim as the first value calculated for average yield
Initial Desert Land	Constant	FAO data
Initial Desertification Time for Degraded Agriculture Land	Constant	FAO data on desert and fallow land
Initial Exhaustion Time for Agriculture Land	Constant	FAO data on agriculture and fallow land
Initial Forest Cover	Constant	FAO data
Initial Forest land	Constant	FAO data
Initial Urban Land	Constant	FAO (Food and Agriculture Organization) data
Pasture Land	Constant	FAO data
PC Space	Constant	Data on urban land and population
Time to Adjust Urban Land	Constant	FAO data on land use
Time to Cover Forest Land	Constant	FAO data on land use
Time to Regenerate Forest Land	Constant	FAO data on land use
Total Land Area	Constant	FAO data

Functional Explanation

The Land module represents land use for different purpose: settlement, forest, arable and other land, where pasture land is the share of other land area. In the following paragraphs, the flows that move land from one use to another, and the land stocks are described.

Other to arable

The flow of *other land* converted into *arable land* per year is calculated as the minimum between *required arable land adjustment* and the maximum possible conversion from other to arable land (calculated as the *other land* area divided by a conversion time):

other to arable = MIN(required arable land adjustment, Other Land/ARABLE LAND ADJUSTMENT TIME)-IF THEN ELSE(Time<1981, INITIAL ARABLE LAND LOSS,0)

Here the *initial arable land loss* is set to zero in the model.

Required arable land adjustment represents the change in the amount of arable land required by crop producers, and is calculated as the difference between the required and the actual amounts of arable land (if this difference is positive, otherwise 0), divided by a conversion time (*arable land adjustment time*):

Required arable land adjustment = (required arable land-Arable Land)/ARABLE LAND ADJUSTMENT TIME

Required arable land is calculated as the initial required amount times the effects of agricultural productivity (*average yield* obtained in Agriculture module) and population.

required arable land = INITIAL REQUIRED ARABLE LAND*Effect Of Productivity On Desired Arable Land*relative population ^ELASTICITY OF POPULATION ON DESIRED ARABLE LAND

The *effect of productivity on desired arable land* is calculated by using a first order smooth formulation (SMOOTH N) to consider that desired arable land responds gradually over time to productivity changes. This time lag is represented by *time for changes in productivity to affect arable land demand*, which is different from the land conversion time (*arable land adjustment time*) used to calculate *required arable land adjustment*.

Effect Of Productivity On Desired Arable Land = SMOOTH N(relative average yield ^ELASTICITY OF PRODUCTIVITY ON DESIRED ARABLE LAND, TIME FOR CHANGES IN PRODUCTIVITY TO AFFECT ARABLE LAND DEMAND, 1,1)

Note that the elasticity of land demand to productivity is negative in the model, reflecting the fact that the improvement in productivity leads to reduced requirement for resources (land).

Forest to Arable

The flow of forestland converted into *arable land* per year is calculated as the amount of *required arable land adjustment* not satisfied by conversion of other land, and is also limited by the maximum possible conversion from forest to arable land (as the forestland area available for conversion divided by a conversion time).

forest to arable = IF THEN ELSE (Time<1981,0,MIN(Forest Land/ARABLE LAND ADJUSTMENT TIME, required arable land adjustment-other to arable))

Other to settlement

Similar to the calculation of other to arable land above, the flow of other land that transformed is into settlement land is calculated as the minimum between *required settlement land adjustment* and the maximum possible conversion from other to settlement land (calculated as the *other land* area divided by a conversion time):

Others to settlement = MIN(required settlement land adjustment, Other Land/SETTLEMENT LAND ADJUSTMENT TIME)

The *required settlement land adjustment* is equal to the difference between the *required settlement land* and total *settlement land*, divided by the conversion time (*settlement land adjustment time*):

Required settlement land adjustment = MAX(0, (required settlement land-Settlement Land)/SETTLEMENT LAND ADJUSTMENT TIME)

The expansion of *required settlement land* is primarily driven by population growth:

Required settlement land = (total population*(1+population growth rate) *SETTLEMENT LAND ADJUSTMENT TIME) *REQUIRED PER CAPITA SETTLEMENT LAND

Arable to settlement

The amount of *required settlement land adjustment* not satisfied by transformation of other land will come from arable land, which is also limited by the maximum possible conversion from forest to arable land (as the arable land available for conversion divided by a conversion time).

arable to settlement= MIN(Arable Land/SETTLEMENT LAND ADJUSTMENT TIME, required settlement land adjustment-other to settlement)

Other to forest

Other land can also be transformed into *forest land.* The flow is calculated as the minimum between *required change in forest land* and the maximum possible conversion from other to forest land (calculated as the *other land* area divided by a conversion time):

other to forest = MIN(required change in forest land, Other Land/FOREST LAND ADJUSTMENT TIME)

The *required change in forest land* is calculated as the difference between target and actual area of *forest land*, divided by the conversion time:

required change in forest land = (target forest land-Forest Land)/FOREST LAND ADJUSTMENT TIME

Land stocks

These flows calculated above then determine the area of different land uses type (arable, forest, settlement and other).

The area for each land type is a stock that accumulates annual inflows (conversion to the land type) and is reduced by annual outflows (conversion of the land type for other uses). As the calculation approach is the same for all land types, the formulation of arable land is shown as an example:

arable land = INTEG (forest to arable +other to arable-arable to settlement,
INITIAL ARABLE LAND)

Pasture land is also estimated in this module, as an exogenous share of other land area.

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FAO, *FAOSTAT 1997*, on CD-ROM.

32. Water Demand module

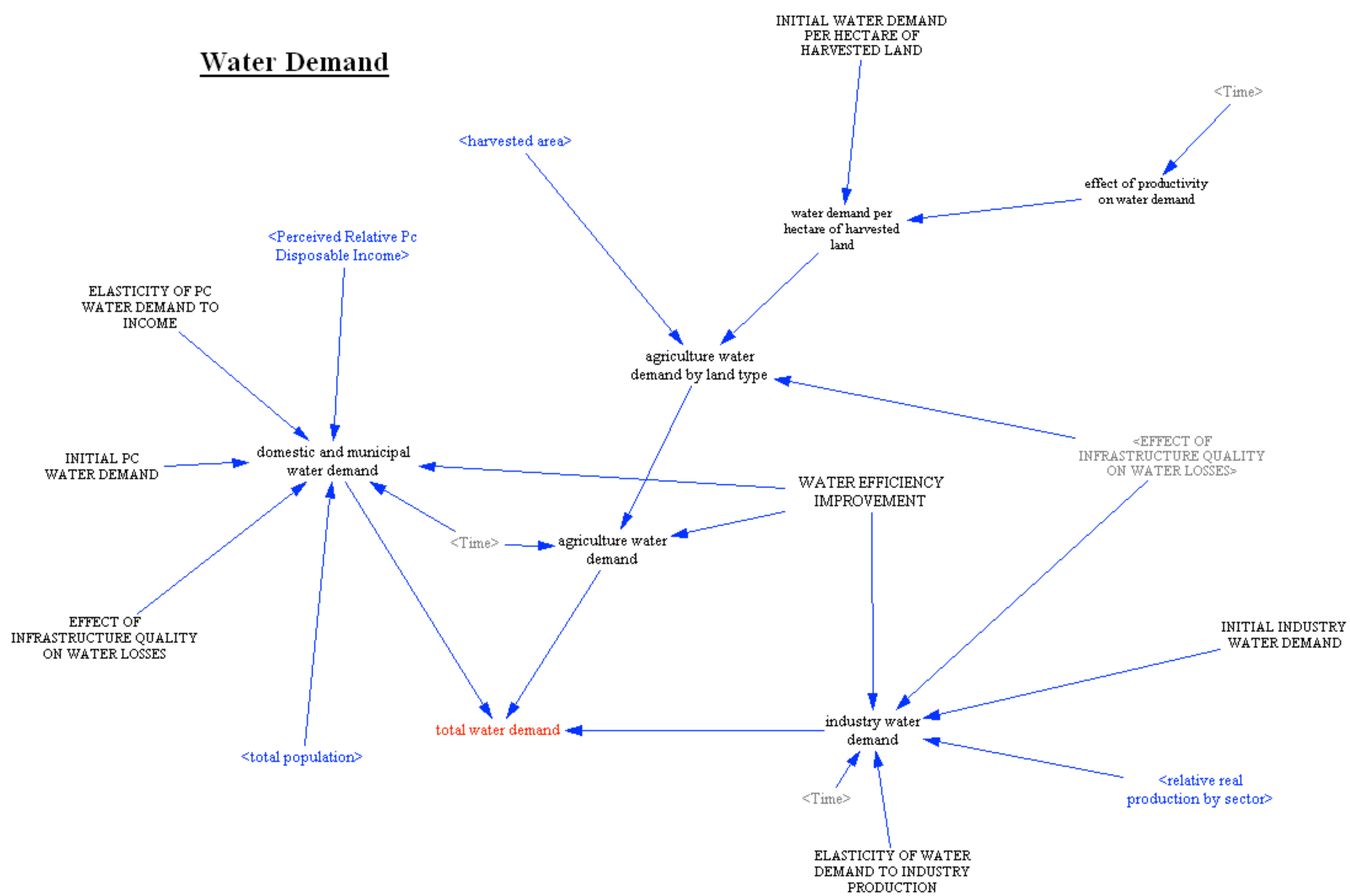


Figure 84: Sketch of the Water Demand module

Purpose and Perspective

Figure 89 illustrates the sketch of the Water Demand module. The purpose of the Water Demand module is to capture medium and long term water demand trends. Total water demand is the sum of water demand from the industry, agriculture and domestic sectors. The efficiency with which the water is used changes with technology and education. The level of aggregation used follows the standard approach used in FAO Aquastat data.

Explanation

Major Assumptions

- Domestic and municipal water demands are influenced by total population, income and efficiency;
- Industry water demand is determined by industry production and efficiency;
- Agriculture water demand is determined by the size of the harvested area and efficiency.

Table 111: Input variables: Water Demand module

Variable Name	Module of Origin
Harvested area	Land
Relative real production by sector	International Trade
Perceived relative pc disposable income	Households
Total population	Population
Total Potential Water Supply	Water Supply

Table 112: Output variables: Water Demand module

	Module of Destination		
Variable Name	**Same Sector**	**Other Environmental Sectors**	**Other Sectors**
Domestic and Municipal Water Demand	Water Supply		
Effect of Water Stress on Agriculture Productivity			Agriculture
Fraction of Water Available			Mortality
Total Water Demand	Water Supply		

Table 113: Constants and table functions: Water Demand module

Variable Name	Type of Variable	Source for Estimation
Elasticity of pc water demand to income	Constant	Data on income (Malaysian Economy in Figures 2011) and water demand (WDI)
Effect of water stress on agriculture productivity table	Table function	Data of agriculture production and water availability (FAO)
Initial pc water demand	Constant	Data on population (UN Pop) and water demand (WDI)
Effect of infrastructure quality on water losses	Constant	IMF (International Monetary Fund) data on Income
Effect of infrastructure quality on water losses	Constant	Set to 1 due to lack of data
Initial water demand per hectare of harvested land	Constant	Data of agriculture land (FAO) and water demand (WDI)
Effect of productivity on water demand		Data of agriculture land (FAO) and water demand (WDI)
Initial industry water demand	Constant	Data on industry production (Malaysian Economy in Figures 2011) and water demand (WDI)
Elasticity of water demand to industry production	Constant	Data on industry production (Malaysian Economy in Figures 2011) and water demand (WDI)

Functional explanation

Total water demand

Total water demand is the sum of industry, agriculture and domestic water demand:

Total water demand = agriculture water demand +domestic and municipal water demand +industry water demand

Agriculture water demand is a sum of water demand for each crop type. For each crop type, the demand is calculated as *harvested area* times the (exogenous) water demand per hectare of arable land, divided by the effect of infrastrucutre*:*

agriculture water demand = (SUM(agriculture water demand by land type[crop type!]))/WATER EFFICIENCY IMPROVEMENT(Time)

agriculture water demand by land type[crop type] = harvested area[crop type]* water demand per hectare of harvested land[crop type]/EFFECT OF INFRASTRUCTURE QUALITY ON WATER LOSSES

The amount of water demanded each year for industry is a function of the initial value, the relative level of industry production, and exogenous efficiency factors:

industry water demand= (INITIAL INDUSTRY WATER DEMAND * relative real production by sector[IND] ^ELASTICITY OF WATER DEMAND TO

INDUSTRY PRODUCTION /EFFECT OF INFRASTRUCTURE QUALITY ON WATER LOSSES)/WATER EFFICIENCY IMPROVEMENT(Time)

Domestic and municipal water demand is affected by *total population*, per capita water demand (driven by disposable income per capita), water use efficiency and the effect of infrastructure:

Domestic and municipal water demand= (total population*INITIAL PC WATER DEMAND*Perceived Relative PC Disposable Income^ELASTICITY OF PC WATER DEMAND TO INCOME(Time)/(EFFECT OF INFRASTRUCTURE QUALITY ON WATER LOSSES))/WATER EFFICIENCY IMPROVEMENT(Time)

References

Hoekstra, A., *AQUA, a Framework for Integrated Water Policy Analysis*, National Institute of Public Health and Environment (RIVM), July 1995.

Miller, G. T., *Living in the Environment*, seventh edition, Wadsworth, 1992

33. Water Supply module

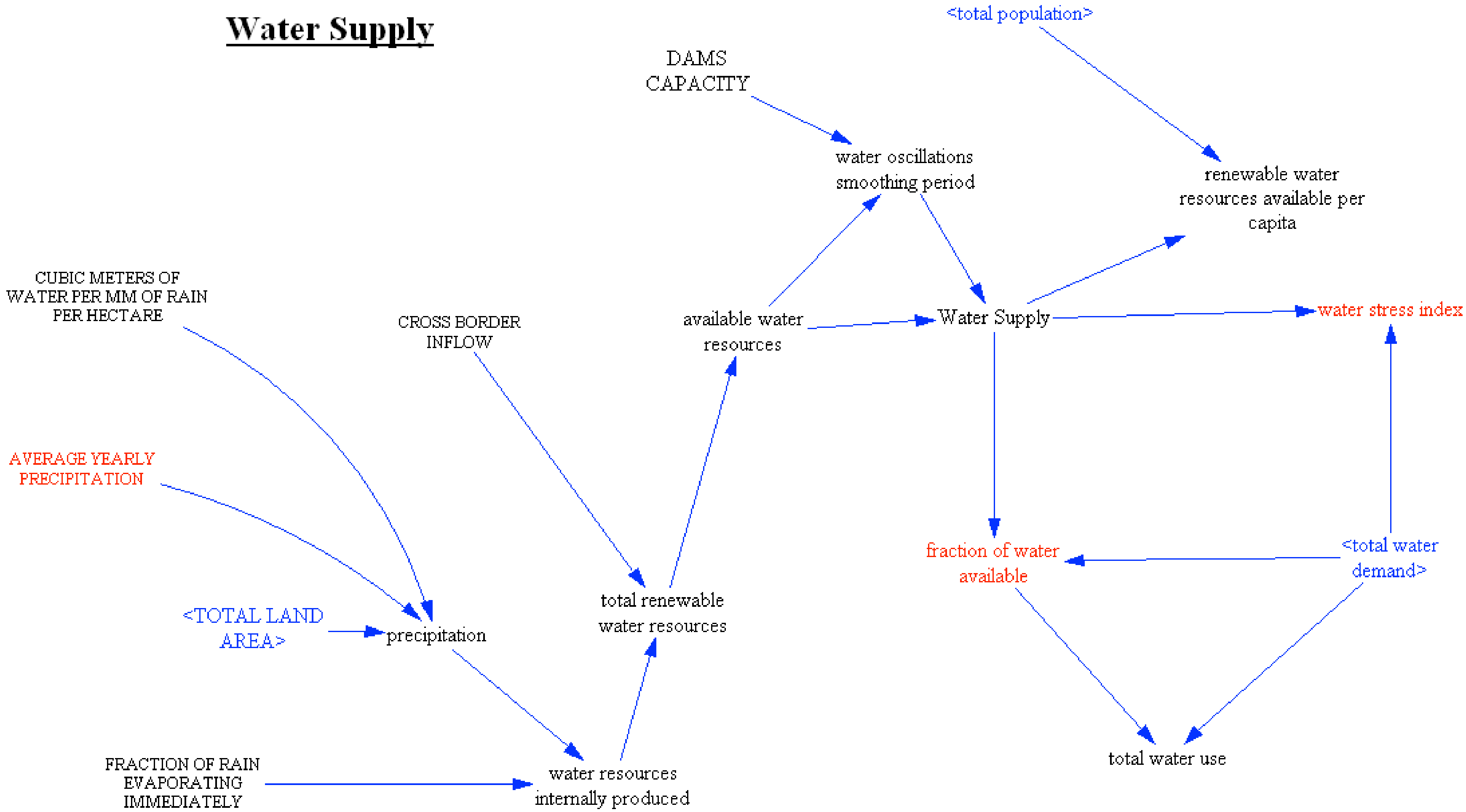


Figure 85: Sketch of the Water Supply module

Purpose and Perspective

This module estimates the quantity of water supply in the country from precipitation, cross border inflows and water storage in dams. The amount is compared to total water demand to obtain the water stress index, which affects crops yield in the Agriculture module.

