UNEVEN PRODUCT DIVERSIFICATION AND DECLINING EXPENDITURE SHARES ON AGRICULTURAL PRODUCTS

By Guzmán Ourens*

This paper documents that product diversification is on average lower in the agricultural sector than in other manufacturing activities. A simple model shows how this regularity can contribute to the decline of the expenditure share on agricultural goods in an intuitive way: when consumers have love for variety, they endogenously reduce their expenditure share on the sector that diversifies production the least. A quantitative exercise shows that this mechanism accounts for over 15% of the decline in the US, on top of the income and price effects normally proposed in the literature. When growth is unbalanced between sectors, the extensive and intensive margins of growth are not qualitatively equivalent. We highlight key differences affecting development in agricultural economies.
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I. Introduction

There is a clear downward trend in the world's expenditure share on agricultural products. In the US, the importance of agricultural goods in expenditure was around 21% in the late 1940's, and 6% in 2010. A similar pattern has been documented for most industrialized nations. The share of agricultural goods in global trade has been declining since at least the 1960's, and a similar pattern is found when looking at values imported for most major economies separately. At the same time, many economies remain highly specialized in agriculture. This is specially the case for low to middle income economies, most notably in South America and Sub-Saharan Africa, where comparative advantage lies in the agricultural sector. For these economies, a shrinking expenditure share in agricultural goods translates to competing for a shrinking share of world value, which compromises their possibilities of real income convergence in the long run. Properly accounting for the driving forces behind the fall in the expenditure share on agricultural goods becomes crucial to understand the development problems faced these economies.

The literature on structural transformation has identified two main sources of expenditure shifts across sectors.[1] As first shown by Kongsamut et al. (2001), when consumers have non-homothetic preferences and their income rises, an *income effect* pushes consumption expenditure away from basic needs and towards more sophisticated goods. On the other hand, Ngai and Pissarides (2007) show that sectors increasing their output at uneven rates create a *price effect*, i.e., a shift in relative prices, that also affects expenditure shares across industries.

This paper introduces a new source of shifts in expenditure shares: uneven product diversification between sectors. Intuitively, when consumers have love for variety and sectors diversify their production at consistently different rates, consumers maximize utility by reducing their expenditure share in the industry where product creation is lower. The proposed mechanism affects expenditure shares independently of price and income movements and has important qualitative differences with these previously established effects.

[1] The literature proposes trade openness and changing wedges between factor costs across sectors as additional sources of shifts in labor or value added shares across sectors (see Matsuyama, 2009 and Buera and Kaboski, 2009). However these sources do not appear as relevant for shifts in expenditure shares.

For example, the standard price effect that derives from uneven growth in the intensive margin pushes relative prices to offset changes in relative quantities produced in the different sectors. However, uneven growth in the extensive margin relaxes this relationship, and prices can move in the opposite direction, enhancing divergence. In this case, the result resembles what an income effect is expected to produce, e.g., relative quantities and prices moving in the same direction. A key difference with the standard income effect derived from the preference side: the fact that product creation is a technological phenomenon, makes it a potential subject of public policy. While governments in an agricultural economy have no power in shaping global preferences towards their production, they certainly can foster product diversification domestically.

The present paper proceeds as follows. First, it presents evidence showing that product diversification is not balanced between sectors, and it is consistently lower in agricultural activities. This result appears both in export and domestic production data. Moreover, the result proves robust to the classification and disaggregation level in which the data are presented, and the definition of agricultural goods employed.

Second, this paper highlights the largely unexplored, but very intuitive role that uneven diversification can play to account for a declining expenditure share in agricultural goods. For this, uneven product creation is introduced into a simple model where expanding varieties is the only source of growth.[2] The model comprises two regions (N and S) and each is completely specialized in one of two industries (M and A, respectively). Within each industry, firms develop new products in every period and the rate of product creation is sector-specific. Love of diversity pushes consumers to increase their expenditure on the industry in which diversification is larger (say M), in both regions. The model highlights how these movements can affect the development path of the different regions in ways that fit key established facts. In the asymptotic balanced growth path of the model, income and welfare in N to dominate that in S. Falling relative wages in S

[2]Krugman (1989) proposes a similar static model to explain terms of trade movements in Japan. Another similar static model is proposed in Epifani and Gancia (2008) to explore movements in skill premium. There are also similarities with the model in Corsetti et al. (2013), although their model is set out to analyze what is known as the transfer problem, so focus is placed on effects through the capital account.

reduces prices of exports relative to imports, moving terms of trade against S, and this further enhances the divergence process. The same result does not obtain in a similar model where unbalanced growth happens in the intensive margin, absent further structure in the preference side.

