Essays in International Trade: Cotton, Seafood, and Meat.

by

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A dissertation submitted to the Graduate Faculty of
Auburn University
in partial fulfillment of the
requirements for the Degree of
Doctor of Philosophy

Auburn, Alabama
December 15, 2018

Keywords: Equilibrium Displacement Model, Survival Analysis, Demand System, Supply Chains Analysis, Seafood Bilateral Trade, Meat Imports Demand

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Abstract

The dissertation consists of three essays as three chapters and it focuses on agricultural trade. Each essay studies a separate agricultural product and applies a different research method.

Chapter 1 applies a Muth-type model to assess the likely effects of labor costs increase on China's cotton yarn industry. The model considers *i*) product differentiation at the yarn level; *ii*) imperfect competition in the markets for cotton yarn and raw cotton fiber, *iii*) input substitution between raw cotton fiber, labor, and capital; and *iv*) offsetting increases in the demand for cotton yarn caused by rising consumer income. Results suggest the effects of rising labor costs on the supply chain are modest, and easily swamped or obscured by the effects of rising income. Increases in industry market power (both oligopoly and oligopsony) have the same effect on the supply chain as increases in labor costs, raising prices to consumers of cotton yarn, and lowering prices to input suppliers, including foreign suppliers of raw cotton fiber. The combined effects of increases in labor costs and income have increased the factor shares for labor and to a lesser extent capital at the expense of raw cotton fiber.

Chapter 2 exams seafood exports of the Association of Southeast Asian Nations (ASEAN) from 1996 to 2014 with approach of survival analysis. Trade duration measures the number of consecutive time periods (e.g., years or months) with non-zero exports of a certain product to one specific market. ASEAN seafood trade duration has a mean value of 4.42 years, which varies by product and trade partner. Frequently traded seafood products have significantly higher survival rates and longer trade durations. Increasing seafood production supports longer trade duration. Sub-Saharan African countries have the smallest mean and median seafood trade durations with ASEAN countries. Our findings suggest refining policies to increase ASEAN seafood exports: supporting sustaining seafood production growth, particularly aquaculture development; encouraging participation in international trade agreements; and implementing efficient cross border policies help lengthen trade duration.

Chapter 3 studies the global trade pattern of aggregate meat and imported pork demand in China. It applies absolute version of Rotterdam demand system to estimate import demand elasticity. It also calculates Hicksian compensating variation and tax incidence to examine Chinese consumers welfare changes because the US-China trade war. The data set covers quarterly export and import quantity and trade value from January 2005 to December 2017, which are collected from the International Trade Center. Results show that (i) meats are price inelastic in the global market; (ii) Meat products of European Union are income elastic, while others are income inelastic; (iii) European Union holds largest marginal expenditure share of in the global market (55.8%), and the United States has the largest marginal expenditure share of in Chinese pork imports market (61.8%); (iv) Chinese pork imports consumers pay 70% of the tariff and suffer from consumer welfare loss.

Acknowledgments

This dissertation holds far more than the cumulation of years of study. I appreciate every generous and inspiring people I have met since I started school.

First of all, I want to thank my family. Without their encouragement and support I could never have begun this journey.

In addition, I want to thank my major advisor, Dr. Henry Kinnucan, for his guidance, advice, and support as I went through this doctoral study. In addition, I want to thank my co-advisor Dr. Duffy Patrica for her endless patience and guidance of paper writing. I would like to thank all my other committee members, Dr. Ruiqing Miao, Dr. Brittney Goodrich, and Dr. Nedret Billor for their insightful comments and suggestions to improve the dissertation.

A special thanks to my government for providing full scholarship to support my doctoral study.

In the end, I also want to thank all my roommates and friends for the happy time we spent together.

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Chapter 1. The Effects of Rising Labor Costs on Global Supply Chains: The Case of China's Cotton Yarn Industry[1]

Introduction

Cotton is one of the most important textile fibers in the world, accounting for some 35% of total world fiber (Krifa and Stevens 2016; USDA 2016). It is a widely planted and highly traded agricultural product. Approximately 80 countries produce cotton and over 150 countries and 350 million people are involved in exports or imports of cotton (USDA 2016). Integrated cotton sectors include the spinning, weaving, and clothing industry (Dadakas and Katranidis 2010; Bassett 2014). Development in these sectors contributes to employment, foreign exchange earnings, and poverty reduction in developing countries (Eneji et al. 2012; Raichurkar and Ramachandran 2015). In the vertical production system for textiles, 95% of cotton goes to spinning mills to produce cotton yarn. Cotton yarn production costs consist of cotton fiber, labor, capital, and other costs. Intermediate input prices such as material inputs and labor costs affect plants' profit margins and productivity as well as entry-exit decisions (Atalay 2014). Cotton fiber accounts for over 60% of cotton yarn production costs in China and thus even modest changes in the world price of cotton fiber have potentially important effects on the economic viability of China's cotton yarn industry (Hasanbeigi and Price 2012).

The elimination of the Agreement on Textiles and Clothing (1995-2005) helped China to become the largest player in the world's textile market. From 2005 to 2015 China imported more than 30% of the world's total exports of cotton and consumed nearly 40% of the world's cotton supply (USDA 2007; 2011; 2016). Consolidation of global textile production coupled with

[1] This chapter has been sent to journal **Applied Economics** for publication. The study is co-authored with Dr. Henry Kinncuan, and Dr. Patricia Duffy.

increasing demand from the downstream industries makes China the largest consumer and importer of cotton yarn. Besides consolidation and trade liberalization, an important factor in the rapid growth of China's textile industry has been relatively low labor costs (Li et al. 2012). For example, in 2003, labor costs accounted for 2% of total cotton yarn manufacturing costs in China, compared to 24% in Italy and 19% in the U.S. (Hasanbeigi and Price 2012). This advantage in labor costs, however, is changing. Between 2000 and 2014 labor costs in China's textile industry have increased 280% in nominal terms, the largest increase among all major textile-producing countries save the Czech Republic (Figure 1.1).

Several factors account for the higher labor costs in China. First, the Chinese economy has developed quickly since 2000. The GDP per capita of China in 2014 was more than seven times that of 2000, increasing from $960 to $7078 (Bank 2017). Second, the value of the yuan increased from USD 0.1208 in 2000 to USD 0.1628 in 2014. A stronger yuan makes Chinese labor more expensive compared to labor in other countries (Ceglowski and Golub 2012). Third, the new labor law that went into effect January 1, 2008, increases minimum wage by 70% and requires corporations to pay higher overtime wages and social security benefits. This law is estimated to have increased labor costs overall by 23.5% in the Greater Pearl River Delta region since 2008 (Zhang, Huang, and Liu 2012). In real terms, per capita incomes in China between 2000 and 2016 increased by 162%, and wages of manufacturing workers increased by 188% (Table 1.1). Similar albeit somewhat slower wage growth has been reported for India (Binswanger and Singh 2018).

The objective of this research is to determine the effects of rising labor costs on global supply chains using China's cotton yarn industry as a case study. As noted, the industry is dependent on imports for a significant share of its raw cotton fiber input, and the cotton yarn produced by the industry is an important input in China's export-dependent textile industry. To what extent might an increase in labor costs increase the price of cotton yarn and thus reduce China's competitive advantage in the textile trade? What are the spill-over effects on cotton producers? To what extent might income growth in China mitigate the foregoing effects? These and related questions are addressed using a Muth-type model.[2]

Muth-type models are well-suited for measuring the impact of supply and demand shocks on global supply chains as exemplified by Alston and Mullen (1992), Kinnucan and Myrland (2000), Rickard and Sumner (2008), and Lin and Zhang (2017). This paper extends the models in these studies by relaxing the assumption that prices are determined under competitive conditions. Specifically, following Kinnucan (2003) measures of oligopoly and oligopsony power are incorporated to allow for the exercise of market power in the purchase of the primary input (raw cotton fiber) and in the sale of the finished good (cotton yarn). An advantage of this extension is that it permits an assessment of the extent to which ongoing consolidation in China's cotton yarn industry might distort price signals and resource allocation. Accordingly, this paper will investigate the extent to which reduced-form elasticities implied by a Muth-type model are affected by imperfect competition as well as the effect of imperfect competition on the transmission elasticities between the price of the raw commodity (cotton) and the price of the finished good (cotton yarn). Although there is some analysis of these questions from a theoretical perspective (Weldegebriel 2004), empirical analysis, as far as we can tell, is non-existent. A purpose of this research, therefore, is to fill this void.

[2] Muth-type models fall in the general category of equilibrium displacement models. For a good overview of these models, including their limitations, see Wohlgenant (2011). For an application to international trade that includes oligopoly behavior, see Ahn and Lee (2010).

The next section reviews recent studies of rising labor costs in China. We then discuss the model, its simulation, and results. The paper concludes with a summary of key findings.

Literature Review

The rapidly rising labor costs in China have received considerable attention from both the academic and business communities. No study, however, has specifically focused on the cotton yarn industry. Long and Yang (2016) used firm-level data across China to study private firms' response to minimum wage regulation. They found that two common responses were the elimination of fringe benefits and the laying off of low-skilled and temporary workers. In their analysis of recent developments in China's labor market, Han and Zhang (2015) concluded that wage pressure comes more from a high demand for young low-skilled labor than from an absolute shortage of labor supply. Rising labor costs also affect China's international competitiveness and export sales. Unit labor costs have been found to have the largest negative impact on China's export competitiveness with Japan, Korea and China (Ito and Shimizu 2015). Gan, Hernandez, and Ma (2016) found that a 10% increase in China's minimum wage decreased China's export sales by 0.9%. Although wages have been rising across China, manufacturing workers in China still earn far less than those in other Asian emerging economies such as Thailand and Philippines (Yang, Chen, and Monarch 2010; Banister and Cook 2011; Ceglowski and Golub 2012). Further, labor cost is not the only driver affecting global competition in the textile industry. Tariffs, supply chains, technology, oil prices, and product quality also matter. China has an advantage over other Asian countries in terms of its infrastructure, supply chain, and skilled workers (Tangboonritruthai, Cassill, and Oxenham 2007).

A large amount of research has been done on China's importance in the world's cotton and textile industries. As the largest producer and consumer of cotton, China plays a major role in world cotton markets. Muhammad, McPhail, and Kiawu (2012) analysed the import demand for cotton from China and found that if U.S. subsidies were eliminated, China's cotton imports might not fully recover from the temporary spike in global prices. Ge, Wang, and Ahn (2010) found that China's cotton market is well integrated with the international market and that China's recent exchange-rate reform and liberalization of its bilateral cotton trade with the United States have had an important impact on cotton futures prices. Using annual data from 1976 to 2009, Traore (2014) found a strong and positive relationship between China's net imports of cotton and the world price of cotton both in the short and long term. Examining the impact of China's sliding scale duty (SSD) on the world cotton market, Wang et al. (2014) found that it increased China's imports of cotton and reduced the domestic price, which benefited cotton processors at the expense of cotton producers. It also raised world cotton prices, which benefited net exporters of cotton at the expense of net importers.

Macdonald et al. (2014) examined the effect of an increase in the Chinese minimum wage on China's textile market and the world cotton market. Econometric results placed the income elasticity of textile demand in China at 0.6. Results from a simulation model suggest that an increase in the minimum wage would increase China's domestic consumption of textiles, decrease its textile exports, increase mill consumption of cotton outside China, and raise clothing prices worldwide. In a related study, Kebede (2012) estimated that a 20% increase in per capita income in China would increase China's textile consumption by 87% and the world price of cotton by 95%. Neither of these studies examined the effect of rising labor costs as an input in the yarn-production process. The studies focused on the effect of rising wage rates on the consumer demand for textiles, but the effect of rising wage rates on the supply of textiles was ignored. In this study, we consider both effects by focusing on a segment of the textile industry, namely cotton yarn.

Structural Model

The Muth-type model (Muth 1964) used in this study is similar to the one used by Kinnucan (2003) in that it allows for imperfect competition in the markets both for the finished good (cotton yarn) and the raw commodity (cotton fiber). It differs from Kinnucan's model in that trade is permitted in both the raw commodity and the final good, and that the production function contains three inputs instead of two. Alston and Mullen (1992) used a three inputs Muth-type model that allowed for trade. In that model, however, prices were assumed to be determined under competitive conditions; the potential for imperfect competition in one or more of the markets was ignored. China is a major producer and consumer of cotton and there has been considerable consolidation in its textile industry (Ge, Wang, and Ahn 2010). Thus, a model that allows for non-competitive pricing is appropriate.

About 20% of China's consumption of cotton yarn is imported. The top five supplying nations are Vietnam, India, Pakistan, Indonesia and Uzbekistan, together accounting for 90% of total imports (Textilebeacon 2018). Vietnam is the fastest growing supplier thanks to Chinese investments in spinning capacity in that country (Textilebeacon 2018). The CIF (cost, insurance, freight) import price differs from the domestic price, which suggests quality differences by source origin (Aptech 2018). Thus, in the model to follow domestic and imported yarn are treated as imperfect substitutes. Cotton fiber is assumed to be homogenous across supply sources. Transportation costs are ignored, as are tariffs and other government policies that might inhibit price adjustments to shocks in supply and demand. China uses a tariff rate quota (TRQ) scheme to stabilize its domestic cotton market. The effects, however, have been sufficiently modest (Wang et al. 2014) for them to be ignored in the present model. China's national minimum wage and the labor market are influenced to a large extent by government policy. Thus, the price of labor is treated as exogenous. The production function for yarn is assumed to exhibit constant returns to scale (CRTS) at the industry level. With these assumptions, the initial equilibrium is expressed by 12 equations as follows:

$Y_d = D(P_{dY}, P_{mY}, \bar{P}_o, \bar{I})$	(demand function for domestic cotton yarn)	(1)
$Y_m = D(P_{dY}, P_{mY}, \bar{P}_o, \bar{I})$	(demand function for imported cotton yarn)	(2)
$P_Y = P_{dY}{}^{S_d} P_{mY}{}^{S_m}$	(Stone price index)	(3)
$Y_m = S(P_{mY})$	(supply function for imported cotton yarn)	(4)
$Y_d = f(C, L, K)$	(production function for domestic cotton yarn)	(5)
$P_C(1 + \bar{\Omega}) = P_{dY} \cdot f_C \cdot (1 - \bar{\psi})$	(domestic demand for raw cotton fiber)	(6)
$\bar{P}_L = P_{dY} \cdot f_L \cdot (1 - \bar{\psi})$	(domestic demand for labor)	(7)
$P_K = P_{dY} \cdot f_K \cdot (1 - \bar{\psi})$	(domestic demand for capital)	(8)
$P_C = S(C_d)$	(domestic production of cotton fiber)	(9)
$P_C = M(C_m)$	(imports of cotton fiber)	(10)
$C = C_d + C_m$	(domestic usage of cotton fiber)	(11)
$P_K = S(K)$	(domestic supply of capital)	(12)

where Y_d and P_{dY} are the quantity and price of domestically-produced cotton yarn; Y_m and P_{mY} are the quantity and price of imported cotton yarn; $S_d = P_{dY}Y_d/(P_{dY}Y_d + P_{mY}Y_m)$ and $S_m = P_{mY}Y_m/(P_{dY}Y_d + P_{mY}Y_m) = 1 - S_d$ are expenditures shares for domestic and imported cotton yarn; C and P_C are the quantity and price of raw cotton fiber; L and $\bar{P}_L$ are the quantity and price of labor; K and P_K are the quantity and price of capital; C_d and C_m are the domestically produced and imported quantities of raw cotton fiber; f_C, f_L, and f_K are the marginal products, respectively, of cotton, labor, and capital used in the domestic cotton yarn industry; $\bar{P}_o$ is the domestic consumer price of all other goods (other than cotton yarn), $\bar{I}$ is consumer income; and $\bar{\Omega} = \theta/\varepsilon$ and $\bar{\psi} = \xi/|\eta|$ are Lerner indices of market power where ε (> 0) is the overall supply elasticity for raw cotton fiber (to be defined later), η (< 0) is the overall demand elasticity for cotton yarn (to be defined later), and $\theta \in [0,1]$ and $\xi \in [0,1]$ are conjectural elasticities denoting the degree of market power exercised, respectively, in the input and output markets. Perfect competition in both markets implies $\theta = \xi = 0$; pure monopsony in the input market for raw cotton fiber and pure monopoly in the output market for cotton yarn implies $\theta = \xi = 1$. Values of θ and ξ between these limits indicate oligopsony/oligopoly behaviour.

The model contains 12 endogenous variables and five exogenous variables ($\bar{P}_L$, $\bar{I}$, $\bar{P}_o$, $\bar{\Omega}$ and $\bar{\psi}$). Five of the endogenous variables correspond to the market for cotton yarn (Y_d, Y_m, P_{dY}, P_{dY}, P_Y), four to the market for cotton fiber (C, C_d, C_m, P_C), and three (L, K, P_K) to the markets for labor and capital. $\bar{P}_o$ and $\bar{I}$ shift the demand curves for cotton yarn; $\bar{P}_L$ shifts the supply curve for labor; $\bar{\Omega}$ shifts the demand curve for cotton fiber; and $\bar{\psi}$ shifts the demand curves for all three inputs.

