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Modelling Economic Effects of Reducing Non-Tariff Measures in the Food Processing Sector of Malaysia Using Computable General Equilibrium

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Abstract: The import intensive food processing sector in Malaysia is highly regulated with non-tariff measures (NTMs) from the import side. However, the ad-valorem equivalents (AVEs) of those NTMs vary substantially across the subsectors of food processing. To assess the trade costs or plausible protection effects associated with NTMs, the computable general equilibrium (CGE) model is employed with partial removal of NTMs from the baseline scenario with NTMs. The disaggregated impact of a reduction in NTMs indicate disproportionate gains in trade (both imports and exports) across the various subsectors, with highest gains derived by the subsectors with relatively high AVEs, namely dairy products, bakery products and animal feeds. The simulation findings further show that the overall impact of a reduction in NTMs on trade is larger in the long run relative to the short run, suggesting slow responses to such policy changes, as NTMs present themselves as a package and not as an instrument.

Keywords: non-tariff measures, trade, ad-valorem equivalent, CGE, Malaysia
JEL classification: F14, F10, F19

1. Introduction

The use of non-tariff measures (NTMs)[1] to regulate trade has been increasing since the 1990s (Gourdon, 2014; WTO, 2012). The World Trade Organization (WTO) (2019) reported that by 2018, the number of NTMs had increased to 50,182. Governments have imposed NTMs for a variety of legitimate non-trade objectives. These include

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[1] NTMs are policy measures, other than ordinary customs tariffs, that can potentially have an economic effect on international trade in goods, changing quantities traded, or prices or both (UNCTAD, 2013).

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measures to protect human, animal and plant health, the environment, national security, and correct market failures such as asymmetric information or externalities. The global food sector, more specifically, is highly regulated by NTMs: 49% of total NTMs notified to the WTO were found in this sector alone in 2016 (WTO, 2019). The imposition of NTMs in this sector is regarded as essential to provide confidence to consumers in the safety, quality and authenticity of what they eat.

NTMs, though legitimate, can act as barriers to trade when their implementation increases compliance costs to firms (Chen, Wilson, & Otsuki, 2008; Disdier & Van Tongeren, 2010; Fontagne, Kirchbach, & Mimouni 2005; Moenius, 2004; Otsuki, Wilson, & Sewadeh, 2001; Peterson, Grant, Roberts, & Karov, 2013; Peterson & Orden, 2008). However, NTMs can also enhance trade when they reduce the problems arising from asymmetric information between buyers and sellers, and thereby reduce transaction costs (Athukorala & Jayasuriya, 2003; Schuster & Maertens, 2015). The effects of NTMs on trade therefore remain ambiguous. There are some countries that resort to using NTMs for political reasons: to restrict trade and serve protectionist purposes (Aisbett & Pearson, 2012; Fischer & Serra, 2000; WTO, 2012). Such (over) regulation may create the need for loosening some of the NTM restrictions to facilitate trade.

Malaysia is also increasingly reliant on NTMs in food imports because of the pervasive issue of food safety. Some 57% of the total number of Malaysia's NTMs are found in the food sector (ERIA-UNCTAD, 2019). Most are technical measures, comprising sanitary and phytosanitary (SPS) measures and technical barriers to trade (TBTs). NTMs in this sector are applied to the whole supply chain from the production process, to trade and to the handling of food. Though these measures are used for legitimate reasons such as health and safety, there could be some NTMs that serve as "hidden" barriers to trade, more so when this sector is highly import intensive and dominated by small and medium-sized enterprises (SMEs) (MIDA, 2018). It can therefore be argued that a reduction of NTMs and non-tariff barriers (NTBs) may be needed to facilitate trade.

According to the WTO (2014), the elimination (of the protection effect) of NTMs or NTBs could deliver a global increase in trade of up to US$1 trillion (RM3.65 trillion) per year, while the estimates by Wilson, Mann and Otsuki (2005) for developing countries showed that merchandise trade increased by US$377 billion between 2000 and 2001 with the removal of restrictive NTMs. There are only a few studies on NTMs in Malaysia, and they all focus on identifying sectoral NTBs (Hanif, 2013; Rabiul, Shaharuddin, & Chamhuri, 2010) and assessing the trade effects of NTMs from an exporter's perspective (Aini, 2011; Devadason, Govindaraju, & Kalirajan, 2018; Kee, Nicita, & Olearraga, 2008; Sithamparam, Devadason, & Chenayah, 2017).

Since NTMs, in general, are opaque and less transparent relative to tariffs, they pose a significant challenge to assess their direct and indirect effects on the economy. There is an ongoing effort in contemporary economic literature to provide improved theoretical methodologies and empirical studies to better measure the actual impact of NTMs. This study contributes to the empirical literature in the following manner. It provides a quantitative assessment of the economic impacts of the reduction of NTMs in the imports of the food processing sector of Malaysia by means of a disaggregated sectoral analysis using the computable general equilibrium (CGE) model. A disaggregated approach is used given that the Malaysian food industry is highly heterogeneous in terms of its trade intensity. The study estimates the production and trade effects, which follow from a reduction in the costs related to NTMs in 11 subsectors of the food processing industry. The focus on the food processing sector is also relevant given the Malaysian government's aim to further this industry due to its strong linkages with other sectors (see also MPC, 2018).

2. Trade Patterns and NTMs in Food Processing

The food processing sector forms a significant part of the overall industrial sector of the Malaysian economy. There are 11 subsectors identified, which include meat, seafood, vegetables and fruits, dairy products, oils and fats, grain mills, bakery products, confectionery, other food processing, animal feeds and beverages. Overall the contribution of the food processing sector to domestic manufacturing output was 13% in 2016 (DOSM, 2017).

Malaysia exports processed foods which was valued at USD13.3 billion in 2016 to more than 200 countries (Table 1). Although exports from this sector have increased rapidly, most of the subsectors are still import intensive. As can be seen from Table 1, Malaysia is a net importer of meat, grain mills, dairy products, vegetables and fruits, animal feeds, and a net exporter of bakery products, other processed food, confectionery, beverages and oils and fats.

Though import dependent, Malaysia's food processing sector is also engaged in two-way trade flows. It is therefore important to find out the extent of trade overlap across the food processing subsectors. Based on the aggregate Grubel-Lloyd (AGL) index (Grubel and Lloyd, 1975), the trade overlap with the rest of the world (ROW) is calculated and presented in Table 2. The table shows that overall, intra-industry trade (IIT) is not quite important for the food processing sector as the AGL indices are below 0.5[2] for the period of the study. This is due to fact that Malaysia usually imports these products as raw materials for domestic processing (MIDA, 2018). Of the 11 food subsectors, only four – other processed food, beverages, animal feeds and seafood – have relatively high shares of IIT (AGL > 0.5).

In Malaysia, the food sector is regulated by the Food Regulations 1985 of the Food Act 1983. The Regulation comprises a range of standards on products, production, processing, labelling and distribution, and it applies to locally produced or imported food, beverages and edible agricultural products. Malaysia's food processing industry is subject to several types of NTMs. A total of 407 out of 641 import measures are found in the food processing sector (ERIA-UNCTAD, 2017). Within import measures, technical measures – which consist of SPS, TBTs and pre-shipment inspections (PSI) and other formalities – predominate, accounting for 98% of the total import measures. All subsectors of food processing are subject to SPS and TBTs (Table 3). SPS and TBTs dominate in the "other processed food" category, followed by beverages and fruits and vegetables. Only these three subsectors of food processing have PSI measures. Malaysia also controls the

[2] It should be noted here that the AGL indices are calculated at the detailed 6-digit level of the harmonised system (HS) to avoid any aggregation bias. However, the 6-digit level could also underestimate the extent of trade overlap.

Table 1. Trade flows of processed food in Malaysia, 2003 to 2016 (USD million)

Subsector	2003		2006		2009		2012		2014		2016	
	Imports	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports	Exports
Meat and meat production	207	35	238	22	357	55	547	83	669	96	608	106
Seafood	195	324	348	437	391	390	584	522	429	263	516	423
Fruits and vegetables	64	56	82	60	150	84	232	129	249	112	336	188
Oils and fats	427	5678	793	6028	1462	9685	2669	14835	1581	11671	1275	9071
Dairy products	298	78	403	114	361	134	669	232	895	297	539	213
Grain mills	217	71	375	82	670	90	849	128	706	167	573	173
Animal feeds	104	31	121	43	159	40	220	105	218	86	198	99
Bakery products	17	114	20	167	32	242	60	336	74	390	80	470
Confectionery	281	396	412	576	599	805	1039	985	1052	1014	903	936
Other food processing	298	314	464	413	617	715	1051	1300	1144	1526	906	1043
Beverages	113	154	167	245	255	334	529	525	533	630	513	582
Total	2221	7252	3422	8187	5054	12575	8450	19179	7550	16254	6447	13304

Source: UN Comtrade (2019).

Table 2. AGL indices for processed food trade, 2003-2016

Subsector	2003	2006	2009	2012	2014	2016
Meat and meat production	0.08	0.05	0.10	0.08	0.09	0.10
Seafood	0.38	0.50	0.55	0.60	0.61	0.55
Fruits and vegetables	0.39	0.41	0.43	0.40	0.42	0.41
Oils and fats	0.08	0.13	0.15	0.22	0.12	0.13
Dairy products	0.40	0.43	0.44	0.30	0.35	0.41
Grain mills	0.26	0.22	0.21	0.24	0.29	0.32
Animal feeds	0.46	0.53	0.41	0.65	0.57	0.67
Bakery products	0.26	0.21	0.23	0.30	0.32	0.29
Confectionery	0.16	0.13	0.14	0.28	0.32	0.31
Other processed food	0.75	0.68	0.71	0.72	0.80	0.76
Beverages	0.54	0.62	0.69	0.61	0.63	0.68
Total	0.34	0.36	0.37	0.40	0.38	0.39

Note: The AGL index is calculated at the HS 6-digit level prior to aggregation. The AGL index ranges between zero (pure inter-industry trade) and one (pure IIT).
Source: Calculated from the UN Comtrade (2019).