To quantify the importance of the mechanism proposed in this paper, uneven product creation is embedded into a general framework that includes the aforementioned price and income effects in the form of sector-specific growth in the intensive margin and non-homothetic preferences. Values for the preference parameters of the model are obtained from estimations compatible with those in the structural change literature (e.g., Herrendorf et al., 2013), using final expenditure for the US and Western Europe. With these results, a quantitative exercise shows that unbalanced growth in the extensive margin accounts for over 15% of the decline in the expenditure share of agricultural goods in the US, on top of the usual price and income effects. The same figure is larger in other economies such as France.

An additional feature of the theory proposed here is to shed light on the main drivers of unbalanced product diversification between sectors to answer the question: why is product diversification lower in the agricultural sector? The model yields expressions for the sector-specific diversification rates, and shows that both higher costs of product creation and higher elasticities of substitution, can provide firms in the agricultural sector with lower incentives to differentiate their products. The parameter conditions that need to hold for diversification to be unbalanced to the detriment of the agricultural sector are supported by existing empirical evidence.

By showing that product diversification is uneven, and by highlighting its consequences for development, this paper introduces a new argument to the literature linking income differences across regions to the sectoral composition of output.[3] In particular, Section V shows how the extensive margin of growth can produce terms of trade movements that enhance, rather than offset income divergence across nations, as would be expected when biased growth happens in the intensive margin only (Acemoglu and

[3]See for example Gollin et al. (2004), Caselli (2005), McMillan et al. (2014), Rodrik (2013) or Duarte and Restuccia (2019) to name a few.

Ventura, 2002). Finally, the paper also contributes to the literature on structural transformation[4] by presenting a new source of the decline of the expenditure share of agricultural goods and showing that it is quantitatively important.

II. Data and definitions

Measuring product diversification is not a straightforward task since there is not a precise definition of what constitutes a product. This paper tackles the issue by using a plethora of definitions and datasets, and showing that results are robust to all of them. International trade data have the advantage of being reported for a large sample of countries, a long periods of time, and in a harmonized classification, at high disaggregation levels. The primary source used here is UNCOMTRADE which gathers trade flows at the five-digit disaggregation level (SITC Rev1) since 1962, thus providing a sufficient time span for evaluating long-term trends. To tackle potential issues with the reliability of reporters, results are also obtained with data presented in Feenstra et al. (2005). This dataset matches reports from exporters with those from importers using the raw UNCOMTRADE data, to establish consistent trade flows at four-digits (SITC Rev2).

This papers follows what has become a standard in the trade literature at least since Feenstra (1994): a good is defined as one code in a classification.[5] Data at five-digits allow for a decent distinction of goods. For example, it is possible to distinguish between code 02221 *Whole Milk and Cream* and code 02222 *Skimmed Milk*. More disaggregated data are available for shorter and more recent periods. Results are also reported using data at six-digits of the HS0 classification also matching reports of exporters and importers for consistency, over the period 1995-2007, as reported by Gaulier and Zignago (2010) (BACI92 hereafter). Such disaggregation level allows further detail, e.g., we can identify code 040221 *Milk and cream powder unsweetened* $<$ 1.5% *fat*. Besides the difference in the time span covered and disaggregation level, there is a relevant difference between data

[4] Within this literature, we should also credit Acemoglu and Guerrieri (2008), Foellmi and Zweimüller (2008), Fieler (2011), Boppart (2014), Caron et al. (2014) or Swiecki (2017) and Comin et al. (2021).

[5] The exercise of counting codes in a classification can only approximate extensive margin growth. Any code is in reality a bundle of goods defined ex-post, so there can always be new production within an already counted code. This issue is mitigated by using highly disaggregated data.

classified using the SITC and HS systems: while SITC is constructed according to goods' stage of production, HS is based on the nature of the commodity. Using both aims at showing that the results are robust to the classification and the disaggregation level.