Explanation

Major Assumptions

- Renewable water resources come from two sources: (1) the fraction of precipitation that is not immediately evaporated, and (2) cross border inflows;
- The actual water use is equal to the amount of water demand that can be satisfied by total water supply.

Table 114: Input variables: Water Supply module

Variable Name	Module of Origin
Total Land Area	Land
Total population	Population
Total Water demand	Water Demand

Table 115: Output variables: Water Supply module

	Module of Destination		
Variable Name	Same Sector	Other Environmental Sectors	Other Sectors
Water stress index			Agriculture
Total potential water supply	Water demand		
Average yearly precipitation			Husbandry, Fishing and Forestry

Table 116: Constants and table functions: Water Supply module

Variable Name	Type of Variable	Source for Estimation
Average yearly Precipitation	Constant	WDI
Cross border inflow	Constant	WDI
Cubic Meters of Water per mm of Rain per Hectare	Constant	WDI
Dams capacity	Constant	Set to 0 due to lack of data
Fraction of Rain Evaporating Immediately	Constant	WDI

Functional Explanation

In this module, total renewable water resources are estimated, coming from internally produced resources by rainfall, and cross border inflows (exogenous):

total renewable water resources= CROSS BORDER INFLOW+water resources internally produced

The *water resources internally produced* represents total water production from the fraction of precipitation that is not immediately evaporated and it is calculated as *precipitation* times 1 minus the fraction of rain that evaporates immediately:

water resources internally produced= precipitation*(1-FRACTION OF RAIN EVAPORATING IMMEDIATELY)

Here the *precipitation* volume per year depends on total land area and the amount of rainfall per ha of land.

On top of the available water resources (total renewable water resources), total *water supply also* takes into account the oscillating water storage in dams, calculated by a SMOOTH N function (representing an exponential average):

Water Supply = SMOOTH N(available water resources, water oscillations smoothing period, available water resources,1)

Water oscillations smoothing period = DAMS CAPACITY/available water resources

Reservoirs evaporation represents the flow of water evaporating from reservoirs. It is calculated as *reservoirs area* multiplied by *temperature*, times evaporation per hectare per degree of temperature of water, per year:

reservoirs evaporation= reservoirs area*TEMPERATURE*EVAPORATION PER HECTARE PER DEGREE PER YEAR

Total water use

Then we estimate the actual water use as the amount of water demand that can be satisfied by total water supply:

total water use = total water demand*fraction of water available

fraction of water available = IF THEN ELSE(Water Supply>total water demand,1, Water Supply/total water demand)

Water stress index

Total water supply is compared to water demand to obtain water stress index:

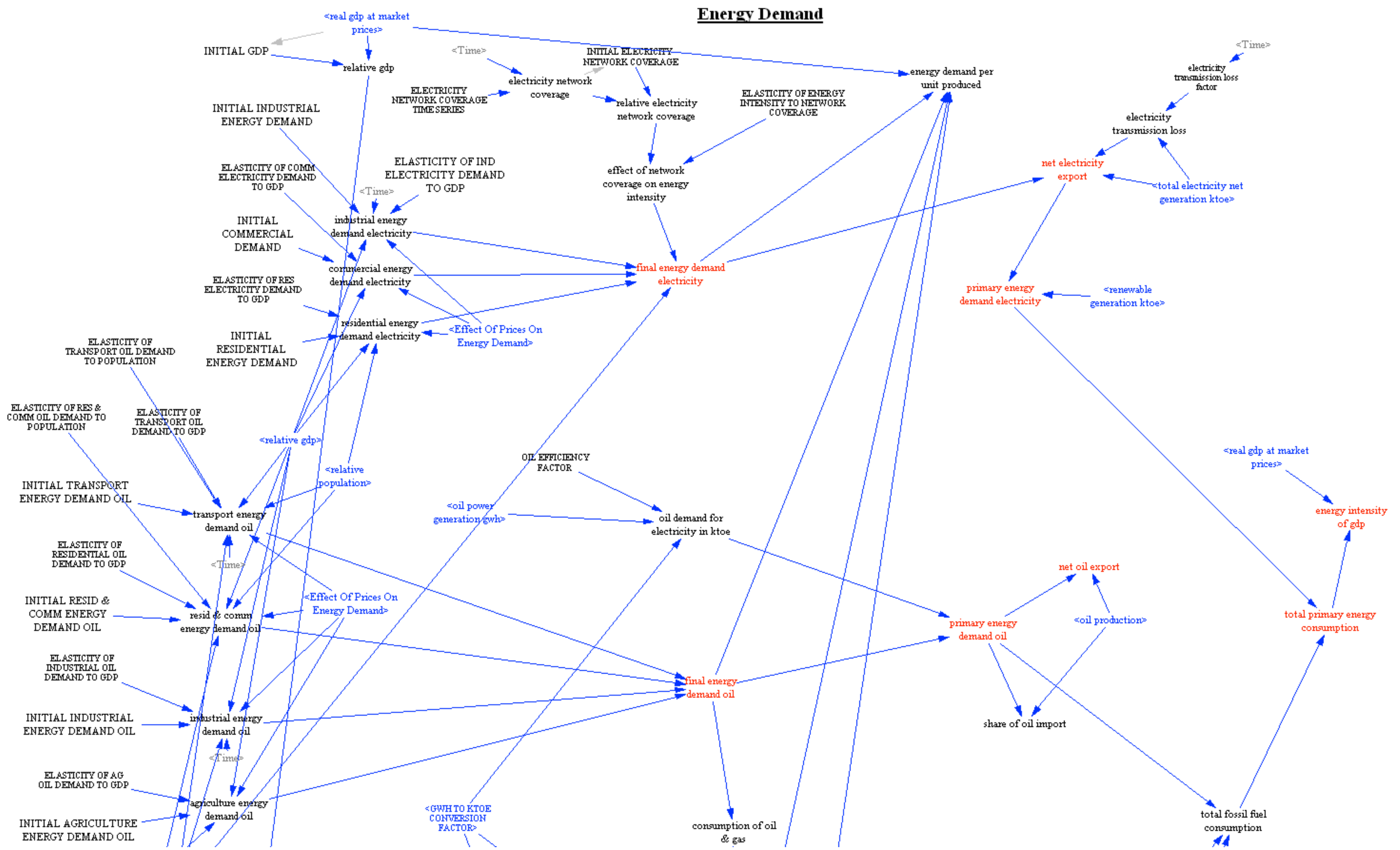
water stress index = total water demand/Water Supply

References

Hoekstra, A., *AQUA, a Framework for Integrated Water Policy Analysis*, National Institute of Public Health and Environment (RIVM), July 1995.

Miller, G. T., *Living in the Environment*, seventh edition, Wadsworth, 1992.

34. Energy Demand module



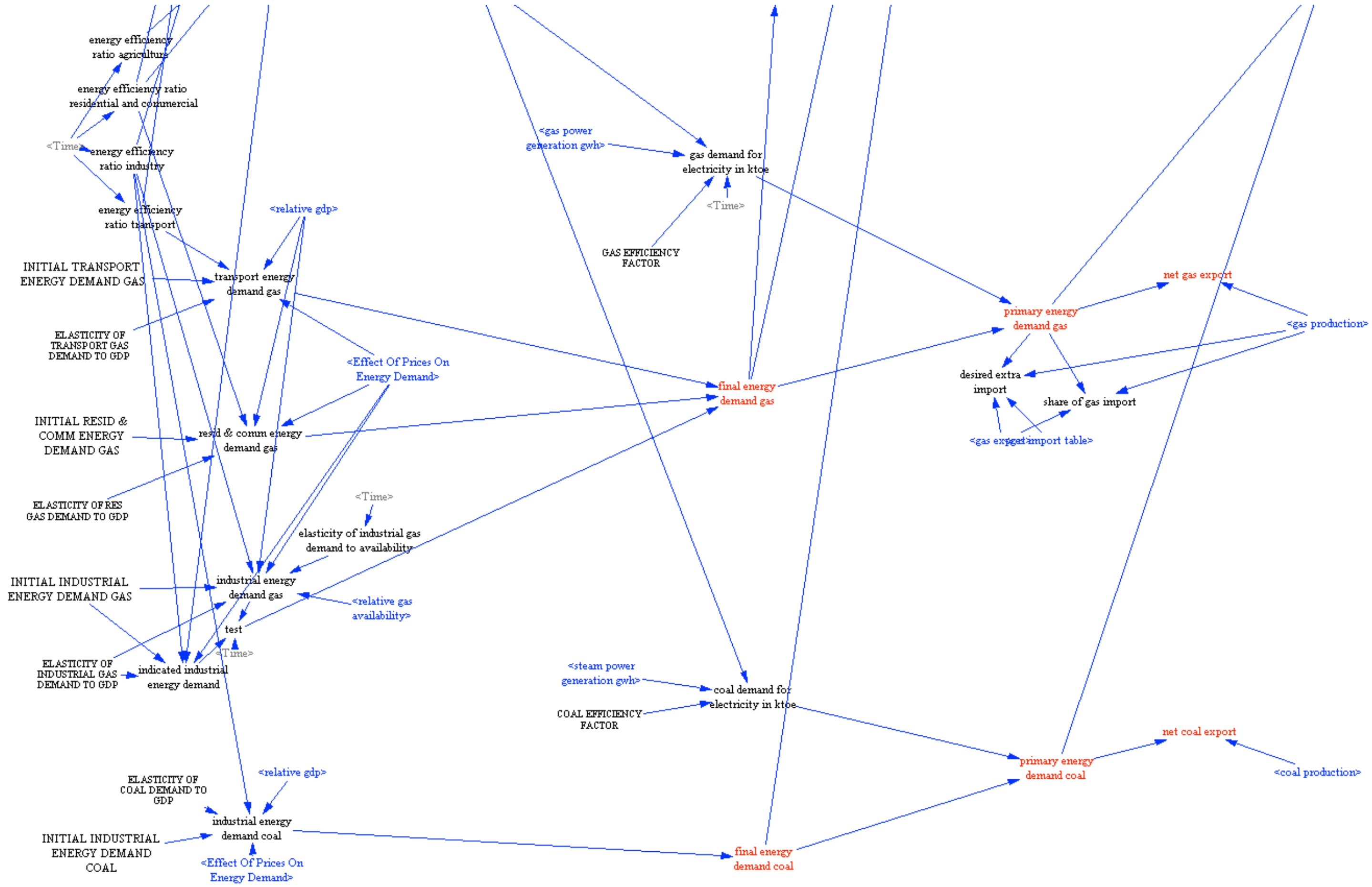


Figure 86: Sketch of the Energy Demand module

Purpose and Perspective

The Energy Demand module (**Figure 91**) represents the major drivers of medium-long term national energy demand of primary sources (electricity, oil, gas and coal) in all energy consuming sectors (agriculture, industry, commercial, residential and transport). Based on these flows, total primary energy consumption and fossil fuel consumption are estimates. The net export of each energy source is calculated in this module.

Explanation

Major Assumptions

- The energy demand of primary sources includes electricity, oil, gas and coal;
- Final demand for each energy source depends on the demand in end-sectors (agriculture, industry, commercial, residential and transport);
- The drivers for energy demand include GDP, energy prices and availability, and efficiency, while electricity demand is also limited by electricity network coverage;
- Primary energy demand covers final energy demand in end-sectors and fuel inputs in power generation;
- Demand for fossil fuels for the generation of electricity depends on fossil fuel-specific technology and prices.

Table 117: Input variables: Energy Demand module

Variable Name	Module of Origin
Effect of prices on energy demand	Energy Prices
Real GDP at market prices	Aggregate production and income
Relative population	Population
Oil power generation GWh	Energy Supply
Steam power generation GWh	Energy Supply
Gas power generation GWh	Energy Supply
Steam power generation GWh	Energy Supply
Renewable generation ktoe	Energy Supply
Total electricity net generation ktoe	Energy Supply
Electricity transmission loss factor	Energy Supply
Renewable resources electricity production	Energy Supply
Relative gas availability	Fossil Fuels Production
Oil production	Fossil Fuels Production
Gas production	Fossil Fuels Production
Coal production	Fossil Fuels Production
Gas export	Fossil Fuels Production
Gas import table	Fossil Fuels Production

Table 118: Output variables: Energy Demand module

	Module of Destination		
Variable Name	**Same Sector**	**Other Environmental Sectors**	**Other Sectors**
Energy Intensity of GDP			MDGs
Primary energy demand gas	Energy Prices		Public Investment and Consumption
Final energy demand oil	Energy Prices		Public Investment and Consumption
Final energy demand electricity	Energy Supply, Energy Prices		
Net oil export	Energy Prices		
Net gas export	Energy Prices		
Net coal export	Energy Prices		
Net electricity export	Energy Prices		
Primary energy demand oil	Energy Prices		
Primary energy demand coal	Energy Prices		
Primary energy demand electricity	Energy Prices		
Total primary energy consumption	Energy Prices		
Final energy demand gas	Energy Prices		
Final energy demand coal	Energy Prices		