Table 3. Frequency counts and AVEs of NTMs in food processing by subsectors

Sector	Types of NTMs (number)					Average AVEs
	Technical measures			Non-technical measures		
	SPS	TBT	PSI	PC	QC	
Meat and meat production	26	24	1	1	0	0.53
Seafood	19	19	0	1	0	0.42
Vegetables and fruits	39	30	1	0	1	0.52
Dairy products	10	2	0	0	0	0.80
Oils and fats	24	27	0	1	2	0.52
Grain mills	29	19	0	1	2	0.50
Bakery products	12	10	0	0	0	1.20
Confectionary	23	17	0	0	0	0.40
Other processed food	70	68	1	2	2	0.70
Animal feeds	3	1	0	1	0	1.00
Beverages	37	39	0	1	0	0.32

Note: SPS – sanitary and phytosanitary, TBT – technical barrier to trade, PSI pre-shipment inspection, PC – price control, QC – quantity control, AVE – ad valorem equivalent.
Source: NTMs are calculated from ERIA-UNCTAD database (2017), and AVEs are computed from Kee et al. (2009).

price and quantity of dairy products, confectionery and bakery products. Worth noting here is that the ad-valorem equivalents (AVEs)[3] in those three subsectors are much smaller than that for subsectors such as bakery products and animal feeds. The number of NTMs are therefore not an indication of the restrictiveness of trade.

Of the technical measures, 206 are in the form of TBTs, and 191 are SPS. Most of the TBTs found in this sector are for quality of product or performance requirements (B7), followed by requirements of labelling and packaging (B31) (Table 4). Similarly, most of the SPS measures are used for controlling the use of some ingredients in foods and feed and their contact materials (A22), followed by labelling requirements (A31).

3. Review of the Literature: NTMs and Trade

The effect of NTMs can vary widely: for example, they can both restrict and promote trade volumes. In the former case, this will usually place a cost (compliance cost and adaptation cost) on producers, and in turn, a high price of the traded good – a lower trade volume. Leland (1979) and Mangelsdorf, Portugal-Perez and Wilson (2012) however view compliance with standards' requirements as helping to solve the problem arising from asymmetric information. In that context, NTMs may produce a signalling effect (van den Bosse, 2013), where NTMs provide information on product characteristics, quality and the risks of harming consumers. NTMs then become a demand-shifting instrument used to correct market failure. In those cases, the quality improvement can enhance rather than reduce demand. The net effect depends on whether the increase in cost to suppliers is outweighed by the positive demand effect.

It can also be argued that NTMs make firms more innovative (Henson, 2006) due to the need to produce products that are differentiated by higher quality and standards surpassing the NTM requirements in the importing countries. Melitz and Ottaviano (2008) show that NTMs change the conditions of competition and productivity of firms given they generate a fixed cost to firms. These costs limit the access for SMEs (Francois, Berden, Tamminen, Thelleand, & Wymenga, 2013; Kox & Nordas, 2007; Moise & Le Bris, 2013) and low-productivity firms, while high productivity firms such as multinational corporations (MNCs) have advantages in terms of their technology and management to cope with the NTMs.

Many studies have identified positive impacts of NTMs on trade (Anders & Caswell, 2009; Beghin, Disdier, Marette, & Van Tongeren, 2012; Crivelli & Gröschl, 2016; Disdier, Fontagne, & Mimouni, 2008; Maertens & Swinnen, 2009a; 2009b; Maur & Shepherd, 2011; Moenius, 2006; Ronen, 2017; Thilmany & Barret, 1997). Conversely, Ghodsi, Gruebler, Reiter and Stehrer (2017) found that trade-impeding effects of NTMs (see also Francois et al., 2013; Gebrehiwet, Ngqangweni, & Kirsten, 2007; Wilson & Otsuki, 2004) accounted for nearly 60% of all total effects, particularly where quantitative restrictions and TBTs are involved. Their study qualifies that TBTs were trade-impeding, while SPS measures were both trade-enhancing and trade-impeding.

[3] The AVEs of NTBs on prices were estimated indirectly: first, the quantity–impact of NTBs on imports were estimated; and second, the quantity–impacts were transformed into price effects using the import demand elasticities (Kee et al., 2009).

Table 4. SPS and TBT chapters in processed food

A	SPS	No.	%
A14	Special authorisation requirement for SPS reasons	6	3.14
A19	Prohibitions/restrictions of imports for SPS reasons n.e.s.	2	1.05
A21	Tolerance limits for residues of, or contamination by, certain (non-microbiological) substances	1	0.52
A22	Restricted use of certain substances in foods and feeds and their contact	89	46.60
A31	Labelling requirements	55	28.80
A33	Packaging requirements	9	4.71
A41	Microbiological criteria of the final product	1	0.52
A42	Hygienic practices during production	6	3.14
A51	Cold/heat treatment	5	2.62
A63	Food and feed processing	2	1.05
A64	Storage and transport conditions	6	3.14
A82	Testing requirement	4	2.09
A83	Certification requirement	3	1.57
A84	Inspection requirement	1	0.52
A86	Quarantine requirement	1	0.52
	Total SPS	191	100

B	TBT	No.	%
B6	Product identity requirement	31	15.05
B7	Product quality or performance requirement	107	51.94
B9	TBT measures, n.e.s.	1	0.49
B14	Authorisation requirement for TBT reasons	7	3.40
B19	Prohibitions/restrictions of imports for objectives set out in the TBT agreement, n.e.s.	1	0.49
B21	Tolerance limits for residues of or contamination by certain substances	1	0.49
B31	Labelling requirements	54	26.21
B33	Packaging requirements	1	0.49
B41	TBT regulations on production processes	1	0.49
B42	TBT regulations on transport and storage	1	0.49
B49	Production or post-production requirements, n.e.s.	1	0.49
	Total TBTs	206	100

Note: n.e.s. – not elsewhere specified.
Source: Calculated based on ERIA-UNCTAD database (2017).

There are several approaches used in the literature in quantifying NTMs. They are inventory approaches (frequency index and coverage ratio), price- or quantity-based approaches, survey-based approach, gravity models and CGE models. CGE models are simulations which can be used to assess the effects of NTMs, or their removal, on factors such as production and trade flows. Both price- and quantity-based approaches can be used as policy shocks in CGE models (Andriamananjara et al., 2004; Chemingui & Dessus, 2008; Ciuriak & Xiao, 2014; Cororaton & Orden, 2015; Fugazza & Maur, 2008; Kee et al., 2009; Petri & Plummer, 2016).

Gilbert, Furusawa and Scollay (2018), by estimating the AVEs – the difference between world and domestic prices not explained by tariff measures – follow the most popular means for measuring the border effect of NTMs. With the aid of AVEs, NTMs can be introduced into the CGE models by two means. The first is as tariff equivalents (this equates to export tax equivalents if exports are involved), while non-revenue generating price wedges (iceberg costs) provide the second means (Andriamananjara et al., 2004; Gilbert et al., 2018). Gilbert et al. (2018) noted there is a need to adjust tariff measures in the CGE to model the introduction of NTMs or their removal in NTMs as tariff equivalents. They identified three methods for adjusting the data of a general equilibrium model. The first involves counterfactual simulation, which is the simplest and employs a shock to the model to simulate a new equilibrium in which NTMs are included. Further simulations are then run, which involve partial or full removal of the NTMs. However, by using this methodology, the simulation distorts the equilibrium following the assumed theory – there is no longer simulations relative to observed data.

A second approach requires the use of counterfactual simulations employing a closure or parameter specification, which minimises the changes in the data. It should be noted that the CGE model results are very sensitive to the relative importance of various activities – such as consumption shares and value-added shares. If the introduction of NTMs is simulated with core elasticities adjusted, the equilibrium can be correspondingly adjusted while maintaining those shares. The old parameters can then be recovered if further simulations are desired. In using this technique, a new social accounting matrix (SAM) needs to be rewritten and recalibrated. A further option involves adjusting the flows in the SAM directly, which produces greater control. That is, it is possible to manipulate tariff revenues, provide precision about how the NTMs influence consumption of the various agents and specify distribution of revenue. If new SAM cell entries are made, a new theory is needed to explain the flow. But by introducing new entries in a SAM cell, this will put the SAM out of balance. Therefore, the use of SAM balancing techniques such as RAS is required after the manipulations have been made.

Studies based on CGE models have found that a reduction of NTMs can benefit an economy (Andriamanajara et al., 2004; Francois, Pindyuk, & Woerz, 2009; Francois et al. 2013), as NTMs reflect real increases in cost of production and delivery. Francois et al. (2009) found that by removing all actionable NTMs, exports of the European Union (EU) increased by over 2%, and by over 6% for the United States (US). They found that economy wide NTM reductions produced cheaper imports, higher economic efficiency and gains in welfare (Beghin et al., 2012). Andriamanajara et al. (2004) estimated global welfare gains at USD90 billion with the removal of NTMs in Japan and Europe, while

Vanzetti, Knebel and Peters (2018) suggested that the net welfare in the Association of Southeast Asian Nations (ASEAN) countries will gain USD3 billion if harmonising of technical NTMs and elimination of non-technical NTMs were fully applied to intra-ASEAN trade. Such gains are estimated to increase to USD12 billion if technical measures on non-ASEAN imports were reformed and about USD18 billion of gains if ASEAN technical measures could be matched to international levels.