To further clear concerns that results could be driven by biases in how classifications are constructed or which goods are traded, results are also presented using domestic production records. The use of these data is not free from shortcomings, as such records are typically harder to collect and less comparable between countries. These data are recorded in domestic classifications, which are normally tailored to production, leaving little room for changes in the number of active codes. An alternative approach is then required to measure product diversification using domestic production data. This paper proposes to count firms producing under each code at different moments in time for the US and EU countries, as is explained in detail below. This approach is consistent with a framework where consumers are not completely indifferent between goods coming from different firms. Data from US firms come from the Census Bureau's Statistics of US Businesses (SUSB) which reports the number of producing firms by six-digit sectors in the NAICS classification for the period 1998-2015. Data on producing firms in the European Union is collected by Eurostat: information for agricultural producers is extracted from the Agricultural Training of Farm Managers dataset covering years 2005, 2010 and 2013. Manufacturing firm records in the EU are reported for the period 2008-2015 in the Structural business statistics (SBS).

In what follows, focus is placed on primary goods of the non-extractive type, denoted as A-goods. Unlike a large part of the literature on the resource curse, goods based on natural resources of the extractive type (E-goods) are excluded from the analysis, so focus is placed on agriculture-based products. The reader can find in the Appendix the list of products classified here as A (Table A.1 in Appendix A.I). A restrictive list of products, called $A1$, includes only narrowly defined non-manufactured goods of the non-extractive type. Results for two broader alternatives are provided as robustness checks. List $A2$ adds to the previous list basic chemical compounds that intensively use primary inputs of a non-extractive nature. List $A3$ further incorporates manufactured goods that use those resources intensively. None of the lists for agricultural products proposed here is a good proxy for homogeneous products.[6] Nevertheless, products classified here as agricultural are perceived by consumers as more substitutable than manufactures. Using elasticities of substitution for four-digit products presented by Broda and Weinstein (2006), we can compare the mean and median elasticity of substitution within each group Ak and Mk (for $k = 1, 2, 3$, and where Mk is the set of all goods remaining when Ak and E are excluded). Results are reported in Table 1 and show both statistics being higher for A-goods. Moreover, notice that as the list for agricultural products gets broader and more inclusive, the mean and median elasticity of substitution is reduced.

Table 1:
Summary statistics: elast. of substitution within lists of goods

k	Ak				Mk			
	mean	median	sd	Obs.	mean	median	sd	Obs.
1	9.851	3.509	20.713	184	5.596	2.527	13.245	491
2	8.954	3.442	19.398	213	5.743	2.527	13.628	462
3	8.335	3.390	18.134	248	5.839	2.527	14.100	427

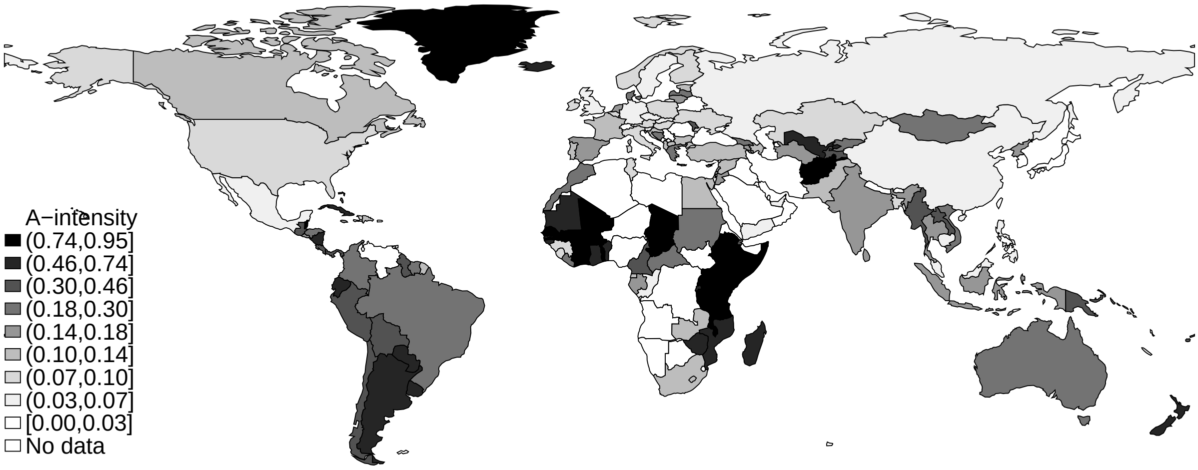
Notes: Elasticities of substitution are as reported by Broda and Weinstein (2006) for four-digit SITCR2 classification. List of products Ak and Mk ($k = 1, 2, 3$) are as listed in Table A.1.