Table 119: Constants and table functions: Energy Demand module

Variable Name	Type of Variable	Source for Estimation
Coal efficiency factor	Constant	Data on conversion efficiency (IEA)
Elasticity of ag oil demand to GDP	Constant	Data on energy demand (National Energy Balance 2008, TNB)
Elasticity of coal demand to GDP	Constant	Data on energy demand (National Energy Balance 2008, TNB)
Elasticity of comm electricity demand to GDP	Constant	Data on energy demand (National Energy Balance 2008, TNB)
Elasticity of energy intensity to network coverage	Constant	Data on energy demand (National Energy Balance 2008, TNB)
Elasticity of ind electricity demand to GDP	Time Series	Data on energy demand (National Energy Balance 2008, TNB)
Elasticity of industrial gas	Time Series	Data on energy demand (National

demand to availability		Energy Balance 2008, TNB)
Elasticity of industrial gas demand to GDP	Time Series	Data on energy demand (National Energy Balance 2008, TNB)
Elasticity of industrial oil demand to GDP	Time Series	Data on energy demand (National Energy Balance 2008, TNB)
Elasticity of res & comm oil demand to population	Constant	Data on energy demand (National Energy Balance 2008, TNB)
Elasticity of res electricity demand to GDP	Constant	Data on energy demand (National Energy Balance 2008, TNB)
Elasticity of res gas demand to GDP	Constant	Data on energy demand (National Energy Balance 2008, TNB)
Elasticity of residential oil demand to GDP	Constant	Data on energy demand (National Energy Balance 2008, TNB)
Elasticity of transport gas demand to GDP	Constant	Data on energy demand (National Energy Balance 2008, TNB)
Elasticity of transport oil demand to GDP	Time Series	Data on energy demand (National Energy Balance 2008, TNB)
Elasticity of transport oil demand to population	Time Series	Data on energy demand (National Energy Balance 2008, TNB)
Electricity network coverage time series	Time Series	Data on electricity network coverage (National Energy Balance 2008, TNB)
Energy efficiency ratio agriculture	Time Series	Data on energy demand (National Energy Balance 2008, TNB)
Energy efficiency ratio industry	Time Series	Data on energy demand (National Energy Balance 2008, TNB)
Energy efficiency ratio residential and commercial	Time Series	Data on energy demand (National Energy Balance 2008, TNB)
Energy efficiency ratio transport	Time Series	Data on energy demand (National Energy Balance 2008, TNB)
Gas efficiency factor	Time Series	Data on conversion efficiency (IEA)
Initial agriculture energy demand oil	Constant	Data on energy demand (National Energy Balance 2008, TNB)
Initial commercial demand	Constant	Data on energy demand (National Energy Balance 2008, TNB)
Initial industrial energy demand	Constant	Data on energy demand (National Energy Balance 2008, TNB)
Initial industrial energy demand coal	Constant	Data on energy demand (National Energy Balance 2008, TNB)
Initial industrial energy demand gas	Constant	Data on energy demand (National Energy Balance 2008, TNB)
Initial industrial energy demand oil	Constant	Data on energy demand (National Energy Balance 2008, TNB)
Initial resid & comm energy	Constant	Data on energy demand (National

demand gas		Energy Balance 2008, TNB)
Initial resid & comm energy demand oil	Constant	Data on energy demand (National Energy Balance 2008, TNB)
Initial residential energy demand	Constant	Data on energy demand (National Energy Balance 2008, TNB)
Initial transport energy demand gas	Constant	Data on energy demand (National Energy Balance 2008, TNB)
Initial transport energy demand oil	Constant	Data on energy demand (National Energy Balance 2008, TNB)
Oil efficiency factor	Constant	Data on conversion efficiency (IEA)

Functional Explanation

The Energy Demand module calculates the final demand for primary sources (electricity, oil, gas and coal) by all end-sectors (agriculture, industry, commercial, residential and transport). By summing up the sectoral flows, final and primary energy demand for each energy source and in total are estimated. The net export of each energy source is also obtained in this module.

Primary energy demand

Total primary energy demand is calculated as the sum of primary energy consumption for fossil fuels (oil, gas, coal) and for electricity:

total primary energy consumption = total fossil fuel consumption + primary energy demand electricity

total fossil fuel consumption = primary energy demand coal +primary energy demand gas +primary energy demand oil

The primary energy demand of each fossil fuel is equal to the total final energy demand and fuel inputs in power generation. The formulation of oil demand, as an example of fossil fuels, is:

primary energy demand oil = oil demand for electricity in ktoe + final energy demand oil

The amount of oil input in power generation is calculated as oil power generation (from the Energy Supply module) divided by an exogenous conversion factor and multiplied by an efficiency factor:

oil demand for electricity in ktoe = oil power generation GWh*GWH TO KTOE CONVERSION FACTOR/ OIL EFFICIENCY FACTOR

The primary energy demand for gas and coal are calculated according to the same logic.

On the other hand, primary energy demand for electricity is obtained as renewables used for power generation (from the Energy Supply module) minus net electricity export:

primary energy demand electricity = renewable generation ktoe - net electricity export

Final energy demand

The final energy demand for each energy source is obtained by summing up final demand for the a specific source in end-sectors (agriculture, industry, residential and commercial, and transport) and fuel inputs in power generation. The formulation of oil demand, as an example of fossil fuels, is:

final energy demand oil = agriculture energy demand oil + industrial energy demand oil + "resid & comm energy demand oil" + transport energy demand oil

The final energy demand of end-sectors in the equation above is a function of the initial demand, relative population, relative GDP, energy efficiency, and the effect of energy prices. For instance, the final oil demand by transport sector is calculated as:

transport energy demand oil = INITIAL TRANSPORT ENERGY DEMAND OIL* relative GDP^ELASTICITY OF TRANSPORT OIL DEMAND TO GDP(Time) *relative population ^ELASTICITY OF TRANSPORT OIL DEMAND TO POPULATION *Effect Of Prices On Energy Demand[OIL] /energy efficiency ratio transport

All flows of (sectoral and total) final energy demand for fossil fuels are calculated following the same approach, and can be understood by analogy.

In terms of electricity, final energy demand for electricity is not only affected by the demand of each end-sector, but is also constrained by the coverage of electricity network.

final energy demand electricity = (industrial energy demand electricity + residential energy demand electricity +commercial energy demand electricity) *effect of network coverage on energy intensity /energy efficiency ratio residential and commercial

While the formulation of sectoral final energy demand for electricity is the same as for fossil fuels explained above, the impact of electricity network coverage is calculated as:

effect of network coverage on energy intensity = relative electricity network coverage ^ELASTICITY OF ENERGY INTENSITY TO NETWORK COVERAGE

Net energy export

Then the next export of each energy source is estimated in this module.

Net export of fossil fuels is equal to the difference between production and primary energy demand. The import share of each fuel is also calculated as the positive value of ratio between import (difference between primary energy demand and production) and demand:

share of oil import = MAX(0, (primary energy demand oil-oil production)/primary energy demand oil)

For electricity, net export is calculated as total electricity net generation minus final energy demand for electricity and electricity transmission loss (determined as a share of net generation):

net electricity export = total electricity net generation ktoe - final energy demand electricity - electricity transmission loss

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35. Energy Supply module

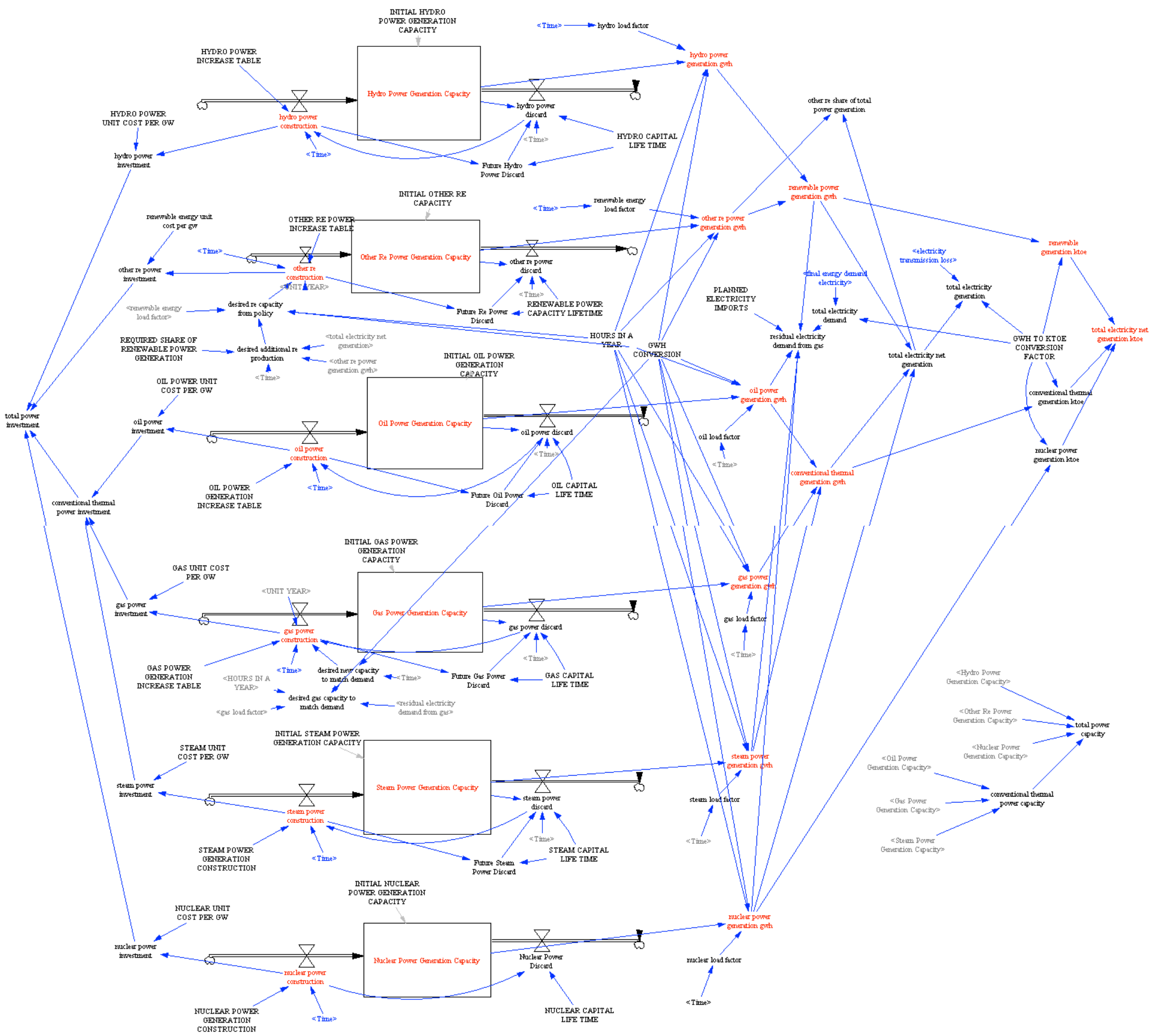

Figure 87: Sketch of the Energy Supply module

Purpose and Perspective

The purpose of the Energy Supply module (**Figure 92**) is to represent the capacity and generation from primary energy sources, including renewables (hydro and other renewables), nuclear and conventional thermal (i.e. fossil fuels oil, gas, coal). The model assumes that electricity generation from each source depends on both plant generation capacity and a load factor. Plant generation capacity is primarily driven by investment.

The production of fossil fuels is represented in the Fossil Fuels Production module.

Explanation

Major Assumptions

- The main energy sources for power generation in Malaysia include renewables (hydro and other renewables), nuclear and fossil fuels (oil, gas, coal);
- The residual demand for electricity that cannot be supplied by other energy sources or imports are provided by gas power plants.

Table 120: Input variables: Energy Supply module

Variable Name	Module of Origin
Final energy demand electricity	Energy Demand

Table 121: Output variables: Energy Supply module

	Module of Destination		
Variable Name	**In the Same Sector**	**In Other Environmental Sectors**	**In Other Sectors**
Electricity transmission loss factor	Energy Demand		
Renewable resources electricity production	Energy Demand		
Hydro power construction	Power employment		
Hydro Power Generation Capacity	Power employment		
Steam power generation GWh	Electricity Generation Cost	Energy Demand	
Oil power generation GWh	Electricity Generation Cost	Energy Demand	
Gas power generation GWh	Electricity Generation Cost	Energy Demand	
Nuclear generation GWh	Electricity		

	Generation Cost		
Other RE power generation GWh	Electricity Generation Cost	Energy Demand	
Hydro power generation GWh	Electricity Generation Cost	Energy Demand	
Total electricity net generation	Electricity Generation Cost	Energy Demand	
Primary energy demand oil	Primary energy demand oil		
Primary energy demand gas	Primary energy demand gas		
Primary energy demand coal	Primary energy demand coal		

Table 122: Constants and table functions: Energy Supply module

Variable Name	**Type of Variable**	**Source for Estimation**
Nuclear Production Capacity	Constant	Data on nuclear production (EIA)
Hydropower Generation	Time series	Data on hydroelectric production (EIA)
Hydro Power Generation	Constant	Data on hydro power production (EIA)

Functional Explanation

The Power Supply module illustrates the electricity production from five primary energy sources, namely hydro, other renewables, nuclear, oil, gas and coal. The structure of hydropower generation (the top part of sketch in **Figure 92**) is shown in **Figure 93** below, as an example. The structures of power generation from other sources are very similar and can be understood by analogy.

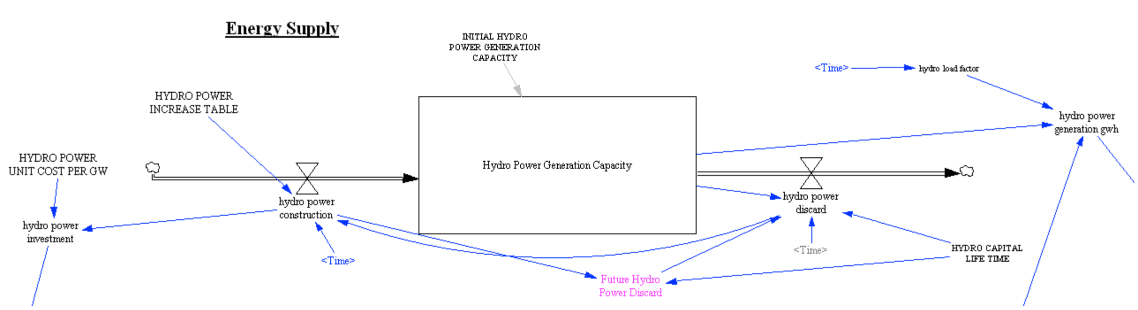

Figure 88: Hydro power generation and capacity

Generation capacity

Power generation capacity is stock that accumulates annual plant construction flow and is decreased by plant discards. Take hydro power as an example, the *Hydro Power Generation Capacity* is calculated as:

> Hydro Power Generation Capacity = INTEG (hydro power construction-hydro power discard, INITIAL HYDRO POWER GENERATION CAPACITY)

The discard of power plants per annum depends on the capacity and the plant lifetime:

> Hydro discard = IF THEN ELSE(Time<2011, Hydro Power Generation Capacity /HYDRO CAPITAL LIFE TIME, Future Hydro Power Discard)

The total power generation capacity is calculated as the sum of capacity of all sources.

Generation Construction and Investment

The construction of hydro power plants is exogenously determined before 2028, and after 2028 it is added by the amount of discard so that the net increase in capacity per annum matches the exogenous *HYDRO POWER INCREASE TABLE*.