The effects of changes in the exogenous variables on the initial equilibrium can be found by taking the total differential of each equation and converting absolute changes in the variables to relative changes to yield:

$$Y_d^* = (S_d\eta - S_m\sigma)P_{dY}^* + S_m(\sigma + \eta)P_{mY}^* - (\eta_I + \eta)\bar{P}_0^* + \eta_I\bar{I}^* \quad (1')$$

$$Y_m^* = S_d(\sigma + \eta)P_{dY}^* + (S_m\eta - S_d\sigma)P_{mY}^* - (\eta_I + \eta)\bar{P}_0^* + \eta_I\bar{I}^* \quad (2')$$

$$P_Y^* = S_dP_{dY}^* + S_mP_{mY}^* \quad (3')$$

$$Y_m^* = \varepsilon_Y P_{mY}^* \quad (4')$$

$$Y_d^* = \frac{s_C(1+\Omega)}{1-\psi}\, C^* + \frac{s_L}{1-\psi}L^* + \frac{s_K}{1-\psi}K^* \quad (5')$$

$$P_C^* = -\left(\frac{s_L/(1-\psi)}{\sigma_{CL}} + \frac{s_K/(1-\psi)}{\sigma_{CK}}\right) C^* + \frac{s_L/(1-\psi)}{\sigma_{CL}} L^* + \frac{s_K/(1-\psi)}{\sigma_{CK}} K^* + P_{dY}^* - \varepsilon_\Omega \bar{\Omega}^* - \eta_\psi \bar{\psi}^* \qquad (6')$$

$$\bar{P}_L^* = \frac{s_C(1+\Omega)/(1-\psi)}{\sigma_{CL}} C^* - \left(\frac{s_C(1+\Omega)/(1-\psi)}{\sigma_{CL}} + \frac{s_K/(1-\psi)}{\sigma_{LK}}\right) L^* + \frac{s_K/(1-\psi)}{\sigma_{LK}} K^* + P_{dY}^* - \eta_\psi \bar{\psi}^* \qquad (7')$$

$$P_K^* = \frac{s_C(1+\Omega)/(1-\psi)}{\sigma_{CK}} C^* + \frac{s_L/(1-\psi)}{\sigma_{LK}} L^* - \left(\frac{s_C(1+\Omega)/(1-\psi)}{\sigma_{CK}} + \frac{s_L/(1-\psi)}{\sigma_{LK}}\right) K^* + P_{dY}^* - \eta_\psi \bar{\psi}^* \qquad (8')$$

$$P_C^* = \frac{1}{\varepsilon_d} C_d^* \qquad (9')$$

$$P_C^* = \frac{1}{\varepsilon_m} C_m^* \qquad (10')$$

$$C^* = k_d C_d^* + k_m C_m^* \qquad (11')$$

$$P_K^* = \frac{1}{\varepsilon_K} K^* \qquad (12')$$

where $X^* = dX/X$ and S_i $(i = d, m)$ are expenditure shares for domestic and imported cotton yarn; k_i $(i = d, m)$ are quantity shares for domestic and imported cotton fiber; and s_i $(i = C, L, K)$ are shares in total costs for each input in competitive equilibrium. The Greek symbols denote elasticities. Specifically, σ (> 0) is the Armington elasticity of substitution between the domestic and imported versions of cotton yarn; η (< 0) is the price elasticity of demand for domestic and imported cotton yarn treated as a composite good; and η_I (> 0) is the income elasticity of demand for the composite good; ε_Y (> 0) is the price elasticity of supply for imported cotton yarn; σ_{ij} (> 0) are Hicks-Allen elasticities of factor substitution where $i, j = C, L, K$; $\eta_\psi = \psi/(1-\psi)$ (≥ 0) and $\varepsilon_\Omega = \Omega/(1+\Omega)(\geq 0)$ are elasticities that indicate shifts in the input demand curves due to isolated changes in oligopoly and oligopsony power; $\varepsilon_d(> 0)$ and $\varepsilon_m(> 0)$ are price elasticities of supply for cotton fiber from domestic and imported sources; and ε_K (> 0) is the price elasticity of supply of capital.

Equations (1') and (2') are based on Armington (1969) treatment of the demand for imports of a particular good vis-à-vis the domestically produced good. The equations are derived in appendix A. In this framework domestic and imported yarn are net substitutes, but may be gross complements depending on the relative magnitudes of σ and $|\eta|$. Homogeneity implies the elasticities in equations (1') and (2') sum to zero. This condition is used to derive the cross-price elasticity $\eta_{P_0} = -(\eta_I + \eta)$. Domestic and imported yarn may be gross substitutes or complements with respect to all other goods depending on the relative magnitudes of η_I and $|\eta|$.

Simulation

Model Calibration

Baseline values for the parameters used to simulate the model are given in Table 1.2. Based on government (USDA 2007; 2011; 2016) and industry (Li 2017) statistics, we set the expenditure share parameters for cotton yarn to $S_d = 0.77$ and $S_m = 0.23$; the quantity-share parameters for cotton fiber to $k_d = 0.68$ and $k_m = 0.32$; and the cost-share parameters for cotton fiber, labor, and capital to $s_C = 0.57$, $s_L = 0.21$, and $s_K = 0.22$. Based on estimates of demand elasticities in the literature (Hudson and Ethridge 1998, Macdonald et al. 2014) we set $\eta = -0.45$ and $\eta_I = 0.59$. Based on estimates of the Armington elasticity and the import elasticity of supply used in the literature for agricultural products (Warr 2008, Kinnucan, Duc Minh, and Zhang 2017) we set $\sigma = 4.00$ and $\varepsilon_Y = 2.00$. Based on estimates of substitution elasticities in the literature (Alston and Mullen 1992, Balistreri, McDaniel, and Wong 2003, Datta and Christoffersen 2005, Young 2013), we set $\sigma_{CL} = \sigma_{CK} = 0.10$ and $\sigma_{LK} = 0.25$. Based on estimates of cotton supply elasticities in the literature (Sumner 2003; Tokarick 2003; Gillson et al. 2004; Poonyth et al. 2004) we set $\varepsilon_d = 0.5$ and $\varepsilon_m = 1.5$. Based on Eichner and Runkel (2012) discussion of capital supply elasticities we set $\varepsilon_K = 0.4$.

There are no known estimates of market power in China's textile industry in general and its cotton yarn industry in particular. The closest related study is one by Pan, Hudson, and Ethridge (2010) in which it was determined that China has buying power in the international market for cotton fiber, reducing import prices by an estimated 5%. A sprinkling of studies focusing on China's tobacco (Hao and Wang 2003), sugar (Si 2005), liquor (Zhou and Wang 2012), dairy (Dai and Wang 2014; Guo, Wang, and Chen 2016) and wine (Zheng and Wang 2017) industries in general have found evidence of substantial departures from competitive pricing, at least at the firm level if not the industry level. In a review of econometric estimates of market-power parameters in U.S. food industries Sexton and Xia (2018) summarized their findings by stating 'Across industries, these studies tended to find only mild departures from perfect competition, with the estimates of θ and ξ generally being less than 0.2, the equivalent of a five-firm symmetric Cournot oligopsony or oligopoly.' Sexton and Xia (2018) go on to state 'In their survey of 38 studies of food or fiber industries, (Perekhozhuk et al. 2017)) reported an arithmetic mean of parameter estimates of either buyer or seller market power of 0.075 for studies that followed Bresnahan (1982) general identification method and 0.188 for those following the production theoretic approach of Appelbaum (1982).' In their study of 42 food processing industries in the United States using panel data from 1990 through 2010, Lopez, He, and Azzam (2018) estimate an average Lerner index of 21%. Setting $\psi = 0.21$ and $|\eta| = 0.45$ implies $\xi = 0.094$, which is consistent Sexton and Xia (2018) survey of the econometric literature. Based on this discussion we set $\xi = 0.10$ and $\theta = 0.15$ as "best-bet" estimates of these parameters. θ is set to a higher value than ξ on the strength of Zheng and Wang (2017) finding that buyer power in China's wine industry is stronger than seller power.

Applying the formulas given in appendix A to $S_d = 0.77$, $S_m = 0.23$, $\eta = -0.45$, $\sigma = 4.00$, and $\eta_I = 0.59$ yields the following values for the Marshallian own- and cross-price elasticities of demand for domestic and imported cotton yarn:

$\eta_{dd} = (S_d\eta - S_m\sigma) = -1.27 \qquad \eta_{dm} = S_m(\sigma + \eta) = 0.82$

$\eta_{md} = S_d(\sigma + \eta) = 2.73 \qquad \eta_{mm} = (S_m\eta - S_d\sigma) = -3.18$

$\eta_{P_0} = -0.14.$

The Armington restrictions imply domestic and imported cotton yarn are gross substitutes for each other and are gross complements with respect to other goods in the economy. An increase in the price of domestic cotton yarn induced by an increase in labor costs will cause the demand for imported cotton yarn to increase. The relevant elasticity (2.73) is relatively large, which suggests the import response is apt to be pronounced. An increase in the price of other goods in the economy, on the other hand, will cause the demand for both imported and domestic cotton yarn to decrease, albeit modestly as the relevant elasticity (-0.14) is tiny.

Yarn consumers can substitute more easily than yarn producers. Specifically, $|\eta| = 0.45 > \sigma_{LK} = 0.25 > \sigma_{CL} = \sigma_{CK} = 0.1$, which means the inputs used in China's yarn industry are gross complements. An isolated increase in the price of any one of the inputs will cause the demand for the other inputs to decrease.

Reduced-Form Elasticities

Reduced-form elasticities implied by the foregoing parameter values are given in Table 1.3. The elasticities are uniformly positive for consumer income, and uniformly negative for the price of other goods. An isolated increase in consumer income is welfare increasing for all participants in the supply chain, while an isolated increase in the price of other goods is welfare decreasing. All the elasticities are less than 1 in absolute value. Prices and quantities throughout the supply chain are relatively insensitive to changes in the considered exogenous variables. The elasticities for labor costs have the same sign as the elasticities for the Lerner indices. This means an increase in market power (whether oligopoly or oligopsony) has the same effect on the supply chain as an increase in labor costs. The elasticities for labor costs are smaller in absolute value than for oligopoly power, which in turn are smaller in absolute value than for income. This suggests an increase in labor costs is less consequential in terms of its welfare impacts on participants in the supply chain than an increase in oligopoly power, which, in turn, is less consequential than an increase in consumer income. Among the considered exogenous variables, the elasticities for income are the largest and the elasticities for oligopsony power are the smallest (in absolute value).

An increase in the price of labor has a negative effect on the prices and quantities of cotton fiber and capital. Specifically, an isolated 1% increase in labor costs reduces the price and quantity of cotton fiber by 0.088% and 0.072%, respectively, and the price and quantity of capital by 0.184% and 0.074%, respectively. That the prices of cotton fiber and capital both decline in response to an isolated increase in the price of labor is to be expected, as the inputs are gross complements. An increase in labor costs generates a negative externality for the suppliers of raw cotton fiber and capital to China's yarn industry. It also encourages imports of cotton yarn at the expense of domestic production (the elasticities are $\frac{Y_m^*}{\bar{P}_L^*} = 0.159$ and $\frac{Y_d^*}{\bar{P}_L^*} = -0.126$).

Graphical Analysis

How the model works can be visualized by reference to Figure 1.2. In this figure we focus on the effect on an increase in labor cost. For simplicity the markets for domestic and imported raw cotton fiber are treated as a unified market, the market for imported cotton yarn is omitted, as is the market for capital. Because the inputs are gross complements the effect of an increase in labor costs on the market for capital is similar to the effect on the market for cotton fiber. The relevance of the market for imported cotton yarn for the domestic yarn industry is primarily through interaction effects as explained later.

An increase the price of labor (Panel C) causes a simultaneous decrease in the demand for cotton fiber (Panel B) and the supply of domestic cotton yarn (Panel A). The decreased supply of domestic cotton yarn causes the price of domestic cotton yarn to increase, which, in turn causes the demand for imported cotton yarn to increase. The higher price of imported cotton yarn feeds back into the market for domestic cotton yarn via an upward shift in the demand curve for domestic cotton yarn as shown in Panel A. The interaction between the markets for domestic and imported cotton yarn causes the demand curve for domestic cotton yarn to steepen (become less price elastic). This is shown in Panel A by a clockwise rotation in the demand curve from D to D_T. (The D curve depicts the relationship between the price and quantity demanded of domestic cotton yarn when the price of imported cotton yarn is held constant; the D_T curve depicts the same relationship when the price of imported cotton yarn is permitted to adjust.)

The upshot is that cross-commodity substitution causes the price effects of a supply shock at the yarn level to be magnified, and the quantity effects to be attenuated. For the entire supply chain, an increase in labor cost *i*) decreases the quantities of labor, capital, and raw cotton fiber used by the domestic industry, *ii*) increases the imports of cotton yarn at the expense of domestic production, *iii*) decreases the prices of raw cotton fiber and capital; and *iv*) increases the prices of domestic and imported cotton yarn. An increase in labor cost benefits exporters of cotton yarn to China at the expense of input suppliers, including exporters of raw cotton fiber to China.

Terms of Trade Effects

Defining terms of trade as the domestic price of cotton yarn divided by the import price of cotton yarn, the effects of changes in the exogenous variables on terms of trade can be determined through division of the reduced-form elasticities as follows:

$$\tau^{\bar{P}_L} = \frac{P_{dY}^*/\bar{P}_L^*}{P_{mY}^*/\bar{P}_L^*} = \frac{0.188}{0.099} = 1.89$$

$$\tau^{\bar{I}} = \frac{P_{dY}^*/\bar{I}^*}{P_{mY}^*/\bar{I}^*} = \frac{0.279}{0.261} = 1.07$$

$$\tau^{\bar{P}_O} = \frac{P_{dY}^*/\bar{P}_O^*}{P_{mY}^*/\bar{P}_O^*} = \frac{-0.066}{-0.062} = 1.06$$

$$\tau^{\bar{\Omega}} = \frac{P_{dY}^*/\bar{\Omega}^*}{P_{mY}^*/\bar{\Omega}^*} = \frac{0.061}{0.032} = 1.91$$

$$\tau^{\bar{\Psi}} = \frac{P_{dY}^*/\bar{\Psi}^*}{P_{mY}^*/\bar{\Psi}^*} = \frac{0.188}{0.099} = 1.90$$

A 1% increase in labor costs has the same proportionate effect on terms of trade as a 1% increase in oligopoly or oligopsony power, and twice the proportionate effect as a 1% increase in income or the price of non-yarn goods. These terms-of-trade elasticities reinforce the basic conclusion that increases in market power are quantitatively similar to increases in labor costs in terms of their distributional impacts on the supply chain.

Robustness Checks

A basic conclusion to be drawn from Table 1.3 is that increases in income are more consequential for China's yarn industry than similar increases in labor costs. For example, the effect of a 1% increase in income on the price of cotton yarn (0.275%) is twice as large as the effect of a 1% increase in labor cost (0.135%). The effect of a 1% increase in income on the price of cotton fiber (0.378%) is four times as large (in absolute value) as the effect of a 1% increase in labor cost (-0.088%). The effect of a 1% increase in income on the price of capital

(0.792%) is four times as large (in absolute value) as the effect of a 1% increase in labor cost (-0.184%). The results in Table 1.3 also suggest increases in seller power are more consequential for input suppliers and consumers of cotton yarn than similar increases in buyer power. Here we examine the robustness of these inferences to the implicit assumption that *i*) Lerner indices are exogenous and *ii*) parameter values are known with certainty.

Endogenous Conduct

As noted by Weldegebriel, Wang, and Rayner (2012) Lerner indices are apt to be endogenous, either increasing or decreasing in response to industry-wide supply or demand shocks. To assess the extent to which inferences might be affected by the exogeneity assumption, we re-simulated the model augmented with the following equations:

$$\Omega^* = \delta P_C^* \qquad (13)$$

$$\psi^* = \mu P_Y^* \qquad (14)$$

where δ is an elasticity that indicates the sensitivity of buyer power to changes in the price of cotton fiber, and μ is an elasticity that indicates the sensitivity of seller power to changes in the price of cotton yarn. As shown in appendix B, $\delta = (\delta_\theta - \delta_\varepsilon)$ where $\delta_\theta = \frac{\partial\theta}{\partial P_C}\frac{P_C}{\theta}$ is an elasticity that indicates the sensitivity of the buyer conduct parameter to changes in the price of cotton fiber, and $\delta_\varepsilon = \frac{\partial\varepsilon}{\partial P_C}\frac{P_C}{\varepsilon}$ is an elasticity that indicates the sensitivity of the supply elasticity for cotton fiber to changes in the price of cotton fiber. Similarly, $\mu = \left(\mu_\xi - \mu_\eta\right)$ where $\mu_\xi = \frac{\partial\xi}{\partial P_Y}\frac{P_Y}{\xi}$ is an elasticity that indicates the sensitivity of the seller conduct parameter to changes in the price of cotton yarn, and $\mu_\eta = \frac{\partial|\eta|}{\partial P_Y}\frac{P_Y}{|\eta|}$ is an elasticity that indicates the sensitivity of the demand elasticity for cotton yarn to changes in the price of cotton yarn.

In their simulations Weldegebriel, Wang, and Rayner (2012) considered alterative values for δ and μ in the closed interval [-0.20, 0.20]. A positive (negative) value for δ implies a supply or demand shock that causes the price of cotton fiber to increase worsens (ameliorates) buyer conduct. Similarly, a positive (negative) value for μ implies a supply or demand shock that causes the price of cotton yarn to increase worsens (ameliorates) seller conduct. Because the effects of negative and positive values for δ and μ on the reduced-form elasticities are symmetric (e.g., $\delta = \mu = -0.10$ and $\delta = \mu = 0.10$ have the same proportionate effect on the elasticities, only in the opposite direction), in our simulations we set the parameters to non-negative values. Specifically, δ was set either to 0 or 0.20, and likewise for μ. Interpreting 0.20 as an upper-limit value, the corresponding simulations are conservative in the sense that observed biases in the reduced-form elasticities associated with the exogeneity assumption are apt to be overstated rather than understated.

Results indicate that endogenizing market conduct does not affect inferences to any extent (Table 1.4). Compared to the situation where conduct is exogenous ($\delta = \mu = 0$), endogenous buyer conduct ($\delta = 0.20, \mu = 0$) alters the reduced-form elasticities by less than 2%, endogenous seller conduct ($\delta = 0,\ \mu = 0.20$) alters the elasticities by less than 4%, and combined endogenous buyer and seller conduct alters the elasticities by less than 6%. For the considered parameter values, permitting the Lerner indices to adjust in response to supply and demand shocks has no material effect on results. Thus, inferences are robust to this issue.

Parameter Uncertainty

To examine the extent to which inferences are affected by parameter uncertainty we re-simulated the model under the assumption that all parameters (except shares) follow a GRK distribution. The GRK distribution is similar to a triangle distribution in that it requires specification of minimum, most-likely, and maximum values for each parameter. But unlike the triangle distribution the GRK permits about 2% of the random draws to fall above and below the specified limits (Rezende and Richardson 2017). In our simulations, the most-likely values of each parameter are set to the values given in Table 1.2. The minimum and maximum values are set to 50% and 150% of the most-likely values. The stochastic simulations are performed using the software package SIMETAR (Richardson 2008), with the number of draws set to 1,000.

