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Demand elasticity of processed food exports from developing countries: A panel analysis of U.S. imports

Wanissa Suanin[1]

Abstract

There has been a growing emphasis in resource-rich developing countries on promoting processed food exports as part of their export expansion and diversification strategy. A key issue for this strategy is whether global market conditions are conducive for significant trade gains. We estimate price and income elasticities of demand for processed food exports from developing countries using a new quarterly panel dataset for the United States, the major market for these products, over the period 1992–2018. Our findings indicate that demand for processed food imports from developing countries has high income elasticity combined with low price elasticity. The implication is that expansion of imports is driven by demand expansion driven by income growth which counterbalances any possible negative impact of an increase in relative prices. Income elasticity of demand for processed food imports is much higher than that for unprocessed food imports, reflecting preferences for processed food.

Keywords: *Demand elasticity*; *Processed food trade*; *Developing countries*; *ARDL estimator*

JEL classifications: *F140, Q110, Q170*

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1. Introduction

Over the recent past, food products exported in processed form (processed food) have expanded at a much faster rate than traditional (unprocessed) food exports.[2] These products have become increasingly important in the export composition of agriculture-focused developing countries. This structural change in world exports has been underpinned by both demand and supply factors. On the demand side, rising income levels, urbanisation, immigration, and internationalisation of food habits have contributed to an increase in the consumption of imported processed food, mostly in developed countries (Athukorala and Jayasuriya, 2003; Euromonitor International, 2012). On the supply side, an expansion of processed food has increased notably thanks to advances in the technology of food processing, improvement in refrigeration, global transportation facilities, and the expansions of contract farming opportunities for an ever-wider variety of food products driven by the supermarket revolution.

The export opportunity in processed food deserves special attention in the context of agricultural resource-rich countries for the following reasons (Athukorala and Jayasuriya 2003; Baiardi et al. 2015; Niimi et al., 2007; Wilkinson, 2012; Zahniser et al., 2017). First, most processed food products have considerably high domestic input content (greater domestic value-added), compared to conventional labour-intensive manufactured products such as garments, footwear, and electronic assembly. Second, since food processing is highly labour-intensive and has a strong rural/agricultural base, these exports contribute to economy-wide spread effects, including employment generation and poverty alleviation. Third, diversification of exports from traditional (unprocessed agricultural) products to processed food products could bring substantial trade gains.

A key issue relating to promoting processed food exports as part of a national development strategy is whether global market conditions are conducive for accommodating export expansion. To this end, it is important to study income and price elasticities of import demands for processed foods from developing countries. There is a large empirical literature on determinants of import (export) demand (e.g., Jones, 2008; Kee et al., 2008; Emran and Shilpi, 2010; Athukorala and Khan, 2016; Ghodsi et al., 2016; Hummels and Lee, 2018). Some studies have examined import (export) demand for agricultural products (e.g., Gale et al., 2015).

[2] The United States Federal Food, Drug and Cosmetic Act (CHAPTER 9, SUBCHAPTER II), defines processed food as "any food other than a raw agricultural commodity and includes any raw agricultural commodity that has been subject to processing, such as canning, cooking, freezing, dehydration, or milling".

However, to the best of our knowledge, there has been only one econometric analysis of income and price elasticities of export demand for processed food products (Baiardi et al., 2015). That study covers processed food exports of eleven leading food-exporting countries[3] during the period 1992–2012. Its key implication is that the price elasticity of demand for processed food is generally below that for unprocessed products, while the opposite holds for income elasticity.

The Baiardi et al. (2015) findings are subject to three methodological limitations. First, given the lack of data on export (import) prices, they used export unit value as a proxy for export price. The unit values, calculated by dividing export (import) values by physical quantity of exports (imports), could yield spurious price changes because changes in the composition of products, and its units of measurement can result in changes in unit values even if the actual export (import) prices remain the same (Silver, 2009). Second, the model formulation is based on the assumption that export demand is homogenous of degree zero in price, without statistically testing whether this model specification is appropriate. Third, the relevance of their findings for informing the policy debate in developing countries is limited because developed (high-income) countries dominate the country coverage: there are notable differences in the composition of processed food exports between developed and developing countries (Section 2).

Our purpose is to estimate the income and price elasticities of demand for processed food imports using a quarterly panel dataset constructed for imports by the United States during the period 1992–2018, focussing on processed food imports from developing countries. For comparative purposes, unprocessed food imports from developing countries and processed food imports from developed countries are also covered in the study. This comparative perspective is needed to understand the potential for promoting processed food exports as part of the export promotion drive in developing countries. The United States is selected for the study for two reasons. First, actual import price indices, rather than unit values, are available for the United States at the two-digit level of the harmonised system (HS) of trade classification for a period of the adequate length required for econometric estimation. Second, the United States is the world's largest importer of processed food products. In 2018, the US accounted for about a quarter of total world imports of processed food from developing countries. In terms of methodological improvements, the econometric technique for panel data is used to identify both short-run and long-run income and price elasticities. It allows us to capture unobserved

[3] Argentina, Australia, Brazil, Canada, China, France, Germany, Italy, Netherlands, Span, and the USA.

effects or variables common to product groups in any years. The import demand function is estimated for total US processed food imports and main subcategories, distinguishing between imports from developing and developed countries. Also, the homogeneity restriction on domestic and import prices is systematically tested to explore the appropriate specification of the import demand function.

The rest of this paper is organised as follows. Section 2 provides an overview of emerging patterns and composition of processed food imports to the US and the relative importance of the US as a market for these products from developing countries in order to place the econometric analysis in context. Section 3 describes the methodology including the model specification, data and measurement as well as econometric procedures. The results are presented in Section 4. A final section summarises the findings and discusses policy implications.