> Hydro construction = IF THEN ELSE(Time<2028, HYDRO POWER INCREASE TABLE(Time), HYDRO POWER INCREASE TABLE(Time)+hydro power discard)

Power investment is then calculated as the positive value of annul construction in GW and the unit cost per GW of plant construction:

> hydro power investment = MAX(0, hydro power construction*HYDRO POWER UNIT COST PER GW)

In the case of non-hydro renewable energy, an additional amount of construction per year (*desired re capacity from policy*) is included to take into account the policy target of increasing power generation from renewables:

> other re construction = OTHER RE POWER INCREASE TABLE(Time)+desired re capacity from policy

> desired re capacity from policy = (desired additional re production/renewable energy load factor/HOURS IN A YEAR)

The desired additional amount of renewable production is calculated as the difference between the target power generation from renewable (determined as total electricity generation times the exogenous target share of renewable) and the actual current generation if positive. It is 0 when the target is met:

> desired additional re production = MAX(0, (REQUIRED SHARE OF RENEWABLE POWER GENERATION(Time)*total electricity net generation)-other re power generation GWh)

Note that according to the assumption described earlier (in Major Assumptions part), gas power plants are responsible for all the residual electricity demand that cannot be supplied by other energy sources or imports. The additional construction to meet the total demand (*desired new capacity to match demand*) is calculated as the difference between desired capacity to meet the residual demand and the existing capacity:

desired new capacity to match demand = IF THEN ELSE (Time<2013, 0, desired gas capacity to match demand-Gas Power Generation Capacity)

desired gas capacity to match demand = residual electricity demand from gas/gas load factor/HOURS IN A YEAR

And the residual demand from gas is calculated as total (final) electricity demand minus imports and generation from all other sources:

residual electricity demand from gas = (total electricity demand-PLANNED ELECTRICITY IMPORTS)-nuclear power generation GWh-oil power generation GWh-renewable power generation GWh-steam power generation GWh

Electricity generation

The amount of power generation depends on the generating capacity and an a load factor:

Hydro power generation GWh = (Hydro Power Generation Capacity*hydro load factor)*HOURS IN A YEAR

Finally, the flows of power generation by energy source are summed up to obtain the renewable power generation, conventional thermal generation, *total electricity net generation* (sum of renewable, nuclear and conventional thermal), and *total electricity generation*.

total electricity net generation = conventional thermal generation GWh +renewable power generation GWh +nuclear power generation GWh

total electricity net generation +electricity transmission loss/GWH TO KTOE CONVERSION FACTOR

References

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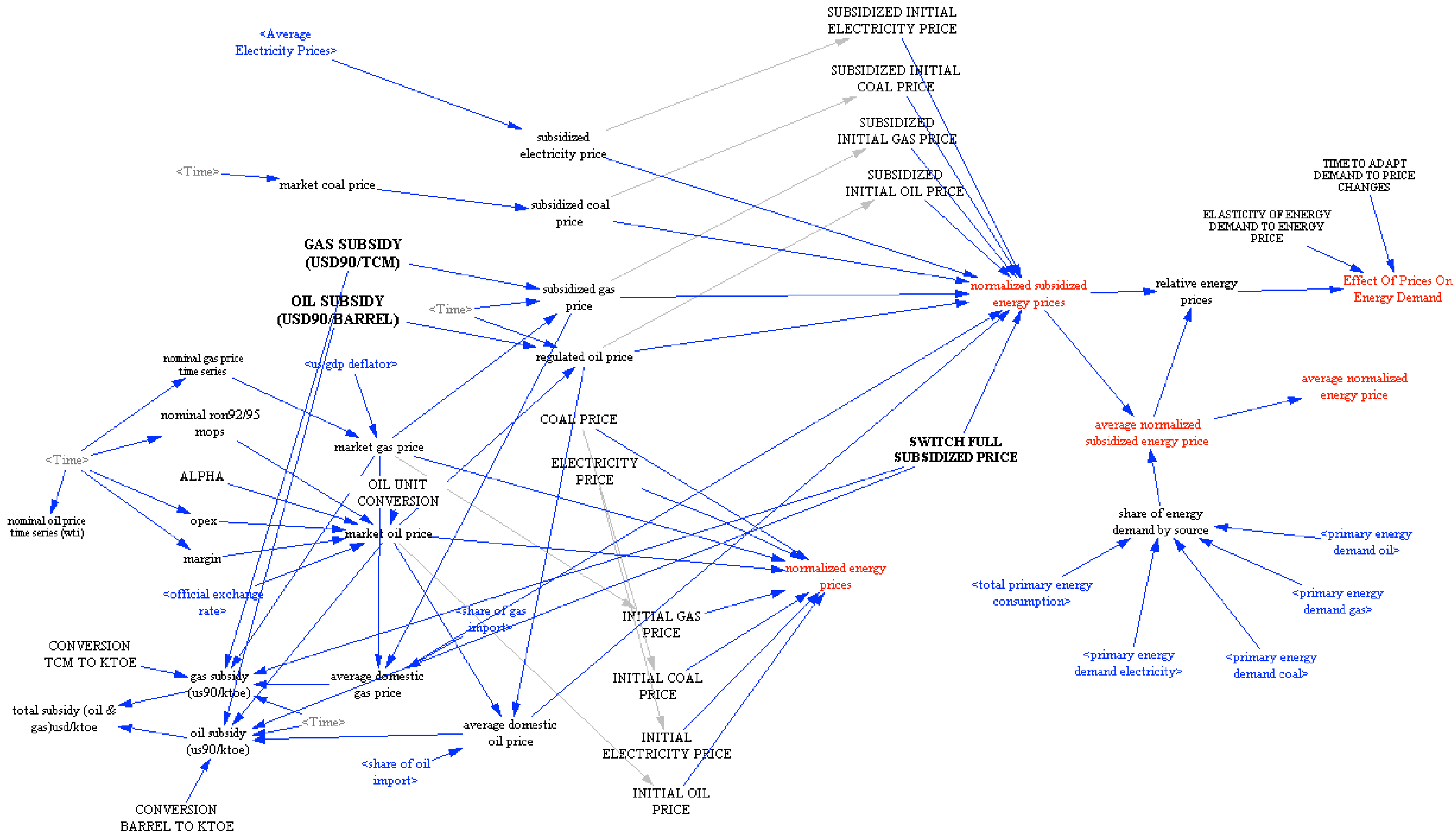
36. Energy Prices module



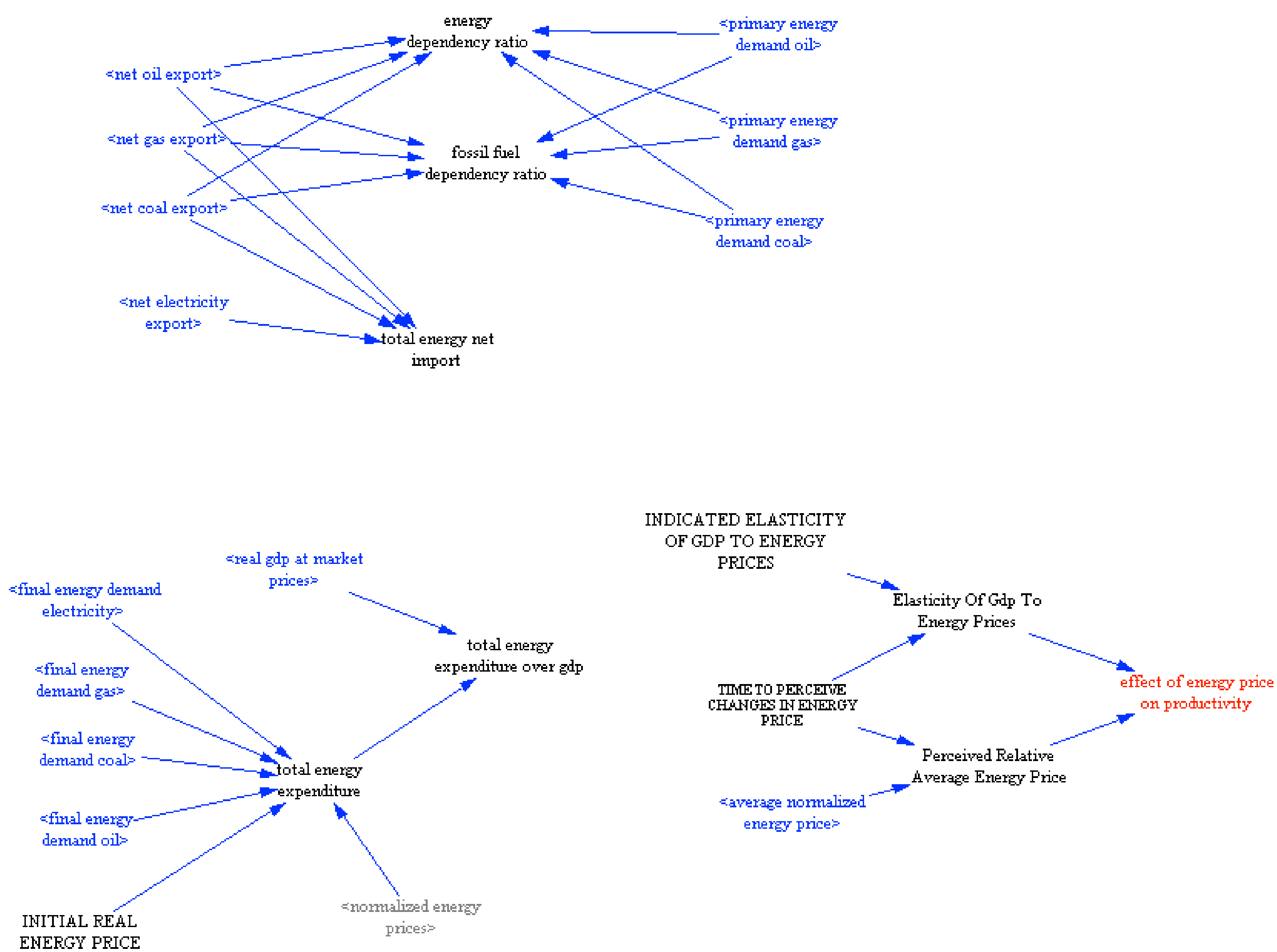


Figure 89: Sketch of the Energy Prices module

Purpose and Perspective

The Energy Prices module calculates prices of primary energy sources (oil, gas, coal, electricity), taking into consideration market prices (driven by the world market) and domestic subsidies on oil and gas. On top of consumption (from Energy Demand module) and the prices, the energy expenditures is estimated. Other key indicators calculated in this module include energy dependency ratio and the effect of energy prices on productivity and on energy demand.

Explanation

Major Assumptions

- The weight attributed to each energy source in the formulation of the average energy price is equal to its market share.

Table 123: Input variables: Energy Prices module

Variable Name	Module of Origin
Net oil export	Energy demand
Net gas export	Energy demand
Net coal export	Energy demand
Net electricity export	Energy demand
Primary energy demand oil	Energy demand
Primary energy demand gas	Energy demand
Primary energy demand coal	Energy demand
Primary energy demand electricity	Energy demand
Total primary energy consumption	Energy demand
Final energy demand oil	Energy demand
Final energy demand gas	Energy demand
Final energy demand coal	Energy demand
Final energy demand electricity	Energy demand
Official exchange rate	Aggregate Production and Income

Table 124: Output variables: Energy Prices module

	Module of Destination		
Variable Name	**In the Same Sector**	**In Other Environmental Sectors**	**In Other Sectors**
Primary energy demand gas			Public Investment and Consumption
Final energy demand oil			Public Investment and Consumption
Normalized energy prices		Fossil Fuels Production	
Perceived relative average energy price			International Trade
Gas subsidy (US90/ktoe)			Government Revenue
Effect of prices on energy demand		Energy Demand	

Table 125: Constants and table functions: Energy Prices module

Variable Name	Type of Variable	Source for Estimation
Nominal gas price time series	Time Series	Petronas
Market coal price	Time Series	Petronas
Nominal RON92/95 MOPS	Time Series	Petronas
Alpha	Constant	Petronas
Opex	Time Series	Petronas
Margin	Time Series	Petronas
Conversion tcm to ktoe	Constant	EIA
Conversion barrel to ktoe	Constant	EIA
Gas subsidy (USD90/tcm)	Time Series	Petronas
Oil subsidy (USD90/barrel)	Time Series	Petronas
Time to adapt demand to price changes	Constant	Data on energy prices and demand (Petronas, EIA)
Elasticity of energy demand to energy price	Constant	Data on energy prices and demand (Petronas, EIA)
Indicated elasticity of GDP to energy prices	Constant	Data on energy prices (Petronas) and GDP (Malaysian Economy in Figures 2011)
Initial real energy price	Constant	Petronas

Energy prices

First the energy prices directly after being subsidized are calculated. For oil and gas which are subsidized, it is obtained as the difference between market price and unit subsidy (both exogenously determined), while the coal energy price is equal to market price. The electricity price is calculated in the Electricity generation cost module.

subsidized gas price = market gas price-"GAS SUBSIDY (USD90/TCM)"(Time)

regulated oil price = market oil price-"OIL SUBSIDY (USD90/BARREL)"(Time)

Then for oil and gas, we calculate average domestic energy prices, as the weighted average of the price of domestically produced (and consumed) and imported energy. The formulation of gas price, for example, is:

average domestic gas price = (market gas price*share of gas import)+(subsidized gas price*(1-share of gas import))

Then average amount of gas and oil subsidy per unit of energy is calculated. In the case that both domestically produced and imported energy are subsidized (controlled by setting *SWITCH FULL SUBSIDIZED PRICE* to 1), the average subsidy is equal to the exogenous unit subsidy (represented by *GAS SUBSIDY (USD90/TCM)*); otherwise if imported energy is not subsidized (*SWITCH FULL SUBSIDIZED PRICE* set to 0), it is equal to the difference between market price and average domestic price obtained above:

gas subsidy (us90/ktoe) = IF THEN ELSE(SWITCH FULL SUBSIDIZED PRICE=1, CONVERSION TCM TO KTOE*"GAS SUBSIDY (USD90/TCM)"(Time), CONVERSION TCM TO KTOE*(market gas price-average domestic gas price))

Average oil price and subsidy are calculated similarly.
The market energy prices are compared to their initial levels to obtain the *normalized energy prices* for each source, which will affect energy expenditure and discovery of fossil fuels (in Fossil Fuels Production module).

Furthermore, the normalized subsidized energy price of each source is computed. For electricity and coal, this is equal to the ratio between current and initial subsidized prices.

normalized subsidized energy prices[ELE] = subsidized electricity price/SUBSIDIZED INITIAL ELECTRICITY PRICE

For oil and gas, on the other hand, when both domestically produced and imported energy are subsidized (*SWITCH FULL SUBSIDIZED PRICE* set to 1), the normalized subsidized energy prices is equal to the ratio between subsidized prices calculated above and its initial value; otherwise if imported energy is not subsidized (*SWITCH FULL SUBSIDIZED PRICE* set to 0), the average domestic prices are compared to the initial value:

normalized subsidized energy prices[GAS] = IF THEN ELSE(SWITCH FULL SUBSIDIZED PRICE=1, subsidized gas price/SUBSIDIZED INITIAL GAS PRICE,average domestic gas price/SUBSIDIZED INITIAL GAS PRICE)

Then we calculate the (weighted) *average normalized subsidized energy price*, as normalized subsidized price times the market share, summed among all energy sources:

average normalized subsidized energy price = SUM(normalized subsidized energy prices[energy type!]*share of energy demand by source[energy type!])

The *normalized subsidized energy price* for each energy source is compared to the *average normalized subsidized energy price* to get the *relative energy prices* for each source. This is used as a driver for energy demand:

average normalized subsidized energy price = SUM(normalized subsidized energy prices[energy type!]*share of energy demand by source[energy type!])