When looking at the share of A-goods in total exports, almost all countries show a decline over recent decades, a fact consistent with the structural change that the world economy has experienced during this period. Only 10 out of 165 countries show an increase in the importance of $A1$-goods in their exports during the period 1962-2000, the most salient cases being Venezuela and Bolivia for which the share of those goods at the beginning of the period was very low (below 12% and 5% respectively). Similar trends appear when considering $A2$ and $A3$ goods. Figure 1 shows in a world map the intensity of exports in $A1$-goods for the year 2000. Inspection of this figure reveals that countries exporting A-goods intensively (A-countries in short) are not necessarily poor. Some rich and middle income countries have remained largely specialized in agricultural

[6] Rauch (1999) classifies goods in three categories, according to how homogeneous they are in world markets. Comparing these categories with the lists for agricultural products defined here, the strongest correlation is 0.3941 (corresponding to our A2 list and Rauch's liberal list including both types of homogeneous goods together), while the smallest correlation is 0.2319 (between the list for A3 here and Rauch's conservative list including only strictly homogeneous goods).

products. In fact, A-countries seem to be characterized not by wealth, but by being rich in fertile land and not densely populated, i.e., features that would give these countries a comparative advantage in agricultural goods.

Figure 1:
Intensity of A-exports by country (2000)



Notes: The list of A1-goods was used for the construction of this figure (check Table A.1). Data on exports from Feenstra et al. (2005).

The probability of remaining highly specialized in agricultural goods is positively correlated with being an important exporter of those products at the beginning of the period and negatively correlated with initial levels of population density and trade openness (see Table A.2 in the Appendix). Explaining why some countries remain specialized in agricultural production is beyond the scope of this paper.[7] Nevertheless, a strong comparative advantage based on factor endowments cannot be ruled out, given this indicative evidence. Other potentially relevant variables such as the initial level of per capita income or the size of the government do not seem to play important roles in the process.