4. Quantifying the Impact of NTM Reductions: A CGE Model for Malaysia

The CGE model, which is primarily used to assess the protection effect of NTMs, is employed to quantify the impacts of a reduction in NTMs on production and trade in Malaysia. The CGE model combines the behaviour of microeconomic agents with closure rules of macroeconomic aggregates to simulate the functioning of a market economy. It can then capture economy-wide impacts of policy interventions on various endogenous variables. The CGE model can simultaneously carry out policy experiments to account for inter-sectoral linkage effects. In addition, the CGE model can also address the issue of the offsetting effects of trade liberalisation working through inter-sectoral shifts, factor price adjustments and exchange rate changes, which are not addressed by partial equilibrium models. A neoclassical comparative static CGE model is adopted since there is lack of data on changes in exogeneous variables. Comparative-static modelling is therefore considered adequate for this study as it only requires benchmark year data and it can be used to consider the impacts of a policy change, from the short-run and long-run perspectives.

In the CGE model, both profit-maximising producers and utility-maximising households interact at factor and product markets where equilibrium prices ensure that supply equals demand. Producers are assumed to operate under constant elasticity of substitution (CES) function, where relative factor prices dictate substitution between production factors while fixed input–output coefficients in Leontief (1936) functions determine intermediate input use. Producers take the decision to export based on a constant elasticity of transformation (CET) function, while the decision by domestic demanders whether to purchase imports or domestic output is determined by a CES Armington function. Since Malaysia is a small country, world market prices are considered fixed at their exogenous level and trade with the rest of the world (ROW) is based on relative prices of exports and imports.

To reflect the structure of the Malaysian economy, the model equations (see Appendix F) are calibrated to the values of a 2010 SAM, utilising the input-output (I-O) table for 2010[4], published by the Department of Statistics, Malaysia (DOSM, 2015). The secondary data employed to build the SAM for 2010 are the national account statistics and balance of payments published by the DOSM, government expenditures and revenues data published by the Ministry of Finance, and the industrial manufacturing survey and labour force survey published by the DOSM (2010). A set of unpublished disaggregated labour data (employment and wages) by occupation are also sourced from the DOSM.

[4] The latest I-O table available for Malaysia at the time of study.

The I-O table for 2010 consists of 124 production sectors. Among these, 12 sectors are for agriculture, four belong to mining and quarrying, 76 to manufacturing and the remaining 32 to the services sector. These sectors were aggregated into 15 sectors to ensure consistency in the classification and the specific focus on the processed food subsectors. The final model in this study consists of 15 sectors (see Appendix A), three institutional agents, two primary factors of production, and the ROW.

NTMs data are obtained from ERIA-UNCTAD (2017). The HS 6-digit processed food product codes are aggregated in accordance with the processed food subsectors set out in the SAM. As in previous works (Cororaton & Orden, 2015; Fugazza & Maur, 2008), this study employs a dataset of AVEs of NTMs developed by Kee et al. (2008, 2009). They provide estimates of the AVEs of NTMs for nearly 5,000 products in 104 countries. To assess the impact of NTMs on the import values, Kee et al. (2009) incorporates the AVEs of NTMs indirectly in a two-step approach with a gravity model. Using the import demand elasticities, the results are converted to AVEs. They restricted their AVEs to those that are positive, which means that all NTMs have only import restricting effects that are comparable to tariffs and quotas. For this study, only those products in the concordance table (see Appendix B) specified at the tariff line based on HS 6-digit food product codes are selected to obtain the AVE of NTMs (see Table 3) for the benchmark dataset.

5. Results of Simulations

The policy simulations demonstrate the impact of a proposed NTM cut on the import side. However, NTMs do not discriminate between foreign and local producers. Therefore, their reduction will affect both import and domestic prices. The reduction of NTMs does not necessarily mean that the number of NTMs is reduced. But instead it can mean reducing the trade restrictiveness of NTMs or reducing compliance costs. Obviously, it is unrealistic to assume that NTMs can be eliminated as countries typically maintain a set of NTMs for public policy objective. Thus, this study estimates the impact of elimination of part of the trade costs or protection effects related with NTMs. This study assumes that AVEs of NTMs are cut by 10% or 50% in all food processing subsectors. This is in line with the Malaysian government's efforts to reduce compliance costs (MPC, 2018). Three scenarios[5] are introduced in this study to analyse the impact of a reduction in NTMs: (i) baseline scenario (BS) – this scenario considers that there are no policy changes and the economy will continue following the existing trends, (ii) modest scenario (MS) – this scenario assumes a 10%[6] reduction of NTMs in the food processing sector, (iii) ambitious scenario (AS) – this scenario assumes a 50%[7] reduction of NTMs in the food processing sector. The results are presented as a cumulative percentage change between the baseline and counterfactual simulations (MS or AS).

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[5] The simulation results should not be viewed as a prediction, but only as an estimate of the strength and direction of the change in the situation *ceteris paribus*.

[6] The 10% reduction in NTMs is realistic in that it reflects ASEAN's targeted 10% reduction in trade transaction costs by 2020 (Damodaran, 2017).

[7] The 50% reduction of NTMs is based on the literature (see Hernandez, 2019, among others).

5.1 Baseline Simulation Results

The summary of the baseline simulation results in the food processing subsectors is reported in Table 5, and it represents a situation where there is no reduction of NTMs. Without reducing NTMs, seven subsectors – namely meat and meat production, grain mills, dairy production, bakery products, confectionery, animal feeds and beverages – experienced trade deficits. In the baseline scenario, the dairy production sector experienced the highest trade deficit. This is mainly caused by its productivity and resource disadvantages. As a result, supply was unable to keep up with the increasing domestic demand. More than 90% of milk and milk products are imported. Another reason is that Malaysia imports dairy products for use as intermediate inputs. These products are processed for human consumption and animal feeds (MIDA, 2018). Since Malaysia is the largest exporter and second largest producer of palm oil in the world and is a large net exporter of oils and fats (90% of its production is exported), oils and fats exports grew by 60% between 2003 and 2016 (UN Comtrade, 2019). Therefore, this sector recorded the highest trade surplus among the subsectors of food processing (MIDA, 2018).

The results[8] from the MS and AS scenarios are compared with the baseline simulation of Table 5 and expressed in terms of percentage change from the baseline. The following sections describe the impact of a reduction of NTMs on production and trade.

Table 5. Baseline simulation (RM million)

Sector	Output	Exports	Imports
Meat and meat production	2077	80	342
Seafood	3323	923	305
Fruits and vegetables	400	242	226
Dairy production	4714	404	1790
Oils and fats	113207	29901	6298
Grain mills	3991	302	703
Bakery products	4290	629	1205
Confectionery	5953	3251	3575
Other food processing	4709	2648	1809
Animal feeds	2835	385	1637
Beverages	4505	425	1405

Source: GAMS simulation by authors.

8 Sensitivity analysis has been performed to determine the robustness of the model results. The study simulates a 30% reduction and a 30% increment from the elasticity parameters (Armington CES and CET functions) in the model. The results of the sensitivity analysis follow existing trends. The magnitude of the changes compared to the results from original assumptions is only marginally different. Thus, the study concludes that the model employed in this study provides stable estimates (see Appendices C, D and E).

5.2 Impact on Production of Processed Food

The simulation results on the impact of a reduction of NTMs in the food processing sector on production in the short run and long run are presented in Figures 1 and 2 respectively.

With the reduction of NTMs in the food processing sector, there are noticeable upturns in production under both the MS and AS scenarios in the short run and long run, though production increases more in the long run. Processed food production increases by more than 14% in the long run under both scenarios, but by less than 1%