Energy expenditure

The energy expenditure for a specific energy source is equal to the amount of final consumption multiplied by normalized energy price (calculated above) and the initial price. The values of each energy source are summed together:

total energy expenditure = (final energy demand electricity *INITIAL REAL ENERGY PRICE[ELE]*normalized energy prices[ELE] +final energy demand oil*INITIAL REAL ENERGY PRICE[OIL]*normalized energy prices[OIL] +final energy demand gas*INITIAL REAL ENERGY PRICE[GAS]*normalized energy prices[GAS] +final energy demand coal*INITIAL REAL ENERGY PRICE[COAL]*normalized energy prices[COAL])*1000

Other indicators

The energy dependency ratio (overall and for each source) are computed in this module as total fossil fuel net exports over primary demand, and they are no larger than 1. The overall energy dependency ratio, for example, as calculated as:

energy dependency ratio = MIN(1, (net coal export+net gas export+net oil export) /(primary energy demand coal+primary energy demand gas+primary energy demand oil))

The formulation for specific energy sources follow the same logic.
The effect of energy price on productivity is also calculated in the module as:

effect of energy price on productivity = Perceived Relative Average Energy Price ^Elasticity Of Gdp To Energy Prices

Perceived Relative Average Energy Price = SMOOTH N(average normalized energy price, TIME TO PERCEIVE CHANGES IN ENERGY PRICE , 1 , 1)

The SMOOTH N function is used in the equation above to represent the time lag between price change and its effect on productivity.

37. Power Supply Employment module

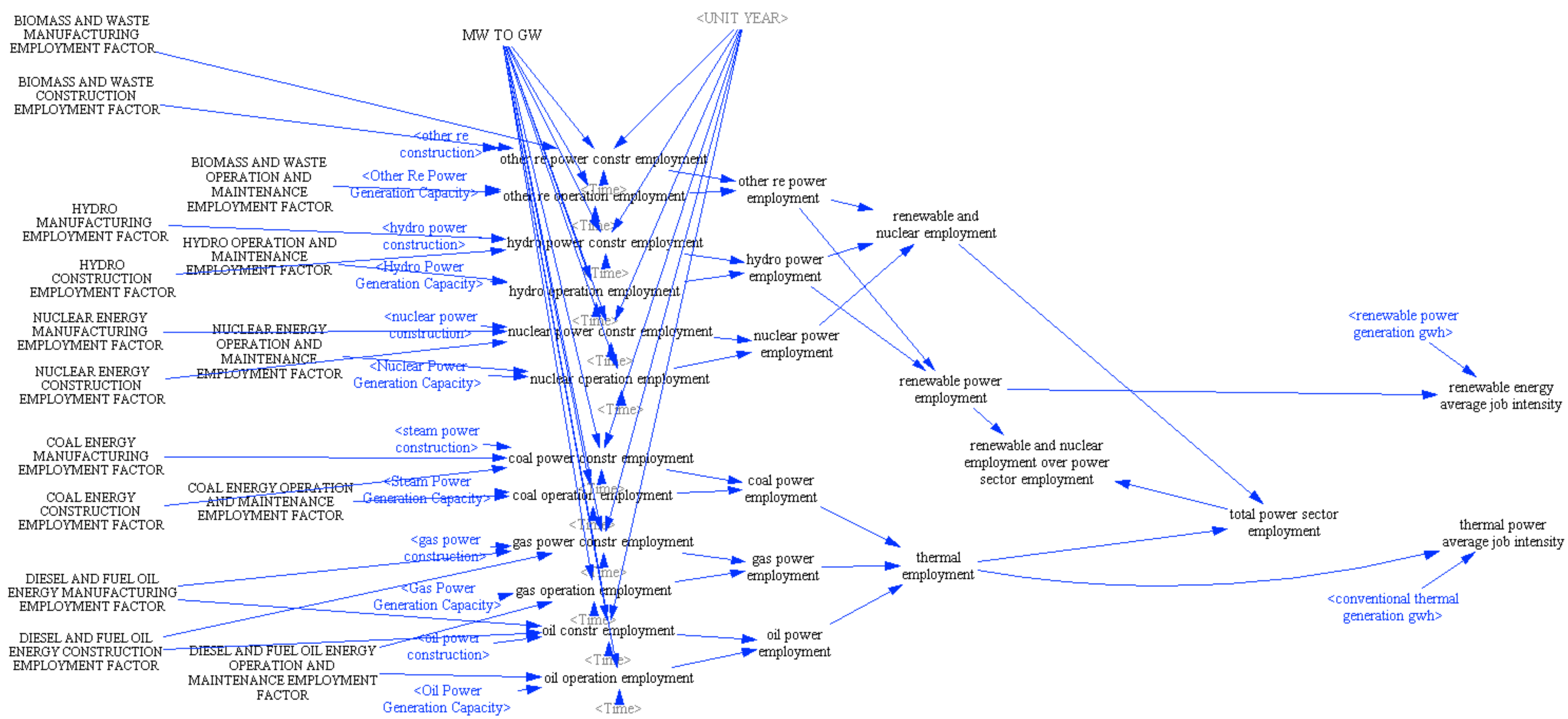


Figure 90: Sketch of the Power Supply Employment module

Purpose and Perspective

The Power Supply Employment module represents the accounting of power sector employment, as is depicted in **Figure 95**. The employment estimation for all energy sources in the Energy Supply module, namely renewables (hydro and other renewables), nuclear, and conventional thermal energy (coal, gas and oil) has similar model structure.
For each energy source, power supply employment consists of both construction and O&M (operation and maintenance) employment, depending on plant construction and capacity respectively.

The total (along with renewable and nuclear, and thermal) power supply employment is calculated as the sum of all items.

Explanation

Major Assumptions

- For each energy source of power generation, employment are created in power plant construction and manufacturing, and O&M (operation and maintenance)
- While power construction and manufacturing employment depends on the amount of construction, O&M employment is a function of the capacity.

Table 126: Input variables: Power Supply Employment module

Variable Name	Module of Origin
Hydro power construction	Energy Supply
Hydro Power Generation Capacity	Energy Supply

Table 127: Output variables: Power Supply Employment module

	Destination Module		
Variable Name	Same Sector	Other Social Sectors	Other Sectors

Table 128: Constants and table functions: Power Supply Employment module

Variable Name	Type of Variable	Source for Estimation
Hydro manufacturing employment factor	Time series	TNB, ILO, Kammen et al.
Hydro construction employment factor	Time series	TNB, ILO, Kammen et al.
Hydro operation and maintenance employment factor	Time series	TNB, ILO, Kammen et al.

Note that the variables related to hydropower employment are listed in the tables above. Those related to power generation employment from the others energy sources can be understood by analogy.

Functional Explanation

The model calculates the employment levels of the power supply from the major types of renewables (hydro and other renewables), nuclear, and conventional thermal (coal, gas and oil) power plants.

For power plants of each energy type, employment is generated in both their construction and manufacturing process, and in the operation and maintenance.

As power employment of all energy sources are calculated according to the same logic, we take the hydropower for illustration (see **Figure 96**). The others can be calculated by analogy.

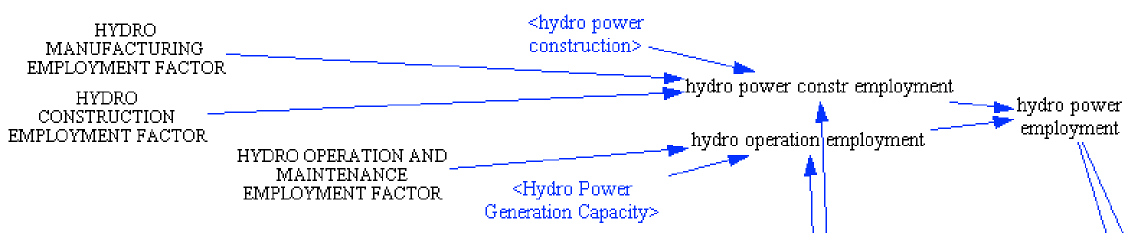


Figure 91: Structure of the Hydropower Supply Employment

The employment level in construction and manufacturing of hydro power plants depends on the yearly construction of new plants (calculated in the Energy Supply module) and *hydro construction employment factor* and *hydro manufacturing employment factor):*

hydro power constr employment = hydro power construction*(HYDRO CONSTRUCTION EMPLOYMENT FACTOR(Time) +HYDRO MANUFACTURING EMPLOYMENT FACTOR(Time))*1000

Note that the item of times 1000 is the equation above is for the purpose of unit conversion: hydro power construction is measured in GWh per year, while the employment factors are in person per MWh of electricity generated. This is the same for operations employment below.

On the other hand, as both existing and newly built power plants require operations and maintenance jobs, the employment level is based on the cumulative capacity, multiplied by the employment factors, as follows:

hydro operation employment = Hydro Power Generation Capacity*HYDRO OPERATION AND MAINTENANCE EMPLOYMENT FACTOR(Time)*1000

Hence, hydro power employment is:

hydro power employment = hydro operation employment + hydro power constr employment

The calculation is the same for other sources.

The renewable and nuclear employment, and thermal power employment are calculated by totalling the corresponding employment items. The sum of the two determines total power sector employment:

total power sector employment = renewable and nuclear employment +thermal employment

38. Electricity Generation Cost module

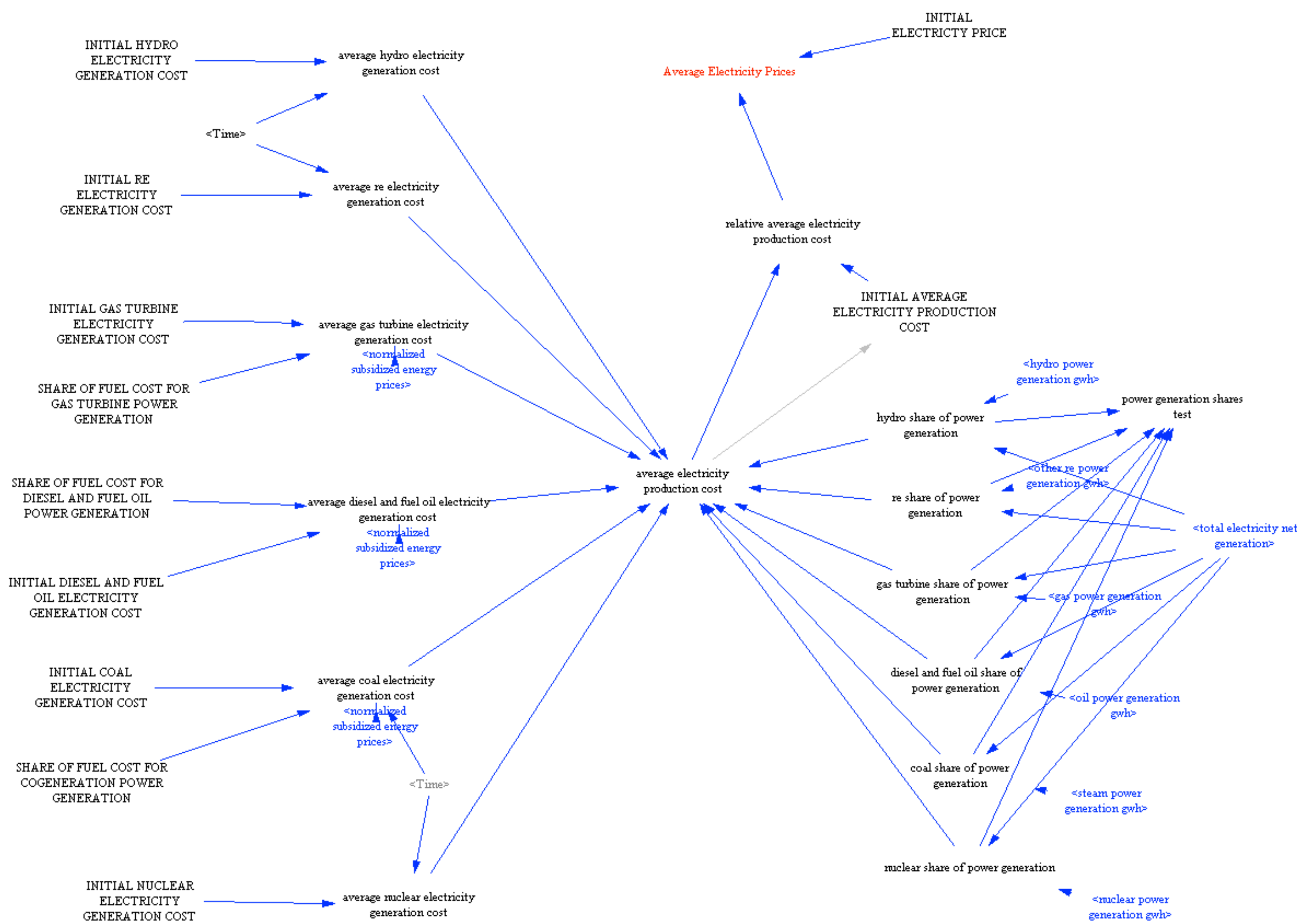


Figure 92: Sketch of the Electricity Generation Cost module

Purpose and Perspective

The purpose of the Electricity Generation Cost module is to calculate electricity production cost. The main approach used is to average the power generation cost of each energy type, weighted by its share of power generation. While the power generation costs of renewables and nuclear are exogenously determined, gas, oil and coal power generation costs are affected by their respective energy prices obtained in the Energy Prices module.

Explanation

Major Assumptions

- Electricity production cost is equal to the weighted average cost of all power generation sources;
- Gas, oil and coal power generation costs are affected by the respective energy prices, while the cost for renewables and nuclear are exogenously determined.

Table 129: Input variables: Electricity Generation Cost module

Variable Name	Module of Origin
Steam power generation GWh	Energy Supply
Oil power generation GWh	Energy Supply
Gas power generation GWh	Energy Supply
Nuclear generation GWh	Energy Supply
Other RE power generation GWh	Energy Supply
Hydro power generation GWh	Energy Supply
Total electricity net generation	Energy Supply

Table 130: Output variables: Electricity Generation Cost module

	Module of Destination		
Variable Name	**In the Same Sector**	**In Other Environmental Sectors**	**In Other Sectors**
Average Electricity Prices	Energy Prices		

Table 131: Constants and table functions: Electricity Generation Cost module

Variable Name	Type of Variable	Source for Estimation
Initial coal electricity generation cost	Constant	IEA
Initial diesel and fuel oil electricity generation cost	Constant	IEA
Initial gas turbine electricity generation cost	Constant	IEA
Initial RE electricity generation cost	Constant	IEA
Initial hydro electricity generation cost	Constant	IEA
Initial nuclear electricity generation cost	Constant	IEA
Share of fuel cost for diesel and fuel oil power generation	Constant	MI’s knowledge

Share of fuel cost for gas turbine power generation	Constant	MI's knowledge
Share of fuel over diesel oil for electricity generation	Constant	MI's knowledge

Functional Explanation

Electricity production cost

The average electricity production cost is calculated as the weighted average power generation cost of each energy type in power supply. Here, the share of power generation from each fuel type is equal to the amount of power generation from that fuel over total electricity generation.

> average electricity production cost = average diesel and fuel oil electricity generation cost*diesel and fuel oil share of power generation+average gas turbine electricity generation cost*gas turbine share of power generation+average hydro electricity generation cost*hydro share of power generation+average re electricity generation cost*re share of power generation+average coal electricity generation cost*coal share of power generation+average nuclear electricity generation cost*nuclear share of power generation

Among all sources of power production, the average generation costs of fossil fuel power plants are endogenously determined on the price of fuel inputs.
Take gas as an example of fossil fuel energy. Its average generation cost is non-linearly dependent on the coal price:

> average gas turbine electricity generation cost = INITIAL GAS TURBINE ELECTRICITY GENERATION COST*(normalized subsidized energy prices[GAS]^SHARE OF FUEL COST FOR GAS TURBINE POWER GENERATION)

The costs of coal and oil power generation are calculated similarly, as a function of the normalized subsidized prices of coal and oil respectively.

Finally, the value of average electricity prices is determined by the initial price and the delayed effect of changes in electricity production cost.