Results are robust in the sense that of the 60 reduced-form elasticities produced by the model, their 90% confidence intervals contain zero in only nine instances. Six of the instances relate to $\bar{P}_L$ and three to $\bar{\Omega}$. The effect of changes in buyer power on the quantities of labor and capital and the price of capital is not different from zero when parameter uncertainty is taken into account. The same is true for the effect of changes in labor costs on domestic production, imports, and price of raw cotton fiber and the price and quantity of capital. All but three of the 60 confidence intervals are bounded on the open interval (-1, 1). (The three exceptions are $\frac{Y_m^*}{\bar{I}^*} = 1.08$, $\frac{C_m^*}{\bar{I}^*} = 1.04$, and $\frac{P_K^*}{\bar{I}^*} = 1.60$.) Thus, the overall conclusion that the supply chain is relatively insensitive to changes in the considered exogenous variables is not much affected by parameter uncertainty. The inference that changes in consumer income potentially are much more consequential for the supply chain than equivalent percentage changes in labor costs, the price of non-yarn goods, and industry market power is affirmed.

Effects of Wage and Income Growth on Factor Shares

Results suggest inputs used in China's cotton yarn industry are gross complements. Consequently, an increase in the price of any one of the inputs will cause the demand for the other inputs to decrease. Results also suggest the derived demand for labor is price inelastic. This suggests an isolated increase in labor cost will increase the factor share for labor at the expense of the factor shares for cotton fiber and capital. To test this hypothesis, we simulated the following equations with $\bar{P}_L^*$ set to 24.9%, the observed increase in real labor costs in China between 2012 and 2016 as reported in Table 1.1:

$$s_C = \frac{P_C C_d}{P_{dY} Y_d} \Rightarrow s_C^* = P_C^* + C_d^* - P_{dy}^* - Y_d^* = \left(\frac{P_C^*}{\bar{P}_L^*} + \frac{C_d^*}{\bar{P}_L^*} - \frac{P_{dY}^*}{\bar{P}_L^*} - \frac{Y_d^*}{\bar{P}_L^*}\right) \bar{P}_L^* \quad (15a)$$

$$s_L = \frac{\bar{P}_L L}{P_{dY} Y_d} \Rightarrow s_L^* = \bar{P}_L^* + L^* - P_{dy}^* - Y_d^* = \left(1 + \frac{L^*}{\bar{P}_L^*} - \frac{P_{dY}^*}{\bar{P}_L^*} - \frac{Y_d^*}{\bar{P}_L^*}\right) \bar{P}_L^* \quad (15b)$$

$$s_K = \frac{P_K K}{P_{dY} Y_d} \Rightarrow s_K^* = P_K^* + K^* - P_{dy}^* - Y_d^* = \left(\frac{P_K^*}{\bar{P}_L^*} + \frac{K^*}{\bar{P}_L^*} - \frac{P_{dY}^*}{\bar{P}_L^*} - \frac{Y_d^*}{\bar{P}_L^*}\right) \bar{P}_L^*. \quad (15c)$$

Also, to assess the relative effect of income growth on factor shares, we simulated the following equations with $\bar{I}^*$ set to 19.7%, the observed increase in real consumer income in China between 2012 and 2016 as reported in Table 1.1:

$$s_C^* = \left(\frac{P_C^*}{\bar{I}^*} + \frac{C_d^*}{\bar{I}^*} - \frac{P_{dY}^*}{\bar{I}^*} - \frac{Y_d^*}{\bar{I}^*}\right) \bar{I}^* \quad (16a)$$

$$s_L^* = \left(\frac{L^*}{\bar{I}^*} - \frac{P_{dY}^*}{\bar{I}^*} - \frac{Y_d^*}{\bar{I}^*}\right) \bar{I}^* \quad (16b)$$

$$s_K^* = \left(\frac{P_K^*}{\bar{I}^*} + \frac{K^*}{\bar{I}^*} - \frac{P_{dY}^*}{\bar{I}^*} - \frac{Y_d^*}{\bar{I}^*}\right) \bar{I}^*. \quad (16c)$$

Results, based on the reduced-form elasticities in Table 1.3, are consistent with expectations. Specifically, the 24.9% increase in real wages caused the factor share for labor to increase by 20.3% and the factor shares for cotton fiber and capital to decrease by, respectively, 3.91% and 7.05% (Table 1.6). Income growth, on the other hand, benefits capital at the expense of labor and cotton fiber. Specifically, the results show the 19.7% increase in real income increasing the factor share for capital by 7.49% and reducing the factor shares for cotton fiber and labor by respectively, 3.19% and 7.68%. The combined effect of the observed increases in real wages and income was to reduce cotton fiber's share by 7.1% and increase labor and capital's share by, respectively, 12.6% and 0.44%. Although income and wage growth have opposite effects on labor's factor share, thanks to a highly inelastic demand for labor the wage effect dominates.

Concluding comments

Labor costs in China over the 17-year period ending in 2016 increased by 188% in real terms, and per capita income increased by 162%. This study uses a Muth-type equilibrium displacement model to assess the likely impact of these increases on a global supply chain as represented by China's cotton yarn industry. Results may be summarized as follows:

- The effects of rising labor costs on China's cotton yarn industry and the world cotton market are easily obscured or swamped by the effects of rising income. The basis for this conclusion is that the reduced-form elasticities for labor costs are modest in size, and much smaller in absolute value than the reduced-form elasticities for income.
- The inputs used to produce cotton yarn are gross complements and the derived demand for labor is highly price inelastic. These results suggest an increase in labor costs will increase the factor share for labor at the expense of the factor shares for capital and cotton. Indeed, model simulations show that the 25% increase in China's real labor cost that occurred between 2012 and 2016 increased the factor share for labor by 20% and decreased the factor shares for capital and raw cotton fiber by, respectively, 7.1% and 3.9%.
- The reduced-form elasticities for the Lerner indices have the same signs and approximate magnitudes as the reduced-form elasticities for labor costs. This suggests increases in oligopoly or oligopsony power will have about the same effect on the supply chain (in terms of their distributional consequences) as similar

percentage increases in labor costs. But as with labor costs, market power effects are apt to be swamped or obscured by the effects of rising income.

- An increase in labor costs encourages imports of cotton yarn at the expense of domestic production (the elasticities are 0.159 and -0.126). An increase in income encourages imports, but also domestic production (the elasticities are, respectively, 0.522 and 0.450). This suggests the domestic yarn industry can continue to grow in the face of rising labor costs provided income growth keeps pace.
- Inferences are not much affected by parameter uncertainty or endogenous market conduct. Permitting the Lerner indices to respond to supply and demand shocks had little effect on the reduced-form elasticities. The 90% confidence intervals for the reduced-form elasticities only tended to confirm the dominance of income effects over labor cost effects.

The conclusion that the effects of increases in labor costs on a global supply chain are apt to be modest in relation to the effects of increases in income needs to be studied in other contexts to determine its robustness. The same is true for our finding that market power effects are similar in sign and magnitude to labor cost effects. Also, these conclusions are based on a partial equilibrium model that ignores interactions among other sectors of the economy and how those interactions feed back into the cotton yarn sector. Broadening the analysis to include general equilibrium effects beyond those of the supply chain under consideration could yield useful added insight. In this sense, our results are best interpreted as hypotheses subject to further verification.

TABLES:

Table 1.1. Growth in Real Income and Wages, People's Republic of China, 2000-2016

Year	Real Income[a] (USD)	Percent Change	Real Wages[b] (USD)	Percent Change
2000	937	--	1305	--
2001	1016	8.47	1448	10.9
2002	1149	13.1	1644	13.5
2003	1250	8.77	1870	13.7
2004	1339	7.11	2026	8.3
2005	1525	13.9	2251	11.1
2006	1680	10.2	2604	15.7
2007	1972	17.4	3025	16.2
2008	2334	18.3	3609	19.3
2009	2595	11.2	4050	12.2
2010	2827	8.95	4574	12.9
2011	3204	13.3	5386	17.8
2012	3599	12.3	6102	13.3
2013	3948	9.72	6801	11.5
2014	4202	6.44	7347	8.0
2015	4398	4.66	7654	4.2
2016	4308	-2.05	7621	-0.4
Annual Average	--	10.1	--	11.8
Cumulative change	--	162	--	188

[a]Per capita disposable income in 2010 dollars: Sources: National Bureau of Statistics (for nominal income figures), People's Bank of China (for exchange rate), and Federal Research Bank of St. Louis (for CPI).

[b]Average annual wages for workers in manufacturing industries in urban areas. Sources: same as above.

Table 1.2. Parameters and baseline values for China's cotton yarn industry

Item	Definition	Baseline Value
S_d	Expenditure share for domestic cotton yarn	0.77
S_m	Expenditure share for imported cotton yarn	0.23
η	Overall price elasticity of demand for cotton yarn	-0.45
σ	Armington elasticity of substitution for cotton yarn	4.00
η_{dd}	Own-price elasticity of demand for domestic cotton yarn	-1.27
η_{mm}	Own-price elasticity of demand for imported cotton yarn	-3.18
η_{dm}	Cross-price elast. for domestic cotton yarn wrt import price	0.82
η_{md}	Cross-price elast. for imported cotton yarn wrt to domestic price	2.73
η_I	Income elasticity of demand for cotton yarn	0.59
η_{P_0}	Cross-price elasticity for cotton yarn wrt price of all other goods	-0.14
ε_Y	Price elasticity of supply for imported cotton yarn	2.00
s_C	Cotton fiber's cost share in yarn production	0.57
s_L	Labor's cost share in yarn production	0.21
s_K	Capital's cost share in yarn production	0.22
σ_{CL}	Elasticity of substitution between cotton fiber and labor	0.10
σ_{CK}	Elasticity of substitution between cotton fiber and capital	0.10
σ_{LK}	Elasticity of substitution between labor and capital	0.25
k_d	Quantity share of cotton fiber produced domestically	0.68
k_m	Quantity share of cotton fiber imported	0.32
ε_d	Price elasticity of domestic cotton fiber supply	0.50

ε_m	Price elasticity of imported cotton fiber supply	1.50
ε	Overall price elasticity of cotton fiber supply ($= k_d\varepsilon_d + k_m\varepsilon_m$)	0.82
ε_K	Price elasticity of capital supply	0.40
θ	Input conjectural elasticity	0.15
ξ	Output conjectural elasticity	0.10

Table 1.3. Reduced-form elasticities for China's cotton yarn industry

Endogenous Variables	Exogenous Variables[a]				
	$\bar{P}_L$	$\bar{I}$	$\bar{P}_o$	$\bar{\Omega}$	$\bar{\psi}$
Price of domestic cotton yarn, P_{dY}	0.151	0.279	-0.066	0.061	0.188
Price of imported cotton yarn, P_{mY}	0.080	0.261	-0.062	0.032	0.099
Price index for cotton yarn, P_Y	0.135	0.275	-0.065	0.054	0.168
Quantity of domestic cotton yarn, Y_d	-0.126	0.450	-0.107	-0.051	-0.157
Quantity of imported cotton yarn, Y_m	0.159	0.522	-0.124	0.064	0.198
Price of cotton fiber, P_C	-0.088	0.378	-0.090	-0.048	-0.132
Quantity of domestic cotton fiber, C_d	-0.044	0.189	-0.045	-0.024	-0.066
Quantity of imported cotton fiber, C_m	-0.132	0.567	-0.134	-0.071	-0.198
Cotton fiber utilization, $C = C_d + C_m$	-0.072	0.310	-0.074	-0.039	-0.108
Labor utilization, L	-0.159	0.339	-0.080	-0.032	-0.119
Price of capital, P_K	-0.184	0.792	-0.188	-0.074	-0.277
Capital utilization, K	-0.074	0.317	-0.075	-0.030	-0.111

[a]Definitions: $\bar{P}_L$ = price of labor, $\bar{I}$ = consumer income, $\bar{P}_o$ = price of goods other than cotton yarn, $\bar{\Omega}$ = Lerner index of oligopsony power, $\bar{\psi}$ = Lerner index for oligopoly power.

Table 1.4. Sensitivity of reduced-form elasticities to endogenous market conduct

Endogenous Variable	$\bar{P}_L$			$\bar{I}$			$\bar{P}_o$		
	A	B	C	A	B	C	A	B	C
P_{dY}	0.993	1.035	1.027	1.016	1.038	1.055	1.016	1.038	1.055
P_{mY}	0.993	1.035	1.027	1.009	1.022	1.031	1.009	1.022	1.031
P_Y	0.993	1.035	1.027	1.015	1.035	1.050	1.015	1.035	1.050
Y_d	0.993	1.035	1.027	0.992	0.980	0.972	0.992	0.980	0.972
Y_m	0.993	1.035	1.027	1.009	1.022	1.031	1.009	1.022	1.031
P_C	0.991	1.042	1.032	0.991	0.980	0.971	0.991	0.980	0.971
C_d	0.991	1.042	1.032	0.991	0.980	0.971	0.991	0.980	0.971
C_m	0.991	1.042	1.032	0.991	0.980	0.971	0.991	0.980	0.971
C	0.991	1.042	1.032	0.991	0.980	0.971	0.991	0.980	0.971
L	0.997	1.021	1.017	0.993	0.980	0.973	0.993	0.980	0.973
P_K	0.993	1.042	1.034	0.993	0.980	0.973	0.993	0.980	0.973
K	0.993	1.042	1.034	0.993	0.980	0.973	0.993	0.980	0.973

A: $\delta = 0.20, \mu = 0$ (endogenous buyer conduct)

B: $\delta = 0, \mu = 0.20$ (endogenous seller conduct)

C: $\delta = \mu = 0.20$ (endogenous buyer and seller conduct).

The numbers in the table are ratios of reduced-form elasticities when conduct is endogenous to reduced-form elasticities when conduct is exogenous ($\delta = \mu = 0$). See text for details.

Table 1.5. 90% Confidence intervals for the reduced-form elasticities

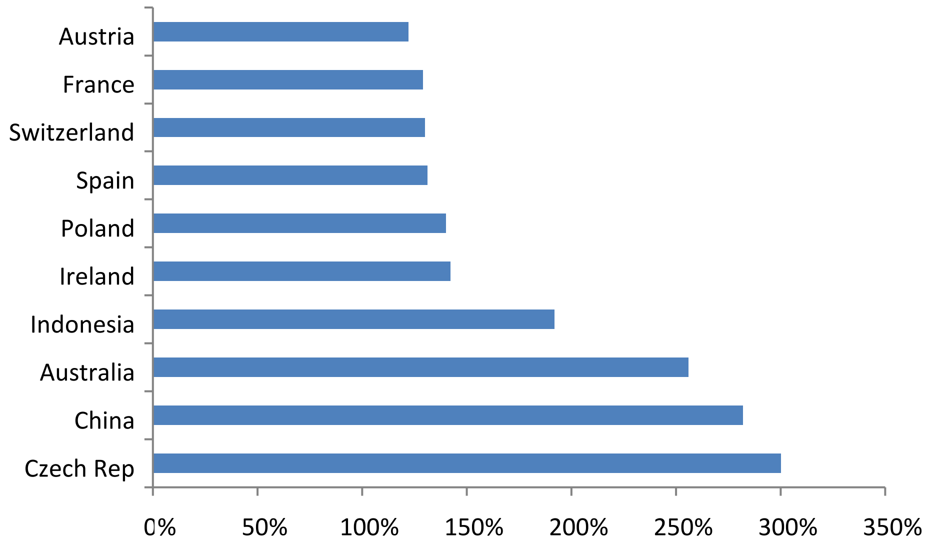
	$\bar{P}_L$		$\bar{I}$		$\bar{P}_o$		$\bar{\Omega}$		$\bar{\psi}$	
Endogenous Variable	5% limit	95% limit	5% limit	95% limit	5% limit	95% limit	5% limit	95% limit	5% limit	95% limit
P_{dY}	0.103	0.227	0.115	0.530	-0.119	-0.029	0.030	0.129	0.077	0.585
P_{mY}	0.041	0.193	0.117	0.573	-0.131	-0.031	0.013	0.096	0.036	0.457
P_Y	0.091	0.213	0.117	0.531	-0.119	-0.031	0.027	0.119	0.068	0.550
Y_d	-0.204	-0.011	0.235	0.796	-0.191	-0.060	-0.111	-0.002	-0.488	-0.007
Y_m	0.078	0.372	0.222	1.073	-0.241	-0.059	0.026	0.190	0.066	0.830
P_C	-0.150	0.011	0.188	0.694	-0.164	-0.048	-0.091	-0.005	-0.343	-0.007
C_d	-0.079	0.005	0.081	0.369	-0.083	-0.020	-0.047	-0.002	-0.167	-0.004
C_m	-0.232	0.012	0.263	1.038	-0.242	-0.064	-0.137	-0.008	-0.494	-0.009
C	-0.119	0.007	0.156	0.542	-0.127	-0.038	-0.072	-0.005	-0.264	-0.005
L	-0.209	-0.060	0.169	0.585	-0.138	-0.042	-0.062	0.004	-0.278	-0.006
P_K	-0.349	0.021	0.378	1.599	-0.379	-0.098	-0.160	0.009	-0.808	-0.013
K	-0.128	0.008	0.150	0.580	-0.134	-0.038	-0.062	0.004	-0.293	-0.005

Table 1.6. Effects of a 24.9% increase in real wages and a 19.7% increase in real income on factor shares in China's yarn industry

Factor share	Wage Growth Effect (%)	Income Growth Effect (%)	Combined Effect (%)
Cotton fiber (s_C)	-3.91	-3.19	-7.10
Labor (s_L)	20.3	-7.68	12.6
Capital (s_K)	-7.05	7.49	0.44

Note: The indicated percentage increases in real wages (24.9) and income (19.7) correspond to the observed increases for the period 2012-2016 as reported in Table 1.1.

