Does international trade affect structural change?

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Abstract

We analyze the effects of international trade on the process of structural change. To put this relationship in context we show that, for developing economies, openness is positively correlated with the share of agriculture. We built a two-sector model and compare the equilibrium under autarky and open economy. The results indicate that, for developing economies, international trade may delay structural change. Indeed, if the comparative advantage is in agricultural goods, trade leads to a greater specialization in this type of goods and therefore a lower participation of retail and services.

Key words: Structural change, international trade, economic growth.
JEL codes: O40, E10, F10

1 Introduction

This article explores theoretically the connection between structural change and international trade. We build a demand-driven structural change model and analyze both the autarkic equilibrium and the open economy equilibrium.

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The traditional literature (e.g Acemoglu (2008)), defines structural change as transforming from the agricultural sector to the manufacturing and services sector, which implies a dynamic context. However, given that the model takes place in a static environment, the article defines structural change (structural transformation) or sectoral change as the active participation of two or more productive sectors in the economy.

The model is built to capture the evidence that in openness economies, structural transformation is slower. The model is also consistent with two clear stylized facts: (i) in the last decades, countries have increased their openness to trade; (ii) for low-income economies, the share of the agricultural sector is higher than the share that developed economies had when they had low-income levels. These facts suggest that poor economies have slow structural change. These countries have specialized in the production of agricultural goods but have not been able to get welfare from international trade (Bourguignon, 2017). We claim that, for developing economies, higher exposure to international trade may lead to a higher share of agriculture and a slower step into structural transformation. The reason is that low-income economies have a comparative advantage in the production of agricultural goods. Therefore, they import goods from other sectors and lag behind in structural transformation.

The other side of the coin is the small share of manufactures and services. Foellmi and Zweimuller (2002) argued that international trade has led poor economies to import more innovative manufactured goods, which replaces their low production in these sectors. This explains how structural change is linked to international trade and because it is slow in developing countries.

We contribute to the discussion about the effects that international trade have on low-income countries and their productive sectors. For this purpose, we provide a theoretical open economy model of structural transformation. The article is divided in five sections including this introduction. The second part makes a brief review of the literature. The third part shows motivation. The fourth part shows the development

of the model. It is finalized by the conclusions.

2 Literature review

Our article is related to two literature lines: Structural change and international trade explained by abundance of factors. The first line of literature was inaugurated in the late 1950s and early 1960s by Kuznets (1966), Chenery (1960), Rostow (1959). The second line originates from the Hecksher-Ohlin model and has been developed by multiple authors, including Ray (2008) and Krugman and Obstfeld (2016).

Structural change models are classified in two types: demand driven and supply driven. Within the former, structural change is driven by Engel's law, that is, increases in income translate into greater demand for goods from the services and manufacturing sectors (Acemoglu, 2008; Kongsamut et al., 2001; Buera and Kaboski, 2009, 2012a,b). The supply driven models emphasize capital intensity differences as the driving force of structural change (Acemoglu and Guerrieri, 2008; Zuleta and Young, 2013).

Literature has also focused on how changes in the productivity of economic sectors affect structural change. Maroto-Sánchez and Cuadrado-Roura (2009), using data from 37 OECD countries, argues that productivity growth in the sector services has an essential effect on productivity growth in the rest of the economic sectors, so the tertiarisation of an economy brings a higher level of productivity overall sectors. Wyszkowska-Kuna (2019) , in the case of Europe with data from 1995-2015, refers to productivity in the services sector that is closed to the productivity in other sectors thought this is lower than in manufacturing firms. Lee and McKibbin (2014) show that in Asia, productivity growth in the services sector contributes to sustained economic growth because higher productivity expands the demand on capital stock provided by the manufacturing sector.

The relationship between structural change and international trade (open economy)

has been explored from the theoretical point of view. Uy et al. (2013) develop a multisectoral model to capture this relationship and perform an empirical analysis for the case of South Korea. In this article, the authors analyze the effects of productivity and cost shocks on the sectoral composition of output. The authors found that the increase of trade cost reduce the share of the agricultural and the manufacturing sectors, so the productivity and the income change too. That increase in costs, change the pattern of specialization: reduce the share of the agricultural sector, and increase the share of the service sector.

There are other empirical approaches to see the effect that structural change has on the composition of exports for Turkey (Saygılı and Saygılı, 2011), for some Latin American countries (Gouvêa and Lima, 2010) and for the development in Asia countries (Gilbert, 2013). Mainly, literature has been focused on empirical approaches. These researches catch the data of structural change with variables of international trade (exports, imports, trade costs, duty fees).

However, there is no theoretical model that collects the results in a conceptual form. We need a simple model that captures, in a general structure, the effects of international trade on sectorial transformation and, even more, that take into account the income differences among countries. The present article seeks to fill this gap.