2. Trends and patterns of US processed food imports

The relative importance of processed food in world agricultural exports has increased considerably over the past few decades, increasing from 43 per cent in 1988 to 56 per cent in 2018.[4] More than half of processed food exports still come from developed countries. However, the share of developing countries increased continuously from 20 per cent in the early 1990s to 33 per cent by 2018. Middle-income countries, in particular, China, Mexico, Indonesia, Brazil, and Thailand, are the major developing country exporters.

The main importing countries of processed foods are the United States, Japan, China, India, and the Netherlands.[5] The United States, Japan, and China, in that order, were the three largest export destinations of processed food products from developing countries in 2018. The United States' share of total world processed food imports increased from about 9 per cent in the early 1990s to 13 per cent in 2018. Its share in total world processed food imports from developing countries increased at a faster rate over this period, from about 15 per cent to 24 per cent.

[4] The shares are calculated from partner-country data compiled from the United Nations Comtrade database. See Appendix Table A1 (on-line) for details on the classification system used for separating processed food from the reported trade data.
[5] The EU, as a whole, is the largest importer of food products from developing countries. However, in this study, we treat individual member countries of the EU separately. The high imports of the Netherlands presumably reflect the role of Rotterdam as a transhipment hub.

As reported in Table 1, The US processed food imports from developing countries increased from about $9 billion to over $48 billion between 1990–94 and 2014–18. The share of imports from developing countries increased from around 41 per cent to 49 per cent between these two periods. The largest shares in 2014–18 came from Mexico (18%), China (5%), Indonesia (3%), Chile (3%), and Thailand (3%), respectively. Mexico's share doubled from approximately 9 per cent in 1990–94 to 18 per cent in 2014–18, which could be related to the North American Free Trade Agreement (NAFTA) and subsequent trade agreements. Similarly, the shares of China, Indonesia, and Chile also exhibited upward trends. However, they had increased more slowly than the share of Mexico. By contrast, the share of Thailand has gradually declined from about 6 per cent in 1990–94 to 3 per cent in 2014–18.

Table 1. Source-country profile of processed food imports by the United States, 1990–2018[a]

	Import values (billion dollars)			Import shares (per cent)		
	1990-94	2000-04	2014-18	1990-94	2000-04	2014-18
Developing countries	**8.7**	**17.1**	**47.7**	**40.6**	**40.7**	**48.6**
Mexico	1.9	5.3	17.4	8.9	12.4	17.7
China	0.5	1.6	5.3	2.6	3.6	5.4
Indonesia	0.3	0.7	2.9	1.3	1.6	3.0
Chile	0.3	0.9	2.8	1.5	2.2	2.8
Thailand	1.2	1.9	2.6	5.8	4.7	2.6
Developed countries	**11.9**	**24.0**	**49.3**	**56.0**	**57.5**	**50.3**
Canada	3.7	9.7	18.4	17.6	23.3	18.8
France	1.1	2.2	5.1	5.3	5.4	5.1
Italy	0.9	2.0	4.6	4.2	4.6	4.7
Australia	1.1	1.8	3.2	5.1	4.3	3.2
United Kingdom	0.8	1.3	2.7	4.0	3.2	2.7
Transition economies	**0.7**	**0.7**	**1.1**	**3.4**	**1.8**	**1.1**
Total	**21.3**	**41.8**	**98.1**	**100**	**100**	**100**

Note: a\ Five-year average shares of processed food import values

Source: Author's calculation using the SITC Rev. 3 import data from the United Nations Comtrade database

There are notable differences in the commodity composition of the US processed food imports from developed and developing countries (Table 2). The composition of imports from developing countries has become notably diversified during 1990–2018. However, it is still heavily concentrated in two products at the two-digit level of the Standard International Trade Classification (SITC), fish and crustaceans (SITC 03) and vegetables and fruits (SITC 05). Developing countries accounted for over two-thirds of total US imports of fish and crustaceans, and vegetables and fruits throughout this period (Table 3). Yet, the share of fish and crustaceans in total imports from these countries has substantially declined from roughly 43 per cent in

1990–94 to around 27 per cent in 2014–2018. Meanwhile, beverage's share has considerably increased from about 5 per cent to 14 per cent between these two periods. The composition of imports from developed countries has undergone only minor changes over time. It is more diversified than imports from developing countries (Table 2). In 2014–18, beverages (33%), meat preparations (15%), and vegetables and fruits (10%) were the major imports from these countries. The import demand for these food categories is estimated in section 4 of this paper.

Table 2. Composition of US processed food imports from developing and developed countries, 1990–2018 (per cent)[a]

SITC[b] code	Product	1990-94	2000-04	2014-18
Total		100.0	100.0	100.0
01	Meat prep.	14.2	11.0	9.5
02	Dairy and eggs prep.	2.6	2.8	2.2
03	Fish and crustaceans	28.6	25.9	18.5
04	Flour and cereals	3.7	5.4	7.3
05	Vegetables and fruits	17.6	16.4	19.6
06	Sugars prep.	2.5	3.2	3.6
07	Coffee, tea, cocoa prep.	4.0	4.0	4.4
09	Miscellaneous edible	2.5	4.1	5.5
11	Beverages	19.8	23.8	23.1
41	Animal oils, fats	0.2	0.2	0.3
42	Vegetable oils, fats	4.3	3.2	6.03
Developed countries		100.0	100.0	100.0
01	Meat prep.	21.5	17.4	14.6
02	Dairy and eggs prep.	4.4	4.6	3.8
03	Fish and crustaceans	17.2	12.1	9.0
04	Flour and cereals	4.9	7.5	9.8
05	Vegetables and fruits	8.0	9.5	10.2
06	Sugars prep.	2.9	3.2	2.6
07	Coffee, tea, cocoa prep.	3.3	4.7	4.9
09	Miscellaneous edible	2.5	4.8	5.9
11	Beverages	31.3	32.6	32.6
41	Animal oils, fats	0.2	0.2	0.4
42	Vegetable oils, fats	3.7	3.3	6.2
Developing countries		100.0	100.0	100.0
01	Meat prep.	4.9	2.5	4.4
02	Dairy and eggs prep.	0.3	0.5	0.5
03	Fish and crustaceans	42.8	43.3	27.3
04	Flour and cereals	1.8	2.7	4.8
05	Vegetables and fruits	31.1	26.5	29.7
06	Sugars prep.	1.8	3.2	4.6
07	Coffee, tea, cocoa prep.	4.9	3.1	4.0
09	Miscellaneous edible	2.3	3.1	5.0
11	Beverages	4.7	11.9	13.6
41	Animal oils, fats	0.1	0.04	0.2
42	Vegetable oils, fats	5.4	3.2	5.9