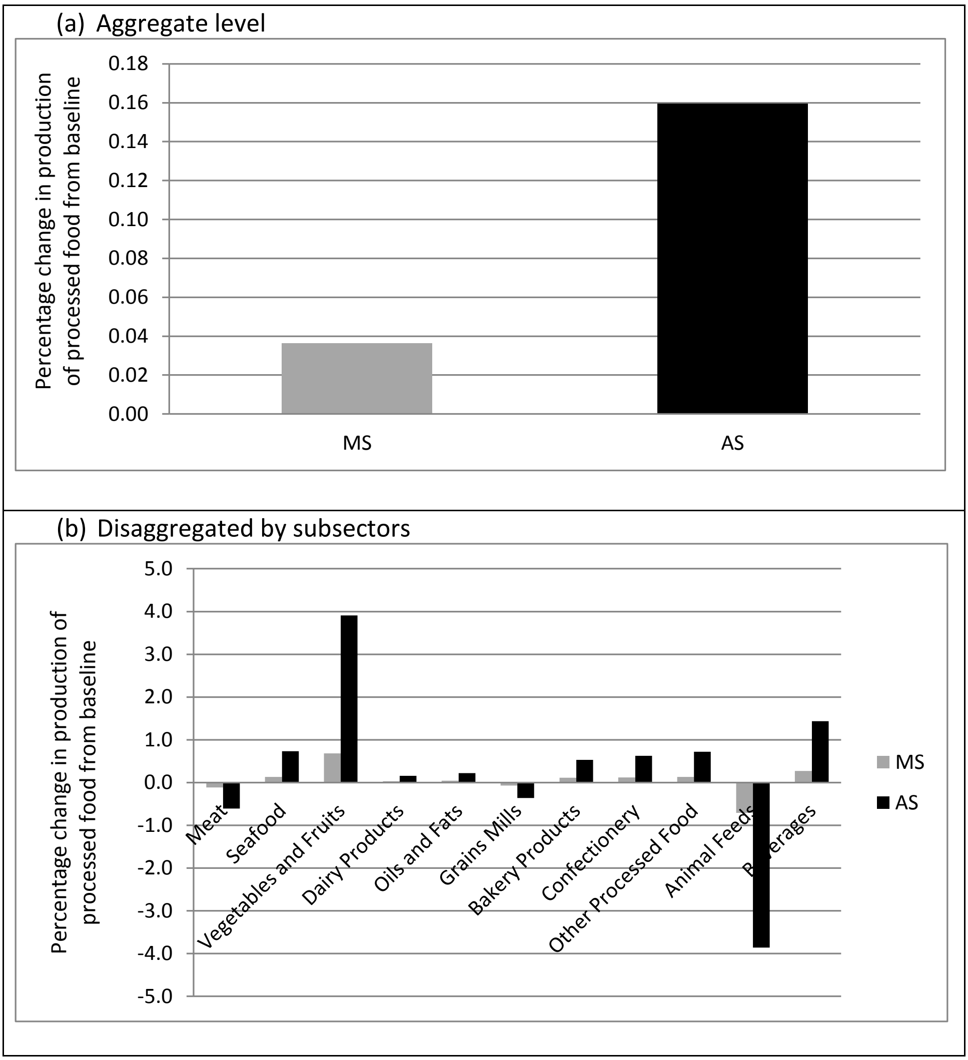

Figure 1. Short run impact of reductions in NTMs on production of processed food
Note: MS – modest scenario (10% reduction in NTMs), AS – ambitious scenario (50% reduction in NTMs).
Source: GAMS simulation by authors.

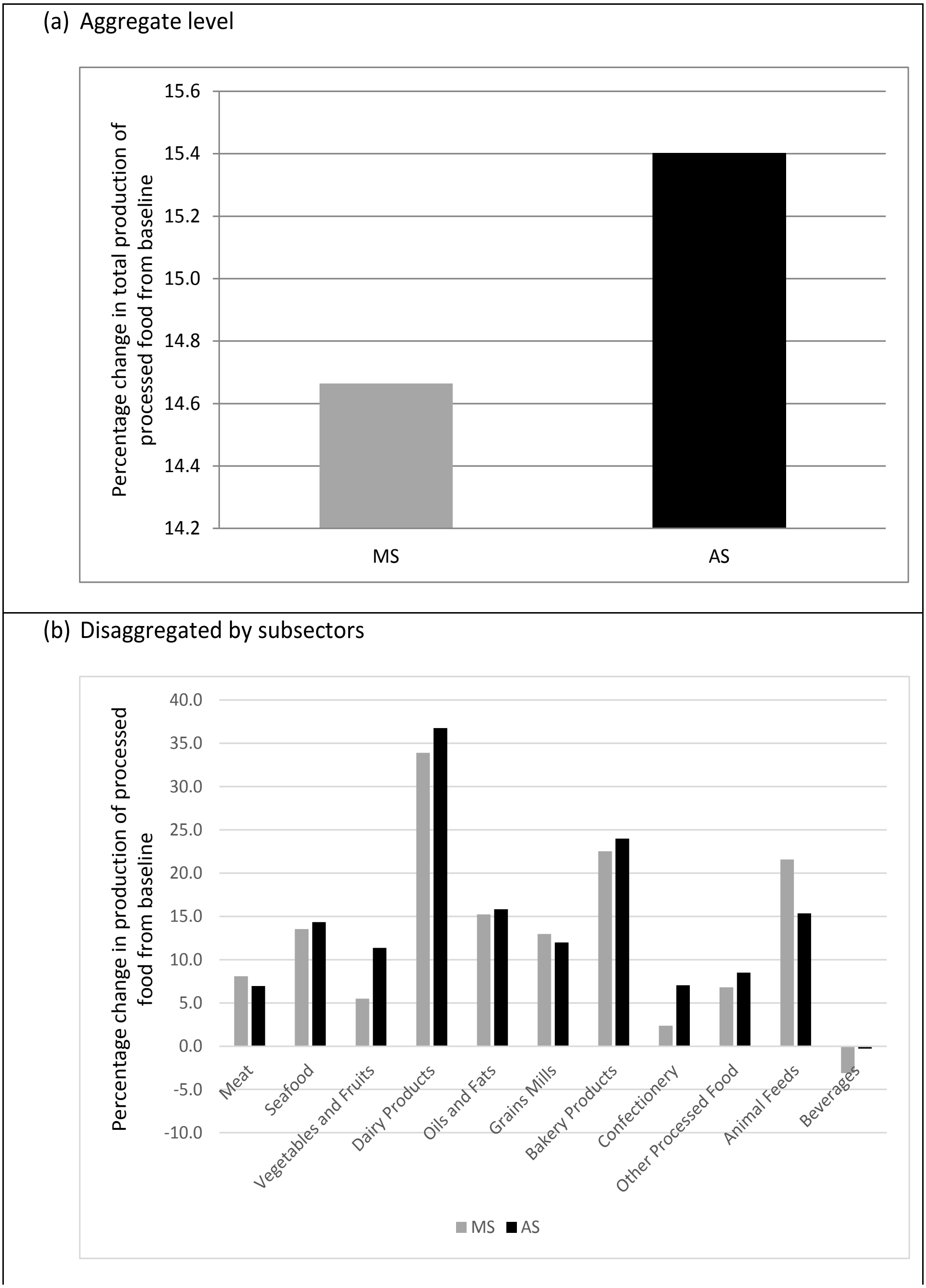

Figure 2. Long run impact of reductions in NTMs on production of processed food
Note: MS – modest scenario (10% reduction in NTMs), AS – ambitious scenario (50% reduction in NTMs).
Source: GAMS simulation by authors.

in the short run under both scenarios. The simulation results confirm the effectiveness of a reduction of NTMs to stimulate the long run production of processed food.

Although processed food production tends to increase overall, there are positive and negative changes in the production across subsectors. The different impact across the food processing subsectors could well reflect the reallocation of factors of production. In the short run, most of the subsectors benefit from a reduction of NTMs, with the exception of meat and meat production, grain mills and animal feeds that suffer reductions in output by less than 5%. Importantly, with the reduction of NTMs the production of all subsectors improves simultaneously in the long run, except for beverages. Worth noting here is that the AVE for beverages is the smallest across the food processing sector (see Table 3). It is observed that the production of dairy products increases the most relative to the other subsectors, recording a rise of 33% and 37% under the MS and AS scenarios respectively. The simulation results confirm the theory relating to NTMs that not all sectors will be winners. The results also show that the impact of a reduction in NTMs on production is disproportionate across the various subsectors.

5.3 Impact on Trade in Processed Food

The impact of a reduction of food processing sector NTMs on trade in the short run and long run is shown in Figure 3. Results from the simulation suggest that a reduction of NTMs in this sector promotes exports and imports in the short run and long run under both the MS and AS scenarios. The increase in imports is relatively greater than the increase in exports in the short run under both scenarios. While NTMs from the import side can have a direct effect on processed food imports, the increase in exports outweighs the increase in imports in the long run under both scenarios. Overall then, trade in processed food increases in the long run by relaxing NTMs in this sector.

Additionally, the impact under the AS scenario is approximately five times larger than the impact under the MS scenario in the short run. However, this is not the case for the long run. Exports deviate from the baseline by about 40% and 46% under MS and AS scenarios, respectively. On the other hand, imports increase from the baseline by about 6% and 25% under the MS and AS scenarios, respectively.

Figures 4 and 5 present the trade impacts of NTM reductions at the subsectoral level of food processing under the same two scenarios in both the short run and long run, respectively. Exports and imports of processed food in all subsectors increase under both scenarios in the short run and long run, with larger increases in imports relative to exports. However, the gains are not evenly shared by all subsectors. In the short run, the sector that derives the largest gain in exports is vegetables and fruits. Specifically, the export impact of NTM reductions under the AS scenario is greater for this subsector, registering a 10% increase from the baseline. The import increase following a reduction of NTMs is largest for bakery products followed by dairy products.

In the long run, exports of all subsectors increase more than in the short run. The most affected sector is dairy products. There is an extremely large increase in this subsector’s exports in the long run – up 180% and 210% from the baseline under the MS and AS scenarios, respectively. The increase in imports of dairy products – which