3 Motivation

The process of structural change happens in all the economies. However, each country faces a different process and this is due, in part, to the relationship they have with the economies of the rest of the world. Economic history provides examples of how the stages of human development have gone through different sectors and how the changes from a stage to the other are related to international trade. For example, the transition from the neolithic era to the metal age (3000 BC), represents the sectorial transformation from agriculture sector to the metallurgic sector, that occurred, among other

things, because there was an increase in the demand for manufactured goods, which led cities to increase their foreign trade (Comín, 2014).

In Medieval Europe, (in the eleventh and twelfth centuries), the agricultural feudal systems gave way to the first urban centers with industrial production. These first cities were commercial ports of the Mediterranean, especially in Italy where the population and income grew to allow a greater demand for the agricultural sector and the development of the industry (Neal and Cameron, 2014).

As history well points out, in Europe, in the modern age, the transition from agriculture to industry was mainly due to the increase of the income of the nobles and merchants in front of agricultural households and the development of international trade[1]. Comín (2014), argues that the increase in demand for the noble class allowed the exchange of basic goods for manufactured goods between Europe and the colonies.

There are many other examples in history. However, this connection among income, international trade, and structural change deepened with the industrial revolution in centuries nineteen and twenty. In these years, the gap in income between countries is more evident as well as their participation in international trade and the speed of structural change.

Acemoglu (2008) shows that in the United States structural change started in the early nineteenth century and has been extended until the twentieth century. At the same time, Comín (2005) argues that the increase in international trade and the process of globalization were important in the economic growth and structural change of the countries.

Bértola and Ocampo (2013) argue that in the case of the Latin American countries at the end of the 19th century and the beginning of the 20th century had profited from

[1]Mesa and Zuleta (2019) explore inequality and structural change relationships.

international trade for the export of primary goods and the import of industrial goods, but the process of structural change was not significant and the economy of these countries was mostly agricultural.

In this case, during the first half of the 20th century, low-income countries such as Latin Americans were lagged in terms of productivity while advanced economies enjoyed rapid technological progress and a large expansion of the manufacturing sector: "consequently, specialization in agricultural products was detrimental to the industrialization of any country" (Comín, 2005).

Another example is given by Inikori (2014) who studies the reverse of fortune in the case of Africa and America between the years 1400 and 1850. The development of international trade in the Atlantic Ocean during the 19th century (along with other demographic and institutional variables) slowed growth in West Africa, leading to its production being concentrated in the agricultural sector. This same trade in the case of America led to its specialization in the export of commodities, given the factorial resource endowment and its productivity. So these continents could not develop their industrial sector.

3.1 Recent process of structural change and international trade.

Now, we can explore recent data on structural change and international trade. The data comes from DataBank[2] and covers the period 1960 - 2017. We consider two periods: 1960-1970 (the oldest decade in the sample), and 2010-2017 (the most recent decade). The data are country-level but not all the countries report data every year, so the panel is not balanced. We classify countries according to their income per capita level, according to World Bank thresholds.

Table 1 shows the mean and standard deviation of the share of the agricultural sector (% of GDP). It is clear that when the level of income increases the share of the

[2]See World Bank web page (World, 2019)

Table 1: Recent evolution of the share of agriculture by income levels.

	Share of agricultural sector (%)	
Level of income	**1960-1970**	**2010-2017**
Low	50.02	29.45
Low-middle	36.08	15.22
Upper-middle	24.85	6.7
High	21.23	2.25

Data: World Development Indicators. Source: Own elaboration

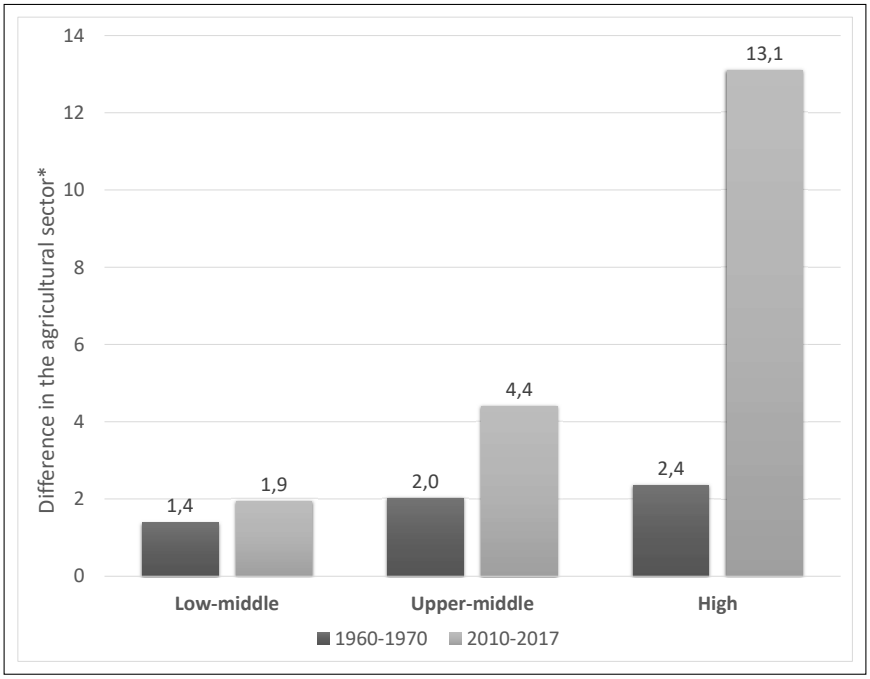
agricultural sector is reduced. Also, for each level of income, the share of agriculture is lower in the present than in the past, and that is a stylized fact of the structural change.