Note: a\ Five-year average shares of processed food import values

b\ Standard International Trade Classification.

Source: Author’s calculation using the SITC Rev. 3 import data from the United Nations Comtrade database

Table 3. The share of developing countries in US processed food imports, 1990–2018 (per cent)[a]

SITC[b] code	Product	1990-94	2000-04	2014-18
01	Meat prep.	14.1	9.1	22.8
02	Dairy and eggs prep.	4.3	7.0	11.8
03	Fish and crustaceans	60.7	68.2	71.7
04	Flour and cereals	20.2	19.9	30.9
05	Vegetables and fruits	71.3	65.9	73.4
06	Sugars prep.	29.5	40.8	62.4
07	Coffee, tea, cocoa prep.	50.2	31.3	44.3
09	Miscellaneous edible	37.3	30.8	42.3
11	Beverages	9.6	20.3	28.6
41	Animal oils, fats	17.2	11.5	28.5
42	Vegetable oils, fats	50.3	40.7	47.9

Note: a\ Five-year average shares of processed food import values

b\ Standard International Trade Classification.

Source: Author's calculation using the SITC Rev. 3 import data from the United Nations Comtrade database

3. Methodology

3.1 The model

The import function can be derived from either the demand side assuming utility maximization by consumers subject to a budget constraint, or the production function approach assuming a cost-minimizing producer. In this study, we specify the import function on the demand side because processed food is a final product, not an intermediate input.[6]

The import demand function, when adapted to a panel dataset, takes the following form:

$$lnQ_{i,t} = \alpha_0 + \alpha_{1i}\ln RP_{i,t} + \alpha_{3i}lnY_{i,t} + \gamma_i + \eta_t + \epsilon_{i,t} \quad (1)$$

where Q is the real processed food import; RP denotes the relative price (the ratio of import and domestic prices: *IPI*/*DM)* of processed food; Y is the income of the importing country.[7] The notation γ is product-specific fixed effects capturing time-invariant unobserved product characteristics; η is time-specific effects, and ϵ is the error term. Price and income elasticities

[6] For surveys of the extensive literature on estimating trade elasticities following this approach, see Goldstein and Khan (1985), Sawyer and Sprinkle (1999), and Marquez (2002).

[7] Given the rapid growth in processed food exports worldwide, product quality is presumably an important determinant of import demand. Real capital stocks, and R&D expenditure are commonly used as indirect measures of product quality. However, tha data on these reasonably good proxies are not available for the processed food industry, which encompasses highly heterogeneous groups of products. In this study, the effect of product quality is assumed to be subsumed in the time-specific fixed effects (η_t). It is reasonable that time-specific fixed effect term captures, at least partly, product quality changes because quality improvement is a time-varying phenomenon. For further research, a weighted average of per capita GDPs of exporters, typically used as a measure of product quality of total exports, could be measured in an industrial level, as applied in the study of Baiardi and Bianchi (2019).

of demand are given by α_1 and α_3, respectively. The subscript *i* and *t* are the *i-th* goods and the *t-th* quarter-year, respectively.

The relative price term (RP) in equation (1) is based on the assumption of homogeneity of degree zero in import and domestic prices. However, consumers may react differently to changes in import and domestic prices (Murray and Ginman, 1976). When this assumption is removed, equation (1) becomes

$$lnQ_{i,t} = \alpha_0 + \alpha_{1i} lnIPI_{i,t} + \alpha_{2i} lnDM_{i,t} + \alpha_{3i} lnY_{i,t} + \gamma_i + \eta_t + \epsilon_{i,t} \qquad (2)$$

The test for the functional form is based on equation (2). If the price homogeneity assumption holds, we will have

$$\alpha_1 = -\alpha_2 \qquad or \qquad \alpha_1 + \alpha_2 = 0$$

This is tested by the Wald test under the null hypothesis of homogeneity in price.

3.2 Data sources and variable construction

The import demand equation is estimated using quarterly import data of the United States for the period 1992–2018. The US merchandise import statistics based on the Standard International Trade Classification, Revision 3 (SITC Rev 3) are taken from the US International Trade Commission. The data on import price index (IPI) based on harmonised system (HS) is collected from the US Bureau of Labor Statistics (BLS) database. Monthly import price indexes of food products are available at the HS 2-digit level (chapter levels) for most products and at the HS-section level for others. Data are compiled by combining HS chapter and section level data as detailed in Appendix A2 (on-line). Monthly data are converted to quarterly averages and then rebased to 2009q4.

Processed and unprocessed (traditional) food products are delineated from trade data at SITC 5-digit level[8] and matched with the HS-based import price data using the HS-SITC concordance available on the website of the U.N. Statistical Office. Nominal (current US$) import data are converted into real terms (at 2009q4 price) using the import price indexes. The

[8] See footnote 4.

source countries of imports (exporting countries) are classified into developing and developed country groups, based on the U.N. Standard Country Classification.[9]

The data on domestic price (DM) of processed and unprocessed foods are measured by producer price index (2009q4 = 100) of processed food and farm products, respectively. They are extracted from the US Bureau of Labor Statistics database. Real income (Y) is measured by real personal consumption expenditure compiled from the US Bureau of Economic Analysis database.