> Average Electricity Prices = DELAY N(INITIAL ELECTRICTY PRICE*relative average electricity production cost*1, 1, INITIAL ELECTRICTY PRICE*1, 1)

39. Fossil Fuels Production module

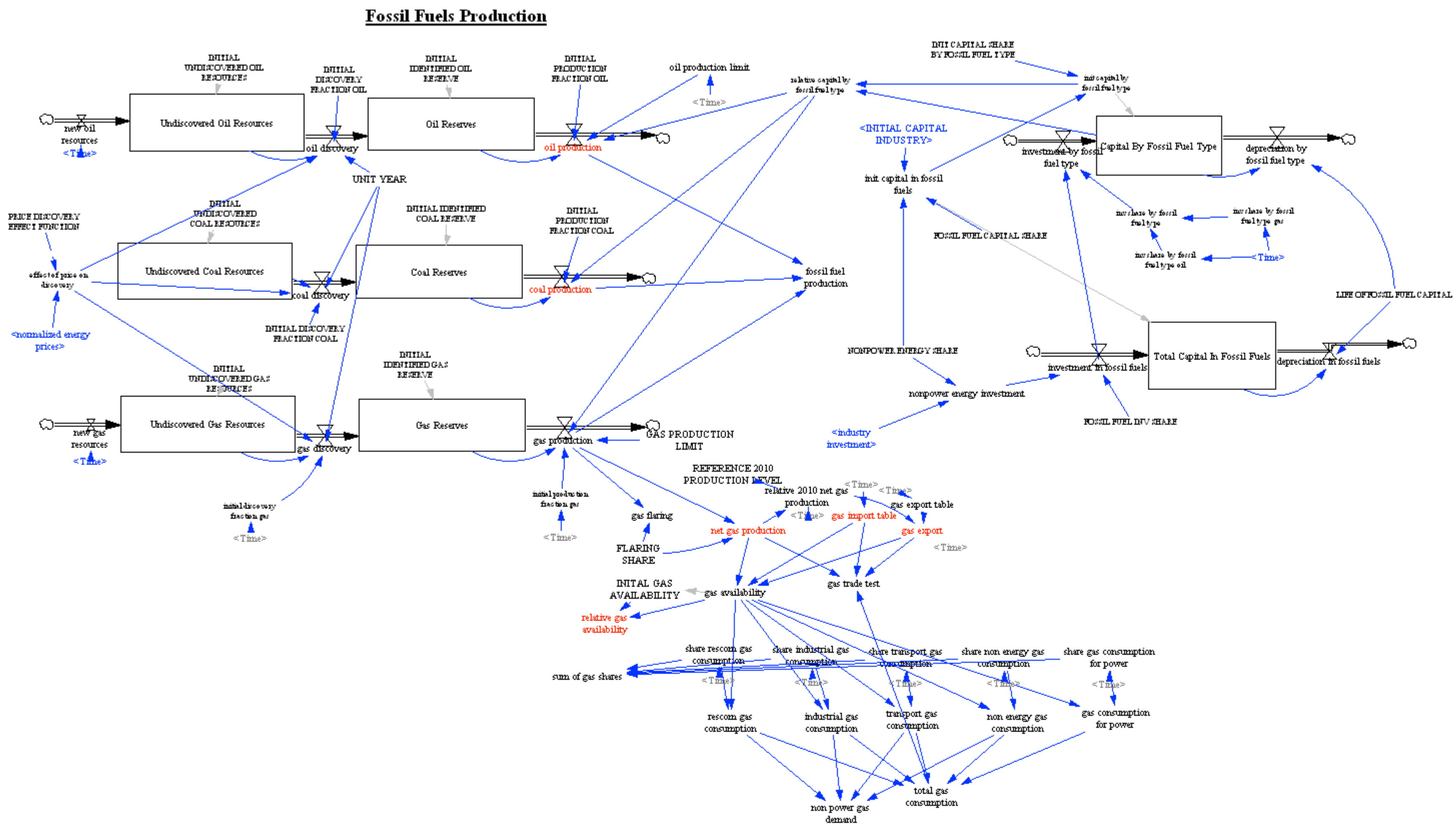


Figure 93: Sketch of the Fossil Fuels Production module

Purpose and Perspective

The purpose of the Fossil Fuels Production module (**Figure 98**) is to calculate oil, gas and coal production and to keep track of both national fossil fuel resources and reserves. The approach used for modeling fossil fuels is based upon the main groups of the McKelvey box (**Figure 100**): undiscovered resources and identified reserves. The structure of the module can be divided into two parts: (1) fossil fuel resources and production flows, in the left part of the sketch, and (2) capital inputs in fuels, in the right part of the sketch shown in **Figure 98**.

Explanation

Major Assumptions

- Fossil fuel resource is finite;
- Exploration and production, separately, determine the availability of recoverable resources for production;
- Fuel exploration activities are affected by energy prices;
- The production of each fuel is driven by the capital availability, and constrained by production limit.

Table 132: Input variables: Fossil Fuels Production module

Variable Name	Module of Origin
Normalized energy prices	Energy Prices
Initial capital industry	Industry
Industry investment	Investment

Table 133: Output variables: Fossil Fuels Production module

	Module of Destination		
Variable Name	**In the Same Sector**	**In Other Environmental Sectors**	**In Other Sectors**
Oil Production	Energy Demand		Government Revenue
Net gas production	Energy Demand		Government Revenue
Coal production	Energy Demand		
Relative gas availability	Energy Demand		
Gas export	Energy Demand		
Gas import table	Energy Demand		

Table 134: Constants and table functions: Fossil Fuels Production module

Variable Name	Type of	Source for Estimation

	Variable	
Initial Discovery Fraction Coal	Constant	Estimated based on resources and production
Initial Discovery Fraction Gas	Constant	Estimated based on resources and production
Initial Discovery Fraction Oil	Constant	Estimated based on resources and production
Initial Identified Coal Reserve	Constant	Estimated based on resources and production
Initial Identified Gas Reserve	Constant	Data on resources and production (PETRONAS)
Initial Identified Oil Reserve	Constant	Data on resources and production (PETRONAS)
Initial Production Fraction Coal	Constant	Estimated based on resources and production
Initial Production Fraction Gas	Constant	Estimated based on resources and production
Initial Production Fraction Oil	Constant	Estimated based on resources and production
Initial Undiscovered Coal Resources	Constant	Estimated based on resources and production
Initial Undiscovered Gas Resources	Constant	Estimated based on resources and production
Initial Undiscovered Oil Resources	Constant	Estimated based on resources and production
Fossil fuel capital share	Constant	Estimated based on resources and production
Nonpower energy share	Constant	Estimated based on resources and production
Fossil fuel inv share	Constant	Estimated based on resources and production
Life of fossil fuel capital	Constant	Estimated based on resources and production
Inv share by fossil fuel type gas	Time Series	Estimated based on resources and production

Functional Explanation

The discovery and production of fossil fuels (oil, gas, and coal) are modeled using the structure illustrated in **Figure 98**. Since the production of fossil fuels is identical for oil, gas, and coal, only oil production is explained in the following paragraphs (see **Figure 99**). Note that all fossil fuel stocks are measured by ktoe, and flows by ktoe per year.

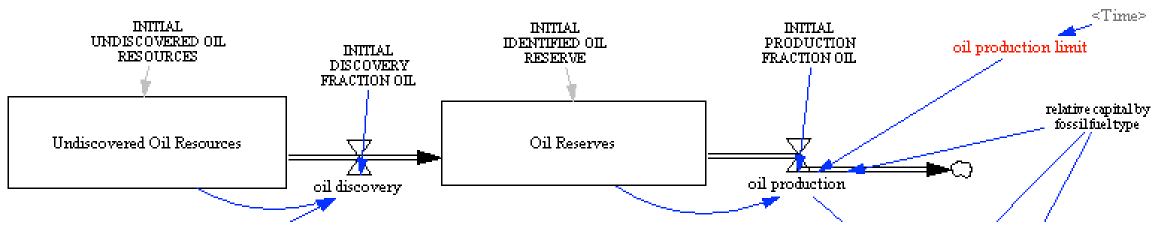


Figure 94: Structure of the Energy Supply Model for Fossil Fuels

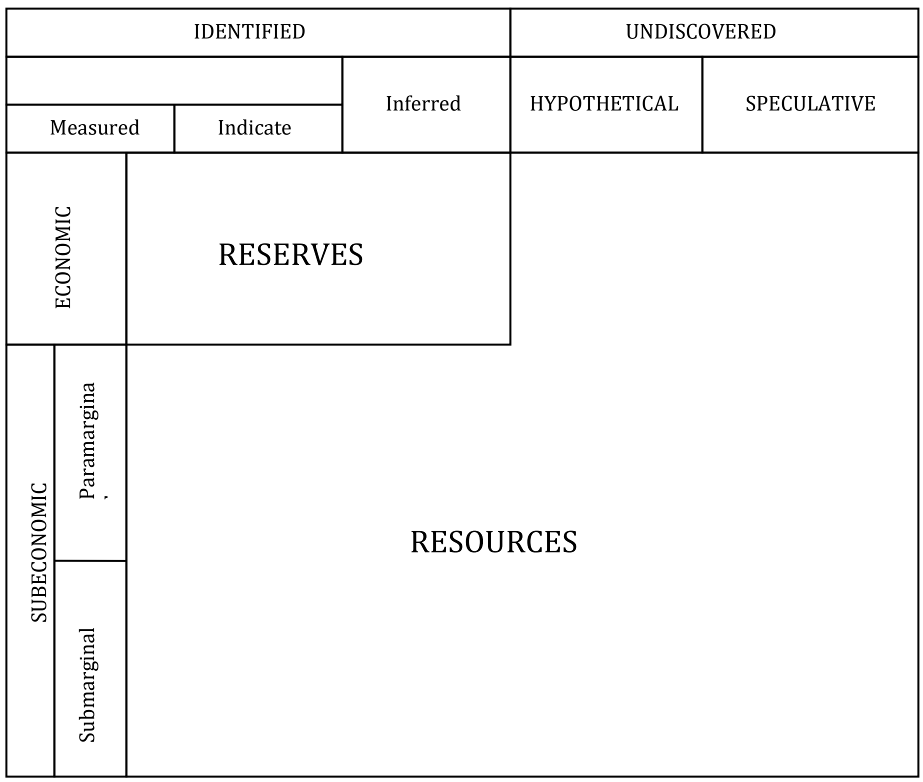


Figure 95: The McKelvey box Defining Terms Used by Resource Geologists and Economists

Geologists and economists categorize both fuel and non-fuel as illustrated in Figure 100: The McKelvey box Defining Terms Used by Resource Geologists and Economists
. In this figure, economic feasibility increases from bottom to top, and geologic assurances increase from left to right. Resources can be economic or sub economic, identified or undiscovered. Reserves are the part of resources that are both economic and identified.

What counts as reserves changes with exploration (i.e. discovery) and production (i.e. recovery). Exploration activities shift the line between identified and undiscovered resources. Recovery activities shift the line between economic and sub economic. Discovery reduces resources, while production reduces reserves and adds to cumulative production. Both technology and price determines the effectiveness of exploration and recovery activities.

In the T21-Malaysia model, we represent the impact of energy prices on exploration and production activities (and their impact on resources and reserves), and the impact of technology on production is represented through capital stock.

Fossil fuel discovery

Exploration leads to discoveries, which gradually reduce the stock of undiscovered resources. The identified oil reserves is increased through discovery and decreased by production.

The annual discovery is equal to *undiscovered resource* multiplied by *initial discovery fraction* and the *effect of energy price on discovery*, and is further limited by the total amount of *undiscovered resources*. As the structure of the three fossil fuels are very similar, only the formulations for oil is presented here as an example:

> oil discovery= MIN(Undiscovered Oil Resources, INITIAL DISCOVERY FRACTION OIL*Undiscovered Oil Resources*effect of price on discovery)

The effect of energy price on discovery rate is calculated as a non-linear function (*price discovery effect function*) of the *normalized* (market) *energy prices* (obtained in the Energy Prices module), assuming that the increase in energy price would stimulate discovery activities yet at a declining rate.

Fossil Fuels Production and Capital

Following the rationale explained above, the production rate is equal to *identified reserve* multiplied by *initial production fraction* and *relative capital by fossil fuel type*, and is further constrained by an exogenously determined *production limit*:

> oil production= MIN(Oil Reserves*relative capital by fossil fuel type[OIL]*INITIAL PRODUCTION FRACTION OIL, oil production limit)

Here the relative capital by fossil fuel type[OIL] is simply the ratio between current and initial capital levels of oil production. The capital level of Fossil Fuels Production is represented by the stock variable *Capital By Fossil Fuel Type*. For each specific fossil fuel type (oil, gas, coal), its capital stock is accumulated by annual investment (*investment in fossil fuels*) and decreased by depreciation. While the latter is calculated as the capital stock divided by capital lifetime, the flow of investment is determined as total *investment in fossil fuels* times the share allocated to the fuel (estimated from their production shares, represented by *inv share by fossil fuel type*). The total *investment in fossil fuels* is further calculated as a share of investment in industry sector.

Note that in terms of gas production, we calculate in this module *net gas production*, i.e., the amount of gas production that is not used for flaring, based on an exogenous flaring share.

net gas production = gas production*(1-FLARING SHARE)

Total *Fossil Fuels Production* is equal to the sum of oil, gas and coal production.

Fossil Fuels Production = gas production +oil production +coal production

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40. Fossil Fuel GHG Emissions module

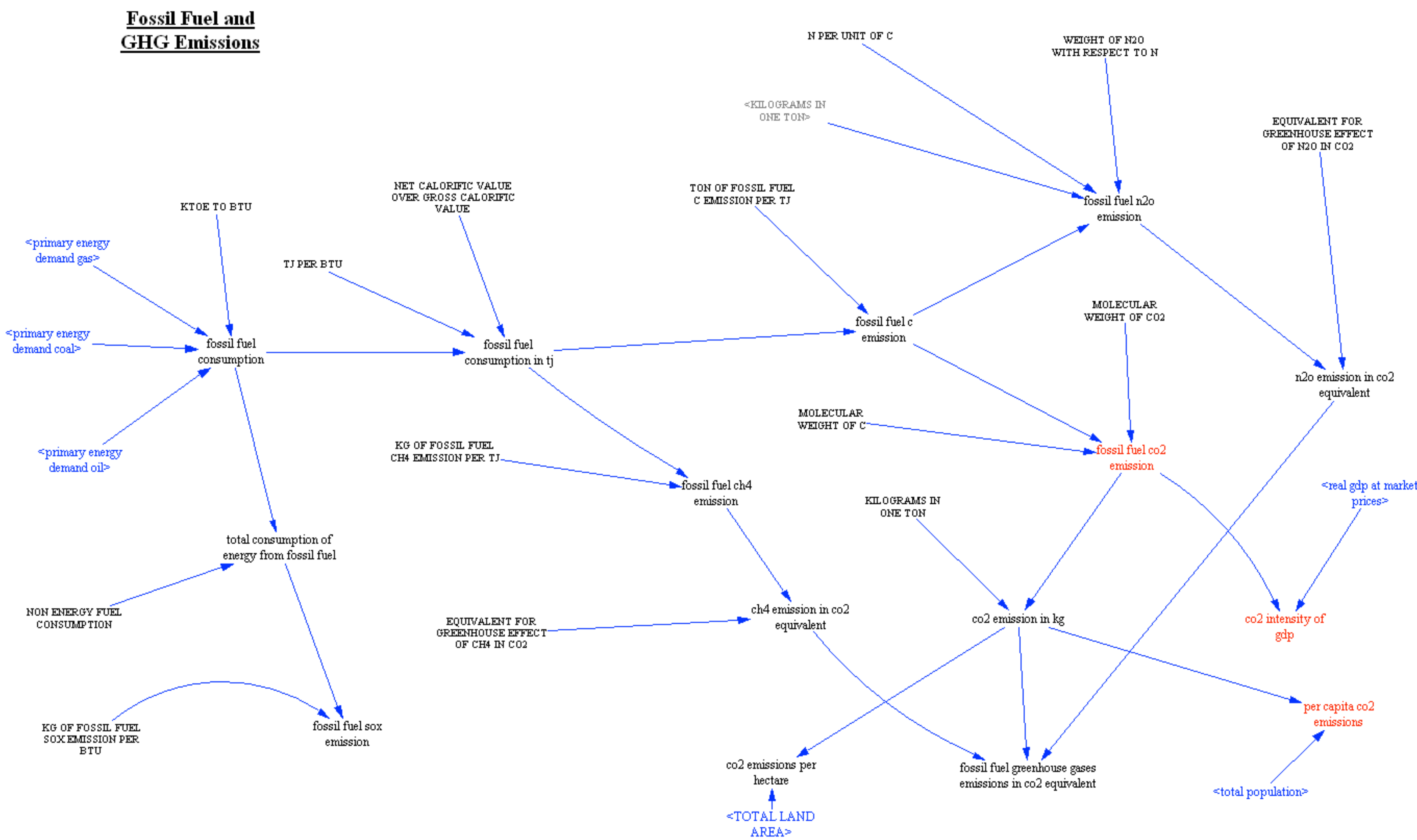

Figure 96: Sketch of the Fossil Fuel and GHG Emissions module

Purpose and Perspective

The Fossil Fuel and GHG Emissions module (**Figure 101**) calculates fossil fuel emissions for CO_2, N_2O, SO_X and CH_4. In addition, it calculates fossil fuel greenhouse gas emissions in CO_2 equivalent. The calculation of emissions is based on fossil fuel consumption and physical conversion factors. This module also calculates the effect of fossil fuel emissions on mortality.