Figure 1, presents a comparison of the relative size of the agricultural sector for different groups of countries. Each bar represents how bigger (number of times) is share of the agricultural sector in low-income countries than the share of the same sector in other countries. The share of the agricultural sector in low-income economies in 1960-1970 was 2.4 times the share of the agricultural sector in high-income economies. In 2010-2017 is about 13 times.

Is this pattern associated with international trade? As we noted before, during the XX and XXI centuries, global trade has increased, so we connect the results showed in table 1 and figure 1 for the case of low-income economies.

Figure 2 shows the share in the agricultural sector in low-economies and its relation to the share of import of manufactures in two decades: 1960-1970 and 2010-2017. This figure suggests a positive correlation between agriculture share and imported manufac-

Figure 1: Difference in Agricultural share of low-income countries and other income levels.



*The difference in the agricultural sector is measure as: Agricultural share of low-income countries/ Agricultural share of other levells-income countries. Own elaboration. Data: World Development Indicators.

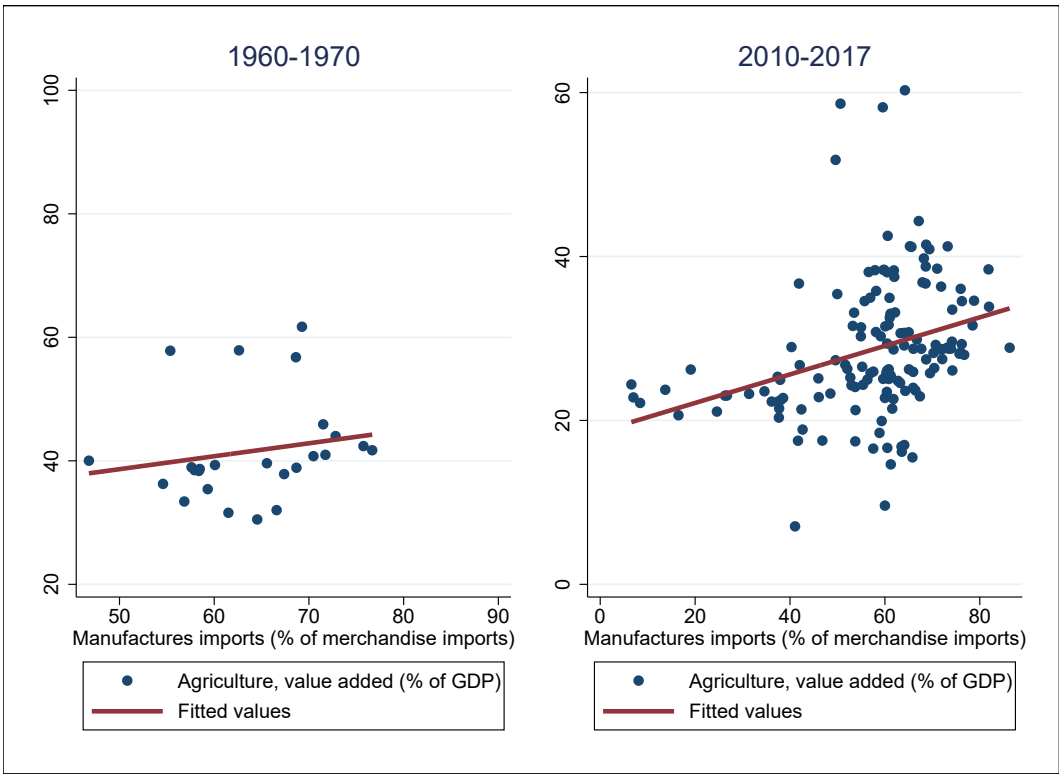
tures.

If we analyze this correlation for countries with different levels of income (table 2), we find that in the decade of the sixties, low income countries with a high level of agricultural share: (i) imported less from developed economies and, (ii) imported more from low-middle income countries. Five decades after, with a consolidated globalization process, low-income countries remained with a relatively high agricultural share, and now it is correlated with more imports from developed countries.