Besides, the quarter-of-year dummy variables are included to capture seasonality in import demand. Also, a dummy variable (GFC), which takes value 1 for 2008q1–2009q4 and 0 otherwise, is included in the model to capture the impact of the global financial crisis on import demand.

3.3 Econometric procedures

The first step in econometric estimation is to examine the time-series properties of the data series. The first-generation panel unit root test (MW) proposed by Maddala and Wu (1999) and the second-generation panel unit root test (CIPS) proposed by Pesaran (2007) are used for this purpose. Also, the (augmented) Dickey-Fuller (DF) test is used to check the unit root of *Y* and *DM*.

The results reported in Table 4 indicate that overall all variables are non-stationary, I(1). According to both MW and CIPS tests, the null hypothesis cannot be rejected at the 1 per cent significance level for processed food imports from developing countries, implying that *Q* is integrated of order 1, I(1). The import price index (IPI) is non-stationary in terms of the MW test but stationary in term of the CIPS test. Moreover, the ADF tests indicate that both *DM* and *Y* are I(1): non-stationary in level and stationary after taking the first difference.

[9] Countries are classified into developed and developing countries based on the U.N. Standard Country Classification (2019 edition). It is available at: https://www.un.org/development/desa/dpad/wp-content/uploads/sites/45/WESP2019_BOOK-ANNEX-en.pdf (last accessed 15 March 2020)

Table 4. The unit root tests

variable	Panel unit root test 1st generation (MW)	2nd generation (CIPS)	Time series unit root test Level (ADF)	1st difference (ADF)
$\ln Q_{i,t}$	71.13	-1.26		
	(0.20)	(0.10)		
$\ln IPI_{i,t}$	37.59	-3.59***		
	(0.99)	(0.00)		
$\ln DM_t$			-0.58	-3.98***
			(0.16)	(0.00)
$\ln Y_t$			-1.38	-2.25**
			(0.17)	(-0.03)

Note: Maddala and Wu (1999) Panel Unit Root test (MW) is the 1st generation while Pesaran (2007) Panel Unit Root test (CIPS) is the 2nd generation; the null hypotheses for MW and CIPS tests are 'series is I(1)'; For the (augmented) Dickey-Fuller (ADF) test, the null hypothesis is 'the series contain unit roots'; The intercept is included in the test equations, and maximum selected lag length is 8; P-values are shown in parentheses where ***, **, * are statistically significant at 0.01, 0.05, 0.1 levels, respectively.

Source: Author's calculation

Given that all variables are I(1), the Pedroni test is used to verify the existence of a long-run relationship between variables (Q, IPI, DM, and Y) (Pedroni, 1999, 2004) (Table 5). According to Pedroni (2004), the panel-v statistic has better power than the other six Pedroni test statistics. The result indicates that all seven statistics are statistically significant. Thus, we can conclude that there is cointegration among variables of interest.

Table 5. Pedroni's cointegration tests

Test Stats	**panel**	**group**
v	1.85**	
rho	-16.30***	-19.60***
t	-16.77***	-20.19***
ADF	4.03***	3.83***

Note: All test statistics are distributed N(0,1) under a null of no cointegration, and diverge to negative infinity (save for panel v); Data has been time-demeaned and a time trend has been included; Akaike information criterion (AIC) is used to decide the optimal lags, and maximum lag length is 8.; ***, **, * indicate statistically significant at 0.01, 0.05, 0.1 levels, respectively.

Source: Author's calculation

As the panel cointegration test indicates that there exists a long-run relationship among variables, the panel Auto-Regressive Distribution Lag (ARDL) estimator is used for estimating the import demand function. There are two advantages of ARDL models. First, the import equation can be reparametrised to a panel error correction model (ECM), allowing us to examine not only the existence of cointegration but also short-run dynamics among variables and the speed of adjustment of the model to equilibrium. Second, the ARDL specification is less susceptible to the endogeneity problem, which possibly results from the simultaneous relation between price and import variables. Pesaran (2015, p.726) indicated that "*ARDL models are robust to integration and cointegration properties of the regressors, and for sufficiently high lag-orders could be immune to the endogeneity problem, at least as far as the long-run properties of the model are concerned.*" Also, the possible endogeneity bias could be asymptotically negligible due to the super consistency property of the ARDL model (Banerjee et al., 1993, p.176). The model specification in equation (2) can be rewritten in ARDL form as follows:

$$lnQ_{i,t} = \sum_{k=1}^{p} \phi_i lnQ_{i,t-k} + \sum_{k=0}^{q} \beta'_{ik} lnX_{i,t-k} + \gamma_i + \eta_t + \epsilon_{i,t} \quad (3)$$

where $Q_{i,t}$ is the dependent variable, $X_{i,t}$ is a vector of explanatory variables that are allowed to be purely I(0) or I(1) or cointegrated; ϕ_i is scalars or the coefficient of the lagged dependent variable; β'_{ik} are coefficient vectors; *p* and *q* are optimal lag orders.

Equation (3) can be reparametrised in an error correction form to examine short-run and long-run relationships between variables as follows:

$$\Delta lnQ_{i,t} = \rho_i\left[lnQ_{i,t-1} - \lambda'_i lnX_{i,t-1}\right] + \sum_{k=1}^{p-1} \zeta_{ik} \Delta lnQ_{i,t-k} + \sum_{k=0}^{q-1} \beta'_{ik} \Delta lnX_{i,t-k} + \gamma_i + \eta_t + \epsilon_{i,t} \quad (4)$$

where $\rho_i = -(1 - \phi_i)$ is the speed of adjustment coefficient (expected that $\rho_i < 0$), representing the speed of adjustment of imports to a shock to move back to long-run equilibrium; λ'_i is the vector of long-run coefficients; $ECT = \left[lnQ_{i,t-1} - \lambda'_i lnX_{i,t-1}\right]$ is the error correction term; ζ_{ik} and β'_{ik} are the short-run dynamic coefficients.