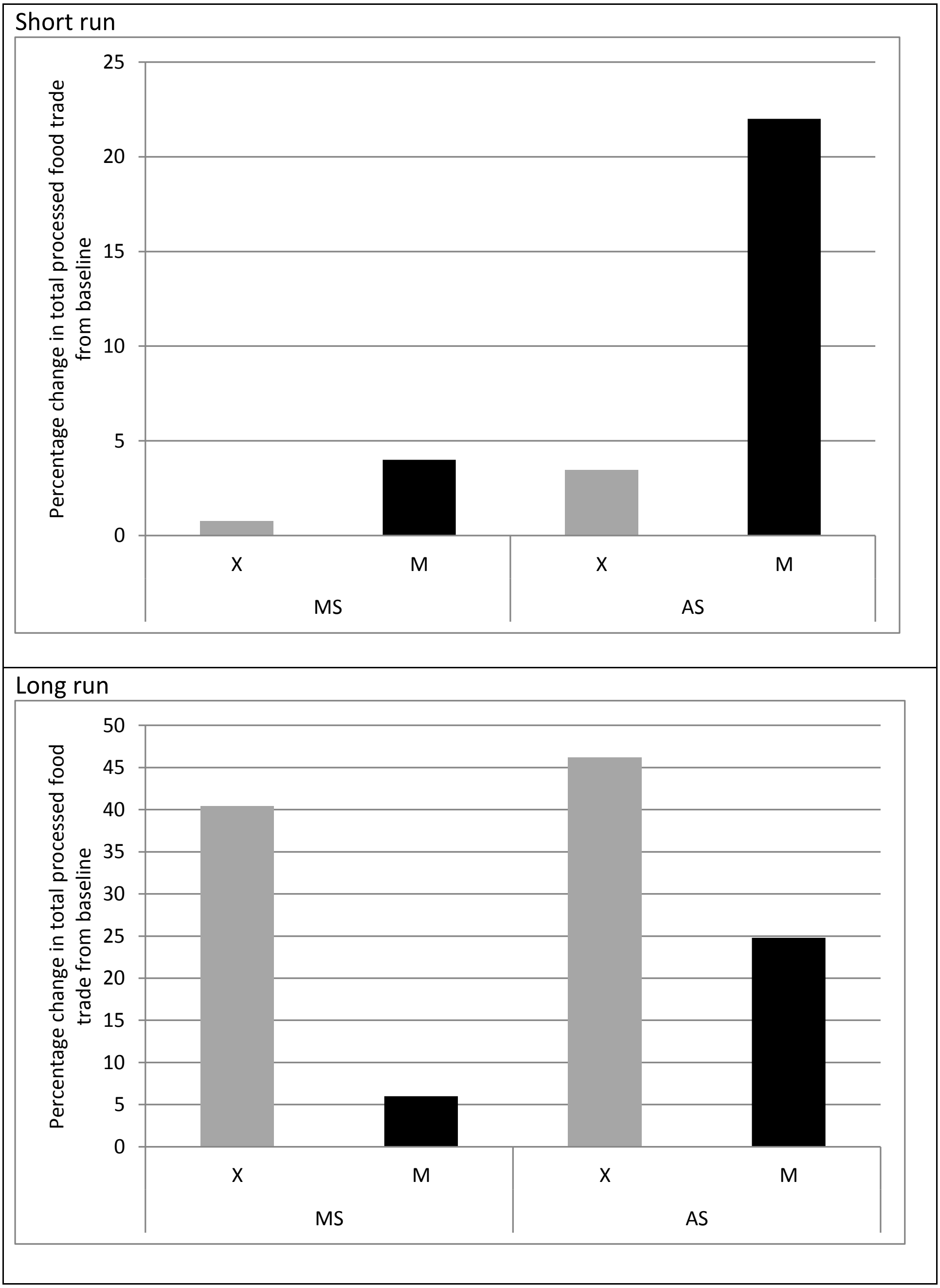

Figure 3. Short run and long run impacts of reductions in NTMs on processed food trade
Note: MS – modest scenario (10% reduction in NTMs), AS – ambitious scenario (50% reduction in NTMs), X – exports, M – imports.
Source: GAMS simulation by authors.

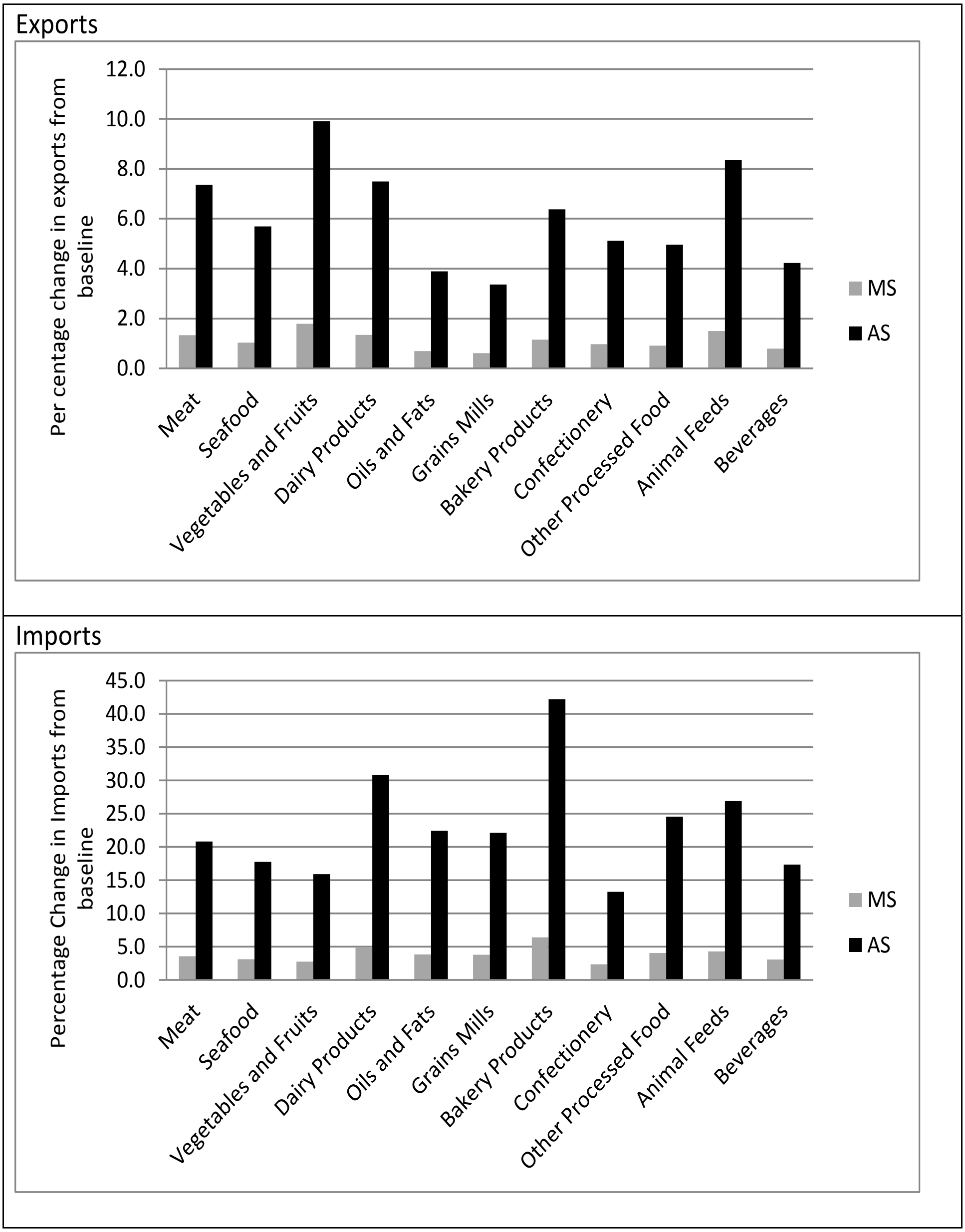

Figure 4. Short run impact of reductions in NTMs on processed food trade by subsectors

Note: MS – modest scenario (10% reduction in NTMs), AS – ambitious scenario (50% reduction in NTMs).

Source: GAMS simulation by authors.

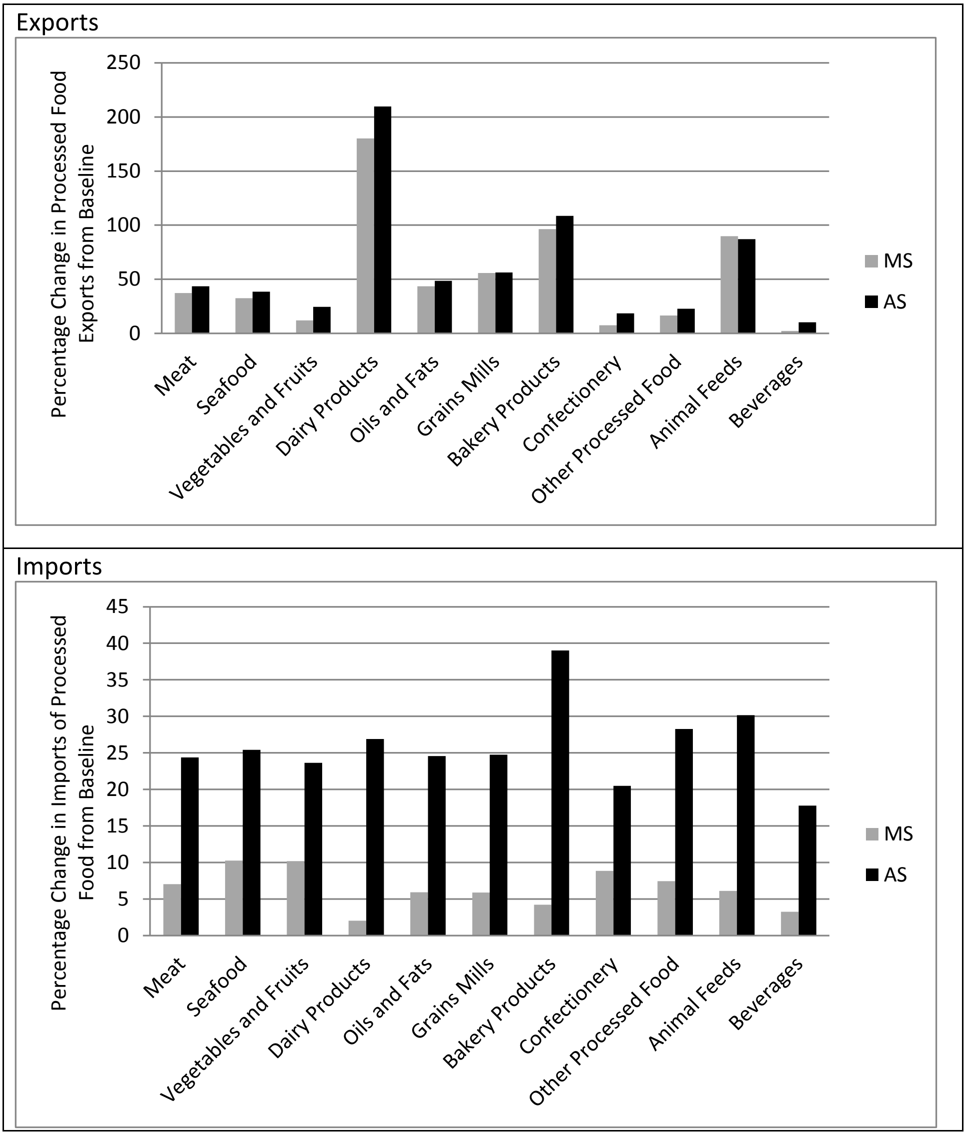

Figure 5. Long run impact of reductions in NTMs on processed food trade by subsectors
Note: MS – modest scenario (10% reduction in NTMs), AS – ambitious scenario (50% reduction in NTMs).
Source: GAMS simulation by authors.

record increases of 5% and 26% under the MS and AS scenarios respectively – is less than the increase in exports. The least affected are the exports of beverages in the long run with increases of 10% under the AS scenario and no changes under the MS scenario. For imports, the most affected sector is bakery products which increase by 4% and 39% under the MS and AS scenarios respectively. The impact of the reduction in

NTMs on exports under the AS scenario is not greatly different from the impact under the MS scenario in the long run. Conversely, this is not the case for imports.