Now, we observe the relationship between agricultural share and exports for low-income countries. Table 3 shows the correlation between agricultural share and exports in low income countries. In the two periods, the results are positive (an increase in agricul-

Figure 2: Share of agriculture and manufactures imports.

Low-income economies.



Data: World Development Indicators. Own elaboration.

tural share would be associated with an increase in agricultural exports), but in the 1960-1970 decade, it is higher than in the 2010-2017 period. However, correlations are not statistically significant.

These results imply that, for developing countries there is a persistence of relatively high levels of agricultural share in developing countries, in a world where global trade is more significant, is clear. Table 4 show some intuitive regressions only for low-income countries. In the model, the dependent variable is the share of agriculture. Independent variables are the level of openness related with high-income countries (*Hopen*) and the level of openness with low-middle income countries (*LMopen*). Also, we control for other factors as the share of industry, the share of services, and GDP (constant dollars of 2010). Table 4 presents a set of regressions for the sixties decade, last decade, and

Table 2: Correlations of agricultural share in low-income countries and imports.

Correlation matrix	**Agricultural Share 1960-1970**	**Agricultural Share 2010-2017**
Imports from high income countries	-0.5079 (0.0007)	0.2186 (0.0013
Imports from low-middle income countries	0.1510 (0.3865)	-0.1556 (0.0231)

Data: World Development Indicators. Source: Own elaboration. p-Values in parentheses

all the sample (the two periods); the data in each case was used as a cross-section.

The results suggest that the effect of trade openness on agricultural share has changed in the two periods for the two groups of countries. In the sixties, an increase in international trade with developed countries reduced the agricultural share, while today (an all the sample), this relationship is positive. When we observe the results for the variable of low-middle countries, more openness in the sixties is correlated with more agricultural share; again, for today, this relationship is the opposite. Even though, the magnitude of the effect is lower today than in the sixties.

International trade is more important today than yesterday; countries have increased their trade volume. With the results above, structural change in developing countries is slow and is connected with international trade, especially when these countries trade with developed countries.

Table 3: Correlations of agricultural share in low-income countries and agricultural exports

Correlation matrix	**Agricultural share**	
	1960-1970	**2010-2017**
Agricultural exports*	0.1147	0.0436
	(0.5850)	(0.6009)

Data: World Development Indicators. Source: Own elaboration. p-Values in parentheses. *Agricultural raw materials exports

4 Model of structural change in open economy

In this section, we develop a model to connect structural change with international trade. The first step is define the concept of structural change, then, setting up a country in autarchy that has two sectors, show that structural change depends on both the level of income and the demand [3]. Second, we compare the closed economy equilibrium with the situation when the economy is open.

4.1 Basic model in closed economy

We start with a basic closed economy model with two sectors: $\{a\}$ produces subsistence goods and sector $\{s\}$ produce other goods. We can think of sector a as agricultural goods and sector s as industrial or manufactured goods. Thus, c_a and c_s are the levels of consumption of goods a and s respectively. Let k be the capital per capita then:

Definition 4.1 ***Structural Change****:*
Suppose that there is a level of k *that in equilibrium* $c_a > 0$ *and* $c_s = 0$*. If there is an exogenous change on* k *such that in the new equilibrium* $c_a > 0$ *and* $c_s > 0$*, then we say that there is a structural change in the economy.*

This economy does not have investment, so all production is consumed. For simplicity, we assume that the economy is in a steady-state and that there is no depreciation. This

[3]The structure of this part is similar to the model of Herrendorf et al. (2014) and Acemoglu (2008).

Table 4: Var dep: Agricultural share

	1960-1970	2010-2017	All	1960-1970	2010-2017	All
Hopen	-0.674*	0.137**	0.108*	-0.0508*	0.0381*	0.0368*
	(-2.29)	(3.15)	(2.42)	(-2.24)	(2.47)	(2.48)
LMopen	1.363***	-0.106**	-0.163***	0.279*	-0.0153	-0.0247
	(4.43)	(-2.69)	(-4.58)	(2.49)	(-0.70)	(-1.17)
Industry				-0.795**	-1.027***	-1.014***
				(-3.33)	(-22.08)	(-24.87)
Services				-0.641***	-0.890***	-0.878***
				(-6.91)	(-15.82)	(-19.99)
Gdp(2010)				9.53e-12*	1.04e-11	7.26e-12
				(2.50)	(1.49)	(1.50)
_cons	40.07***	30.20***	34.00***	75.93***	88.39***	88.15***
	(14.59)	(18.80)	(22.40)	(27.45)	(31.44)	(42.74)
N	17	208	225	16	208	224
R^2	0.490	0.064	0.082	0.997	0.871	0.888

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Data: World Development Indicators. Source: Own elaboration

simplification does not affect the results of the model.