The Akaike information criterion (AIC) is used to decide the choice of lags for each product group per variable, and then the most common lag for each variable is chosen to represent the lags for the model. To explore potential heterogeneity of parameters, we utilise three alternative methods, including the Dynamic Fixed Effects estimator (DFE), the Pooled Mean Group estimator (PMG), and the Mean Group estimator (MG). The standard Dynamic Fixed Effects estimator (DFE) allows the intercepts to differ freely across groups, while all other coefficients and error variances are constrained to be the same. Although this estimator could be biased when applied to dynamic models, the size of the bias tends to zero as the time dimension grows (Nickell, 1981). Meanwhile, the Mean Group estimator (MG) is the estimator that allows coefficients to differ freely across groups. It is obtained by estimating one equation per group and taking the average across groups. The Pooled Mean Group estimator (PMG) proposed by Pesaran, Shin, and Smith (1999) is an intermediate between the DFE and MG estimations. That is, short-run coefficients, intercepts, and the variances are allowed to differ freely across groups, but the parameter is constrained to be the same in the long run.

The most appropriate estimator is selected using the test proposed by Hausman (1978). The Hausman test compares two estimators (λ_1, λ_2) where λ_1 is known to be consistent while λ_2 is efficient under the assumption that the covariance matrices are based on the estimated disturbance variance from the efficient estimator. The estimator λ_2 will be selected if the test cannot reject the null hypothesis that λ_2 is indeed an efficient (and consistent) estimator of the actual parameter λ.

4. Results

The Hausman test suggests that DFE is the most efficient estimator.[10] The estimated import demand functions for processed food imports from developing and developed countries and unprocessed food imports from developing countries are reported in Table 6. The hypothesis of homogeneity of import response to import and domestic prices is rejected by the Wald test for all three equations.

In the equation for processed food import from developing countries (column 1 of Table 6), the long-run estimates have expected signs, and they are significant at the 1 per cent level. The coefficient of the speed of adjustment term is statistically significant, confirming the existence of the cointegrated relation among processed food imports, prices, and income. In the short term, the import demand is statistically sensitive to a change in prices and income. In the long run, both prices and income also affect the processed food import, with the demand for processed food being own price inelastic (-0.6), cross-price elastic (2.9) and income elastic (2.0). The low own-price elasticity is consistent with other studies in food and agricultural exports from developing countries in general (e.g., Islam and Subramanian, 1989; Bredahl et

[10] The alternative PGM and MG estimates are available upon request.

al., 1979; Baiardi et al., 2015). Similarly, the magnitude of income elasticity is also consistent with the findings in previous studies of food and agricultural products, which are typically around two (e.g., Islam and Subramanian, 1989; Baiardi et al., 2015), but it is lower than the income effect of (final) manufacturing products reported in Athukorala and Khan (2016).

A comparison of results relating to demand for processed food imports from developing and developed countries (columns 1 and 3 of Table 6) yields three interesting points. First, the import from developing countries faced a slightly higher income elasticity of demand (2.0), compared with developed countries (1.8), which is comparable to that of Baiardi et al. (2015).[11] Second, the demand for processed food imports from both developed and developing countries is price inelastic. The magnitude of elasticity is smaller for imports from developing countries (0.6 < 0.9), in contrast to the findings of Baiardi et al. (2015). Third, the estimated cross-price elasticity of demand for imports from developing countries is much larger in magnitude (2.9 > 0.5), suggesting that the imported processed food from these countries are substituted for domestic processed food products.

A comparison of processed and unprocessed (traditional) food imports from developing countries (column 1 and 2 of Table 6) indicates that the magnitude of long-run income elasticity of processed foods (2.0) is larger than that of unprocessed food imports (1.7). In other words, when an economy grows, consumers tend to import processed food products more proportionally than an increase in their income and more than unprocessed food imports from developing countries. This finding is consistent with that of Bailardi et al. (2015).

[11] Processed foods provide consumers with more choices and a greater variety of food consumption. Urbanization, immigration, and internationalization of food habits have resulted in an upward trend in processed food consumption. See the survey-based results reported in Euromonitor international (2012).

Table 6. Price and income elasticities of the US import demands for food products from developing and developed countries

	Developing countries		Developed countries
Dependent variable :	**Processed Food** (1)	**Unprocessed Food** (2)	**Processed Food** (3)
Long-run effects			
ln IPI	-0.60***	-0.14**	-0.90***
	(0.13)	(0.06)	(0.23)
ln DM	2.91***	1.38***	0.51*
	(0.25)	(0.18)	(0.32)
ln Y	2.02***	1.75***	1.78***
	(0.32)	(0.61)	(0.05)
Short-run effects			
Δ ln IPI_t	-1.99****	-1.17***	-0.39***
	(0.01)	(0.08)	(0.01)
Δ ln IPI_{t-1}	0.42***		-0.06
	(0.03)		(0.07)
Δ ln IPI_{t-2}			0.07***
			(0.02)
Δ ln DM_t	0.17	0.56***	0.50***
	(0.15)	(0.14)	(0.10)
Δ ln DM_{t-1}	3.07***		
	(0.27)		
Δ ln DM_{t-2}	-2.86***		
	(0.15)		
Δ ln Y_t	1.60***	-5.91	1.43
	(0.02)	(3.72)	(0.89)
Δ ln Y_{t-1}	-2.10***	-6.86***	-3.36***
	(0.13)	(0.82)	(0.98)
Δ ln Y_{t-2}		8.32***	1.11***
		(0.85)	(0.18)
GFC	-0.10***	-0.09**	-0.03**
	(0.002)	(0.05)	(0.01)
Speed of adjustment	-0.25***	-0.37***	-0.26***
	(0.002)	(0.01)	(0.002)
constant	-7.56***	-8.02***	-3.42***
	(0.98)	(3.68)	(0.30)
ARDL	(1, 2, 3, 2)	(1, 1, 1, 3)	(1, 3, 1, 3)
method	DFE	DFE	DFE
No. of observations	2,652	2,060	2,737
No. of groups	26	20	31
Quarter-of-year dummy	yes	yes	yes
Product fixed effects	yes	yes	yes
Wald test of price homogeneity	37.47***	106.62***	35.02***
Hausman test			
(PMG, DFE)	0.00	2.22	0.13
(MG, DFE)	0.03	0.05	0.00