5.4 Discussion of Findings

The simulation results of a partial reduction in NTMs from the import side are found to be beneficial to both domestic food production and exports, not just for imports. Total food production and exports increase by more than 14% to 40% in the long run following a policy change of NTMs from the import side. This is because domestic producers and exporters can source imported raw materials at cheaper prices (see also Chemingui & Dessus, 2008). The cut in import related NTMs can have a profoundly positive impact on food processing as it is a sector heavily dependent on imported intermediate goods (see Table 2). These findings suggest that it is costly for importers, and domestic producers and exporters to comply with some import related NTM requirements. It can be inferred indirectly that the food processing sector may be overregulated. Therefore, relaxing some NTMs in the food sector could help to reduce trade costs and improve market access.

The simulation results also show that the impact of a reduction in NTMs is larger in the long run relative to the short run (see also OECD, 2011). This is because adjustments to a policy change take time since NTMs present themselves as a package rather than a single instrument, as they comprise several requirements to be complied with for a single NTM measure, involving certification, testing, inspection and approval by official and analytical bodies. Despite the reduction in NTMs, existing SMEs who had not complied with the older regulations may still lack the capacity in terms of the soft or hard infrastructure to take advantage of production and trade opportunities within a short term (see also UNESCAP, 2015). Another reason that should be considered is that the model assumes that capital is fixed and only labour is a variable input in the short run. The reduction of NTMs will therefore be expected to induce a reallocation of resources in the long run, when both inputs can freely move across the subsectors in the long run.

This study has also found that the impact of NTM reduction is uneven across food subsectors. In the long run, the dairy products subsector gains the most in terms of production (30%) and exports (150%), followed by bakery products and animal feeds. This is mainly because NTMs in these subsectors are very restrictive (see Table 3; and Tao, Luckstead, Zhao, & Xie, 2016). In the case of animal feeds, it is also highly dependent on imported inputs for their production processes (see Table 2).

6. Concluding Remarks

The Malaysian government is looking to reduce business compliance costs (MPC, 2018) to increase the productivity and competitiveness of the industry. The focus of this paper on the impact of a partial reduction of NTMs on the highly regulated food processing sector is therefore highly relevant. The core finding of the study is that a change in production and trade following NTM cuts are substantial, especially in the long run. The subsectors with high AVEs benefit the most as they can access cheaper imported inputs since business compliance costs are reduced with reductions in NTMs. The study therefore supports a reduction of NTMs in the food processing industry to enhance production and trade.

Though the complete removal of NTMs is not an option, as they are necessary and legitimate instruments to ensure food safety and quality, the positive gains in trade observed through a reduction in NTMs underscore the plausibility of existing restrictive (high trade costs) or protectionist NTMs (that have not been identified) in this sector. To reduce the incidence of measures that impede trade, policymakers need to address the design and method of adoption of NTMs across the food processing subsectors separately. Further, to ensure that SMEs can realise the benefits associated with a reduction of NTMs, policy support in terms of capacity building and infrastructure improvements should be accorded to these firms, given their constraints.

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Appendix A. Sector aggregation

Sectors	Sectors from IO 2010
SEC1 – Agriculture	1–12
SEC2 – Mining and quarrying	13–16
SEC3 – Meat and meat production	17
SEC4 – Seafood	18
SEC5 – Fruits and vegetables	18
SEC6 – Dairy products	20
SEC7 – Oils and fats	21
SEC8 – Grain mills	22
SEC9 – Bakery products	23
SEC10 – Confectionery	24
SEC11 – Other processed food	25
SEC12 – Animal feeds	26
SEC13 – Beverages	27–28
SEC14 – Other manufacturing	29–92
SEC15 – Services	93–124

Appendix B. Product concordance for processed food

Subsector	MSIC 2008	HS 6-digit
Meat and meat production	10101, 10102, 10103, 10104, 10109	020110, 020120, 020130, 020210, 020220, 020230, 020311, 020312, 020319, 020321, 020322, 020329, 020410, 020421, 020422, 020423, 020430, 020441, 020442, 020443, 020450, 020500, 020610, 020621, 020622, 020629, 020630, 020641, 020649, 020680. 020690, 020711, 020712, 020713, 020714, 020724, 020725, 020726, 020727, 020732, 020733, 020734, 020735, 020736, 020810, 020830, 020840, 020850, 020890, 020900, 021011, 021012, 021019, 021020, 021091, 021092, 021093, 021099, 150100, 150200, 160100, 160220, 160231, 160232, 160239, 160241, 160242, 160249, 160250, 160290, 160300, 230110
Seafood	10210, 10202, 10203, 10204, 10205	030270, 030311, 030319, 030321, 030322, 030329, 030331, 030332, 030333, 030339, 030341, 030342, 030343, 030344, 030345, 030346, 030349, 030351, 030352, 030361, 030362, 030371, 030372, 030373, 030374, 030375, 030376, 030377, 030378, 030379, 030380, 030411, 030412, 030419, 030421, 030422, 030429, 030491, 030492, 030499, 030510, 030520, 030530, 030541, 030542, 030549, 030551, 030559, 030561, 030562, 030563, 030569, 030611, 030612, 030613, 030614, 030619, 030729, 030739, 030749, 030759, 030799, 051191, 160411, 160412, 160413, 160414, 160415, 160416, 160419, 160420, 160430, 160510, 160520, 160530, 160540, 160590
Vegetables and fruits	10301, 10302, 10303, 10304, 10305, 10306	071010, 071021, 071022, 071029, 071030, 071040, 071080, 071090, 071120, 071140, 071151, 071159, 071190, 071220, 071231, 071232, 071233, 071239, 071290, 081110, 081120, 081190, 081210, 081290, 081400, 110510, 110520, 200110, 200190, 200210, 200290, 200310, 200320, 200390, 200410, 200490, 200520, 200540, 200551, 200559, 200560, 200570, 200580, 200591, 200599, 200791, 200799, 200811, 200819, 200820, 200830, 200840, 200850, 200860, 200870, 200880, 200891, 200892, 200899, 200911, 200912, 200919, 200921, 200929, 200931, 200939, 200941, 200949, 200950, 200961, 200969, 200971, 200979, 200980, 200990
Manufacture of dairy products	10501, 10502, 10509	040110, 040120, 040130, 040210, 040221, 040229, 040291, 040299, 040310, 040390, 040410, 040490, 040510, 040520, 040590, 040610, 040620, 040630, 040640, 040690, 170211, 170219, 210500

Appendix B. Continued

Subsector	MSIC 2008	HS 6-digit
Oils and fats	10401, 10402, 10403, 10404, 10405, 10406, 10407	120810, 120890, 140420, 150300, 150410, 150420, 150430, 150600, 150710, 150790, 150810, 150890, 150910, 150990, 151000, 151110, 151190, 151211, 151219, 151221, 151229, 151311, 151319, 151321, 151329, 151411, 151419, 151491, 151499, 151511, 151519, 151530, 151550, 151590, 151610, 151620, 151710, 151790, 152110, 152200, 230400, 230500, 230610, 230620, 230630, 230641, 230649, 230650, 230660, 230690
Grain mills	10611, 10612, 10613, 10619, 10621, 10622, 10623	100620, 100630, 100640, 110100, 110210, 110220, 110290, 110311, 110313, 110319, 110320, 110412, 110419, 110422, 110423, 110429, 110430, 110610, 110620, 110630, 190410, 190420, 190430, 190490, 190120, 110811, 110812, 110813, 110814, 110819, 110820, 110900, 151521, 151529, 170230, 170240, 170250, 170260, 170290, 190300
Bakery products	10711, 10712, 10713, 10714	190510, 190520, 190531, 190532, 190540, 190590
Confectionery	10721, 10722, 10731, 10732, 10733	170111, 170112, 170191, 170199, 170220, 170310, 170390, 170410, 170490, 180310, 180320, 180400, 180500, 180610, 180620, 180631, 180632, 180690, 200600
Other processed food	10741, 10742, 10750, 10791, 10792, 10793, 10794, 10795, 10799	040811, 040819, 040891, 040899, 090112, 090121, 090122, 090190, 090210, 090230, 160210, 190110, 200510, 190190, 200710, 210111, 210112, 210120, 210130, 210210, 210220, 210230, 210310, 210320, 210330, 210390, 210410, 210420, 220900, 210610, 210690, 190211, 190219, 190220, 190230, 190240
Animal feeds	10800	230910, 230990
Beverages	11010, 11020, 11030, 11041, 11042	220110, 220190, 220210, 220290, 220300, 220410, 220421, 220429, 220430, 220510, 220590, 220600, 220710, 220720, 220820, 220830, 220840, 220850, 220860, 220870, 220890, 110710, 110720

Note: MSIC – Malaysia Standard Industrial Classification, HS – harmonised system.
Source: DOS (2008).