The representative household maximizes the utility function:

$$u\left(c_a, c_s\right) = \begin{cases} log\left(c_a\right) + log\left(c_s\right) & \text{if } c_a > \gamma \\ log(c_a) & \text{if } c_a \leq \gamma \end{cases} \tag{1}$$

The parameter $\gamma \geq 0$ is the minimum consumption level for subsistence. If the agent does not cross this threshold, his utility depends only of the consumption of the subsistence good. The representative household sells labor and capital, in the factor market at prices w and r.

The total income of the economy is $Y = wL + rK$. The economy has a total fixed amount of labor L where $L = L_a + L_s$ (and is equal to the population) and a total fixed stock of capital K, where $K = K_a + K_s$. Therefore, the capital-labor ratio of the economy, k, is fixed and constant in the model. The budget constraint in per capita terms is $y = w + rk$ where $k = \frac{K}{L}$. The price of good s is normalized to one, $p_s = 1$, and the price of c_a is $p_a > 0$, in this way, the budget constraint is:

$$w + rk = p_a c_a + c_s \tag{2}$$

With the equations 1 and 2 we can solve the problem of the household[4]. The first order conditions get us the consumption demand for a and s, so we have:

$$c_a = \begin{cases} \frac{w+rk}{2p_a} & \text{if } c_a > \gamma \\ \frac{w+rk}{p_a} & \text{if } c_a \leq \gamma \end{cases} \tag{3}$$

[4]Notice that we assume that the prices of labor and capital in the two sectors are equal: $w = w_a = w_s$ and $r = r_a = r_s$. This condition implies that the household is indifferent to which sector gives the production factors.

$$c_s = \begin{cases} \frac{w+rk}{2} & \text{if } c_a > \gamma \\ 0 & \text{if } c_a \leq \gamma \end{cases} \tag{4}$$

Equations 3 and 4 imply that when $c_a \leq \gamma$ then good s is not consumed by the household and all the income is expended in c_a. In other words, γ is a threshold level of income that permits consumption of the good s[5].

The production of each sector $j \in \{a, s\}$ is modeled with a Cobb-Douglas function. The production Y_j depends on the total factor productivity $A_j > 0$, capital $K_j > 0$ and labor $L_j > 0$. Also, each sector has a different capital share, α_j and it defines in which sector the economy is intensive.

$$Y_j = A_j K_j^{\alpha_j} L_j^{(1-\alpha_j)} \tag{5}$$

Dividing by L, we get the per capita production function:

$$y_j = A_j k_j^{\alpha_j} l_j^{(1-\alpha_j)} \tag{6}$$

Where l_j is the share of labor employed by sector j, and k_j is the capital per capita in sector j. Using equation 6, and assuming competitive factor markets, the marginal product of each factor equals its price:

$$w = p_j A_j \left(1 - \alpha_j\right) \left(\frac{k_j}{l_j}\right)^{\alpha_j} \quad \text{and} \quad r = p_j A_j \alpha_j \left(\frac{l_j}{k_j}\right)^{1-\alpha_j} \tag{7}$$

Using equation 7 and assuming factor mobility ($w = w_a = w_s$ and $r = r_a = r_s$):

$$\frac{l_s k_a}{l_a k_s} = \frac{\left(1 - \alpha_s\right) \alpha_a}{\left(1 - \alpha_a\right) \alpha_s} \tag{8}$$

[5]If $c_a \leq \gamma$ then sector s is not turn on and all the income is for the consumption of the good of sector a: $p_a c_a = w + rk$, so $\frac{w+rk}{p_a} \leq \gamma$.

Since $1 = l_a + l_s$ and $k = k_a + k_s$, we rearrange the last equation:

$$k_s = \frac{l_s k \left(1 - \alpha_a\right) \alpha_s}{l_s \left(\alpha_s - \alpha_a\right) + \alpha_a \left(1 - \alpha_s\right)} \tag{9}$$

Equation 9 defines capital per capita of sector s as a function of capital-labor k and the labor share of the sector, l_s. Thus, if capital-labor k increases, *ceteris paribus*, then k_s increases in the same proportion; and if l_S increases, k_s increases but with diminishing returns[6]

4.1.1 Interior solution

We now consider the interior solution under closed economy. This solution happens when the consumption of good a is greater than the level of subsistence ($c_a > \gamma$).

Definition 4.2 *The equilibrium in the economy is defined as the vector of production factors* $[k_a,\ l_a,\ k_s,\ l_s]$*, such that firms maximize profits in sectors* $[a,\ s]$*, given factor prices* $[w,\ r]$*, the total supply of factors* $[k,\ l]$*, and the productivities* $[A_a,\ A_s]$*. Consumers choose consumption,* $[c_a,\ c_s]$*, to maximize utility,* $[u\left(c_a, c_s\right)]$*, given income, goods prices,* $[p_a]$ *and factor prices. At equilibrium, goods prices clear the goods market and factor prices clear factor markets.*