Note: the standard errors are shown in parentheses; ***, **, * are statistically significant at 0.01, 0.05, 0.1 levels, respectively.

The import demand equation estimated for six important categories of processed food imported from developing countries are reported in Table 7. Under this disaggregation, import price elasticities of these products vary in the range -0.46 to -1.39, with only fish and crustaceans, sugar preparations, and beverages exhibiting elastic demand in the long-run. These results are consistent with the estimates of import demand for disaggregated agricultural products by Islam and Subramanian (1989), Ghodsi et al. (2016), and Yang and Koo (1994) as well as import demand for beverages by Jones (2008). In contrast to the findings of Islam and Subbramaniun (1989), demand for all product categories is highly income elastic in the long run, with beverages, flour and cereals, and sugar preparation products, recording elasticity coefficients of around four. Besides, only the cross-price elasticities of demand for flour and cereal, and vegetable and fruit imports are cross-price elastic, implying that only these two imported product categories are significantly substituted for domestic products.

Table 7. Price and income elasticities of the US import demands for selected processed food categories from developing countries

Dependent variables:	**SITC 01 Meat**	**SITC 03 Fish and Crustaceans**	**SITC 04 Flour and cereals**	**SITC 05 Vegetables and Fruits**	**SITC 06 Sugar prep.**	**SITC 11 Beverages**
Long-run effects						
ln IPI	-0.62***	-1.32**	-0.46*	-0.73***	-1.39**	-1.37***
	(0.23)	(0.66)	(0.27)	(0.18)	(0.55)	(0.34)
ln DM	-0.70	0.51	1.15***	1.27***	0.50	0.13
	(0.90)	(0.88)	(0.43)	(0.32)	(0.64)	(0.49)
ln Y	1.71**	2.89***	4.40***	1.39***	3.72***	4.42***
	(0.81)	(0.88)	(1.60)	(0.19)	(0.20)	(0.36)
Short-run effects						
Δ ln IPI_t			-1.62***	-1.95***		
			(0.29)	(0.33)		
Δ ln IPI_{t-1}				0.50***		
				(0.15)		
Δ ln DM_t					-0.98	-0.77
					(1.10)	(0.69)
Δ ln DM_{t-1}					0.73	0.73
					(1.41)	(0.62)
Δ ln DM_{t-2}					-1.21	-1.46***
					(0.67)	(0.17)
Δ ln Y_t		-2.68				
		(1.64)				
Δ ln Y_{t-1}		3.07***				
		(1.08)				
GFC	-0.22**	-0.02	0.04	0.06	0.05	-0.07***
	(0.11)	(0.04)	(0.03)	(0.05)	(0.03)	(0.03)
Speed of adjustment	-0.29***	-0.19***	-0.23***	-0.76***	-0.78***	-0.34***
	(0.13)	(0.07)	(0.06)	(0.10)	(0.10)	(0.01)
constant	-3.12**	-5.26 ***	-13.87***	-7.36**	-32.63***	-17.49***
	(1.23)	(3.18)	(9.04)	(3.09)	(4.68)	(2.67)
ARDL	(1, 0, 0, 0)	(1, 0, 0, 2)	(1, 1, 0, 0)	(1, 2, 0, 0)	(1, 0, 3, 0)	(1, 0, 3, 0)
No. of observations	416	412	312	412	104	208
Quarter-of-year dummy	yes	yes	yes	yes	yes	yes
Product fixed effects	yes	yes	yes	yes	yes	yes
No. of groups	4	4	3	4	1	2
Wald test of price homogeneity	3.90**	3.60*	16.76***	7.22***	21.08***	68.34**

Note: the standard errors are shown in parentheses; ***, **, * are statistically significant at 0.01, 0.05, 0.1 levels, respectively.

Robustness checks

There is the possibility that processed food imports are substituted not only for domestically processed food in the US but also for unprocessed food: the demand can shift between processed and unprocessed food in response to changes in their relative prices. To test this possibility, an alternative specification of the import demand equation is estimated with prices of imported and domestic unprocessed food added as explanatory variables.

The results are reported in Table A4, Appendix (on-line). There is no evidence that processed food imports are substituted for unprocessed food. The coefficients of the two unprocessed food price variables are not statistically significant. More importantly, the estimated price and income elasticities of processed food import demand are resilient to the inclusion of the variables in the model.

The estimates for processed food imports reported in Table 6 are based on the implicit assumption that import demand elasticities have remained constant over the period of study. The validity of this assumption is, however, questionable for three reasons. First, the product composition of processed food imports has undergone some changes during this period (Table 2). Second, the estimates, undertaken for the main products (Table 7), also show some heterogeneity in terms of the degree of price and income elasticities. Third, there is evidence of a substantial change in the demographic profile of the US in recent decades, which could have had some impact on food demand patterns (Kochhar et al., 2014). These changes in the composition of processed food imports and importer's preference could have possibly led to a change in elasticities of import demand estimated over time.