FIGURES:



Note: Unit is U.S.$ per production hour

Source: Werner International Company Hourly Labor Cost Textile Industry Report

Figure 1.1. Labor cost increases in the top 10 textile-producing countries, 2000 – 2014

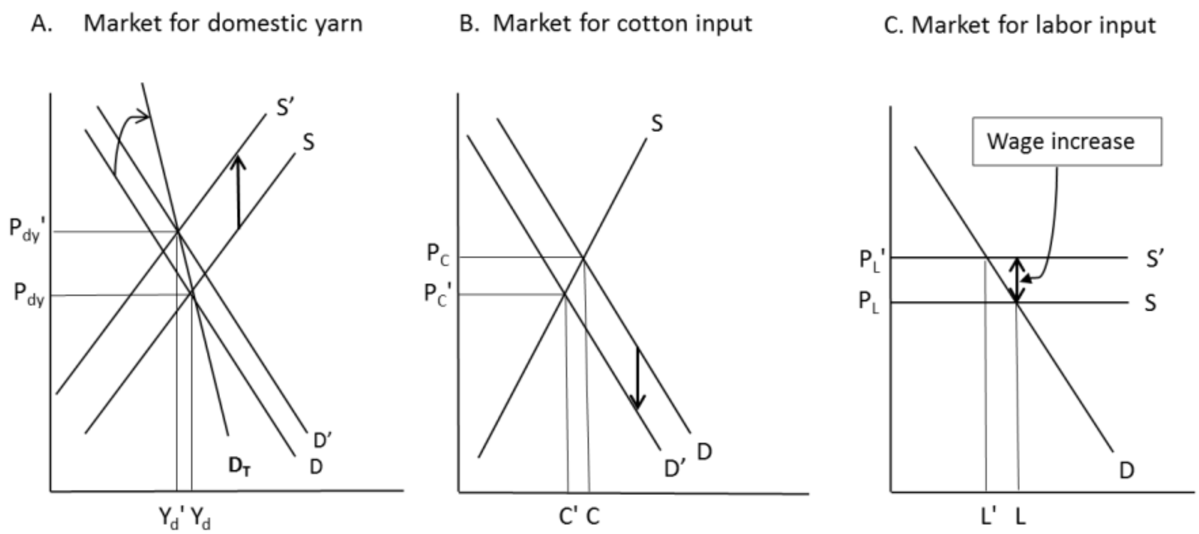


Figure 1.2 Effects of an increase in labor costs on China's cotton yarn industry

Chapter 2. An Analysis of Seafood Trade Duration: The Case of ASEAN[3]

Introduction

Seafood (fish) presently accounts for 20% of animal protein supply and is a prominent contributor to human food and nutrition security (Troell et al. 2014; Gephart and Pace 2015; Chan et al. 2017). As one of the most traded agricultural products in the world, seafood accounts for nearly 10% of global food trade, with an estimated 78% of seafood products traded internationally (Tveterås et al. 2012). In value terms, seafood trade has also grown significantly, with seafood exports increasing from $8 billion in 1976 to $148 billion in 2014 (Smith et al. 2010; Tveterås et al. 2012; Chan et al. 2017). International seafood trade is an important mechanism to enhance the welfare of local and global fish food systems for developed and developing countries. The rapid growth of seafood trade in developing countries brings foreign exchange and earnings, creates jobs, and contributes to poverty alleviation and hunger eradication (Smith et al. 2010; Gephart and Pace 2015; FAO 2016; Gephart et al. 2016; Chan et al. 2017). Developing countries export high-value seafood to developed markets to achieve a broader goal of poverty alleviation, while retaining and importing lower-value seafood products to help achieve food security goals (Asche et al. 2015; Watson et al. 2017). In contrast, developed countries are increasingly dependent on seafood imports as a main source of fish. With increased seafood trade, consumers in developed countries can enjoy higher-quality, relatively less expensive seafood products.

Given its importance, the analysis of seafood trade is critical for policy and decision making in fishery and aquaculture sectors. Beyond analyzing seafood trade value, quantities,

[3] This chapter has been published on the journal **Marine Resource Economics**. The study is co-authored with Dr. Nhuong Tran, Dr. Norbert Wilson, Chin Yee Chan, and Danh Dao. DOI: http://dx.doi.org/10.1086/700599

and prices (Asche et al. 2015; Gephart and Pace 2015; Watson et al. 2017), researchers (e.g., Straume 2017 and Asche et al. 2017) recently examined the duration and stability of seafood trade relationships. Asche et al. (2017) investigate trade duration of Norwegian cod exports and find that at least 45% of cod trade relationships last approximately one year. Similarly, Straume (2017) analyzes the trade duration of Norwegian salmon exports and concludes that at the firm level, the trade relationships of Norwegian salmon exports last four years, on average.

Trade duration indicates the number of consecutive time periods (e.g., years or months) with non-zero exports of a certain product to one specific market (Shao, Xu, and Qiu 2012). Without further explanation, the trade duration is measured at country level in this study. Investigating the duration of trade of US imports, Besedeš and Prusa (2006b) and Straume (2017) show that the characteristics of traded products and aggregation level affect length of trade duration. Our study examines bilateral seafood trade between the Association of Southeast Asian Nations (ASEAN) and its importers. Despite the increasingly important role that ASEAN plays in global seafood production and trade, to our knowledge, no study has assessed the duration of ASEAN seafood exports. The purpose of this study is to attempt to fill this literature gap. We assess the factors affecting seafood trade duration of ASEAN countries and evaluate the ASEAN seafood exports duration. Specifically, our study assesses the number of years ASEAN seafood exports to global markets exist without interruption and determines implications of seafood trade policies for ASEAN countries.

ASEAN countries are among the largest seafood exporters in the world, with Indonesia, Thailand, and Vietnam among the top 10 largest seafood exporters globally. The region accounted for 10.4% of world seafood exports by value in 2017, and the value of its seafood trade in 2017 was more than 2 times that of 2001 (Figure 2.1). Fish production, especially aquaculture, has grown rapidly in ASEAN countries. The share of aquaculture in ASEAN's total fish production, by quantity, increased from 15.7% in 1996 to 38.6% in 2014 (FishStatJ 2016). Thanks to aquaculture growth, ASEAN's share of fish exports in its total fish output, by quantity, grew from 20.4 to 28% during the same period. Chan et al. (2017) projected that ASEAN countries may account for a quarter of global fish production by 2030 and will maintain this share to 2050. Thus, understanding the seafood trade patterns of ASEAN countries is helpful to capture the characteristics of global seafood trade.

The remainder of this study is structured as follows. The next section provides a literature review on seafood trade and survival analysis; followed by the data and methods description; the estimation results are presented after that; and the last section is the conclusions and policy implications.

Literature Review and Research Motivation

Rising income, population growth, and increased urbanization leads to increased seafood consumption, which fuels seafood production and international seafood trade (Watson et al. 2016). Global seafood trade value reached $119.4 billion in 2017, which is more than 2.8 times greater than that in 2001 (Figure 2.1). Copious studies have been done on relevant seafood trade issues, including seafood safety and food security regulations (Anders and Caswell 2009; Baylis, Nogueira, and Pace 2010; Tran, Wilson, and Anders 2012; Tran, Nguyen, and Wilson 2014; Lee and Rahimi Midani 2017), the effects of seafood trade on ecosystem and fishery sustainability (Roheim, Asche, and Santos 2011; Uchida et al. 2014; Blomquist, Bartolino, and Waldo 2015), market integration between farm-raised and wild-captured species (Bronnmann, Ankamah-Yeboah, and Nielsen 2016; Ankamah-Yeboah, Ståhl, and Nielsen 2017), and global seafood demand structure (Asche and Zhang 2013; Zhang, Tveterås, and Lien 2014; Xie and Zhang 2017).

In additional to conventional research areas, research on trade duration has grown in recent years. In their pioneering work, Besedeš and Prusa (2006a) examine the imports trade duration of US and find that the mean trade duration is from two to four years. They discover that trade patterns of homogeneous goods are distinctly different from differentiated goods; homogenous goods have at least a 23% higher failure rate of trade activity than differentiated goods (Besedeš and Prusa 2006b). Subsequently, several studies have discussed the duration of commodity trade in other countries. Nitsch (2009) examines the duration of German imports from 1995 to 2005 and concludes that about 50% of trade duration is one year, and the majority of trade activities do not last for more than three years. The author argues that exporter characteristics, type, and market features of traded products determine the length of trade period. Hess and Persson (2011) perform an empirical description and analysis of the duration of European Union (EU) imports. They find that the EU has a shorter import duration than the US, and trade diversification lowers the hazard rate of trade. Most importantly, they argue that trade duration has been stable since the 1960s. Esteve-Perez, Requena-Silvente, and Pallardo-Lopez (2013) analyze trade activities of Spanish firms by destination from 1997 to 2006. They find that firm-country export relationships have an average length of two years, and both firm and destination heterogeneity affect trade activity stability. Survival analysis of merchandise trade in China and Lao PDR also reach consistent conclusions that trade duration is short (Shao, Xu, and Qiu 2012; Stirbat, Record, and Nghardsaysone 2015).

Research on single products also reaches a similar conclusion. Straume (2017) finds that farm-raised salmon from Norway has a four-year trade duration. Both firm-specific and market-specific factors affect the volatility of trade duration. For example, market competitiveness increases the probability of higher hazard rates (trade failure), while large initial shipment size reduces the trade failures. Asche et al. (2017) study trade dynamics and duration of Norwegian cod exports and conclude that high transaction costs of the traditional supply chain shortens trade duration. Peterson, Grant, and Rudi-Polloshka (2017) apply a discrete survival model to identify factors that affect the trade duration of fresh fruits and vegetables imported into the US. Their focus is phytosanitary treatments considering unique features of the commodity.

Across these trade duration studies, researchers have applied different methods to assess trade duration. Of these, the Cox proportional hazard model is a widely used method to estimate effects of determinants on trade failure (Besedeš and Prusa 2006a, b; Nitsch 2009, Shao, Xu, and Qiu 2012; Asche et al. 2017; Straume 2017). However, considering the weaknesses of the Cox proportional model, other researchers have applied the discrete-time model (Brenton, Saborowski; and Von Uexkull 2010; Hess and Persson 2012; Besedeš and Prusa 2013; Peterson, Grant, and Rudi-Polloshka 2017). Brenton, Saborowski, and Von Uexkull (2010) provide a test of the proportional hazard rate assumption of the Cox model and find evidence against it. Hess and Persson (2012) point out three major drawbacks of the Cox model that result in biased results. They state that the Cox model faces tied duration times, fails to control unobserved heterogeneity, and imposes a restrictive proportional hazard rate assumption. To investigate the effect of an antidumping petition on hazard rate, Besedeš and Prusa (2013) also apply the discrete-hazard survival model. They conclude that antidumping cases increase the hazard rate by more than 50%. Harris and Li (2011) apply a discrete survival model to firm-level data to analyze the determinants of a firm’s decision to exit from exporting in UK. They suggest that productivity is determining whether a firm would cease to export; profitability and other financial issues are additional factors that influence a firm's exit decision. Furthermore, industry concentration or factors that increase trade costs help explain the exit decision. Based on a discrete survival model, Padmaja and Sasidharan (2017) find that previous trade experience significantly influences the decision of Indian firms to enter or exit export markets.

Data Description

To examine the seafood trade duration between ASEAN countries and the rest of the world, we use annual bilateral export data of eight ASEAN countries (Cambodia, Indonesia, Malaysia, Myanmar, Philippine, Singapore, Thailand, Viet Nam) from 1996 to 2014. Considering data availability based on the harmonized system (HS) 1996 system[4], we exclude Brunei Darussalam and Lao PDR from this study. The HS six-digit level trade data are from the United Nations Commodity Trade Statistics Database (UN Comtrade), which has the most detailed disaggregated data that is internationally comparable and publicly available (Obashi 2010). The dataset consists of all 87 seafood products from HS Chapter 03 (fish & crustacean; mollusk & other aquatic invertebrate) at the six-digit level and 187 trade partners of ASEAN countries. We treat each product by bilateral pair individually, which yields a total of 66,423 observations. Gravity model variables, such as GDP per capita and total population of each exporter and importer, geographic distance between exporter and importer, geographic location (continent and region classification), contiguity, WTO membership, and urbanization level of importers are from the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII). Seafood production of ASEAN members, which is comprised of output from fisheries and aquaculture, are from FAO (2018). Table 2.1 presents description of study variables.

[4] The Harmonized System (HS) of tariff nomenclature is an internationally standardized system of names and numbers to classify traded products. Learn more from Wikipedia https://en.wikipedia.org/wiki/Harmonized_System

The unit of observation is bilateral trade period by exporter, importer, and traded product at the six-digit level. The observation is at country level. We measure trade periods by discrete years. For example, if the trade relationship existed each year from 1996 to 2006 for a bilateral trade pair, that is considered a single trade period, with a length of 10 years. Multiple periods reflect bilateral trade activity that stops for one or more years, then reoccurs subsequently. For example, from 1996 to 2006, if the trade activity stopped in 2000 and restarted in 2001, then there are two trade periods of four and five years respectively. In our study, more than half (56.3%) of observations have multiple periods in this study (Table 2.1).

Censored dependent variables are a common issue of international trade data. Our data are from HS 96, which helps mitigate the censoring problem caused by product description differences over the years. In this study, censoring occurs when information regarding the existence of trade activity is missing. Since the study period starts in 1996 and ends in 2014, if the trade relationship started before 1996 or ended after 2014, we would encounter a left- or right-censored data problem. Left censoring means we could not capture the exact starting point, so the length of trade period might be incorrect. While for the right-censored observation, we fail to know the exact ending point of the trade period. Only 0.2% of the data is left censored in this study, while right-censored data accounts for 6.3%. ASEAN countries started to enter international markets in the early 2000s, which explains why we have few left-censored data. Hence, we can ignore the left censored issue; however, the effects of right censored data are addressed later.

Methods

Trade duration (survival analysis) models explore the length of trade relationships. In modeling survival analysis, researchers measure the probability that the trade relationship continues after period t (Nitsch 2009; Hess and Persson 2012). The survivor function is given as:

$$S_t = P(T \geq t) \quad , \tag{1}$$

where T is the length of a trade period. The hazard function measures the conditional probability that the trade relationship stops after period t:

$$\lambda_t = P(T = t | T \geq t). \tag{2}$$

Kaplan-Meier estimation is a non-parametric method to estimate the survivor function. With this estimator, researchers calculate the number of observations that survive divided by total number of observations that are at risk in period t:

$$\widehat{S_t} = \prod_{t_i \leq t} \frac{n_i - f_i}{n_i}, \tag{3}$$

where t_i is the i^{th} year that the trade continuously survives. The number of subjects[5] at risk of failing at t_i is n_i. The number of observed failures is f_i. All the survival times are ranked, such as $0 < t_1 < t_2 < \cdots < t_i$. The Kaplan-Meier estimator is robust to censoring and uses information from both censored and non-censored observations (Besedeš and Prusa 2006a).

To measure the effects of influencing factors on the failure/hazard rate, the Cox proportional hazard rate model is a commonly used parametric method (Besedeš and Prusa 2006b, Asche et al. 2017, Straume 2017):

$$h(t, \boldsymbol{X}_{ik}, \boldsymbol{\beta}_i) = h_0(t) \cdot e^{\boldsymbol{X}_{ik}\boldsymbol{\beta}_i}, \tag{4}$$

[5] In our study, bilateral trade partners represent unique unidirectional trade flows; that is, trade from exporter m to importer n is different than trade from exporter n to importer m, m≠n.

where $h_0(t)$ is the baseline hazard rate. The Cox model assumes a proportional hazard rate, which implies that the ratio of the hazard rate of two factors is the same at all time points. However, if the assumptions are violated, the model performs poorly (Wey, Connett, and Rudser 2015). Hence, Brenton, Saborowski, and Von Uexkull (2010) and Hess and Persson (2012) suggest a discrete-time estimation model that performs better with efficient and unbiased results, such as a logit regression. Unlike the Cox model, which uses the hazard ratio to measure the effects of covariates, the logit model measures conditional probability, written as:

$$Logit(Event_{it}) = P(T_i < t_{i+1} | T_i \geq t_i, \boldsymbol{X}_{ik}) = \alpha_i + \boldsymbol{\beta_i} \cdot \boldsymbol{X}_{ik}, \tag{5}$$

where, in both equations (4) and (5), $\boldsymbol{X}_{ik}$ is a vector of explanatory variables, and $\boldsymbol{\beta_i}$ is a vector of coefficients. Informed by the gravity model and variables for the survival analysis, $\boldsymbol{X}_{ik}$ includes total bilateral seafood trade value per year, seafood output of ASEAN countries per year, GDP per capita and total population of importer and exporter per year, distance between importer and exporter, landlocked dummy indicator of importer, GATT/WTO membership of exporter and importer, percentage of total value of imported goods over GDP of importer per year, and ASEAN dummy variable (to capture whether the export destination is one of the other ASEAN members) (Besedeš and Prusa 2006a, b; Baier and Bergstrand 2007; Nitsch 2009; Anders and Caswell 2009; Hess and Persson 2011; Tran, Wilson, and Anders 2012; Esteve-Perez, Requena-Silvente, and Pallardo-Lopez 2013).

The difference between the current study and traditional gravity models is the dependent variable. Instead of using trade values, we create a dummy variable for equation (5). A failure indicator (event) is set to one if trade fails relative to the previous year, and zero otherwise. The estimated model (equation 5) describes the effects of the covariates on the probability of trade failures. A *year* dummy variable is included as an explanatory variable to control for the random effect over time.

We hypothesize that traditional gravity variables that indicate an increase (decrease) in trade will follow the same pattern to decrease (increase) the probability of trade failure. Therefore, higher income (GDP per capita of the importer and exporter), contiguity, membership in GATT, and trade openness (percentage of total imports over importer's GDP) should decrease the probability of event occurrence (trade failure). We hypothesize that larger populations for both partners are less likely to experience trade failures. On the other hand, longer distance and landlocked importers should increase the probability of trade failure. Beyond the traditional gravity model variables, we include the value of bilateral seafood trade and ASEAN seafood production. We hypothesize that higher trade value and higher seafood production are less likely to experience trade failures. The level of urbanization of importers may shape the seafood industry in ASEAN countries; thus, we assume that a higher urbanization rate decreases trade failure. Sub-Saharan African importers have lower income and weaker infrastructure by which to import perishable products like seafood; thus, we hypothesize that this dummy variable will reflect a greater probability of trade failure.

Results

Kaplan-Meier Estimators

Table 2.2 presents the mean value of trade duration and the numeric value of Kaplan-Meier estimators in specific years, and figures 2.2-2.4 provide a visual representation of those estimators. Based on full sample estimation, the mean bilateral seafood trade duration between ASEAN and its importers is 4.42 years. Table 2.2 suggests that multiple periods result in lower survival rates and shorter trade duration. The effect of the number of periods on trade failure occurrence is presented in table 2.4. As discussed in the data description section, the effects of right-censored data on trade duration should be considered. As presented in table 2.2, by dropping the right-censored observations, the mean length of a trade period is 4.29 years. The sub-sample with a right-censored data exclusion has a trade duration that is 0.13 years shorter and a 2% lower survival rate than the full sample. However, the difference in the survival rate between them is the same over the study period. The censored data generate a slightly longer trade duration; however, given the small and consistent differences, we report the results of analysis of the full sample.