In interior solution the equilibrium is $y_a = c_a$ and $y_s = c_s$. Replacing equation 4 when $c_a > \gamma$, with equations 6 and 7 the optimal per capita labor in equilibrium in each sector are:

$$l_s = \frac{1 - \alpha_s}{2 - \alpha_a - \alpha_s} \tag{10}$$

[6]Namely, in equation 9:

$$\frac{\partial k_s}{\partial k} = \frac{l_s(1-\alpha_a)\alpha_s}{l_s(\alpha_s-\alpha_a)+\alpha_a(1-\alpha_s)}$$

and:

$$\frac{\partial k_s}{\partial l_s} > 0;\ \frac{\partial^2 k_s}{\partial l_s^2} < 0$$

$$l_a = \frac{1-\alpha_a}{2-\alpha_a-\alpha_s} \tag{11}$$

From equations 8 to 11, we can find k_j in each sector:

$$k_s = \frac{k\alpha_s}{\alpha_a+\alpha_s} \tag{12}$$

$$k_a = \frac{k\alpha_a}{\alpha_a+\alpha_s} \tag{13}$$

Using equations seven and ten to thirteen, the relative price of subsistence goods is:

$$p_a = \frac{A_s}{A_a}\frac{\alpha_s^{\alpha_s}}{\alpha_a^{\alpha_a}}\frac{(1-\alpha_s)^{(1-\alpha_s)}}{(1-\alpha_a)^{(1-\alpha_a)}}\left[\left(\frac{2}{\alpha_a+\alpha_s}-1\right)k\right]^{(\alpha_s-\alpha_a)} \tag{14}$$

The derivative of p_a with respect to k is:

$$\frac{\partial p_a}{\partial k} = (\alpha_s-\alpha_a)\frac{A_s}{A_a}\frac{\alpha_s^{\alpha_s}}{\alpha_a^{\alpha_a}}\frac{(1-\alpha_s)^{(1-\alpha_s)}}{(1-\alpha_a)^{(1-\alpha_a)}}\left(\frac{2}{\alpha_a+\alpha_s}-1\right)^{(\alpha_s-\alpha_a)}k^{(\alpha_s-\alpha_a-1)} \tag{15}$$

As $2 > \alpha_a+\alpha_s$ and if $\alpha_s > \alpha_a$, then the derivative is positive.

Proposition 1 *If:*

$$k > \left(\frac{\gamma}{A_a}\right)^{\frac{1}{\alpha_a}}\left(\frac{2-\alpha_a-\alpha_s}{1-\alpha_a}\right)^{\frac{1-\alpha_a}{\alpha_a}}\left(\frac{\alpha_s+\alpha_a}{\alpha_a}\right) \tag{16}$$

and equations 1 to 14 holds, then:

$$c_a > \gamma \tag{17}$$

and sector s is active.

This result comes from equilibrium $y_a = c_a > \gamma$ replacing with equations 6, 11 and 13:

$$\begin{aligned}
y_a &> \gamma \\
A_a k_a^{\alpha_a} l_a^{(1-\alpha_a)} &> \gamma \\
A_a\left(\frac{k\alpha_a}{\alpha_a+\alpha_s}\right)^{\alpha_a}\left(\frac{1-\alpha_a}{2-\alpha_a-\alpha_s}\right)^{(1-\alpha_a)} &> \gamma \\
\left(\frac{k\alpha_a}{\alpha_a+\alpha_s}\right)^{\alpha_a} &> \frac{\gamma}{A_a}\left(\frac{2-\alpha_a-\alpha_s}{1-\alpha_a}\right)^{(1-\alpha_a)} \\
k^{\alpha_a} &> \frac{\gamma}{A_a}\left(\frac{2-\alpha_a-\alpha_s}{1-\alpha_a}\right)^{(1-\alpha_a)}\left(\frac{\alpha_a+\alpha_s}{\alpha_a}\right)^{\alpha_a}
\end{aligned}$$

From the last line, we get equation 16 that establishes the condition under equilibrium to get active sector s. The consumption and production of sector a must be higher than γ. Notice that $\gamma > 0$, $\left(\frac{2-\alpha_a-\alpha_s}{1-\alpha_a}\right) > 0$, and $\alpha_a < 1$ are necessary conditions in the interior solution for structural change.

The total income of the household is $y = p_a y_a + y_s = w + rk$. Replacing with equations under equilibrium, we get:

$$y = 2A_s \left(\frac{k\alpha_s}{\alpha_a + \alpha_s}\right)^{\alpha_s} \left(\frac{1-\alpha_s}{2-\alpha_a-\alpha_s}\right)^{1-\alpha_s} \tag{18}$$

In other words, the total revenue is $y = 2y_s$ in interior solution[7]. Naturally, the level income is greater than the consumption of the good of the sector a: $y > p_a c_a > p_a \gamma$. Note that the income of the household under equilibrium, must be greater than the level of subsistence ($y > p_a \gamma$) and this is a necessary but not sufficient condition ($y > p_a c_a > p_a \gamma$) for sector s to be active.