Mindful of these considerations, the stability of elasticity estimates is tested by re-estimating the import demand equations by dividing the period under study into three subperiods, 1992–1999, 2000–2009, and 2010–2018. The results are reported in Table A5, Appendix (on-line). The standard Chow test suggests that there is a structural change in the three estimated equations between the three subperiods. The magnitudes of long-run coefficients of three subperiods are substantially different. Over the three past decades, processed food exports from developing countries tended to be more inelastic in import price and elastic in income.[12] The results confirm that the demand for processed food imports from developing countries is inelastic in import price, but is responsive to changes in income and domestic price.

[12] Testing parameter stability of the import demand function by estimating impulse-response functions or time-varying parameter estimation is a subject for further research.

5. Conclusion and policy implications

Processed foods have become increasingly important in the export composition of agricultural resource-rich developing countries. We estimate price and income elasticities of import demand for processed foods using a new quarterly panel dataset constructed for imports by the US over the period 1992 to 2018. The data set permits estimating import functions for total processed food imports and product categories that are specifically relevant for developing countries, using import prices to avoid estimation biases resulting from using unit import values. Heterogeneity of import response to import and domestic prices is taken into account in the specification of the import function. The panel Auto Regressive Distributed Lag (panel-ARDL) method, which provides for delineating short-run and long-run (steady-state) elasticities while minimising potential endogeneity bias in estimates, is used to estimate import demand.

There is cointegration among processed food imports, prices, and income. The relative price specification of the traditional import demand model is inappropriate for estimating parameters of demand for processed food imports from developing countries, implying that the import price effect does not always match the US domestic price effect one-for-one even in the long run. In the long term, the import demand for processed food from developing countries is inelastic in own price (with an estimated elasticity of around -0.6) and highly income elastic with a measure of 2, on average. In addition, processed food imports from developing countries are faced with a high-income elasticity and a low own-price elasticity, compared with those from developed countries. Also, income elasticity of demand for processed food imports from both developed and developing countries is much higher than that for unprocessed food imports. This seems to reflect a change in food habit in favour of imported processed food. Finally, there is evidence of high cross-price elasticity of processed vegetable and fruit as well as flour and cereal imports from developing countries, implying a high degree of substitutability of these products for domestic food products.

In sum, rapid growth in processed food exports from developing countries depends on a more substantial increase in demand driven by income growth that counterbalances a possible decline in export volume in response to a rise in price. Agricultural resource-rich developing countries have the potential to achieve rapid growth in processed food exports as the US (and, by implication, other developed countries) continues to grow. In particular, the import demand for beverages, sugar preparation products, flour and cereals are highly income elastic and are major processed products supplied by developed countries. Thus, this would be an opportunity for developing countries to expand their market shares in these product categories to gain the benefits of income growth. On the other hand, any contraction in the US (and other developed economies) implies a substantial decline in developing country exports. Applying the income elasticity estimate to the IMF's growth projection for the US economy suggests that, *ceteris paribus*, processed food exports from developing countries to the US are expected to contract roughly 12 per cent in 2020, and then increase around 9 per cent in 2021.[13] In addition, given the growing concern in developing countries over the possible escalation of the US tariff war, our price elasticity estimates suggest that developing countries' flour and cereal exports are less affected than the other processed food categories while beverages and sugar preparation products are most affected. Also, given the nature of data availability, this study has focused solely on demand for processed food exports to the US. Further studies focusing on other major markets are needed to broaden our understanding of demand prospects for this emerging product line for developing countries. It is also important for further research to explore an appropriate measure of product quality to improve import demand estimation.

[13] International Monetary Fund (2020) projects the US real GDP growth at -5.9 per cent and 4.7 per cent in 2020 and 2021, respectively.

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Demand elasticity of processed food exports from developing countries: A panel analysis of U.S. imports

Wanissa Suanin

Online Appendix

Table A1. List of Processed Food Products

Number	SITC code	Product Description
1.	01	Meat and preparations
2.	02 - 025	Dairy products
3.	03	Fish, crustacean and mollusks and preparations
4.	046 + 047 + 048	Flour and cereals
5.	054 + 056	Vegetables, roots and tubers, chilled, frozen or simply preserved
6.	058 + 059 + 0621	Fruit, preserved, and fruit preparations
7.	025	Eggs and egg yolks, dried or preserved
8.	06 – (0611 + 0615 + 0621)	Sugar preparations and honey
9.	0713 + 0722 + 0723 + 0724 + 073 + 07413 + 0743	Coffee extracts, instant tea, cocoa-based products
10.	09	Edible products and preparations
11.	11	Beverages
12.	4 – (41134 + 41135 + 42111 + 42121+ 42131 + 42151 + 42161 + 42171+ 42211 + 42221 + 42231+ 42241 + 43)	Processed animal and vegetable oils and fats

Note: Food Products consist of SITC 0 + 1 + 4 + 22 – (43 + 121); unprocessed foods are simply identified by subtracting processed foods from total foods; the outliers are adjusted, and then processed food products in section 0 and section 1 are used in the estimation.

Table A2. The US import price index (1992M1 – 2018M12)

HS codes	description
01 - 05	Section I - Live animals; animal products
06 - 14	Section II – Vegetable products
16 - 24	Section IV – Food stuffs
02	Meat and edible meat offal
03	Fish and crustaceans
07	Edible vegetables and certain roots and tubers
08	Edible fruit and nuts
09	Coffee, tea
15	Animal or vegetable fats and oils
16	Edible preps of meat, of fish, or of aquatic invertebrates
18	Cocoa and cocoa preparations
20	Preparations of vegetables, fruit, nuts or other parts of plants
22	Beverages, spirits and vinegar

Source: The US Bureau of Labor Statistics

Table A3. Summary statistics

variables	units	mean	s.d.	Min	Max	Obs.
Y	Trillions of US Dollars	9,709.9	1,879.2	6,344.4	13,044.2	105
DM	Index	92.9	18.4	69.1	124.7	105
Q	Millions of USDollars	217.0	353.0	0.0	2,950.0	2,730
IPI	Index	95.8	26.6	27.0	173.7	2,730

Note: the panel data of processed food imports from developing countries

Source: Author’s calculation

Table A4. Price and income elasticities of the US import demands for food products from developing and developed countries, allowing for the substitution between processed and unprocessed foods.