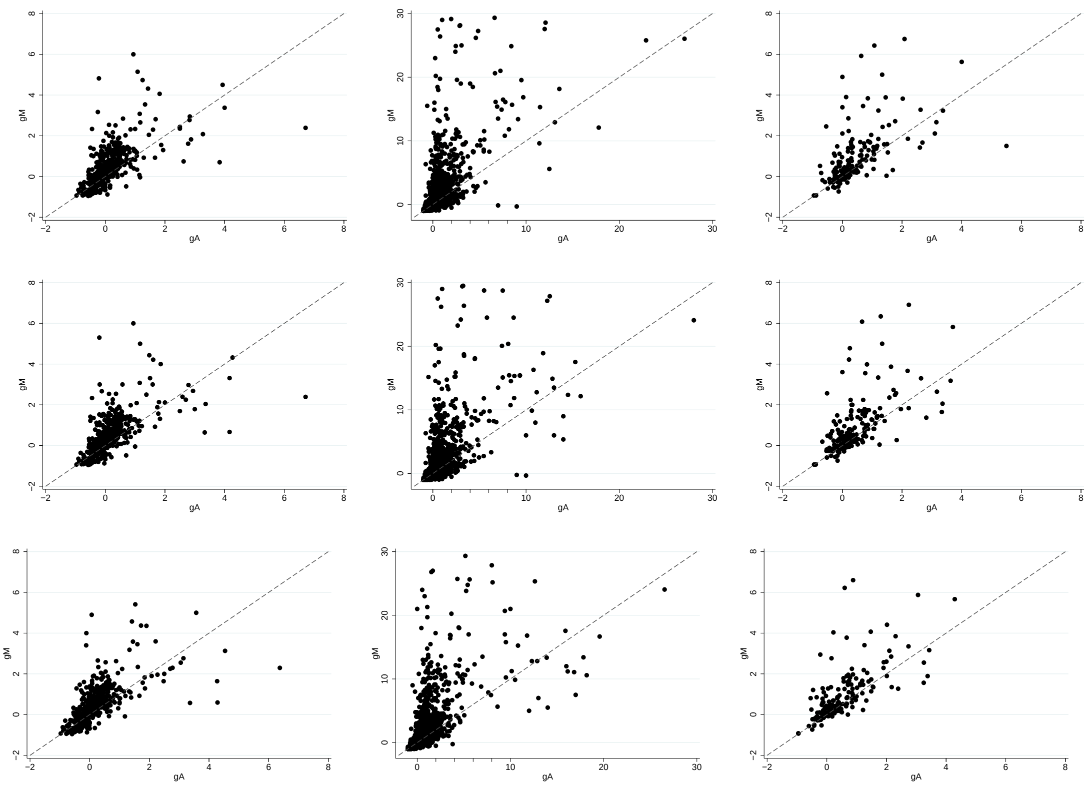
III. Uneven product diversification

The rate at which countries diversify their production is significantly unbalanced to the detriment of agricultural goods. To show this, diversification rates in both industries (g_A

[7] In most market economies specialization is the outcome of decentralized decisions made by firms. While governments can provide incentives to direct it strategically, the effectiveness of those measures is limited by incomplete information, bounded rationality problems in general, or changes in leaders priorities, among many other factors.

and g_M respectively) for each country are compared. A diversification rate is computed here as $g_{ckt} = (n_{ckt+dt} - n_{ckt})/n_{ckt}$, where n_{ckt} is the number of goods produced by country c, in industry $k = A, M$, at moment t.

Figure 2:
Diversification rates g_{Ak} and g_{Mk} (export data)



Notes: Each dot represents a pair (g_{Ak},g_{Mk}) for one country in one sub-period. Figures in row $k = 1, 2, 3$ use lists Ak, and its complement Mk. Rates in the first column use four-digit exports from Feenstra et al. (2005) and for 10-year periods starting in 1962, 1972, 1982 and 1991. Rates in the second column use five-digits UNCOMTRADE data and are calculated for each 10-year period starting between 1962-2004. The last column features rates for six-digit data from BACI92 constructed for only one 13-year period starting in 1995.

Figure 2, plots the resulting rates for periods of ten years using export data, along with a 45-degree line. Inspection of these figures show that while both rates are normally positive, the rate of diversification in manufactures tends to be larger than that in non-extractive primary goods. Several mean tests are performed, where the null hypothesis is that on average $g_A = g_M$. As shown in Table 2, these reject $g_A = g_M$ and $g_A > g_M$, but not $g_A < g_M$, at a high confidence level.

Given that the diversification rates are computed by counting codes in a given classification, they are sensitive to how the classification is built. If one of the broad sectors

Table 2:
DIFFERENCES IN DIVERSIFICATION RATES (EXPORT DATA)

	4-digits			5-digits			6-digits		
$gMk = gAk$	$k = 1$	$k = 2$	$k = 3$	$k = 1$	$k = 2$	$k = 3$	$k = 1$	$k = 2$	$k = 3$
mean(gM)	0.681	0.673	0.653	0.379	0.362	0.368	0.766	0.770	0.754
sd(gM)	5.599	5.478	4.935	1.013	0.981	0.998	1.264	1.281	1.218
mean(gA)	0.210	0.233	0.270	0.162	0.192	0.198	0.375	0.393	0.428
sd(gA)	1.668	1.725	1.997	0.516	0.551	0.559	0.806	0.759	0.812
Obs.	559	559	559	4,679	4,674	4,658	219	219	217
$Ha : gM < gA$	0.996	0.995	0.998	1.000	1.000	1.000	1.000	1.000	1.000
$Ha : gM \neq gA$	0.008	0.009	0.004	0.000	0.000	0.000	0.000	0.000	0.000
$Ha : gM > gA$	0.004	0.005	0.002	0.000	0.000	0.000	0.000	0.000	0.000

Notes: Each column presents the result of a mean-comparison t-test, where the null hypothesis is $g_{Mk} = g_{Ak}$ for $k = 1, 2, 3$ as listed in Table A.1. The first and third row give the mean of g_{Mi} and g_{Ai} respectively, while the second and fourth provide the respective standard deviation. The last three rows show the p-value of a t-test for different alternative hypothesis.

defined here (A and M) is split into many more codes than the other in the classification used, balanced product creation between sectors could artificially appear uneven in these exercises. It must be noted that in all classifications used, the broader definition of agricultural goods (A3) regularly comprises a similar number of codes to M goods. In any case, to reach results that are less dependent on how classifications distribute codes, and provided that the data prevents going deeper into the classifications, results moving in the opposite direction are tested. We proceed to compute diversification rates for a given sector as the simple average of diversification rates in each two-digit product line belonging to that sector. It is expected that results from this exercise are less affected by a biased availability of codes for each industry. Table 3 shows the outcome of this exercise, providing further support for the previous finding.