In this economy, the sectors are determined by the demand side: if the household's income exceeds the minimum consumption threshold in the primary sector, they would demand new goods from other sectors. In other sense, the economy has a threshold that is constant because in equation 16, k is constant, α_j and γ are parameters, and by proposition 1 this condition allows that the sector s is active.

4.1.2 Corner Solution

In autarky, when the income is lower than γ, all the income is expended in sector a. So, $c_a \leq \gamma$, and from equations 3 and 4, $c_s = 0$, we have a corner solution. Formally we resume this idea in proposition 2:

Proposition 2 *If:*

$$k \leq \left(\frac{\gamma}{A_a}\right)^{\frac{1}{\alpha_a}} \tag{19}$$

[7]Using equations 14 and 16, we can see that $p_a y_a = y_s$, so $y = p_a y_a + y_s = 2y_s$.

and equations 1 to 7 holds, then:

$$c_a \leq \gamma, \ \ and, \ c_s = 0 \tag{20}$$

and there is not structural change.

The proof for proposition 2 is straightforward: given K and L, the ratio capital-labor k is given too. In corner solution $c_s = 0$ so $y_s = 0$, it implies that sector a uses all the production factors. Thus, $l_a = 1$ and $k_a = k$. if $c_a \leq \gamma$, then $c_a = \frac{w+rk}{p_a}$, under equilibrium, using equation 7, we have $A_a k^{\alpha_a} \leq \gamma$. Proposition 2 tells us that per capita income is lower than the subsistence level, so it is not possible to demand goods from the sector s. In this case, the total income of the household is $y = y_a = w + rk$ and is given by:

$$y = A_a k^{\alpha_a} \tag{21}$$

4.1.3 An intermediate configuration.

Propositions 1 and 2 determine the solutions in equilibrium to have or, not structural change. Now, let k_0 be the value of k in the inequality of proposition 1 (equation 16):

$$k_0 > \left(\frac{\gamma}{A_a}\right)^{\frac{1}{\alpha_a}} \left(\frac{2-\alpha_a-\alpha_s}{1-\alpha_a}\right)^{\frac{1-\alpha_a}{\alpha_a}} \left(\frac{\alpha_s+\alpha_a}{\alpha_a}\right) \tag{22}$$

Again, equation 22 says that for any k greater than or equal than k_0, sector s is active ($k \geq k_0$). Now, let k_1 be the value of k in proposition 2 (equation 19):

$$k_1 \leq \left(\frac{\gamma}{A_a}\right)^{\frac{1}{\alpha_a}} \tag{23}$$

Equation 23 says that for any k lower than or equal than k_1, sector s is not active.

Note that for any value of α_a and α_s, $k_1 > k_0$. The results state that if $k_0 \leq k \leq k_1$

sector s is active (by proposition 1), but at the same time, it is not active (by proposition 2). To avoid this problem, we impose the following assumption: *If* $k_0 \leq k \leq k_1$, *then the household consumes* $c_a = \gamma$ *and* $c_s = w + rk - p_a\gamma$.

This assumption implies that when the household has a level of capital per capita such that $k_0 \leq k \leq k_1$, then sets the consumption of good a to the subsistence level, and the rest of the income is spent on the consumption of good s. Then, under equilibrium, we have: $\gamma = A_a k_a^{\alpha_a} l_a^{1-\alpha_a}$. Now from equation 8 and using $1 = l_a + l_s$ and $k = k_a + k_s$:

$$\frac{(1-l_a)\,k_a}{l_a\,(k-k_a)} = \frac{(1-\alpha_s)\,\alpha_a}{(1-\alpha_a)\,\alpha_s}$$

$$k_a = \frac{l_a k\,(1-\alpha_s)\,\alpha_a}{l_a\,(\alpha_a-\alpha_s)+\alpha_s\,(1-\alpha_a)}$$

Replacing k_a in the equilibrium conditión:

$$\gamma = A_a \left(\frac{l_a k\,(1-\alpha_s)\,\alpha_a}{l_a\,(\alpha_a-\alpha_s)+\alpha_s\,(1-\alpha_a)}\right)^{\alpha_a} l_a^{1-\alpha_a}$$

Now, from the last result, we can establish proposition 3.

Proposition 3 *If* $k_0 \leq k \leq k_1$, *then* $c_s = w + rk - p_a\gamma$, *and,*

$$\left(\frac{\gamma}{A_a l_a}\right)^{\frac{1}{\alpha_a}} (l_a\,(\alpha_a-\alpha_s)+\alpha_s\,(1-\alpha_a)) = k\alpha_a\,(1-\alpha_s) \tag{24}$$

so there is structural change.

Equation 24 is the condition for equilibrium in the intermediate configuration. The labor amount l_a is determined by k, α_a, and α_s.