Appendix C. Sensitivity analysis for production (% change from baseline)

Sector	MS						AS					
	Short run			Long run			Short run			Long run		
	Original assumption	CES & CET reduced by 30%	CES & CET increased by 30%	Original assumption	CES & CET reduced by 30%	CES & CET increased by 30%	Original assumption	CES & CET reduced by 30%	CES & CET increased by 30%	Original assumption	CES & CET reduced by 30%	CES & CET increased by 30%
Meat and meat production	-0.1	-0.1	-0.1	8.1	7.8	8.5	-0.6	-0.5	-0.7	7.0	6.7	7.2
Seafood	0.1	0.1	0.1	13.5	13.1	13.8	0.7	0.6	0.8	14.3	13.9	14.8
Fruits and vegetables	0.7	0.6	0.8	5.5	5.3	5.6	3.9	3.8	4.1	11.4	11.2	11.7
Dairy products	0.0	0.0	0.1	33.9	33.0	34.6	0.2	0.1	0.3	36.8	35.0	38.0
Oils and fats	0.0	0.0	0.1	15.2	14.8	15.7	0.2	0.1	0.2	15.8	15.2	16.1
Grain mills	-0.1	-0.1	-0.1	13.0	12.6	13.5	-0.4	-0.3	-0.5	12.0	11.6	12.3
Bakery products	0.1	0.1	0.1	22.5	22.0	23.1	0.5	0.4	0.6	24.0	23.3	24.8
Confectionery	0.1	0.1	0.1	2.4	2.3	2.5	0.6	0.5	0.7	7.0	6.7	7.2
Other processed food	0.1	0.1	0.1	6.8	6.6	6.9	0.7	0.6	0.8	8.5	8.2	8.7
Animal feeds	-0.7	-0.6	-0.8	21.6	21.0	22.1	-3.9	-3.8	-4.1	15.4	15.1	15.8
Beverages	0.3	0.2	0.4	-3.1	-3.0	-3.2	1.4	1.3	1.5	-0.3	-0.2	-0.4

Note: MS – modest scenario (10% reduction in NTMs), AS – ambitious scenario (50% reduction in NTMs).
Source: GAMS Simulation.

Appendix D. Sensitivity analysis for exports (% change from baseline)

Sector	MS						AS					
	Short run			Long run			Short run			Long run		
	Original assump-tion	CES & CET reduced by 30%	CES & CET increased by 30%	Original assump-tion	CES & CET reduced by 30%	CES & CET increased by 30%	Original assump-tion	CES & CET reduced by 30%	CES & CET increased by 30%	Original assump-tion	CES & CET reduced by 30%	CES & CET increased by 30%
Meat and meat production	1.3	1.2	1.4	37.4	35.4	39.2	7.4	7.1	7.6	43.5	38.8	48.2
Seafood	1.0	0.9	1.1	32.5	30.6	34.0	5.7	5.5	6.0	38.6	37.3	40.0
Fruits and vegetables	1.8	1.7	1.9	11.9	11.2	12.5	9.9	9.5	10.2	24.7	23.8	25.5
Dairy products	1.3	1.2	1.4	180.2	172.5	188.0	7.5	7.2	7.7	209.8	200.0	218.0
Oils and fats	0.7	0.6	0.7	43.6	41.9	45.6	3.9	3.8	4.0	48.6	46.8	49.6
Grain mills	0.6	0.5	0.6	55.9	53.8	58.6	3.4	3.3	3.6	56.3	54.3	58.0
Bakery products	1.2	1.1	1.3	96.4	92.4	100.8	6.4	6.1	6.6	108.6	104.0	112.0
Confectionery	1.0	0.9	1.1	7.6	7.3	7.9	5.1	4.9	5.2	18.6	18.0	19.3
Other processed food	0.9	0.8	1.0	16.6	15.8	17.3	5.0	4.8	5.1	22.7	21.8	23.7
Animal feeds	1.5	1.4	1.6	89.9	87.0	93.0	8.3	8.0	8.6	87.1	84.0	90.0
Beverages	0.8	0.7	0.8	2.4	2.3	2.5	4.2	4.0	4.3	10.2	9.8	10.6

Note: MS – modest scenario (10% reduction in NTMs), AS – ambitious scenario (50% reduction in NTMs).
Source: GAMS Simulation.

Appendix E. Sensitivity analysis for imports (% change from baseline)

Sector	MS						AS					
	Short run			Long run			Short run			Long run		
	Original assump-tion	CES & CET reduced by 30%	CES & CET increased by 30%	Original assump-tion	CES & CET reduced by 30%	CES & CET increased by 30%	Original assump-tion	CES & CET reduced by 30%	CES & CET increased by 30%	Original assump-tion	CES & CET reduced by 30%	CES & CET increased by 30%
Meat and meat production	3.6	3.5	3.7	7.1	6.9	7.4	20.8	20.0	21.3	24.4	23.8	24.9
Seafood	3.1	3.0	3.2	10.3	10.0	10.7	17.8	17.4	18.5	25.4	24.8	26.1
Fruits and vegetables	2.7	2.6	2.8	10.2	9.7	10.6	15.9	15.5	16.4	23.6	23.0	24.3
Dairy products	5.0	4.8	5.1	2.0	1.9	2.1	30.8	30.0	31.7	26.9	26.1	27.6
Oils and fats	3.8	3.6	3.9	5.9	5.7	6.0	22.4	21.7	23.2	24.6	24.0	25.3
Grain mills	3.8	3.7	4.0	5.9	5.8	6.2	22.1	21.5	22.8	24.7	24.2	25.5
Bakery products	6.4	6.2	6.5	4.2	4.0	4.3	42.2	41.0	43.5	39.0	37.8	40.0
Confectionery	2.4	2.3	2.5	8.9	8.6	9.1	13.3	12.9	13.8	20.5	20.0	21.2
Other processed food	4.1	4.0	4.2	7.4	7.1	7.6	24.6	24.0	25.3	28.3	27.5	29.5
Animal feeds	4.3	4.1	4.4	6.1	5.8	6.3	26.9	26.0	27.6	30.2	29.0	31.0
Beverages	3.1	3.0	3.2	3.2	3.1	3.4	17.3	16.8	17.9	17.8	17.3	18.2

Note: MS – modest scenario (10% reduction in NTMs), AS – ambitious scenario (50% reduction in NTMs).
Source: GAMS Simulation.

Appendix F. Model equations

(i) Price Block

Import price:

$$PM_c = (1 + tm_c + m_c) \cdot EXR \cdot pwm_c \tag{1}$$

$$\begin{bmatrix} \textit{import price} \\ (\textit{DCU}) \end{bmatrix} = \begin{bmatrix} \textit{tariff and} \\ \textit{AVEs of NTMs} \\ \textit{adjustment} \end{bmatrix} \cdot \begin{bmatrix} \textit{exchange rate} \\ (\textit{DCU per FCU}) \end{bmatrix} \cdot \begin{bmatrix} \textit{import price} \\ (\textit{foreign currency}) \end{bmatrix}$$

Export price:

$$PE_c = (1 - te_c) \cdot EXR \cdot pwe_c \tag{2}$$

$$\begin{bmatrix} \textit{export price} \\ (\textit{DCU}) \end{bmatrix} = \begin{bmatrix} \textit{tariff} \\ \textit{adjustment} \end{bmatrix} \cdot \begin{bmatrix} \textit{exchange rate} \\ (\textit{DCU per FCU}) \end{bmatrix} \cdot \begin{bmatrix} \textit{export price} \\ (\textit{foreign currency}) \end{bmatrix}$$

Absorption price:

$$PQ_c \cdot QQ_c = \left[(PD_c \cdot QD_c) + (PM_c \cdot QM_c)_{c \in CM} \right] \cdot (1 + tq_c) \tag{3}$$

$$[\textit{absorption}] = \begin{bmatrix} \textit{domestic sales price} \\ \textit{times} \\ \textit{domestic sales quantity} \end{bmatrix} + \begin{bmatrix} \textit{import price} \\ \textit{times} \\ \textit{import quantity} \end{bmatrix} \cdot \begin{bmatrix} \textit{sales tax} \\ \textit{adjustment} \end{bmatrix}$$

Domestic output value:

$$PX_c \cdot QX_c = PD_c \cdot QD_c + (PE_c \cdot QE_c) \tag{4}$$

$$\begin{bmatrix} \textit{producer price} \\ \textit{times} \\ \textit{domestic output quantity} \end{bmatrix} = \begin{bmatrix} \textit{domestic sales price} \\ \textit{times} \\ \textit{domestic sales quantity} \end{bmatrix} + \begin{bmatrix} \textit{export price} \\ \textit{times} \\ \textit{export quantity} \end{bmatrix}$$

Activity price:

$$PA_a = \sum_{c \in C} PX_c \cdot \theta_{ac} \tag{5}$$

$$\begin{bmatrix} \textit{activity} \\ \textit{price} \end{bmatrix} = \begin{bmatrix} \textit{producer price} \\ \textit{times} \\ \textit{yields} \end{bmatrix}$$

Value-added price:

$$PVA_a = PA_a - \sum_{c \in C} PQ_c \cdot ica_c \tag{6}$$

$$\begin{bmatrix} \textit{value-added} \\ \textit{price} \end{bmatrix} = \begin{bmatrix} \textit{intermediate input cost} \\ \textit{per unit of aggregate} \\ \textit{intermediate input} \end{bmatrix} - \begin{bmatrix} \textit{input cost} \\ \textit{per activity unit} \end{bmatrix}$$