Explanation

Major Assumptions

- CO_2, N_2O, and CH_4 are the chief determinants of greenhouse gas generation;
- CO_2 emissions per hectare are a good proxy for PM10, the main determinants of mortality related to fossil fuels emissions;
- Conversion factors used to calculate emissions out of fossil fuel consumption are constant.

Table 135: Input variables: Fossil Fuel and GHG Emissions module

Variable Name	Module of Origin
Primary energy demand oil	Energy Supply
Primary energy demand gas	Energy Supply
Primary energy demand coal	Energy Supply
Real GDP at Market Prices	Aggregate Production and Income
Total Land Area	Land
Total population	Population

Table 136: Output variables: Fossil Fuel and GHG Emissions module

	Module of Destination		
Variable Name	**In the Same Sector**	**In Other Environmental Sectors**	**In Other Sectors**
Fossil fuel CO_2 emission			International Trade
CO_2 intensity of GDP			International Trade
Average normalized energy price			International Trade
Per capita co2 emissions		Ecological Footprint	MDGs

Table 137: Constants and table functions: Fossil Fuel and GHG Emissions module

Variable Name	Type of	Source for Estimation

	Variable	
Equivalent for Greenhouse Effect of CH_4 in CO_2	Constant	ANPA (Agenzia Nazionale per la Protezione dell'Ambiente) data
Equivalent for Greenhouse Effect of N_2O in CO_2	Constant	ANPA data
Kg of Fossil Fuel SO_X Emission per BTU	Constant	Fossil 2 model
Kg of Fossil Fuel CH_4 emission per TJ	Constant	IPCC data
Kilograms in one Ton	Constant	
Molecular Weight of CO_2	Constant	IPCC data
Molecular Weight of C	Constant	IPCC data
N per Unit of C	Constant	IPCC data
Net Calorific Value Over Gross Calorific Value	Constant	IPCC (Intergovernmental Panel on Climate Change) data
Non Energy Fuel Consumption	Constant	Data on energy consumption (EIA)
TJ per BTU	Constant	Data on energy consumption (EIA)
Ton of Fossil Fuel C Emission per TJ	Constant	IPCC data
Weight of N_2O with Respect to N	Constant	IPCC data

Functional Explanation

In this module, fossil fuel emissions are calculated by converting consumption of oil, coal and gas into CO_2, N_2O, SO_X and CH_4 emissions equivalent.

Fossil fuel SO_X emission

The emission of SO_X from burning fossil fuels is calculated as the total consumption of energy from fossil fuels times the SO_X emissions per BTU of fossil fuels burned:

fossil fuel sox emission=SUM(total consumption of energy from fossil fuel[fossil fuel!]*KG OF FOSSIL FUEL SOX EMISSION PER BTU[fossil fuel!])

Fossil fuel CH_4 emission in CO_2 equivalent

Fossil fuel CH_4 emissions are calculated as total fossil fuel consumption multiplied by the CH_4 emission per TJ of fossil fuels used:

fossil fuel ch4 emission= SUM(fossil fuel consumption in tj[fossil fuel!]* KG OF FOSSIL FUEL CH4 EMISSION PER TJ[fossil fuel!])

Fossil fuel *CH_4 emissions in CO_2 equivalent* represent the emissions of CH_4 expressed as the CO_2 emissions that would produce the same greenhouse effect. *CH_4 emissions in*

CO_2 equivalent are calculated as *fossil fuel CH_4 emissions* multiplied by the constant to convert the CH_4 emissions into the greenhouse-effect equivalent CO_2 emissions:

ch4 emission in co2 equivalent= fossil fuel ch4 emission * EQUIVALENT FOR GREENHOUSE EFFECT OF CH4 IN CO2

Fossil fuel N_2O emission in CO_2 equivalent

As for the CH_4 emissions in CO_2 equivalent, N_2O emissions in CO_2 equivalent are obtained as the *fossil fuel N_2O emission* multiplied by a conversion factor that represents the greenhouse-effect equivalent of one unit of *N_2O* in CO_2.

Fossil fuel CO_2 emission

The total emission of CO_2 from the burning of fossil fuels is calculated as *fossil fuel C emission* multiplied by the *molecular weight of CO_2*, divided by the *molecular weight of C*. It is assumed that all C becomes CO_2, even though a small percentage becomes CO and CH_4:

fossil fuel co2 emission= fossil fuel c emission*MOLECULAR WEIGHT OF CO2 /MOLECULAR WEIGHT OF C

Fossil fuel greenhouse gases emissions in CO_2 equivalent

The total annual emissions of greenhouse gases by the country, in CO_2 equivalents, is calculated as the sum of CO_2 emissions, CH_4 emissions, and N_2O emissions, the last two in CO_2 equivalents.

References

AES Corporation, An Overview Of The IDEAS MODEL: A Dynamic Long-Term Policy Simulation Model Of U.S. Energy Supply And Demand, Prepared For The U.S. Department Of Energy Office Of Policy, Planning, And Evaluation, Arlington, VA, October 1993.

Intergovernmental Panel on Climate Change (IPCC), IPCC Guidelines for National Greenhouse Gas Inventories: Greenhouse Gas Inventory Workbook. Greenhouse Gas Emissions.

41. Ecological Footprint module

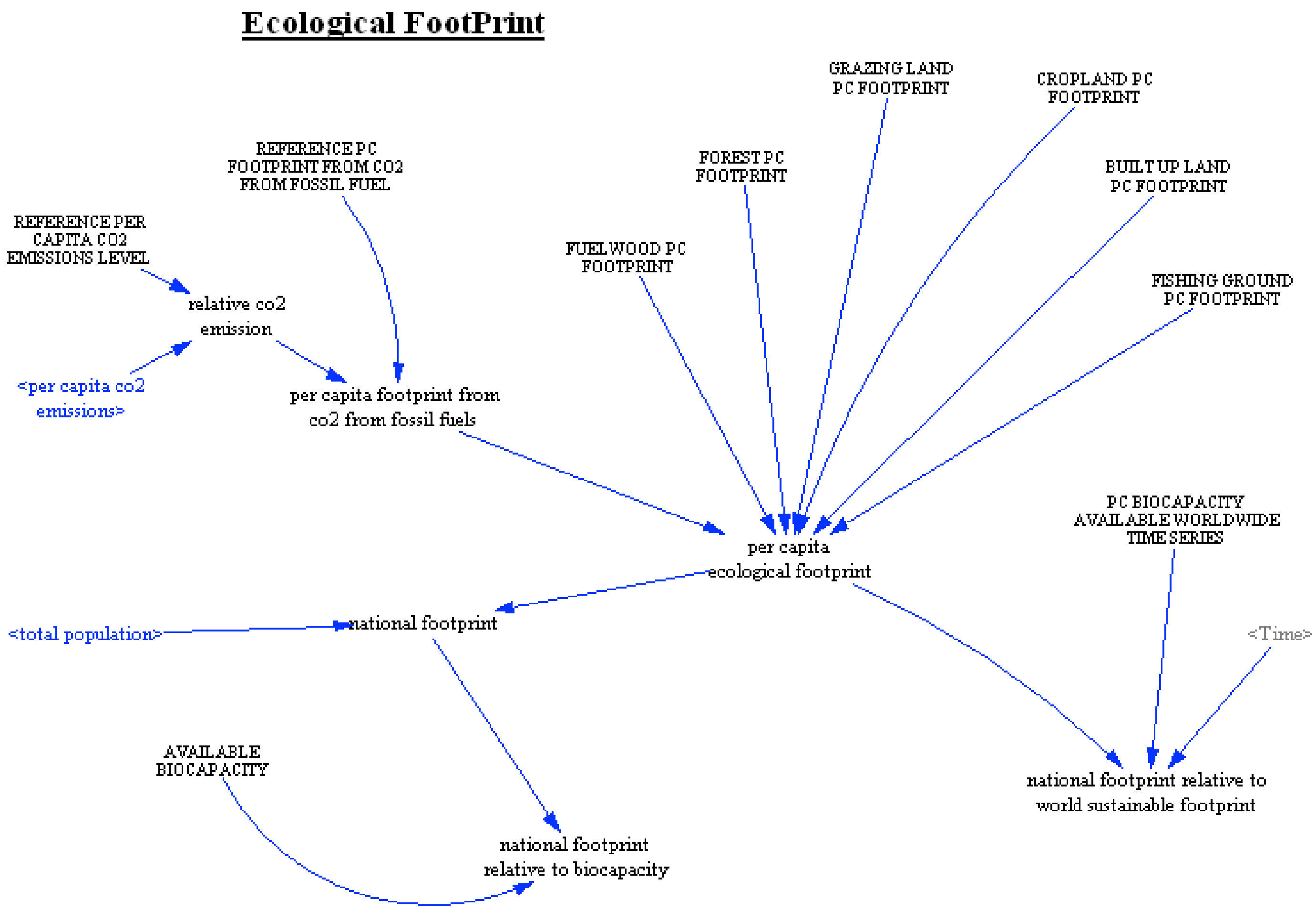

Figure 97: Sketch of the Ecological Footprint module

Purpose and Perspective

The Ecological Footprint module calculates the *Per Capita Footprint*, *National Footprint Relative to Biocapacity*, and the *National Footprint Relative to World Sustainable Footprint*. The ecological footprint of a person measures the biologically productive areas necessary to continuously provide the resources needed to maintain his/her current lifestyle and to absorb the wastes he/she produces. As illustrated in **Figure 102**, national footprint depends on the size of the population and on the PC footprint. Various elements and habits contribute the size of the per capita footprint. Those elements can develop at different paces, depending on the specific characteristics of the country analyzed. In the example of **Figure 102**, the only component of the PC footprint that is assumed to change substantially in the time horizon of the simulation is the CO_2 footprint. The other components are assumed to be constant. When there is evidence that those components could significantly change over the time horizon of the simulation, they can be treated as endogenous or represented by time dependent functions.

Explanation

Major Assumptions

- The available biocapacity is constant;
- The PC biocapacity available worldwide is exogenous;
- Apart from per capita footprint from CO_2 from fossil fuels, the other factors affecting the per capita ecological footprint are constant.

Table 138: Input variables: Ecological Footprint module

Variable Name	Module of Origin
per capita CO_2 emissions	Fossil Fuel and GHG Emissions
Total Population	Population

Table 139: Output variables: Ecological Footprint module

	Module of Destination		
Variable Name	In the Same Sector	In Other Environmental Sectors	In Other Sectors

Table 140: Constants and table functions: Ecological Footprint module

Variable Name	Type of Variable	Source for Estimation
Available Biocapacity	Constant	WWF (World Wildlife Fund) data
Built Up Land PC Footprint	Constant	WWF (World Wildlife Fund) data
Cropland PC Footprint	Constant	WWF (World Wildlife Fund) data

Fishing Ground PC Footprint	Constant	WWF (World Wildlife Fund) data
Forest PC Footprint	Constant	WWF (World Wildlife Fund) data
Fuelwood PC Footprint	Constant	WWF (World Wildlife Fund) data
Grazing Land PC Footprint	Constant	WWF (World Wildlife Fund) data
PC Biocapacity Available Worldwide table	Time series	Data from: Mathis Wackernagel, M. Lillemor Lewan and Carina Borgström Hansson, 1999
PC Footprint from Reference CO_2 from Fossil Fuel	Constant	WWF (World Wildlife Fund) data
Reference per Capita CO_2 Emission Level	Constant	WWF (World Wildlife Fund) data

Functional Explanation

Per Capita Footprint from CO_2 from Fossil Fuels

The per capita ecological footprint in hectares, due to emissions from the burning of fossil fuels (*per capita footprint from co2 from fossil fuels*), is calculated as the reference per capita footprint from fossil fuels multiplied by the relative level of *CO_2* emissions:

per capita footprint from co2 from fossil fuels= PC FOOTPRINT FROM REFERENCE CO2 FROM FOSSIL FUEL*relative co2 emission

The CO_2 footprint is the only component of the *per capita ecological footprint* that is assumed to change substantially in the time horizon of the simulation.

Per capita ecological footprint

The *per capita ecological footprint* represents the productive land and water one person requires to produce the sustainable resources he or she consumes and to absorb his/her sustainable wastes, all using prevailing technology. It is calculated as the sum of per capita footprint from various sources, assuming that only the CO_2 from fossil fuels per capita footprint varies over time:

per capita ecological footprint= BUILT UP LAND PC FOOTPRINT+per capita footprint from co2 from fossil fuels+CROPLAND PC FOOTPRINT+FISHING GROUND PC FOOTPRINT+FOREST PC FOOTPRINT+FUELWOOD PC FOOTPRINT+GRAZING LAND PC FOOTPRINT

National footprint

The *national footprint* represents the amount of productive land and water the country requires to produce the sustainable resources it consumes and to absorb the waste it generates, using currently available technology. It is calculated as the *total population* times the *per capita ecological footprint*:

national footprint= total population*per capita ecological footprint

The *national footprint relative to biocapacity* is an indicator of the long-term sustainability, given nature's biologically productive capacity. It is calculated as the *national footprint* divided by *available biocapacity*.