The literature on trade with differentiated varieties often treats varieties as pairs of goods and country of origin, since consumers tend to perceive product-origin pairs as imperfect substitutes (following the Armington approach). This can be true for goods belonging to both A and M. For example, some consumers perceive guitars produced in the US as different from those from Mexico, similarly coffee from Colombia is regarded as a different variety to that from Costa Rica. The diversification rate of product-origin pairs within each broad industry (A and M) are computed for each year in the database. This approximates the yearly change in the availability of varieties for a *global consumer*,

Table 3:
DIFFERENCES IN DIVERSIFICATION RATES (WITHIN TWO-DIGITS)

	4-digits			5-digits			6-digits		
$gMk = gAk$	$k=1$	$k=2$	$k=3$	$k=1$	$k=2$	$k=3$	$k=1$	$k=2$	$k=3$
mean(gM)	0.530	0.541	0.540	0.625	0.608	0.622	1.302	1.310	1.352
sd(gM)	1.398	1.606	1.604	1.553	1.521	1.593	2.651	2.653	2.611
mean(gA)	0.266	0.285	0.314	0.313	0.354	0.393	1.021	1.052	1.080
sd(gA)	0.649	0.705	0.764	0.666	0.791	0.872	1.917	1.949	2.220
Obs.	562	562	561	491	490	489	876	879	884
$Ha : gM < gA$	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
$Ha : gM \neq gA$	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$Ha : gM > gA$	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Notes: Each column presents the result of a mean-comparison t-test, where the null hypothesis is $g_{Mk} = g_{Ak}$ for $k = 1, 2, 3$ as listed in Table A.1. The reported diversification rate in each sector (A and M) is the simple average of diversification rates computed within every two-digit line belonging to that sector. The first and third row give the mean of g_{Mk} and g_{Ak} respectively, while the second and fourth provide the respective standard deviation. The last three rows show the p-value of a t-test for different alternative hypothesis.

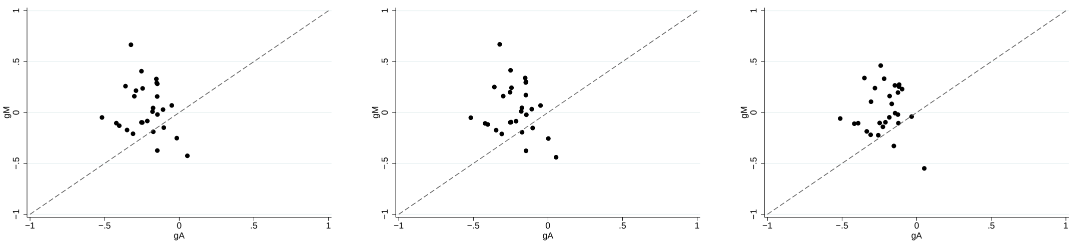
i.e., one that can shop around the world. Moreover, this exercise can be considered to better reflect the structure of the model in Section IV, where products are created by regions. While the evidence presented thus far does not disentangle between product adoption and product creation, every new good-origin can be considered as a variety created. Comparing the resulting rates gives similar results as obtained before.[8]

Finally, it is possible to see the same regularity emerging in domestic production data. Using the data described in Section II, diversification rates in each sector are computed by counting firms producing in each of them, within EU countries and the US. Given the limited time frames of these data, one observation per country is obtained using the information for the first and last years available. This gives 29 observations. Results are presented in Figure 3. The observation that $g_A < g_M$ holds with domestic production data helps rule out the possibility of the regularity being exclusively driven by M-goods being more tradeable or more finely classified than A-goods.

The fact that product diversification happens at a lower rate in the agricultural sector than in manufacturing is compatible with a growing literature arguing that technological linkages between production lines are not uniformly distributed. For example, evidence in Hidalgo et al. (2007) and Hausmann and Hidalgo (2011) supports the notion that

[8]See Section B of the Appendix.