4.2 Open economy

In this section, we consider structural transformation under an open economy. Building on the model developed, we will analyze how structural change and international trade are related.

Now we introduce an exogenous relative international price p_a^* for god a. The difference is that our economy can not determine the international price, p_a^* so the home economy is a price taker. In autarky, the model endogenously gives us p_a, but in an open economy, global markets define it.

Proposition 4 *If $p_a < p_a^*$ then the home economy produces and exports the good a and imports good s, so there is no structural change even though $c_s > 0$.*

If $p_a < p_a^*$ home economy has incentives to produce and export good a while import good s. We suppose that in this case, it uses all its resources to produce good a, which means that $l_a = 1$ and $k = k_a$. The country needs to produce good a for both consumption and export: $y_a = c_a + x_a$, in which x_a are the exports. Besides, in this context, we would have that $y_s = 0$.

We observe that $p_a < p_a^*$ means that $c_a > \gamma$, so international price guarantees that the home economy consumes above subsistence level. The surplus produced is exported:

$$x_a > 0$$

$$y_a - c_a > 0$$

$$A_a k_a^{\alpha_a} l_a^{(1-\alpha_a)} - c_a > 0$$

Replacing with $l_a = 1$, $k = k_a$ and equation 3

$$A_a k^{\alpha_a} - \frac{w + rk}{2p_a^*} > 0$$

Using equations 7 and p_a^*

$$\frac{A_a k^{\alpha_a}}{2} > 0$$

The exports in the home economy are $x_a = \frac{A_a k^{\alpha_a}}{2}$. It is half of the good a. This country imports the amount m of the goods s from the foreign economy. It analogously is $m_s = \frac{A_s^* k^{*\alpha_s^*}}{2}$ which k^* is the capital-labor, A_s^* is the productivity of sector s, and α_s^* is

the capital intensity in sector s of the foreign economy.

If the terms of trade for home economy are one, we have:

$$\frac{p_a^* x_a}{m_s} = 1$$
$$\frac{p_a^* A_a k^{\alpha_a}}{A_s^* k^{*\alpha_s^*}} = 1$$
$$p_a^* = \frac{A_s^* k^{*\alpha_s^*}}{A_a k^{\alpha_a}}$$

This expression has two comments. First, suppose capital-labor and the intensity of the use of capital in the sectors are the same in the home economy and foreign economy, namely $k^* = k$ and $\alpha_s^* = \alpha_a$. In that case, international price is given by the productivity ratio of each sector $p_a^* = \frac{A_s^*}{A_a}$.

Second, suppose capital-labor and the productivity of each sector are the same in the two countries, namely $k^* = k$ and $A_s^* = A_a$. In that case, the international price is given by the differences in the intensity of the use of capital $(\alpha_s^* - \alpha_a)$.

In an open economy, structural transformation is given by international prices. As in the traditional international trade theory, the difference between the internal and external price determines the productive specialization in one sector and defines the terms of trade. Furthermore, international price in our model reflects the gap in both productivity (technology) and intensive use of capital in each sector. Thus, the behavior of technology and intensive use of production factors reflect institutions and endowments of countries.

In this context, international trade through international price decelerates structural transformation because a country can be specialized in the production of one sector and won't develop other sectors to consume another kind of goods. This result supports the conclusion that we observe in the data analysis for for low-middle income countries.

5 Conclusions

The relationship between international trade and structural change has been always present in economic development. In recent decades, data suggest that international trade has increased worldwide but poor countries continue with a slow process of structural change.

Exploring the data for low-income countries in the decade of sixties and the period 2010-2017, we found stylized facts. In essence, the share of the agricultural sector remains high levels relative to other countries with a further level of income. The pattern is correlated with both an increase in the import of manufactured goods from developed countries and the increase in agricultural exports. Thus, structural change in developing countries is affected by trade with high-income countries because it is related to the persistence of the high share of the agricultural sector.

To explain this, we make a model that in autarky shows that structural change depends on the share of capital in the production of each sector, the income of the household and the consumption of subsistence. In autarky, interior solution, exogenous capital-labor ratio defines the endogenous price and structural change process.

Under an open economy, international trade is given by international price that is now exogenous. If this price exceeds the internal price, the home economy specialized in producing in one sector and imports from other countries the goods it needs. Thus, there is no structural change. In this case, international price defines the whole process, and we think that its behavior will depend on the productivity of sectors and the intensity of use of capital.

There are more ways to explore. The effect of structural change under the open economy on both welfare and economic growth. On the one hand, structural change comes with an increase in income and trade between countries too, thus the effect of trade on

structural change can affect income and its distribution. In the same context, the rates of economic growth vary due to international trade and sectoral change, so observing such dynamics becomes relevant. Finally, we can think to resolve the model let the free mobility of production factors between countries, so this modifies the ratio capital-labor and the production possibilities are different.

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