The survival rate of all seafood exports from ASEAN countries in the first year is 0.83 (Table 2.2), which indicates that 17% of trade failures occur after the first year. In the third year, the survival rate is 0.74; thus 9% of failures occur during the second and third years. In the tenth year, 66% of trade relationships survive, and over the first 10 years the average failure rate is 3.4% per year. From the 10th to 19th year, the survival rate decreases from 66 to 59%, and the average failure rate is 0.78% per year. The average failure rate of first 10 years is more than 4.36 times of that in later years.

Trade period lengths differ by product. Ornamental fish (HS code 030110), frozen shrimp and prawns (HS code 030613), tilapia (HS code 030379), squid (HS code 030749), and shrimps and prawns (HS code 030623) are the top five most frequently exported seafood products from ASEAN countries. Further, results reported in table 2.2 suggest that those frequently traded products have longer trade period lengths than the average trade period lengths of all products. For example, frozen shrimps and prawns have the longest trade period length, 5.68 years, which is 1.26 years longer and 28.5% higher than average.

The income of importers correlates directly with the stability of the bilateral seafood trade relationship[6]. Table 2.3 suggests that wealthier fish importers have longer trade relationships. For high-income importers, the average trade period length is 4.78 years. In contrast, low-income importers have an average trade period length of 1.68 years. Not surprising, trade relationships with upper middle-income importers are more stable than those with lower middle-income importers. The trade period length of upper middle-income importers are 0.82 years longer than those of lower middle-income importers, but 0.5 years shorter than those of high-income countries. Although the survival rate is decreasing across all countries by income level, the higher-income countries have lower failure rates, or higher marginal survival rates, over time. The survival rate difference between the first and the third years is 0.08% for high-income countries, 0.1% for upper middle-income countries, 0.12% for lower middle-income countries, and 0.2% for low-income countries. The declining survival rate observed in the first three years in low-income countries is steepest, and it is 2.5 times steeper than that in high-income countries. Trade period length is shortest in low-income countries, which is at most 10 years, and 50% shorter than in higher-income countries.

Comparing across regions, ASEAN has the most stable trade relationship with North America. The average trade period length is 5.09 years, which is 0.67 longer than the mean. East Asia and Pacific importers show the second longest trade period length, which is also longer than the mean. Not only are the trade periods length longer, the survival rate is higher than the mean in every year. For example, only 13% of trade failures after the first year occur in East Asia and Pacific and North America, while in South Asia they are more than 20%. Higher

[6] We divide importers into different income levels based on World Bank classifications. See details on the World Bank website: https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups.

incomes and larger market size might explain why North America maintains a stable trade relationship. As to East Asia and Pacific, just as our first hypothesis states, the benefits of proximity may support the relatively long trade periods. However, the Sub-Saharan Africa market is the least stable market with a trade period of 2.63 years. About 52% of that is in East Asia and Pacific markets. In the East Asia and Pacific markets, 91% of trade relationships in the first year are still active after three years while in Sub-Saharan Africa it is 79%[7].

Proportional Hazard Rate Assumption Test

Researchers have clarified the assumptions and weaknesses of the Cox model (Brenton, Saborowski, and Von Uexkull 2010; Hess and Persson 2012; Besedeš and Prusa 2013). To select the suitable duration model for this study, we test the proportional hazard rate assumption of the Cox model and present the results below.

The Cox model determines a proportional hazard rate that assumes the hazard ratio of two variables (x_i and x_j) does not change over time: i.e., the ratio is time independent. The ratio is expressed as below:

$$\frac{h(t;x_i)}{h(t;x_j)} = \frac{h_0(t)*\exp(\beta_1 x_{i1}+\cdots+\beta_k x_{ik})}{h_0(t)*\exp(\beta_1 x_{j1}+\cdots+\beta_k x_{jk})} = \exp(\beta_1(x_{i1}-x_{j1})+\cdots+\beta_k(x_{ik}-x_{jk})). \quad (6)$$

Considering this restrictive assumption, Brenton, Saborowski, and Von Uexkull (2010) suggest two methods to test: the Kaplan-Meier estimator and a Schonenfeld plot of the residuals.

The proportional hazard assumption should result in parallel lines of Kaplan-Meier plot for one variable at different levels. For example, *Income* has four levels (low, lower middle, higher middle, and high). If the data satisfy the proportional hazard assumption, the Kaplan-

[7] In the East Asia and Pacific market, the second and third years have 15,317 and 12,222 observations with 884 and 416 lost, respectively. Combined with equation (1), the conditional survival rate is $S = \frac{15317-884}{15317} \cdot \frac{12222-416}{12222} = 0.91$.

Meier should have four parallel lines for *Income*. Figure 2.3 presents the Kaplan-Meier estimator of *Income*; the lines are not parallel. The proportional hazard assumption is rejected because at least one variable does not pass the test, which indicates the Cox model assumption may not suitable for this study.

Further, the proportional hazard rate assumes that the covariates are time independent (equation 6), meaning that the scaled residuals of the Cox function are time independent. The scaled Schoenfeld residuals are useful to test if the slope of scaled residuals over time is zero, which is an analogous test of the independence between scaled residuals and time. The null hypothesis (H_0) is that the slope of scaled Schoenfeld residuals over time is zero. Table 2.3 presents individual covariate parameters and global test results. Individual test shows that, except for *ln(POP_i)*, *import*, *urbanization*, and *contiguity*, all variables reject the null hypothesis at the 10% statistical significance level. The global test rejects the null hypothesis as well. The visual evaluation of the plot of the scaled Schoenfeld residuals also suggests we should reject the null hypothesis, since at least one variable does not show zero slope. The plot of scaled Schoenfeld residuals of *ln*(*value*) shows the slope of scaled Schoenfeld residuals is about -0.25 (Figure 2.5.1), while the slope of *ln*(*POP_i)* is close to zero (Figure 2.5.2).

Regression Estimates

Based on the test results presented above, we have evidence against the continuous Cox model. Thus, a discrete model (logit) is used. Besides the logit model, Brenton, Saborowski, and Von Uexkull (2010) also provide a discrete time complementary log-logistic model (cloglog) as a robustness check, which is equivalent to the continuous-time Cox model. Despite rejection of the Cox model assumption, we present estimation results of the Cox model to compare with the discrete time model. Instead of the hazard rate, we present the coefficients of the model's covariates. A positive coefficient means a higher event occurrence probability (more trade failures), while a negative coefficient indicates a lower probability of trade failure.

The study applied backward selection procedure to decide variables included in the estimation mode. The Appendix presents the selection results. Table 2.4 provides estimation results. As a robustness check of the logit model, the cloglog model provides consistent results in terms of signs and statistical significance except for *landlocked* which is insignificant. Compared to the logit model, the Cox model presents different significant levels of variables *ln(POP_e)* and *GATT_i*, and the Cox has smaller absolute value of all coefficients. Given that we found evidence against assumptions of the Cox model above and inconsistent results between the models, we consider the results of the Cox model biased. The following discussion is based on the results of the logit model.

Estimation results presented in table 2.4 confirm our hypotheses. The gravity variables, which are positively related to trade flows, have negative coefficients. Higher GDP per capita and larger populations of both importers and exporters lower the probability of trade failures, while longer distance between seafood exporters and importers increases the probability of seafood trade failures. The larger seafood production of ASEAN countries also helps to prevent trade failures. Higher trade values lower the chance of a trade failure. The table also shows that an additional unit of seafood trade value decreases the log odds of trade interruption by 25.8%[8]. This finding is consistent with the conclusion of Hess and Persson (2011) that trade duration is longer with larger trade orders. Economy openness is critical to international trade development. It is easier to maintain a trade relationship if the exporter is a member of GATT/WTO. As

[8] The logit model provides the effect/coefficient of another unit increase in the independence variable on the log odds of the dependent variable. The log odds ratio is the log of the probability of the event divided by the probability that event does not happen (log(P)/(1-P)).

hypothesized, trade with Sub-Saharan Africa is associated with an increased probability of trade failure.

Multiple trade periods significantly increase the probability of trade failures. Specifically, an additional trade period increases the log odds of trade failure by 59.7%, which is the highest effect among covariates (except 1997, when the *year* dummy variable is negative and significant). The coefficient is usually larger in later years compared to the earlier years. For example, if a trade activity starts in 2013, its survival rate of it is much higher than that in 1998.

Discussion and Policy Implications

Estimation results indicate that the average length of bilateral seafood trade periods between ASEAN and the rest of the world is 4.42 years, which is longer than other aggregated commodities in previous studies (around three years). This study helps fill the literature gap in the application of survival models by analyzing the export duration of multiple seafood products from developing countries. Our research is complementary to that carried out by Asche et al. (2017) and Straume (2017) in that their two studies investigate the duration of seafood exports from a developed country (Norway) and focus on a single product. Table 2.4 presents how specific factors correlate with trade duration. Based on the analysis, we offer the following trade policy implications:

The Kaplan-Meier estimator suggests that the conditional survival rate in years four through six is higher than that in the first three years. We conclude that if a trade activity can survive for three years, the easier for them to survive longer. From table 2.4, we provide evidence that a higher GDP per capita and a more populous trade partner are positively correlated with trade duration. To maintain a longer trade relationship, our suggestion to seafood exporters from ASEAN is to start trading with partners from more stable markets, such as developed nations or East Asian and Pacific countries.

Table 2.4 presents evidence that the larger seafood output of the ASEAN region decreases the probability of trade failures. In other words, increasing the ASEAN seafood supply is helpful to extend trade relationships. Although capture fisheries continue to be the dominant source of fish supply, aquaculture has become the major source of seafood output growth in the region, as it grew faster than capture fisheries (annual growth rate 7.4 vs. 1.1%) in the past decade (FAO 2018). Aquaculture's share in the ASEAN region's total seafood production has increased from 15.7% in 1996 to 40.8% in 2016 (FAO 2018), and this increase is projected to continue (Chan et al. 2017). Therefore, creating favorable enabling policies and as wells as a positive regulatory environment for sustainable aquaculture growth and development, such as lowering the interest rate on loans for aquaculture enterprises or encouraging aquaculture technology innovation are essential. Along the value chain, aquaculture expansion stimulates the development of the seed, feed, and logistic supply sectors. Research and development investments that provide higher quality and more variety seeds and feeds will increase seafood output, resulting in longer trade periods. Improvements, such as reduced post-harvest loss, may help increase seafood supply and quality.

Table 2.4 shows that WTO membership of exporters decreases the probability of trade failures, which indicates that open markets and trade liberalization support longer seafood trade period duration. An open economy tends to have standardized, transparent trade regulations and rules. To participate in the world market and enjoy the benefits of trade, countries must follow international rules.

Market competitiveness affects the survival rate of business. Table 2.4 suggests that the ASEAN seafood trade duration is much longer if the export destination is a landlocked market. Landlocked countries have lower seafood production capacity, and as such, seafood exporters from ASEAN countries face less competitiveness from domestic producers. Exporting to landlocked countries increases higher transport costs, which suppresses trade activities. However, infrastructure, trade facilitation, fuel price, and demand elasticity of imported products also affect trade costs significantly (Golub and Tomasik 2008, Behar and Venables 2011). Income (GDP) and population determines the market size and demand elasticity of seafood imports. Table 2.4 shows the positive effect of GDP and population, which mitigates the negative effect of transportation costs (*Distance*). In our case, we consider that increasing demand and lower market competitiveness of landlocked seafood markets induce more trade opportunities and extend the length of the seafood trading period.

Considering perishability of seafood, shorter trade process time from exporters to importers provides higher-quality products and stabilizes seafood trade duration. Table 2.4 also illustrates that longer distance between exporters and importers increases the probability of bilateral seafood trade failure. Wilson (2007) argues that improving the efficiency of non-tariff measures, for example administrative procedures, also benefits international trade. Governments should work together to minimize border-crossing time and implement time saving policies to help seafood trade development sustainably. Seafood trade partners could improve logistical management to minimize seafood transportation time.

TABLES:

Table 2.1. Statistical Summary and Description of Main Variables

	Variable Description	Mean	Std. Dev.	Min.	Max.
Continuous Variable					
ln(Production)	Log of exporter's seafood production	14.24	2.22	8.55	16.19
ln(Value)	Log of trade value	10.34	3.17	0.00	20.71
ln(GDP_e)	Log of GDP per capita of exporter	8.11	1.20	5.70	10.93
ln(GDP_i)	Log of GDP per capita of importer	9.45	1.41	4.66	12.17
ln(POP_e)	Log of population of exporter	18.05	0.16	15.12	18.41
ln(POP_i)	Log of population of importer	16.90	2.04	9.22	21.03
ln(Distance)	Log of distance	8.39	0.90	6.23	9.89
Import	Imported goods over GDP (%)	54.87	48.53	0.12	246.81
Dummy Variable		Sample Share (%)			
Event	Whether the trade activity fails	29.80			
Multiple	Whether there are multiple spells for same exporter-importer-product pair	56.3			
Left-censored	Whether the data is left censored	0.20			
Right-censored	Whether the data is right censored	6.33			
Landlocked	Importer is a landlocked country	4.31			
GATT_e	Exporter is member of GATT	86.50			
GATT_i	Importer is member of GATT	85.17			
ASEAN	Importer is member of ASEAN	19.89			
Contiguity	Whether two countries share border	8.83			

Table 2.2. Trade Duration and Estimated KM Survival Rate

	Trade Duration (Years)	Estimated KM Survival Rate				
		1st	3rd	10th	15th	19th
Benchmark: full sample	4.42	0.83	0.74	0.66	0.61	0.59
Right censored dropped	4.29	0.81	0.72	0.64	0.58	--
Observations with multiple spells	3.17	0.69	0.53	0.36	0.28	0.26
Income level of importer						
High	4.78	0.85	0.77	0.70	0.65	0.62
Upper middle	4.28	0.83	0.73	0.65	0.60	0.58
Lower middle	3.41	0.77	0.65	0.56	0.50	0.48
Low	1.68	0.53	0.33	0.00	0.00	0.00
Region of importer (full sample)						
East Asia & Pacific	5.00	0.87	0.79	0.72	0.68	0.66
South Asia	3.28	0.72	0.59	0.50	0.46	0.44
Central Asia	3.34	0.80	0.66	0.56	0.51	0.00
Europe	3.86	0.80	0.70	0.60	0.52	0.47
Middle East & North Africa	3.35	0.76	0.66	0.56	0.50	0.00
Sub-Saharan Africa	2.63	0.67	0.53	0.40	0.33	0.00
Latin America & Caribbean	4.39	0.81	0.72	0.64	0.61	0.58
North America	5.09	0.87	0.81	0.73	0.68	0.65
Specific products (full sample)						
030110: Ornamental Fish	5.58	0.91	0.86	0.82	0.74	0.59
030379: Tilapia	5.22	0.89	0.83	0.77	0.73	0.70
030613: Frozen Shrimps and Prawns	5.68	0.89	0.84	0.79	0.71	0.70
030749: Squid	5.52	0.89	0.83	0.79	0.73	0.71
030623: Shrimps and Prawns	5.35	0.87	0.82	0.78	0.74	0.74

Note: 1st, 3rd, 10th, 15th, and 19th indicate the first, third, tenth, fifteenth, and nineteenth years.

Table 2.3. Test of Proportional-Hazards Assumption

Time: log(t)	rho	chi2	Df	Prob>chi2
ln(value)	-0.0.09	109.51	1	0.0000
ln(production)	-0.061	66.39	1	0.0000
ln(GDP_e)	-0.066	78.77	1	0.0000
ln(GDP_i)	-0.017	4.93	1	0.0264
ln(POP_e)	0.029	11.14	1	0.008
ln(POP_i)	-0.0004	0.00	1	0.9566
ln(Distance)	0.016	4.66	1	0.0309
Landlocked	-0.013	2.88	1	0.0899
Contiguity	0.008	1.01	1	0.3153
GATT_e	-0.112	228.75	1	0.0000
GATT_i	-0.025	11.16	1	0.0008
Import	0.0002	0.00	1	0.9826
Urbanization	0.002	0.06	1	0.8089
Sub-Sahara	0.019	6.15	1	0.0131
Global test		653.14	16	0.0000

Table 2.4. Estimation Results of the Cox, Logit and Cloglog Model

	Cox Regression		Logit Estimation		Clogclog Estimation	
	Coefficient	SE	Coefficient	SE	Coefficient	SE
ln(value)	-0.203***	0.003	-0.258***	0.004	-0.186***	0.003
ln(production)	-0.039***	0.01	-0.094***	0.013	-0.071***	0.010
ln(GDP_e)	-0.143***	0.021	-0.235***	0.028	-0.184***	0.022
ln(GDP_i)	-0.215***	0.011	-0.255***	0.016	-0.198***	0.012
ln(POP_e)	-0.022	0.052	-0.151**	0.070	-0.118**	0.050
ln(POP_i)	-0.082***	0.004	-0.089***	0.006	-0.074***	0.004
ln(Distance)	0.291***	0.016	0.376***	0.021	0.276***	0.016
Landlocked	-0.062*	0.034	-0.097**	0.05	-0.038	0.035
Contiguity	0.0003	0.036	0.065	0.047	0.037	0.037
GATT_e	-0.907***	0.033	-0.911***	0.044	-0.697***	0.034
GATT_i	-0.066***	0.024	-0.05	0.034	-0.029	0.025
Import	-0.001***	0.002	-0.001**	0.000	-0.001***	0.0003
Urbanization	0.001	0.001	0.001	0.001	0.001	0.001
Sub-Saharan	0.187***	0.037	0.345***	0.056	0.245***	0.039
# of trade spells	0.535***	0.008	0.597***	0.010	0.400***	0.007
Year dummy						
1997	0.02	0.105	0.132	0.139	0.081	0.110
1998	-0.441***	0.109	-0.331**	0.141	-0.296***	0.112
1999	-0.575***	0.102	-0.518***	0.133	-0.439***	0.105
2000	-0.808***	0.099	-0.665***	0.130	-0.556***	0.102
2001	-0.963***	0.098	-0.708***	0.129	-0.578***	0.102
2002	-1.057***	0.098	-0.727***	0.129	-0.602***	0.101
2003	-1.183***	0.098	-0.802***	0.129	-0.602***	0.101
2004	-1.194***	0.098	-0.785***	0.129	-0.666***	0.102
2005	-1.385***	0.099	-0.952***	0.130	-0.780***	0.102
2006	-1.395***	0.099	-0.871***	0.130	-0.743***	0.102
2007	-1.339***	0.099	-0.668***	0.130	-0.587***	0.102

	Cox Regression		Logit Estimation		Clogclog Estimation	
	Coefficient	SE	Coefficient	SE	Coefficient	SE
2008	-1.456***	0.101	-0.810***	0.131	-0.701***	0.104
2009	-1.552***	0.100	-0.908***	0.131	-0.771***	0.103
2010	-1.639***	0.102	-0.95***	0.133	-0.834***	0.105
2011	-1.487***	0.102	-0.494***	0.134	-0.502***	0.105
2012	-1.635***	0.103	-0.816***	0.135	-0.709***	0.106
2013	-1.817***	0.104	-1.123***	0.136	-0.933***	0.107
Number of obs	56,566		56,566		56,566	
Log likelihood	-169,768		-27,430		-27,892	
Prob>chi2	0.000		0.000		0.000	

Note: SE is the standard error.
***, **, and * indicate statistical significance at the 0.01, 0.05, and 0.1 levels respectively.