	Developing countries		Developed countries
Dependent variable :	**Processed Food** (1)	**Unprocessed Food** (2)	**Processed Food** (3)
Long-run effects			
ln IPI	-0.63***	-0.91**	-0.84***
	(0.09)	(0.07)	(0.24)
ln DM	1.85***	0.003	0.84
	(0.46)	(0.30)	(0.70)
ln Y	2.09***	1.35***	1.74***
	(0.20)	(0.29)	(0.40)
ln IPI_unprocessed	-0.04	0.43	-0.37
	(0.06)	(0.33)	(0.26)
ln DM_unprocessed	-0.03	1.05	0.04
	(0.20)	(0.82)	(0.29)
Short-run effects			
Δ ln IPI_t	-0.16	-1.23***	-0.31***
	(0.47)	(0.51)	(0.05)
Δ ln IPI_{t-1}	0.07	0.15	
	(0.31)	(0.38)	
Δ ln DM_t	-4.82**	0.48	-0.99***
	(2.43)	(0.43)	(0.70)
Δ ln DM_{t-1}			0.36
			(0.57)
Δ ln $IPI\_unprocessed_t$	-0.39	0.15	-0.22**
	(0.33)	(0.68)	(0.10)
Δ ln $IPI\_unprocessed_{t-1}$			-0.27
			(0.24)
Δ ln $DM\_unprocessed_t$	0.84*	3.10	-0.28
	(0.48)	(4.10)	(0.24)
Δ ln $DM\_unprocessed_{t-1}$	1.57	-3.59	0.05
	(1.25)	(4.82)	(0.14)
Δ ln $DM\_unprocessed_{t-2}$	-0.15	-0.67	
	(0.26)	(2.34)	
GFC	-0.09***	0.13	-0.05***
	(0.001)	(0.10)	(0.01)
Speed of adjustment	-0.59***	-0.48***	-0.26***
	(0.05)	(0.06)	(0.05)
constant	-15.39***	-5.95***	-3.28**
	(1.24)	(0.90)	(1.60)
ARDL	(1, 2, 1, 0, 1, 3)	(1, 2, 1, 0, 1, 3)	(1, 1, 2, 0, 2, 2)
method	PMG	PMG	DFE
No. of observations	2,652	2,060	2,761
No. of groups	26	20	31
Quarter-of-year dummy	yes	yes	yes
Product fixed effects	yes	yes	yes
Wald test of price homogeneity	6.69***	106.62***	12.11***
Hausman test			
(PMG, DFE)	626.37***	26.99***	0.03
(MG, DFE)	0.00	0.87	0.01

Note: the standard errors are shown in parentheses; ***, **, * are statistically significant at 0.01, 0.05, 0.1 levels, respectively; *IPI_unprocessed* and *DM_unprocessed* denote IPI and DM of unprocessed food for the processed food import demands in column (1) and (3) while they are IPI and DM of processed food for the unprocessed food import demand in column (2).

Table A5. Price and income elasticities of processed food imports from developing countries, estimated separately in three subperiods.

Time	1992-1999	2000-2009	2010-2018
Long-run effects			
ln IPI	-0.63***	-0.48***	-0.23***
	(0.07)	(0.02)	(0.12)
ln DM	1.33***	4.50***	1.24***
	(0.09)	(0.25)	(0.02)
ln Y	1.71***	1.45***	2.35***
	(0.46)	(0.31)	(0.24)
Short-run effects			
Δ ln IPI_t	-1.39***	-2.10***	-0.73***
	(0.01)	(0.001)	(0.06)
Δ ln IPI_{t-1}		0.52***	
		(0.01)	
Δ ln DM_t	-2.03**	2.77***	0.54***
	(0.64)	(0.10)	(0.08)
Δ ln DM_{t-1}	4.93***	2.10***	1.73***
	(1.08)	(0.21)	(0.26)
Δ ln DM_{t-2}	-2.18***	-3.49***	-0.13***
	(0.52)	(0.07)	(0.04)
Δ ln Y_t	-1.95**	8.62***	-3.85***
	(0.77)	(1.01)	(1.26)
Δ ln Y_{t-1}	1.89	-4.77***	2.75***
	(1.22)	(0.71)	(0.62)
GFC		-0.16***	
		(0.01)	
Speed of adjustment	-0.50***	-0.42***	-0.83***
	(0.003)	(0.003)	(0.004)
constant	-8.93**	-11.96***	-24.45***
	(3.70)	(1.68)	(2.59)
ARDL	(1, 1, 3, 2)	(1, 2, 3, 2)	(1, 1, 3, 2)
method	DFE	DFE	DFE
No. of observations	676	1,040	936
Quarter-of-year dummy	yes	yes	yes
Product fixed effects	yes	yes	yes
Wald test of price homogeneity	984.63***	219.63***	104.65***
Hausman test:			
(PMG, DFE)	1.67	0.76	2.00
(MG, DFE)	0.02	0.03	0.01
Chow test	F(3, 2646) = 275.76***		

Note: The null hypothesis of the Chow test is no structural break in three periods; the standard errors are shown in parentheses; ***, **, * are statistically significant at 0.01, 0.05, 0.1 levels, respectively.