Consumer price index:

$$\overline{CPI} = \sum_{c \in C} PQ_c \cdot cwts_c \tag{7}$$

$$\begin{bmatrix} consumer \\ price\ index \end{bmatrix} = \begin{bmatrix} price\ times \\ weights \end{bmatrix}$$

(ii) Production Block

Activity production function:

$$QA_a = \sigma_a \prod_f F_a \cdot QF_f^{\alpha f} \tag{8}$$

$$\begin{bmatrix} activity \\ level \end{bmatrix} = f \begin{bmatrix} factor \\ inputs \end{bmatrix}$$

Factor demand:

$$WF_f * WFDIST_{fa} = \alpha_{fa} * PVA_a \left(\frac{QA_a}{QF_{fa}} \right) \tag{9}$$

$$\begin{bmatrix} marginal\ cost \\ of\ factor\ f \\ in\ activity\ a \end{bmatrix} = \begin{bmatrix} marginal\ revenue \\ product\ of\ factor \\ f\ in\ activity\ a \end{bmatrix}$$

Intermediate demand:

$$QINT_{ca} = ica_{ca} * QA_a \tag{10}$$

$$\begin{bmatrix} intermediate \\ demand \end{bmatrix} = f \begin{bmatrix} activity \\ level \end{bmatrix}$$

Output function:

$$QX_c = \sum_a \theta_{ac} * QA_a \tag{11}$$

$$\begin{bmatrix} domestic \\ output \end{bmatrix} = f \begin{bmatrix} activity \\ level \end{bmatrix}$$

Composite supply (Armington) function:

$$QQ_c = \alpha_c^q \cdot \left(\delta_c^q \cdot QM_c^{-p_c^q} + (1 - \delta_c^q) \cdot QD_c^{-p_c^q} \right)^{\frac{1}{-p_c^q}} \tag{12}$$

$$\begin{bmatrix} composite \\ supply \end{bmatrix} = f \begin{bmatrix} import\ quantity, \\ domestic\ use\ of \\ domestic\ output \end{bmatrix}$$

Import–domestic demand ratio:

$$\frac{QM_c}{QD_c} = \left[\frac{PD_c}{PM_c} \cdot \frac{\delta_c^q}{1-\delta_c^q}\right]^{\frac{1}{1+p_c^q}} \tag{13}$$

$$\begin{bmatrix} import\text{ -} \\ domestic \\ demand\ ratio \end{bmatrix} = f \begin{bmatrix} domestic\text{ -} \\ import \\ price\ ratio \end{bmatrix}$$

Composite supply for non-imported commodities:

$$QQ_c = QD_c \tag{14}$$

$$\begin{bmatrix} composite \\ supply \end{bmatrix} = \begin{bmatrix} domestic\ use\ of \\ domestic\ output \end{bmatrix}$$

Output transformation (CET) function:

$$QX_c = \alpha_c \left[\delta_c \cdot QE_c^{pc} + (1-\delta_c) QD_c^{pc}\right]^{\frac{1}{pc}} \tag{15}$$

$$\begin{bmatrix} domestic \\ output \end{bmatrix} = f \begin{bmatrix} export\ quantity, \\ domestic\ use\ of \\ domestic\ output \end{bmatrix}$$

Export–domestic supply ratio:

$$\frac{QE_c}{QD_c} = \left[\frac{PE_c}{PD_c} \cdot \frac{1-\delta_c}{\delta_c}\right]^{\frac{1}{\rho_{c-1}}} \tag{16}$$

$$\begin{bmatrix} export\text{ -} \\ domestic \\ supply\ ratio \end{bmatrix} = f \begin{bmatrix} export\text{ -} \\ domestic \\ price\ ratio \end{bmatrix}$$

Output transformation for non-exported commodities:

$$QX_c = QD_c \tag{17}$$

$$\begin{bmatrix} domestic \\ output \end{bmatrix} = \begin{bmatrix} domestic\ sales\ of \\ domestic\ output \end{bmatrix}$$

(iii) Institution Block

Factor income:

$$YF_f = shry_{hf} \sum_{\alpha \in A} WF_f \cdot WFDIST_{fa} \cdot QF_{fa} \tag{18}$$

$$\begin{bmatrix} factor\ income \end{bmatrix} = \begin{bmatrix} income\ share\ to \\ household\ h \end{bmatrix} \cdot \begin{bmatrix} factor\ income \end{bmatrix}$$

Household income:

$$YH_h = \sum_{f\in F} YF_{hf} + tr_{h,gov} + EXR \cdot tr_{h,ROW} \qquad (19)$$

$$\begin{bmatrix} household\ income \\ from\ factor\ f \end{bmatrix} = \begin{bmatrix} factor \\ incomes \end{bmatrix} + \begin{bmatrix} transfer\ from\ government \\ and\ rest\ of\ world \end{bmatrix}$$

Household consumption demand:

$$QH_{ch} = \frac{\beta_{ch} \cdot (1 - mps_h) \cdot (1 - ty_h) \cdot YH_h}{PQ_c} \qquad (20)$$

$$\begin{bmatrix} household\ demand \\ for\ commodity\ c \end{bmatrix} = f \begin{bmatrix} household\ income, \\ composite\ price \end{bmatrix}$$

Investment demand:

$$QINV_c = \overline{qinv}_c \cdot IADJ \qquad (21)$$

$$\begin{bmatrix} investment\ demand \\ for\ commodity\ c \end{bmatrix} = \begin{bmatrix} based\ year\ investment \\ times\ adjustment\ factor \end{bmatrix}$$

Government revenue:

$$\begin{aligned} YG = {} & \sum_f YH_{ht} * ty_h + EXR * tr_{Gov,Row} + \sum_{c\in CM} (tq_c * PQ_c * QD_c) + (PM_c * QM_c) + \\ & \sum_{c\in CM} tm_c * EXR * pwm * QM_c + \sum_{c\in CE} te_c * EXR * pwe_c * QE_c + \\ & \sum_{c\in CM} m_c * EXR * pwm_c + yg_i \end{aligned} \qquad (22)$$

$$\begin{bmatrix} government \\ revenue \end{bmatrix} = \begin{bmatrix} direct\ taxes \\ from\ institutions \end{bmatrix} + \begin{bmatrix} transfer \\ from \\ ROW \end{bmatrix} + \begin{bmatrix} sales \\ tax \end{bmatrix} + \begin{bmatrix} import \\ tariffs \end{bmatrix} + \begin{bmatrix} export \\ tariffs \end{bmatrix} + \begin{bmatrix} AVEs \\ of \\ NTMs \end{bmatrix}$$

Government expenditure:

$$EG = \sum_c PQ_c \cdot QG_c + \sum_h tr_{h,GOV} \qquad (23)$$

$$\begin{bmatrix} government \\ expenditure \end{bmatrix} = \begin{bmatrix} government \\ consumption \end{bmatrix} + \begin{bmatrix} household \\ transfer \end{bmatrix}$$

Real gross domestic product:

$$RGDP = \sum_c (\sum_h QH_{ch} + QG_c + QINV_c) + \sum_c QE_c - \sum_c QM_c \qquad (24)$$

$$\begin{bmatrix} Real \\ GDP \end{bmatrix} = \begin{bmatrix} real\ household\ consumption + \\ real\ government\ spending + \\ real\ investment + \\ real\ export - real\ import \end{bmatrix}$$

(iv) System Constraint Block

Factor market:

$$\sum_{a\in A} QF_{fa} = QFS_f \tag{25}$$

$$\begin{bmatrix} \text{demand for} \\ \text{factor } f \end{bmatrix} = \begin{bmatrix} \text{supply of} \\ \text{factor } f \end{bmatrix}$$

Composite commodity market:

$$QQ_c = \sum_{a\in A} QINT_{ca} + \sum_{h\in H} QH_{ch} + QG_c + QINV_c \tag{26}$$

$$\begin{bmatrix} \text{composite} \\ \text{supply} \end{bmatrix} = \begin{bmatrix} \text{composite demand,} \\ \text{sum of intermediate,} \\ \text{household,} \\ \text{government and} \\ \text{investment demand} \end{bmatrix}$$

Current account balance:

$$\sum_{C\in CE} pwe_c \cdot QE_c + \sum_i tr_{i,ROW} + \overline{FSAV} = \sum_{C\in CE} pwm_c \cdot QM_c + irepat + yfrepat_{CAP} + yfrepat_{LAB} \tag{27}$$

$$\begin{bmatrix} \text{export} \\ \text{revenue} \end{bmatrix} + \begin{bmatrix} \text{transfer from} \\ \text{ROW to households} \\ \text{and government} \end{bmatrix} + \begin{bmatrix} \text{foreign} \\ \text{saving} \end{bmatrix} = \begin{bmatrix} \text{import} \\ \text{spending} \end{bmatrix}$$

Savings-investment balance:

$$\sum_h mps_h \cdot (1 - ty_h) * YH_h + (YG - EG) + (EXR \cdot \overline{FSAV}) = ygi + (EXR \cdot irepat) + \sum_{c\in C} PQ_c \cdot QINV_c + WALRAS_t \tag{28}$$

$$\begin{bmatrix} \text{household} \\ \text{savings} \end{bmatrix} + \begin{bmatrix} \text{government} \\ \text{savings} \end{bmatrix} + \begin{bmatrix} \text{foreign} \\ \text{savings} \end{bmatrix} = \begin{bmatrix} \text{fixed} \\ \text{investment} \end{bmatrix} + \begin{bmatrix} \text{WALRAS} \\ \text{dummy} \\ \text{variable} \end{bmatrix}$$