FIGURES:

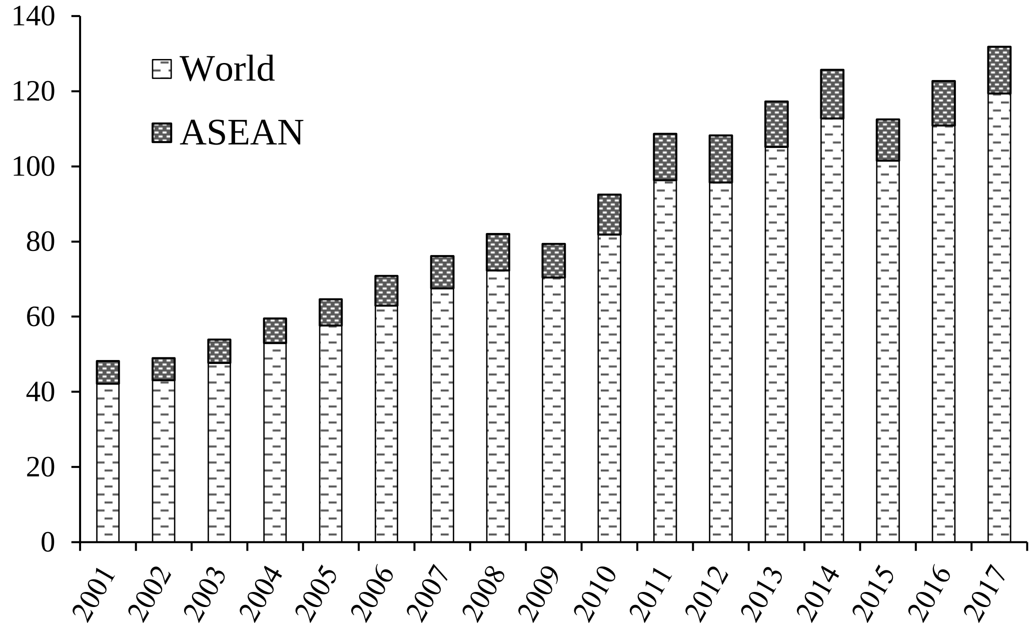


Figure 2.1. Seafood Export Value from 2011-2017 (USD billions)

Source: International Trade Center http://www.intracen.org/itc/market-info-tools/trade-statistics/
Note: Trade value is in nominal terms.

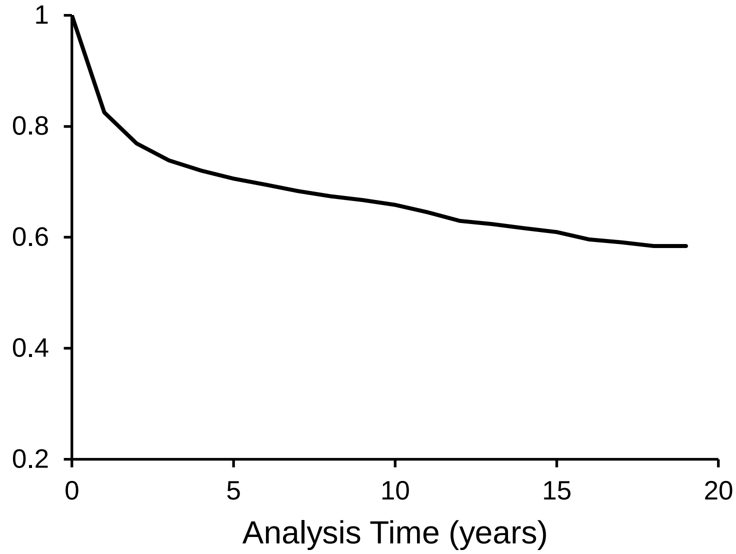


Figure 2.2. Kaplan-Meier Survival Estimates at the Aggregate Level

Note: The vertical axis indicates the survival rate in specific years. The horizontal axis indicates the analysis time in specific years.

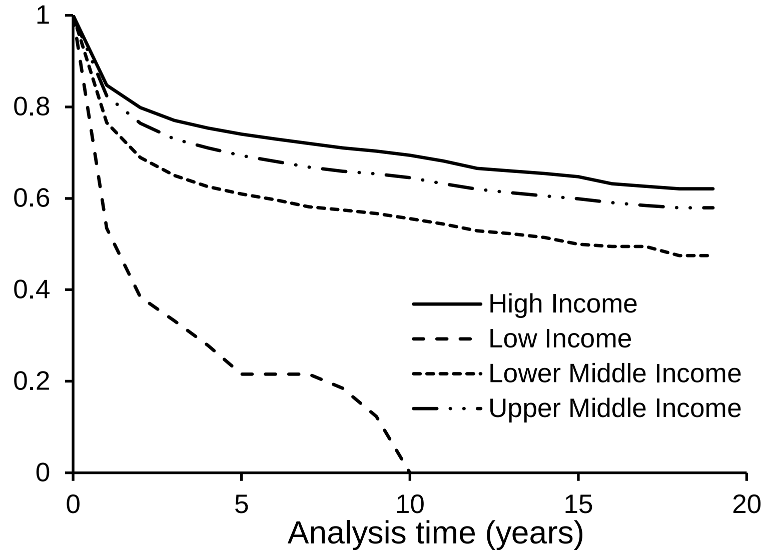


Figure 2.3. Kaplan-Meier Survival Estimates at the Income Level

Note: The vertical axis indicates the survival rate in specific years. The horizontal axis indicates the analysis time in specific years.

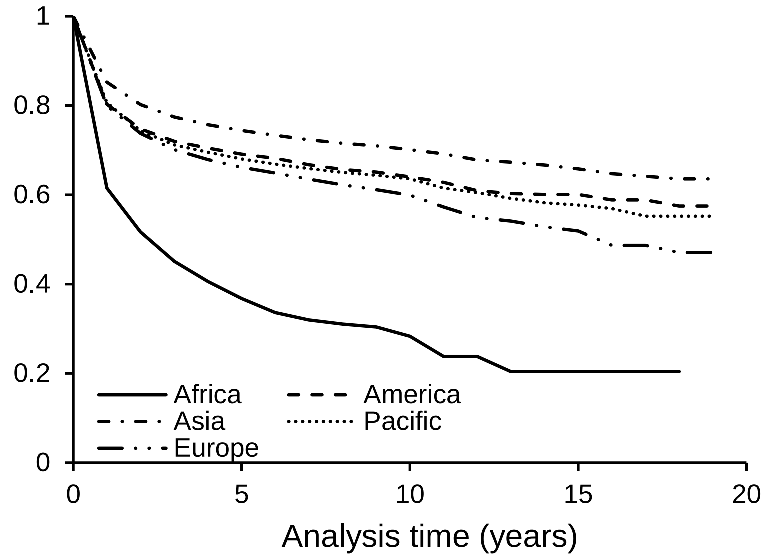


Figure 2.4. Kaplan-Meier Survival Estimates at Continent Level

Note: The vertical axis indicates the survival rate in specific years. The horizontal axis indicates the analysis time in specific year. America includes North and South America continent.

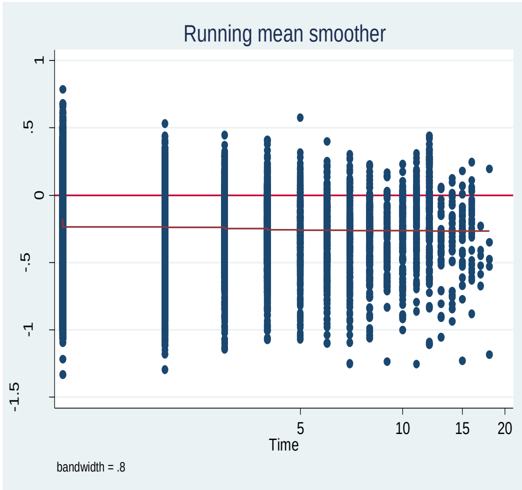


Figure 2.5.1. SSR of *value*

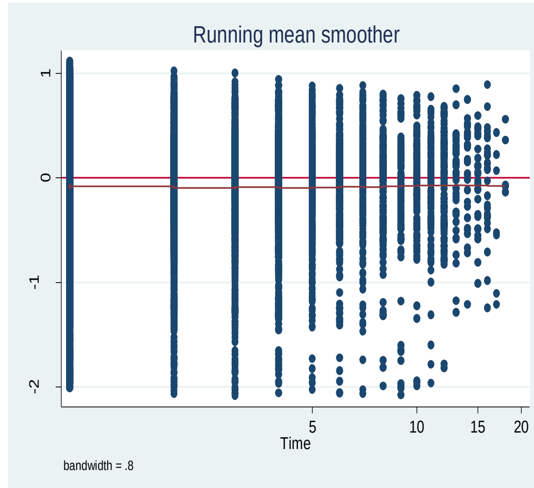


Figure 2.5.2. SSR of *ln(POP_i)*

Figure 2.5. Plots of Scaled Schoenfeld Residuals (SSR)

Note: The horizonal solid line below zero indicates the value of the scaled Schoenfeld residual

Chapter 3. The US-China Trade War: Structure of Global Meat Imports

Introduction

As income improves, food demand has shifted from traditional staples to more refined foods, and to animal-source products (meat, fish, milk and eggs) that are of higher nutrient value or increased health benefits (e.g., Thurstan & Roberts, 2014). Meat consumption has been increasing over decades across the world. Globally, per capita meat consumption is around 43 kilograms in 2014 which is approximately twice that in 1961(Roser 2018). Although the US and EU are large and traditional meat consumers, Revell (2015) projected global meat consumption will increase by more than 60% to 464 million tons, with the greatest increase in Asia and Africa. As consumption is growing, international trade of meat also expands. In quantity terms, the global meat export was 1447 tons in January 2000 and it increased to 9 million tons in January 2018 (Figure 1). The US, EU, Brazil, and Australia are traditional meat exporters. They have accounted for more than 80% of global meat exports since 2005. Global meat trade is closely related to consumers' meat demand pattern. Knowledge of import demand structure of meat provides comprehensive understanding of global food trade market. This study contributes to the literature on the demand of global meat imports.

China is one of the largest meat consumers and the consumption growth rate is increasing rapidly (Ortega, Wang, and Chen 2015). In 2011, per capita meat consumption in China is 57.73 kg which is more than 5 times than that in 1971 (Table 1). Total meat consumption in China is projected to reach 98.5 million tons in 2023 and per capita meat consumption increases by 2.4% annually (Luo and Tian 2018). The meat consumption pattern in China is different from the ones in developed countries. Chinese consumers prefer animal offal and cut that are less desired in the US and European market (Wang et al. 1998; Oh and See

2012). Exporting the offal to China provides US livestock industry a chance to add values to carcasses while at the same time reduce cut price that is desired in their domestic markets. Ortega, Holly Wang, and Eales (2009) found that pork is the primary meat product and considered as a necessity in China; they also projected pork would capture the highest (50.63%) marginal meat expenditure among all meat products.

The livestock production process is complained to emit a large quantity of greenhouse gas, pollute water and soil, and even cause deforestation and other environmental problems. Constraints of livestock production, such as limited agricultural space, water pollution, land deterioration, animal disease, etc. force China to increase meat imports to meet the growing demand. In terms of quantity, China has been a net meat importer since 2005 and the trade deficit of meat is growing over time (Table 2). Increasing meat imports of China provides a good opportunity for U.S meat producers (Ortega, Wang, and Chen 2015).

The primary purpose of this research is to analyze the market structure of global meat exports and estimate demand elasticity of pork imports in China. It measures market competitiveness of exporters. As an animal protein provider, beef, pork, chicken, and other meat is highly substituted to each other. The study aggregates all types of meat under chapter 02 (Meat and Edible Meat Offal) of Harmonized Commodity Description and Coding System (HS) to evaluate global demand structure of meat imports[9]. The US meat exports have been affected by the controversial trade barriers and political disputes. In January 2018, the Trump administration stated that it would impose an extra tariff on almost all imports from China in the future. In retaliation, China put an additional 25% tariff on imported pork from the US. The secondary

[9] The Harmonized System is an international nomenclature for the classification of products. Learn more about HS at https://unstats.un.org/unsd/tradekb/Knowledgebase/50018/Harmonized-Commodity-Description-and-Coding-Systems-HS

purpose of this research is to investigate the effects of trade disputes on livestock farmers in the US and consumers in China.

The paper arrangements are as follows: the literature review presents a brief overview of studies on meat demand, such as demand elasticity estimation, animal disease effects, and estimation techniques; followed by the model discussion; the data section provides data and variable description; the results section presents assumption tests and empirical estimation results; the US-China trade war analysis; and the last section discusses the conclusions.

Literature Review

Previous studies of meat demand focus on individual domestic markets such as China, Saudi Arabia, Australia, Japan, Nordic countries and the US (Zhou et al. 2016; Selvanathan et al. 2016; Wong, Selvanathan, and Selvanathan 2015; Ishida, Ishikawa, and Fukushige 2010; Rickertsen, Kristofersson, and Lothe 2003; Dahlgran and Fairchild 2002; Mo 2013, Lusk and Tonsor 2016). They are important in establishing the magnitudes of country-specific domestic demand elasticities. Domestic demand is inevitable affected by the international market. Import demand elasticity is an important factor to measure exporters' market competitiveness and study the global market structure. Deriving import demand from domestic demand and production function, Wang et al. (1998) assessed Chinese domestic demand and the net import of pork and poultry with respect to its potential tariff reduction. They concluded that as import demand of China is expanding the US will capture most of the market. Taking Norway, UK, and Chili as major exporters, Xie, Kinnucan, and Myrland (2009) estimated the world demand elasticities and market competition of farmed salmon. They concluded the UK faces the highest competition in the global fresh salmon market. However, there is a lack of studies that apply the demand system to estimate the global meat exports market.

Animal disease outbreaks, such as Bovine Spongiform Encephalopathy (BSE) and HPAI are believed to undermine meat demand because of health concerns. Ishida, Ishikawa, and Fukushige (2010) investigated the impact of BSE and HPAI on meat consumption in Japan. They found significant substitution between unaffected (pork and fishery) and affected meat (beef and chicken) products. However, compared to BSE, the effects of avian influenzas have a relative short-run effect. Wang and Beville (2017) examined the impact of news reports about avian influenza outbreaks on chicken consumption in the US. They found that consumers would reduce poultry demand whether or not the avian influenza is in US; however the magnitude of the effect is much lower if the outbreak is from overseas. Zhou et al. (2016) conducted a field survey to quantify the impact of H7N9 bird flu in urban China. Bird flu decreases demand of regular chicken meat while consumers' WTP to safer chicken products do not increase either. To date, the effects of HPAI on global meat/chicken trade is unknown.

Henneberry, Mutondo, and Brorsen (2009) argued that the global meat industry is a highly segmented market, affected by cross-product relationships resulting from supply source preference. Mutondo and Henneberry (2007) applied the Rotterdam model to estimate price and expenditure elasticities of meat demand in the US based on source differences. They concluded that the Canadian beef would benefit most from meat expenditure expansion in the US since it has the largest meat expenditure elasticities. Muhammad and Jones (2011) investigated the importance of the origin source in determining US demand of imported salmon using the Rotterdam model. They concluded that import preference is not homogeneous across all exporters, and we would lose some information if source differentiation is not considered. Kutlina-Dimitrova (2017) assessed the economic impact of the Russian embargo on agricultural food products from major developed countries. The modelling simulation results show that meat products from the US experienced at least 24% declines. Following previous arguments, this study estimates the global demand of meat imports based on source differentiation. To our knowledge, there is no study that applies export data to estimate the Engle curve of aggregate meat in the global market. This study aims to fill the literature gap.

Model

The Rotterdam model has been frequently used to estimate world trade structure (Selvanathan 1991; Mutondo and Henneberry 2007; Muhammad and Jones 2011). Following previous discussions, this study applies the absolute price version of the Rotterdam demand system to analyze global meat demand structure. To our knowledge, this is the first study that examines global demand structure and market competition of meat products using the system-wide approach. The Rotterdam model of this study can be written as (we omit time for simplification):

$$\bar{R}_i dlnq_i = \alpha_i + \sum_j^m \theta_{ij}\, dlnp_j + \mu_i dlnQ + \sum_{s=1}^n \beta_s \boldsymbol{O}_s \qquad (1)$$

The subscripts i and j indicate products, m represents the number of products, n represents the number of other influencing factors. q_i is trade quantity of product i, while p_i is the unit price. The "purchase unit value" is taken as the unit price (Gibson and Kim 2013), which equals to total export (import) value divided by total export (import) quantity. $R_i = p_i q_i / \sum_{i=1} p_i q_i$ is the budget share of total expenditure on goods i. $\bar{R}_i$ is the two periods average of R_i, for example, $\bar{R}_t = (R_t + R_{t-1})/2$. *dln*() is the log-change operator, for example, $dlnq_i = \log(q_i)_t - \log(q_i)_{t-1}$. θ_{ij} is the Slutsky price coefficient which measures own and cross price effects. $dlnQ = \sum_{i=1} R_i dlnq_i$ is the Divisia volume index for the change in real expenditure on all exported meats. μ_i is the share weighted expenditure elasticity on product i . Vector $\boldsymbol{O}$ contains all the other influencing factors, such as seasonality, animal disease outbreaks, and GDP per capita in China. α_i is a random disturbance term, which captures the trend effects over time.