National Footprint Relative to World Sustainable Footprint

This variable in an indicator of the proportion of the world's per capita biocapacity, used per person in the country. It is calculated as the ratio of the *per capita ecological footprint* and *PC BIOCAPACITY AVAILABLE WORLDWIDE TABLE* (using as input *Time*):

national footprint relative to world sustainable footprint= per capita ecological footprint/PC BIOCAPACITY AVAILABLE WORLDWIDE TABLE(Time)

References

World Wildlife Fund, *Living Planet Report*, Washington: World Wildlife Fund, 2002

42. MDGs module

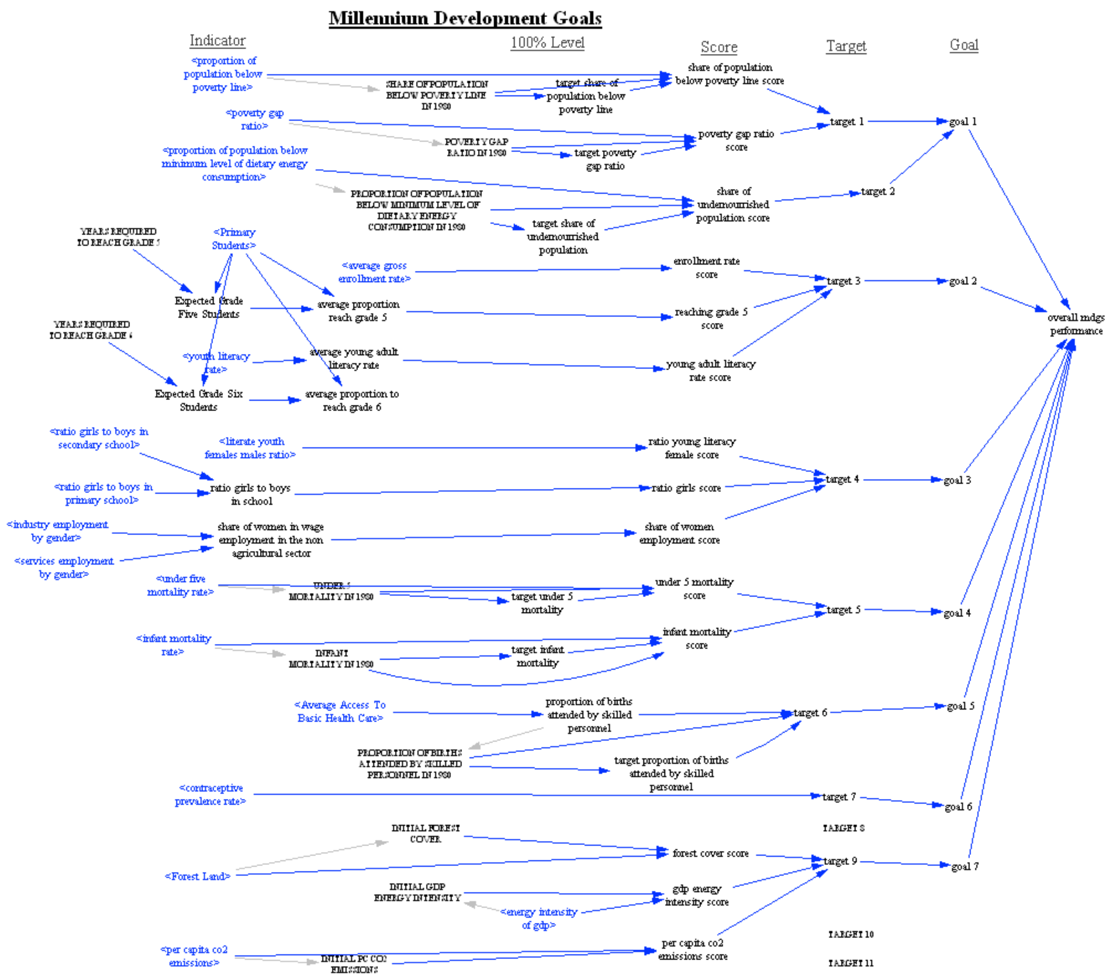

Figure 98: Sketch of the MDGs module

Purpose and Perspective

The MDGs module evaluates the sustainability of the country in terms of achieving Millennium Development Goals. Seven goals are assessed in this module based on a series of indicators endogenously determined in the social and environmental spheres.

Explanation

Table 141: Input variables: MDGs module

Variable Name	Module of Origin
Proportion of population below poverty line	Income Distribution
Poverty gap ratio	Income Distribution
Proportion of population below minimum level of dietary energy consumption	Nutrition
Average gross enrollment rate	Primary Education
Primary students	Primary Education
Youth literacy rate	Primary Education
Literate youth females males ratio	Primary Education
Ratio girls to boys in secondary school	Secondary Education
Ratio girls to boys in primary school	Primary Education
Industry employment by gender	Labor Availability and Unemployment
Services employment by gender	Labor Availability and Unemployment
Under five mortality rate	Mortality
Infant mortality rate	Mortality
Average access to basic health care	Healthcare
Contraceptive prevalence rate	Fertility
Forest land	Land
Energy intensity of GDP	Energy Demand
Per capita CO_2 emissions	Fossil Fuel and GHG Emissions

Table 142: Output variables: MDGs module

	Module of Destination		
Variable Name	**In the Same Sector**	**In Other Environmental Sectors**	**In Other Sectors**

Table 143: Constants and table functions: MDGs module

Variable Name	Type of Variable	Source for Estimation

According to UN's definition of MDGs, this module assesses seven quantifiable, based on a range of social and environmental indicators calculated in other modules. These goals (along with the monitoring indicators) include:

- Poverty level (proportion of population below poverty line, poverty gap ratio, and share of under-nourished population),
- Primary education (enrollment rate, proportion of students reaching grade 5, and youth literacy rate),
- Gender equality (share of female in literate youth, in primary and secondary school students, and in industry and services employment)
- Child mortality (infant and under five),
- Maternal health (access to basic health care),
- HIV/AIDS (contraceptive prevalence rate)
- Environmental sustainability (forest land, energy intensity, and CO_2 emissions)

As the calculation approach for each goal is very similar, the Goal 2 – "Achieve universal primary education" is described below as an example.

The evaluation of each goal is divided into indicators, scores, target and goal, based on the definition of MDGs. In terms of primary education, the target (represented by variable *target 3* in the model) is for both male and female children to be able to complete a full course of primary schooling by 2015, as defined by the Millennium Development Goals. This is evaluated by the average of three scores: enrollment rate score, reaching grade 5 score, and youth adult literacy rate score.

goal 2 = target 3

target 3 = (enrollment rate score +reaching grade 5 score +young adult literacy rate score) /3

The enrollment rate score represents relative progress towards the primary enrollment-rate. It is equivalent to the average gross enrollment rate (the target is 100%):

enrollment rate score = MAX(0,average gross enrollment rate)

Similarly, the reaching grade 5 score represents relative progress towards the proportion of students reaching level 5 in school. It is equivalent to the average proportion reaching level 5 (the target is 100%):

reaching grade 5 score = MAX(0, average proportion reach grade 5)

The young adult literacy rate score represents relative progress towards the young adult literacy rate target, and is equivalent to the average young adult literacy rate (the target is 100%):

young adult literacy rate score = MAX(0,average young adult literacy rate)

Note that the MAX functions are used in the equations above to make sure that the scores are non-negative.

While *average gross enrollment rate* and *average young adult literacy rate* (equivalent to *youth literacy rate*) are calculated in the Primary Education module, average proportion reach grade 5 is calculated in this module as a ratio of current total number of Grade 5 students over the expected number of Grade 5 students (a five-year delay of current Grade 1 students):

average proportion reach grade 5 = SUM(Primary Students[sex!,GRADE 5])/Expected Grade Five Students

Expected Grade Five Students = DELAY N(SUM(Primary Students[sex!,GRADE 1]), YEARS REQUIRED TO REACH GRADE 5 , SUM(Primary Students [sex!,GRADE 1]) , 5)

Finally, the *overall mdgs performance* is calculated as the average of all calculated goals.

References

United Nations, Millennium Development Goals Indicators, Available at: http://mdgs.un.org/unsd/mdg/Default.aspx, Accessed 2011.

43. HDI and GDI module

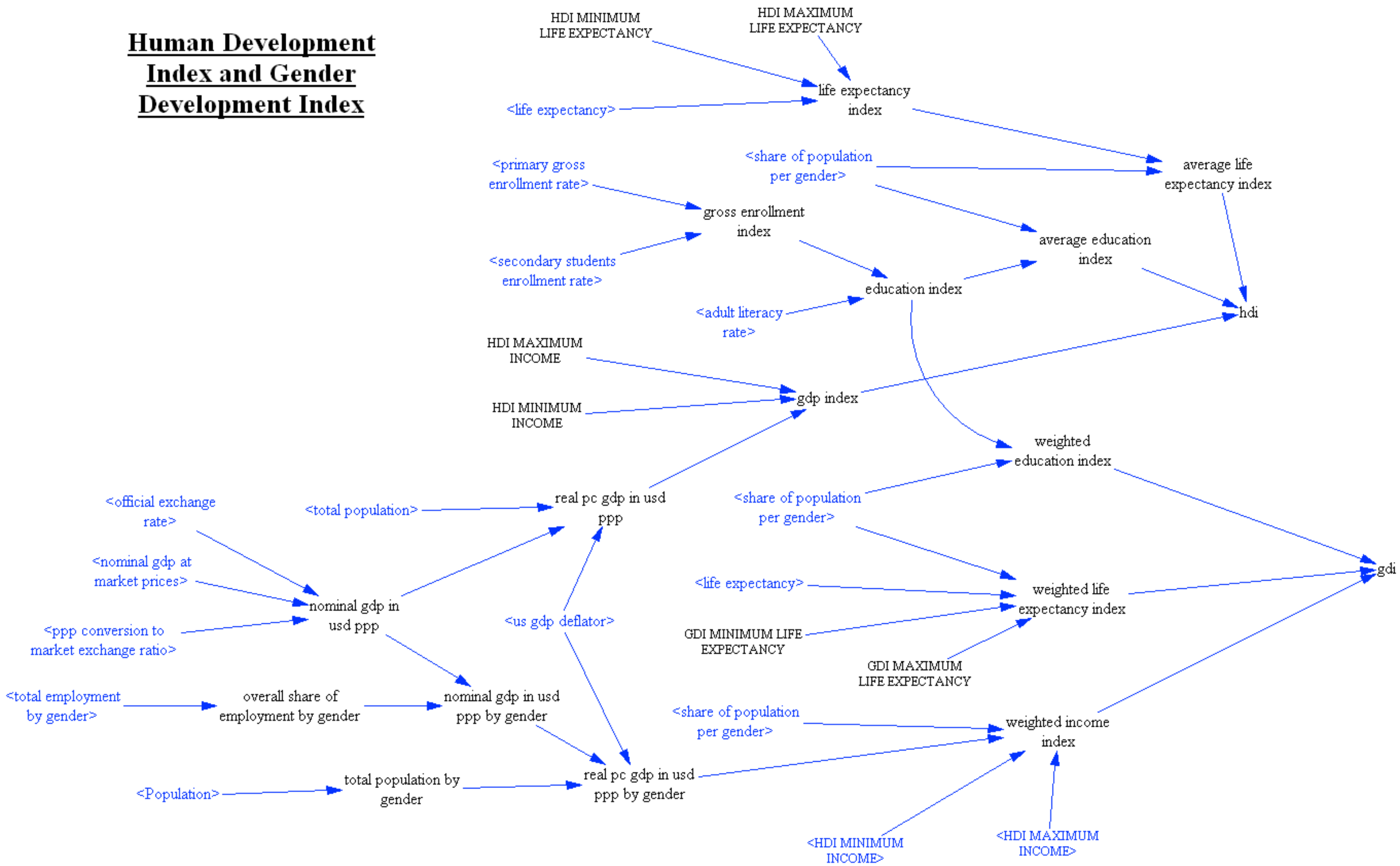

Figure 99: Sketch of the HDI and GDI module

Purpose and Perspective

The HDI and GDI module (see **Figure 104**) evaluates Malaysia's social and economic development measured by Human Development Index (HDI) and Gender Development Index (GDI).

According to UNDP's definition, HDI is composed of three dimensions: health (measured by life expectancy), education (measured by enrollment rate and adult literacy rate) and income (measured by GDP per capita). GDI measures the same basic national achievements, and yet highlights gender equality.

Explanation

Input variables: HDI and GDI module

Variable Name	Module of Origin
Life expectancy	Mortality
Real pc GDP in USD PPP	Mortality
Share of population per gender	Population
Total population	Population
Population	Population
Primary gross enrollment rate	Primary Education
Secondary students enrollment rate	Secondary Education
Adult literacy rate	Primary Education
Official exchange rate	Aggregate Production and Income
Nominal GDP at market prices	Aggregate Production and Income
PPP conversion to market exchange ratio	Aggregate Production and Income
US GDP deflator	Aggregate Production and Income
Total employment by gender	Labor Availability and Unemployment

Output variables: HDI and GDI module

	Module of Destination		
Variable Name	**In the Same Sector**	**In Other Environmental Sectors**	**In Other Sectors**

Constants and table functions: HDI and GDI module

Variable Name	Type of Variable	Source for Estimation
HDI minimum life expectancy	Constant	UNDP
HDI maximum life expectancy	Constant	UNDP
HDI minimum income	Constant	UNDP
HDI maximum income	Constant	UNDP
GDI minimum life expectancy	Constant	UNDP
GDI maximum life expectancy	Constant	UNDP

Functional Explanation

The HDI and GDI module evaluates the Human Development Index (HDI) and Gender Development Index (GDI) of Malaysia, as a measure of the nation's social and economic development according to UNDP's definition. The calculation of the overall and components of HDI (top part of the sketch in **Figure 104**) and GDI (bottom part of the sketch), as described below, is based on the corresponding indicators calculated in the respective modules.

HDI

The overall HDI is an average of three indices:

- Health index (measured by life expectancy),
- Education index (measured by enrollment rate of primary and secondary students and adult literacy rate)
- GDP index (measured by GDP per capita in USD PPP).

Each index (expressed as a value between 0 and 1) is calculated by comparing the country's current level to the maximum and minimum level set by HDI.

The *life expectancy index*, for instance, is calculated as the difference between the national and HDI minimum levels, divided by the difference between HDI maximum and minimum levels. The *average life expectancy index* is then obtained as the weighted average of *life expectancy index* by *share of population per gender*:

average life expectancy index = life expectancy index[FEMALE]*share of population per gender [FEMALE]+life expectancy index[MALE]*share of population per gender [MALE]

life expectancy index[sex]= (life expectancy[sex] - HDI MINIMUM LIFE EXPECTANCY) / (HDI MAXIMUM LIFE EXPECTANCY - HDI MINIMUM LIFE EXPECTANCY)

The other two HDI components - education index and GDP index – are calculated by using the same approach. Note that the education index is a weighted average of three indicators (adult literacy rate, primary enrollment rate and secondary enrollment rate) with a higher weight (2/3) for literacy rate, according to UNDP, before weighted by population per gender.

GDI

GDI measures the same basic national achievements as HDI, and yet highlights gender equality. It can be regarded the HDI discounted for gender disparity. The greater the gender disparity, the low the GDI compared to its HDI value.

The calculation of GDI *weighted education index* to measure the education equality between women and men, based on HDI *education index* obtained above, as an example, is as follows:

weighted education index = ((share of population per gender [FEMALE]*(education index [FEMALE]^-1))+ (share of population per gender [MALE]*(education index[MALE]^-1)))^-1

References

United Nations Development Programme (UNDP), Human Development Reports, Indices and Data: Human Development Index (HDI), Available at: http://hdr.undp.org/en/statistics/hdi/, Accessed 2011;

United Nations Development Programme (UNDP), Human Development Reports, Indices and Data: Measuring inequality: Gender-related Development Index (GDI) and Gender Empowerment Measure (GEM), Available at: http://hdr.undp.org/en/statistics/indices/gdi_gem/, Accessed 2011;

United Nations Development Programme (UNDP), Human Development Reports 2003: Technical Report.