Figure 3:
DIVERSIFICATION RATES g_{Ak} AND g_{Mk} (DOMESTIC PRODUCTION, EU & US)



Notes: Each dot represents a pair (g_{Ak},g_{Mk}) for one country. Figures in column $k = 1, 2, 3$ use lists Ak and its complement Mk. Rates are computed by counting firms from Eurostat and the US Census Bureau.

technological proximity within manufacturing is much greater than that within primary activities, suggesting that it may be easier for diversification to happen in the former industry rather than the latter. In a different vein, Koren and Tenreyro (2007) argue that industry-specific volatility is a very important factor preventing diversification in developing economies. These elements may help explain uneven diversification between sectors. The model in the next section provides a theory for which factors determine diversification and how they interact with each other, finding that both technological and preference factors play a role.

IV. Theory

This section proposes a simple model to illustrate the macroeconomic consequences of uneven product creation across sectors and, in particular, its potential in driving shifts in expenditure shares across them. In this stylized version of the model product creation is the only source of growth. Time is continuous and the world is composed of two regions (denoted $c = N, S$) and two sectors ($i = M, A$). In both sectors, technology is such that labor is the sole input and each region is endowed with an amount L_c of labor. Trade is perfectly free and each region is perfectly specialized in one industry: region N produces M-goods and region S produces A-goods. [9] This setting allows us to eliminate

[9]Although not necessary for the mechanism to hold, this assumption greatly simplifies the exposition and allows to focus on the trends that emerge when sectors diversify production at different rates without the need to establish what this means to specialization over time. Specialization could be originally rooted in an asymmetric distribution across regions of a specific factor of production not included in the model (i.e., fertile land).

general equilibrium effects going through wages and endogenous specialization, to focus on the trajectory of expenditure shares, while at the same time, providing an interesting framework to analyse development path across regions. Every firm in each industry undertakes two activities: they engage in R&D efforts to develop a new product, and then they use that knowledge and labor to produce and sell their product. Their R&D efforts generate a private return but also spillovers to other firms within the industry. Firms within a given sector are homogeneous. There is no population growth and labor cannot move between regions. Finally, financial resources are also constrained within borders.

IV.A. Consumers

Consumers from country c face three choices at each moment t. First, they choose how much to consume and save, i.e., they decide their optimal expenditure level $E_c(t)$ for a given income $Y_c(t)$. Aggregate expenditure in region N is set as *numeraire* ($E_N = 1$). Then, they choose how much to spend in each industry, i.e., $E_{ci}(t)$ with $E_c(t) = E_{cM}(t) + E_{cA}(t)$. In the third stage, consumers split their industry-specific expenditure among the different products of that industry available at each t. Welfare in country c at t is defined as the present value of future consumption of the final good composite $Q_c(t)$, that is:

$$U_c(t) = \int_t^{\infty} e^{-\rho(s-t)} \ln\left[Q_c(s)\right] \mathrm{d}s \tag{1}$$

where $\rho > 0$ is the rate of pure time preference, common to individuals in both regions. Consumers maximize (1) subject the usual budget constraint. The conditions for an optimal path for expenditure arising from this dynamic problem are a transversality condition and the standard Euler equation $\dot{E}_c(t)/E_c(t) = r_c(t) - \rho$. Each of the L_c consumers in country c is endowed with one unit of labor which is inelastically supplied in the labor market in return for a wage w_c. Consumers also receive the returns on their past savings at rate $r_c(t)$.

Given $E_c(t)$, consumers choose how much to spend in each industry $i = M, A$, following:

$$Q_c(t) = \left[\omega_M^{\frac{1}{\beta}} Q_{cM}(t)^{\frac{\beta-1}{\beta}} + \omega_A^{\frac{1}{\beta}} Q_{cA}(t)^{\frac{\beta-1}{\beta}}\right]^{\frac{\beta}{\beta-1}} \tag{2}$$

with $\beta > 0$. Here $\omega_i > 0$ represents consumers' taste for the composite of industry i and $\omega_M + \omega_A = 1$.