Different from other ad-hoc demand estimations, the system-wide Rotterdam demand equations are derived from sound economic theory. Hold total expenditure on meat/poultry constant and under utility maximization assumptions, the demand model meets homogeneity and symmetry restrictions. Homogeneity of prices indicates that equal proportionate change in all prices has no effect on the demand quantity for any product. Symmetry, also called *Slutsky symmetry*, implies the effect of a proportional increase in the price of product *j* on the demand for product *i* is equal to the effect of a same proportional increase price of product *i* on the demand of product *j*. Adding-up restrictions which are derived from Engle and Cournot aggregation are assumed to fit the model automatically. In estimation system, because of singularity issue in the variance-covariance we need to drop one equation. Adding-up assumptions are used to recover the parameters coefficient of the omitted equation. One condition to make sure the estimation results are invariant to the deleted equation is that the disturbances are serially independent (Berndt and Savin 1975, Thong 2012). The Breusch-Godfrey test is applied to test whether there is autocorrelation in the errors of the model. The null hypothesis (H_0) is that there is no serial correlation of any order up to p orders. The major difference between the Breusch-Godfrey test and the widely used Durbin-Watson method is that the latter one only tests the first-order linear association and it might get inconclusive result. Theoretical restrictions are written as follows:

Homogeneity: $\sum_{j=1}^{m} \theta_{ij} = 0$ (2A)

Symmetry: $\theta_{ij} = \theta_{ji}$ (2B)

Adding-up: $\sum_{i=1}^{m} \alpha_i = 0, \sum_{i=1}^{m} \mu_i = 1, \sum_{i=1}^{m} \theta_{ij} = 0,$

$$\sum_{i=1}^{m} \delta_{si_m} = 0,\ \sum_{i=1}^{m} \beta_{i_m} = 0, \sum_{i=1}^{m} \Upsilon_{i_m} = 0 \qquad (2C)$$

Price and expenditure elasticities are elementary tool to study market demand structure. Compensated and uncompensated demand elasticities and Allen substitution elasticity are calculated using the parameters estimation based on following formulas:

$$A_i = \frac{\mu_i}{R_i} \qquad \text{Expenditure elasticity} \qquad (3A)$$

$$e_{ij}^* = \frac{\theta_{ij}}{R_i} \qquad \text{Compensated price elasticity} \qquad (3B)$$

$$e_{ij} = e_{ij}^* - R_j A_i \qquad \text{Uncompensated expenditure elasticity} \qquad (3C)$$

$$\sigma_{ij}^* = \frac{e_{ij}^*}{R_j} \qquad \text{Allen Substitution elasticity} \qquad (3D)$$

Data

The study uses quarterly export and import data[10], they are restricted to 1st quarter 2005 to 4th quarter 2017 based on data availability. The data are downloaded from International Trade Center (ITC). The Unit value[11] of export (import) price is used to measure market price, which is the total export (import) value divided by total export (import) quantity. Export trade data of aggregated meat (HS02) are used to do global demand structure analysis. It estimates the global import demand elasticities to assess market competition among major meat exporters. China is one of large pork importers. The study analyzes effects of the "trade war" between US and China on pork producers and consumers.

[10] Global export data are used to measure global meat demand structure, and it is FOB value; China import data are used to estimate pork imports demand in China, and it is CIF value.
[11] The unit price of export equals to export value (FOB) divided by export quantity. The unit price of import equals to import value (CIF) divided by import quantity.

Table 3 provides data description of variables to estimate global import demand structure of meat. The global meat market is highly concentrated, with the top four exporters accounting for 81.5% of the market share. The European Union (EU) has the largest market share in the meat market, accounting for almost half of the imported meat supply (49.6%), and it is followed by the US, Brazil, Australia (Figure 2). In quantity terms, the EU has exported largest amount of meat as well. However, the US has the lowest unit price ($1992/ton), which is only 47.18% of the price of Australia (the highest price). Compared to the aggregated meat category, price of imported pork does not vary a lot among different sources. Contrary to the aggregated meat price, the EU has the lowest unit price of pork products ($1430/ton). Imported pork products market of China is more concentrated compared to the global aggregated meat market. EU holds 50.3% of the imported pork market of China, the US and Canada almost equally shares the remaining market equally.

Animal diseases, such as HPAI, BSE, foot and mouth, and classical swine fever affect livestock production and bring consumers health concern. Animal disease outbreaks report is collected from the World Organization for Animal Health (OIE). HPAI and BSE are two types of animal diseases happens in major meat exporters during our research period which might affect the global meats trade. The dummy variable indicator of animal disease existence in major meat exporters is included in the model to estimate the effects of animal disease (HPAI and BSE) outbreaks on meats trade market. To simplify the study, we assume there is no outbreaks in the rest of world (ROW). We hypothesize that animal disease would decrease meats exports, hence it has a negative coefficient in estimation system. S1, S2, and S3 are dummy variables to represent the first (January-March), second (April-June), and third (July-September) quarter season. Quarter dummy variable is used to examine whether seasonality determines meat demand pattern. Income is one of important factors affect meat consumption pattern. GDP per capita of China is included in the Chinese import demand estimation model. The World Bank datasets provides GDP per capita data.

Estimation results

The Godfrey's Serial Correlation test is applied to check whether the data present a time serial correlation. The null hypothesis (H_0) of the test is that there is no serial correlation. Table 3.4 presents the test results under different scenarios. The raw data without imposing homogeneity and symmetry restriction do not present serial correlation, we accept H_0 at 99% statistic significant level. After posing restrictions, at least one equation present a serial correlation. Following the discussion of Feleke and Kilmer (2007), the lagged dependent variable and error term are included as explanatory variables to correct correlation problems in the estimation system. The last column of Table 4 presents the Godfrey test results after imposing restrictions and including the lagged explanatory variables. In the global meat imports estimation system, the null hypothesis (H_0) is accepted at 99% statistical significance level and conclude there is no serial correlation.

Parameter estimations of the global imports demand of meat are shown in Table 5. Intercept captures time trend effect of meat consumption. For example, intercept of the US demand equation implies whether consumers' preference of meat imports from the US is increasing or not. No intercept shows statistic significant results, which indicates that importers' preference of meat imports does not vary to country origins over time. Although BSE and HPAI decreases poultry and other meat products consumption (Ishida, Ishikawa, and Fukushige 2010; Zhou et al. 2016), the estimation shows that outbreaks of animal disease in major meat producers did not significantly changes the global meat exports structure. One reasonable explanation is that there are highly substitution effects among beef, pork, chicken, lamb and other meat since they are all animal protein sources. The BSE or HPAI outbreaks that reduces production and consumption of beef or poultry would be complemented by the other meats, hence overall meat consumption has not been affected a lot.

All elasticities of this study are estimated at the mean of expenditure share (R¯_(i_m)). Table 6 presents price and expenditure elasticities of meat exports from major exporters. The absolute value of all own-price elasticities is less than one, while the EU has the largest own price elasticity (-0.904) followed by the US (-0.836). The results indicate that exported meat is considered as necessity. Compensated price elasticity between the EU and US is statistically positive significant, which indicates the exported meat from the EU and US are statistically substitute to each other. Similarly, cross compensated price elasticity between the EU and Brazil, EU, and Australia are also positive statistically significant. The estimation results conclude that the EU faces the most market competition in the global meat market. While the EU would benefit most from higher meat expenditure since it has the largest expenditure elasticity (1.124). Expenditure elasticity times average market share is called marginal expenditure share, it measures how the additional expenditure on meat imports are allocated among exporters (Wang et al. 1998). Last column of Table 6 presents marginal expenditure share of major meat exporters. The results suggest the global market is likely to allocate additional meat expenditure as follows: 51.7% to EU, 22% to other emerging exporters, both Brazil and US has 10%, and the remaining 5.3% to Australia. As buying power and meat market of Asia and Africa grows consistently, EU can benefit most from the expanding markets. The US, in contrast, does not benefit much because it has the smallest expenditure elasticity and marginal expenditure share except Australia.

Consistent with economic demand theory, own-price elasticities of imported pork of China from different sources are all negative (Table 7). The absolute value of the own-price elasticities is less than 1, indicating pork imports are considered as necessity in China. Pork from non-traditional exporter has the highest price elasticity, while the pork from the US has the largest expenditure elasticity (2.684). The US has the highest marginal share (61.8%), which means the US will benefit most from the expanding Chinese pork consumption market. Although the EU holds half of the pork imports market in China, it has a much smaller expenditure elasticity (0.54) and marginal expenditure elasticity (0.271).

US-China trade war analysis

In January 2018, the US initiated the US-China trade war by imposing an extra tariff on solar panel imports from China. On July 6, the US imposed a 25% tariff on $34 billion of imported Chinese goods which intensified the trade war. Furthermore, on September 24, the Trump administration imposed an extra 10% tariff on $200 billion of Chinese goods while China retaliated immediately with new 5 to 10% on $60 billion of US goods including meat. The new round tariff on China has applied to more than $250 billion of Chinese goods which is almost half of all Chinese goods exported to US. As part of Chinese retaliation, China imposed a 25% tariff on pork imports from the US and it threatened to increase the tariff level in the future.

Tariffs are a debated topic and believed to cause dead weight losses and intensify trade distortions for both importers and exporters. While the traditional opinion of trade wars argue that bigger countries win trade wars, or larger countries suffer less from trade wars than smaller ones (Syropoulos 2002, Kennan and Riezman 2013), the trade wars between the US and China is controversial as both of them are claimed to be “large” country. Bouët and Laborde (2018) applied a computable general equilibrium (CGE) model to evaluate trade and macroeconomics effects of US-China trade wars on both US and China under different scenarios, namely unilateral, bilateral, and Nash tariffs equilibria. They concluded that any type of trade wars would deteriorate the US economy, negatively affect agricultural and non-agricultural sectors, skilled and unskilled workers; while the third partner might benefit from the US-China trade wars.

Export supply and import demand elasticity is vital to analyze trade policy effects, which determines the changes of trade volume. Economists believe that trade participants with smaller elasticity bear more tax because it is harder for them to find a replaceable partner (Koo and Kennedy 2005; Li, Gunter, and Epperson 2011). Li, Gunter, and Epperson (2011) calculate consumers tax incidence (I^C) to determine what is the percentage of tariff that consumers need to pay.

$$I^C = \frac{e_x}{e_x + e_m} \tag{4}$$

where e_x is the price elasticity of export supply ($e_x > 0$), and e_m is the absolute value of price elasticity of import demand ($e_m > 0$).

Export supply elasticity of pork of US lacks estimation. Export supply elasticity of US beef to South Korean was hypothesized at 2, 5, and 10 (Kim and Park 2017). To estimate who bears most cost of agricultural support in the OECD countries, Tokarick (2005) assumed export supply elasticity ranged from 1.5 to 10 depending on the product. Lusk and Anderson (2004) estimated the supply elasticity of hog of US close to 0.4. In this study, we assume export supply elasticity of pork of US (e_x) is 1.5. Based on the import demand elasticity estimation in Table 7, e_m is -0.64. $I^C = 0.7$. As a results of US-China trade war, pork consumers in China bear most (70%) tariff.

Hicksian compensating variation (CV) measures the changes of expenditure to compensate consumers as prices change. Positive CV implies decrease in consumer welfare because it means more spending required to maintain same utility level. While a negative CV indicates increasing consumer welfare. Huang and Huang (2000) evaluated consumer welfare changes of tariff reform applying Hicksian compensating variation (CV).

$$CV = E(p^1, u^0) - E(p^0, u^0) = p^1 \cdot q^{h}[12](p^1, u^0) - p^0 \cdot q^0 = p^1 \cdot dq^h + q^0 \cdot dp \qquad (5)$$

Based on initial price (p^0) and consumption quantity (q^0), changes of compensated demand quantity (dq^h) and price (dp) are key components to calculate CV. Bottom panel of Table 7 presents Hicksian price elasticity of US pork imports in China (-0.026). Imports quantity changes are shown in second and third columns of Table 8. The price (p^0) and quantity (q^0) of the fourth quarter of 2017 is considered as base value for welfare estimation, where $p^0 = \$1800/ton$ and $q^0 = 38479\ tons$. Other factors that influence price changes are assumed to be constant, the price changes (dp) varies to tariff levels. First column of Table 8 presents dp responding to different tariff imposed. CV under different scenarios are listed in the last column. Despite the CV has difference, they are all positive. It concludes that the extra imposed tariff on US pork products will cause consumer welfare loss in China.

Not only consumers in China, hog producers in US also suffer from the trade war. The Herfindahl-Hirschman index (HHI) measures market concentration. The concentration level is an indicator of market structure, the higher value of HHI the closer to monopoly market (Rhoades 1993, Naldi and Flamini 2014). Imported pork market in China is highly concentrated,

[12] q^h is a vector of Hicksian compensated demand at given price p^1 and at the same initial utility level u^0. $dp = p^1 - p^0$, and $dq^h = q^h(p^1, u^0) - q^0$

with the top three exporters accounting for 97.04% market share. And the HHI of the three exporters is 3620 which is much higher than the critical value of 2500. It is reasonable to argue that imported pork market is imperfectly competitive. Weldegebriel, Wang, and Rayner (2012) found that the degree of price transmission from markets to farmers price under imperfect competition is greater than that under perfect conditions. Tax incidence (I^C) concludes that suppliers of US pork products at least pay 30% of the tax. Pork is a lucrative slice of US exports to China (Buckley and Wee 2018), facing higher tariff would hurt hog producers' benefits clearly.

Conclusion

The study applies the Rotterdam demand system to estimate price and expenditure elasticity of the global meat imports and pork imports demand in China separately. It contributes to the literature on Engle curve estimation of global meat trade market. It also analyzes consumer and producer welfare changes after China threatened to impose 25% tariff on the US pork imports.

The elasticities provide hints to analyze market competitiveness. The estimation results conclude imported meat is price inelastic and considered as necessity of daily life. The EU accounts for the largest market share of global meats export and it will benefit most from the growing global meat market as well. However, the EU faces the highest competitions from the other exporters. The US has a very small marginal expenditure share in the global meat market (9%). To main its market share and benefit from the growing market, the US needs to explore new market and improve product quality.

In contrast to the aggregate meat market, imported pork in China is less competitive. The top three exporters accounting for 97.04% of market share. Consumer tax incidence calculation concludes that the pork consumers in China pay 70% of tariff, while the hog producers in the

US needs to pay 30% of tariff. Hicksian compensating variation (CV) finds that consumers in China bear welfare loss following the tariff China imposed on the imported pork from the US.

TABLES:

Table 3.1. Meats consumption per capita in China (unit: kg/year)

	World	China	US	EU
1961	23.08	3.79	88.65	51.95
1971	27.57	10.03	108.53	66.8
1981	30.55	15.02	108.48	79.42
1991	33.58	26.53	114.27	84.62
2001	37.17	44.77	120.78	83.99
2011	42.27	57.73	116.29	84.42

Note: Meat includes cattle, poultry, sheep/mutton, goat, pig meat, and wild game. Figures are given in terms of dressed carcass weight, excluding offal and slaughter fats.
Source: https://ourworldindata.org/meat-and-seafood-production-consumption

Table 3.2. Meats trade balance of China

	Value ($million)			Quantity (1000 tons)		
	Import	Export	Balance	Import	Export	Balance
2005	598	841	-243	633.43	474.84	158.59
2006	627	665	-38	850.65	485.76	364.89
2007	758	646	112	1340.23	367.58	972.65
2008	476	707	-231	1830.17	303.51	1526.66
2009	587	743	-156	1364.61	301.91	1062.70
2010	686	747	-61	1542.52	367.72	1174.79
2011	1,520	731	788	1904.41	335.42	1569.00
2012	2,320	798	1,522	2084.08	293.69	1790.39
2013	1,701	764	937	2562.46	308.84	2253.62
2014	2,225	995	1,230	2457.89	347.45	2110.44
2015	3,411	1,075	2,336	2725.31	340.39	2384.91
2016	4,108	981	3,127	4532.64	293.59	4239.05
2017	5,930	989	4,941	3941.83	310.21	3631.62

Note: Balance=Import-Export
Source: International Trade Center http://www.intracen.org/itc/market-info-tools/trade-statistics/

Table 3.3. Description of quantity, price, market share, and other variables

Parameter	Label	Unit	Mean	Std Dev
Global import demand of meats estimation				
US_Q	global imported meats from US	tons	1565301	254611
EU_Q	global imported meats from EU	tons	3134713	790996
Brazil_Q	global imported meats from Brazil	tons	1354799	158416
Australia_Q	global imported meats from Australia	tons	425114	61713
ROW_Q	global imported meats from other exporters		1479241	401275
US_P	unit price of imported meats from US	$1000/ton	1.992	0.372
EU_P	unit price of imported meats from EU	$1000/ton	3.996	0.591
Brazil_P	unit price of imported meats from Brazil	$1000/ton	2.187	0.377
Australia_P	unit price of imported meats from Australia	$1000/ton	4.222	0.665
ROW_P	unit price of imported meats from others	$1000/ton	3.131	0.383
US_R	share of imported meats from US		0.125	0.014
EU_R	share of imported meats from EU		0.496	0.044
Brazil_R	share of imported meats from Brazil		0.120	0.009
Australia_R	share of imported meats from Australia		0.073	0.011
ROW_R	share of imported meats from others		0.185	0.035
Imported Pork Demand in China				
US_CQ	imported pork from US	tons	27555	25855
EU_CQ	imported pork from EU	tons	77829	83721
Canada_CQ	imported pork from Canada	tons	15422	13829
ROW_CQ	imported pork from other importers	tons	6308	10301
US_CP	price of imported pork from US	$1000/ton	1.460	0.515
EU_CP	price of imported pork from EU	$1000/ton	1.430	0.510
Canada _CP	price of imported pork from Canada	$1000/ton	1.511	0.367
ROW_CP	price of imported pork from others	$1000/ton	2.326	0.702
US_CR	share of imported pork from US		0.230	0.187
EU_CR	share of imported pork from EU		0.503	0.218
Canada _CR	share of imported pork from Canada		0.238	0.221
ROW_CR	share of imported pork from others		0.030	0.033

Table 3.4. Godfrey's Serial Correlation Test

		Without restrictions		With restrictions			
		Original		Original		Lagged	
A.		LM	Pr	LM	Pr	LM	Pr
Global meat imports demand	US	1.16	0.28	1.78	0.18	1.51	0.22
	EU	4.23	0.04	11.7	<0.01	4.19	0.04
	Brazil	4.64	0.03	7.78	0.01	3.75	0.05
	Australia	1.72	0.19	1.68	0.19	1.27	0.26
B.	US	0.28	0.6	6.92	0.01	5.37	0.04
Pork Imports demand of China	EU	0.06	0.81	5.34	0.02	10.8	<0.01
	Canada	1.83	0.18	6.02	0.01	2.54	0.27

Note: "Lagged" means lagged dependent and error term is included as explanatory variables. LM and Pr is rounded to 2 digits decimal points; Pr is the Probability.

Table 3.5. Non-Price and Non-Expenditure Estimation Parameters of Global Meats Trade

	Global Meat Imports Demand System				
	US	EU	Brazil	Australia	ROW
Intercept	0.001	-0.479	-0.003	0.476	0.005
	(0.002)	(1161)	(0.004)	(1.16)	(0.005)
S1	-0.003	-0.004	0.002	-0.008***	0.013
	(0.004)	(0.012)	(0.006)	(0.003)	(0.01)
S2	0.005	0.012	0.002	-0.005**	-0.015**
	(0.003)	(0.009)	(0.005)	(0.002)	(0.006)
S3	0.001	0.01	0.006	-0.006***	-0.011
	(0.003)	(0.009)	(0.004)	(0.002)	(0.007)
US_disease	-0.005	-0.021	0.005	-0.002	0.023
	(0.007)	(0.019)	(0.009)	(0.003)	(0.015)
EU_disease	-0.004*	0.006	0.001	-0.0001	-0.003
	(0.002)	(0.006)	(0.003)	(0.001)	(0.005)
Australia_disease	-0.001	-0.002	0.002	0.001	0.0002
	(0.004)	(0.01)	(0.005)	(0.002)	(0.008)
Brazil_disease	-0.002	0.001	-0.001	-0.006*	0.009
	(0.005)	(0.015)	(0.007)	(0.003)	(0.012)
Adjusted R^2	0.557	--	0.503	0.822	0.237
DW	2.138	--	2.191	1.945	1.843
GF Test (Pr)	0.215	--	0.01	0.256	0.035

Table 3.6. Marshallian, Hicksian Price and Expenditure Elasticities of Global Meat Imports

	US	EU	Brazil	Australia	ROW	Expenditure	Marginal Expenditure
				Marshallian Elasticity			
US	-0.836***	-0.071	-0.025	0.069	0.144	0.719***	0.1***
	(0.19)	(0.079)	(0.158)	(0.1)	(0.205)	(0.219)	(0.03)
EU	-0.069	-0.904***	-0.024	-0.027	-0.1	1.124***	0.517***
	(0.043)	(0.061)	(0.054)	(0.029)	(0.092)	(0.16)	(0.073)
Brazil	-0.054	-0.005	-0.31	-0.073	-0.494**	0.935***	0.1***
	(0.162)	(0.108)	(0.232)	(0.118)	(0.24)	(0.305)	(0.034)
Australia	0.123	0.04	-0.088	-0.402	-0.35	0.678*	0.052**
	(0.161)	(0.06)	(0.178)	(0.324)	(0.219)	(0.278)	(0.021)
ROW	0.059	-0.222	-0.331**	-0.164*	-0.37	1.028***	0.22***
	(0.139)	(0.134)	(0.155)	(0.085)	(0.272)	(0.325)	(0.07)
				Hicksian Elasticity			
US	-0.845***	0.286**	0.061	0.121	0.277		
	(0.186)	(0.131)	(0.148)	(0.097)	(0.193)		
EU	0.072**	-0.346***	0.111**	0.055**	0.107		
	(0.033)	(0.095)	(0.044)	(0.024)	(0.071)		
Brazil	0.064	0.459**	-0.198	-0.004	-0.321		
	(0.155)	(0.18)	(0.22)	(0.113)	(0.218)		
Australia	0.208	0.376**	-0.007	-0.353	-0.224		
	(0.167)	(0.161)	(0.185)	(0.31)	(0.201)		
ROW	0.188	0.288	-0.208	-0.089	-0.18		
	(0.131)	(0.191)	(0.142)	(0.08)	(0.242)		

Table 3.7. Marshallian, Hicksian Price and Expenditure Elasticities of Pork Imports in China

	US	EU	Canada	ROW	Expenditure	Marginal Budget Share
			Marshallian			
US	-0.644	-1.064*	-0.727***	-0.249	2.684***	0.618***
	(0.678)	(0.59)	(0.165)	(0.235)	(0.324)	(0.041)
EU	0.006	-0.544*	0.048	0.047	0.54***	0.271***
	(0.279)	(0.274)	(0.107)	(0.092)	(0.124)	(0.087)
Canada	-0.148	0.034	-0.543**	0.388***	0.269***	0.064***
	(0.154)	(0.216)	(0.197)	(0.099)	(0.084)	(0.01)
ROW	-1.685	0.269	2.807***	-2.968**	1.578	0.047
	(1.863)	(1.62)	(0.848)	(1.379)	(1.35)	(0.085)
			Hicksian			
US	-0.026	0.285	-0.089	-0.17		
	(0.665)	(0.595)	(0.153)	(0.234)		
EU	0.131	-0.273	0.08	0.062		
	(0.273)	(0.278)	(0.105)	(0.092)		
Canada	-0.086	0.169	-0.479**	0.396***		
	(0.148)	(0.222)	(0.193)	(0.099)		
ROW	-1.322	1.061	3.182***	-2.921**		
	(1.82)	(1.561)	(0.794)	(1.375)		

Table 3.8. Hicksian Compensating Variation under Different Scenarios

Tariff (%)	dp (\$)	dq^h (%)	dq^h (ton)	p^0 (\$/ton)	q^0 (ton)	p^1 (\$/ton)	CV (\$)
10%	180	-0.26%	-4.68	1800	38479	1980	6916954
25%	450	-0.65%	-11.7	1800	38479	2250	17289225
50%	900	-1.3%	-23.4	1800	38479	2700	34567920
100%	1800	-2.6%	-46.8	1800	38479	3600	69093720

Note: dp is changes of price over last 5 years, which is calculated based on 3% 5%; dq^h is changes of compensated demand quantity; p^0 and q^0 is price and quantity of fourth quarter of 2017.

FIGURES:

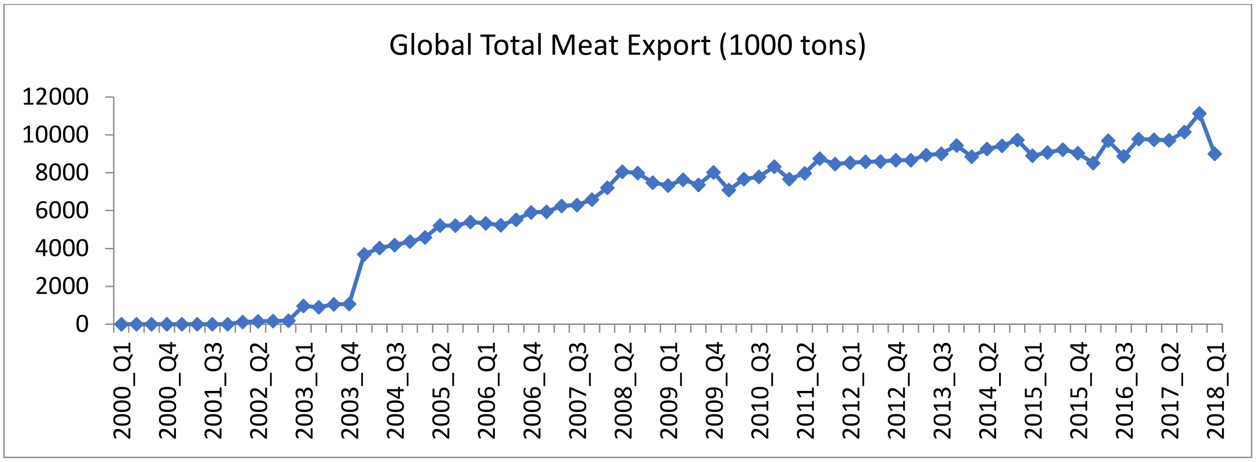


Figure 3.1. Global Total Meat Export (1000 tons)

Source: International Trade Center http://www.intracen.org/itc/market-info-tools/trade-statistics/

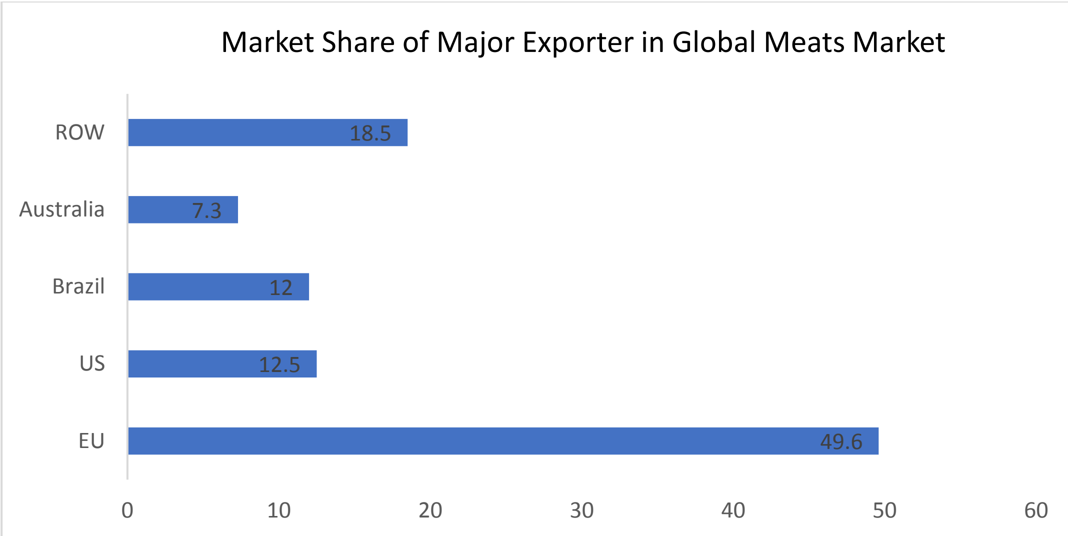


Figure 3.2. Market Share of Major Exporter in Global Meats Market (%).

Appendix A: Derivation of text equations (1') and (2')

The conditional demand equations for Y_d and Y_m implied by Armington's (1969) framework can be written in proportionate change form as follows:

$$Y_d^* = \sigma S_m(P_{mY}^* - P_{dY}^*) + Y^* \quad \text{(A1)}$$

$$Y_m^* = \sigma S_d(P_{dY}^* - P_{mY}^*) + Y^* \quad \text{(A2)}$$

where Y^* denotes the proportionate change in demand for the composite of the domestically produced and imported versions of the good. The unconditional demand functions are obtained by specifying a demand equation for the composite good. For this purpose, and following Warr (2008), let the proportionate change in the demand for Y depend on the prices of the imported and domestically-produced versions of the good, each weighted by their shares in expenditure, "other" consumer prices, and consumer income. Thus,

$$Y^* = \eta(S_d P_{dY}^* + S_m P_{mY}^*) + \eta_{P_0} P_0^* + \eta_I I^* \quad \text{(A3)}$$

Substituting equation (A3) into equations (A1) and (A2) yields the unconditional demand equations for cotton yarn

$$Y_d^* = (S_d\eta - S_m\sigma)P_{dY}^* + S_m(\sigma + \eta)P_{mY}^* + \eta_{P_0} P_0^* + \eta_I I^* \quad \text{(A4)}$$

$$Y_m^* = S_d(\sigma + \eta)P_{dY}^* + (S_m\eta - S_d\sigma)P_{mY}^* + \eta_{P_0} P_0^* + \eta_I I^*. \quad \text{(A5)}$$

The unconditional demand curves are flatter (more elastic) than the conditional demand curves. Also, the domestic and imported versions of the good are net substitutes, but may be gross complements depending on the relative magnitudes of σ and $|\eta|$. Homogeneity requires that the coefficients in equations (A4) and (A5) sum to zero. Imposing this restriction yields

$$Y_d^* = (S_d\eta - S_m\sigma)P_{dY}^* + S_m(\sigma + \eta)P_{mY}^* - (\eta_I + \eta)P_0^* + \eta_I I^* \quad \text{(A6)}$$

$$Y_m^* = S_d(\sigma + \eta)P_{dY}^* + (S_m\eta - S_d\sigma)P_{mY}^* - (\eta_I + \eta)P_0^* + \eta_I I^*. \quad \text{(A7)}$$

Equations (A6) and (A7) are identical to text equations (1') and (2').

Appendix B: Derivation of conduct elasticities

Following Weldebebriel et al. (2012, p. 296) let $\Omega = g(P_C)$ and $\psi = h(P_{dY})$, i.e., industry conduct with respect to buying (selling) power is responsive to induced changes in the input (output) price. With this assumption, and recalling that $\Omega = \theta/\varepsilon$ and $\psi = \xi/|\eta|$, the implied elasticities of Ω and ψ with respect to price can be derived as follows. Focusing first on Ω:

$$\Omega^* = \frac{d\Omega}{\Omega} = \frac{d\left(\frac{\theta}{\varepsilon}\right)}{\frac{\theta}{\varepsilon}} = \frac{\varepsilon}{\theta}\left(\frac{\varepsilon\frac{\partial\theta}{\partial P_C} - \theta\frac{\partial\varepsilon}{\partial P_C}}{\varepsilon^2}\right)dP_C$$

$$= \left(\frac{\partial\theta}{\partial P_C}\frac{P_C}{\theta} - \frac{\partial\varepsilon}{\partial P_C}\frac{P_C}{\varepsilon}\right)\frac{dP_C}{P_C}$$

$$= (\delta_\theta - \delta_\varepsilon)P_C^* \qquad \text{(B1)}$$

The elasticity of oligopsony power with respect to cotton price equals the difference between the elasticities of θ and ε with respect to cotton price.

Turning to ψ:

$$\psi^* = \frac{d\psi}{\psi} = \frac{d\left(\frac{\xi}{|\eta|}\right)}{\frac{\xi}{|\eta|}} = \frac{|\eta|}{\xi}\left(\frac{|\eta|\frac{\partial\xi}{\partial P_Y} - \xi\frac{\partial|\eta|}{\partial P_Y}}{|\eta|^2}\right)dP_Y$$

$$= \left(\frac{\partial\xi}{\partial P_Y}\frac{P_Y}{\xi} - \frac{\partial|\eta|}{\partial P_Y}\frac{P_Y}{|\eta|}\right)\frac{dP_Y}{P_Y}$$

$$= \left(\mu_\xi - \mu_\eta\right)P_Y^* \qquad \text{(B2)}$$

The elasticity of oligopoly power with respect to cotton yarn price equals the difference between the elasticities of ξ and $|\eta|$ with respect to cotton yarn price.

Appendix C. Backward Selection Results

begin with full model						
p = 0.7513 >= 0.1000 removing		import				
p = 0.5100 >= 0.1000 removing		ASEAN				
Logistic regression		Number of obs=60381				
		LR chi2(13) =9849.23				
		Prob > chi2=0				
Log likelihood = -30774.418		Pseudo R2=0.1379				
event	Coef.	Std. Err.	z	P>z	[95% Conf.Interval]	
value	-0.272	0.004	-75.330	0.000	-0.279	-0.265
production	-0.075	0.009	-8.810	0.000	-0.092	-0.059
ln_gdp_o	-0.197	0.017	-11.780	0.000	-0.230	-0.164
ln_gdp_d	-0.153	0.014	-10.720	0.000	-0.181	-0.125
ln_pop_o	-0.585	0.064	-9.170	0.000	-0.710	-0.460
ln_pop_d	-0.066	0.005	-12.620	0.000	-0.076	-0.055
ln_distance	0.334	0.015	22.320	0.000	0.305	0.363
landlocked	-0.194	0.046	-4.220	0.000	-0.284	-0.104
contig	0.136	0.044	3.110	0.002	0.050	0.222
gatt_o	-0.758	0.034	-22.540	0.000	-0.824	-0.692
gatt_d	-0.094	0.031	-3.010	0.003	-0.155	-0.033
urbanization	-0.003	0.001	-3.570	0.000	-0.005	-0.001
Sub_Saharan_Africa	0.353	0.052	6.800	0.000	0.252	0.455
_cons	15.572	1.111	14.020	0.000	13.395	17.748

Appendix D. Correlation Matrix of Covariance Variables

		V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13
V1	value	1												
V2	production	0.06	1											
V3	ln_gdp_o	-0.10	-0.79	1										
V4	ln_gdp_d	0.13	0.21	-0.12	1									
V5	ln_pop_o	-0.09	0.15	0.09	0.06	1								
V6	ln_pop_d	0.15	0.02	-0.02	-0.28	-0.01	1							
V7	ln_distance	-0.05	0.25	-0.21	0.36	0.05	0.04	1						
V8	landlocked	-0.13	0.05	-0.03	-0.04	0.06	-0.11	0.08	1					
V9	contig	0.04	-0.05	0.08	-0.21	-0.04	-0.02	-0.54	0.01	1				
V10	gatt_o	-0.17	-0.15	0.44	-0.07	0.14	-0.02	-0.05	-0.02	0.04	1			
V11	gatt_d	0.06	0.01	-0.07	0.43	-0.04	-0.10	0.09	-0.08	-0.02	-0.03	1		
V12	urbanization	0.12	0.19	-0.16	0.84	0.02	-0.27	0.19	-0.13	-0.15	-0.06	0.35	1	
V13	Sub_Sahara	-0.05	0.01	-0.01	-0.08	0.01	-0.14	0.15	0.36	-0.06	-0.02	0.04	-0.16	1

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