At each t, consumers must decide how much of their expenditure in industry i is spent in each product θ belonging to the set $\Theta_i(t)$ of available products in that industry $(i = M, A)$. Free trade implies that the set $\Theta_i(t)$ is the same in both regions $\forall i = M, A$. Consumer preferences over products within a given industry are also CES. This, together with Dixit-Stiglitz competition in the market of final goods yields:

$$Q_{ci}(t) = \left[\int_{\theta\in\Theta_i(t)} q_{ci}(\theta,t)^{\frac{\sigma_i-1}{\sigma_i}} \mathrm{d}\theta\right]^{\frac{\sigma_i}{\sigma_i-1}}, \ P_{ci}(t) = \left[\int_{\theta\in\Theta_i(t)} p_{ci}(\theta,t)^{1-\sigma_i} \mathrm{d}\theta\right]^{\frac{1}{1-\sigma_i}} \tag{3}$$

with $\sigma_i > 1 \forall i = M, A$ driving the elasticity of substitution between any two products. Here, $q_{ci}(\theta, t)$ and $p_{ci}(\theta, t)$ represent quantities demanded and price paid in c for each product θ of industry i at time t. Without trade costs, the price charged for a certain product is the same in every market so $p_{ci}(\theta, t) = p_i(\theta, t)\ \forall\theta \in \Theta_i(t)$, which gives $P_{ci}(t) = P_i(t)$, $\forall i = M, A$ and $\forall t$. Consumers from different regions of the world have the same preferences, which is reflected here by the fact that ρ, β, ω_i and σ_i, are not country-specific. This gives $P_c(t) = P(t)\ \forall c = N, S$. In words, the price index faced by consumers in both regions of the world are the same. This means that any difference in consuming possibilities between regions is going to be rooted in their respective expenditure paths. Finally, global expenditure is the sum of expenditure in each region of the world $E(t) = E_N(t) + E_S(t)$.

IV.B. Producers

Any potential entrant to industry i must develop a blueprint for producing good θ which implies incurring a one-time sunk cost that is independent of future production. The fact that it is costless for producers to differentiate their production, together with all products entering within-industry preferences symmetrically, gives firms no incentive to produce a good that is produced by a competitor. Moreover, there are no multi-product firms, so firms and products are matched one to one. Once in business, a firm continues to produce forever. After sinking the cost of developing a product, a firm can perfectly estimate their expected stream of income. Since only one sector operates in each region, the use of the country sub-index can be spared in this section.

Technology in each industry i is represented by a linear cost function where labor is the sole input and there are no fixed costs. Every firm in i sets the same price of

$$p_i(t) = \frac{\sigma_i w_i(t)}{(\sigma_i - 1)\phi_i} \tag{4}$$

In the previous expression, $\phi_i > 0$ is the productivity level in terms of labor of final goods production in sector i and $\phi_i = 1, \forall i = M, A$ is assumed for simplicity.[10] The assumption of homogeneous firms in sector i, together with (3) gives $Q_i(t) = q_i(t)n_i(t)^{\sigma_i/(\sigma_i-1)}$ and $P_i(t) = p_i(t)n_i(t)^{1/(1-\sigma_i)}$, where $n_i(t)$ is the number of existing products in industry i at time t.

Consumers' love of diversity and the absence of trade costs, results in all firms of industry i being present and enjoying the same market share in both regions $1/n_i(t)$. The pricing rule in (4) gives operating profits of any single firm within that sector are $\pi_i(t) = [E_{Ni}(t) + E_{Si}(t)]/n_i(t)\sigma_i$. Equilibrium in the capital market requires the returns from investing in financing the production of final goods to equal those of a risk-free loan, which imposes $\pi_i(t) + \dot{v}_i(t) = r_i(t)v_i(t)$.

A firm developing a final product in industry i generates its own private return by acquiring the right to sell its product forever. But the activity of product creation also generates spillovers in the form of knowledge within that industry. Product creation in industry i follows $\dot{n}_i(t) = L_{R,i}(t)K_i(t)/a_i$, where $L_{R,i}(t)$ represents the amount of labor devoted to the creation of products and $K_i(t)$ is the level of knowledge in industry i. This stock of knowledge is the measure of spillovers within sector i and the larger it is, the more productive are resources devoted to research in that sector. We follow Grossman

[10] Regions' full specialization in this model could be rationalized by assuming that $\phi_{A,N}$ and $\phi_{M,S}$ are small enough, while maintaining $\phi_{M,N} = \phi_{A,S} = 1$.

and Helpman (1991) in setting $K_i = n_i$. That is, the stock of knowledge is equal to the number of products existing in that industry, which is a simple way of introducing learning-by-doing at the industry level. Finally, $1/a_i$ represents the part of efficiency in R&D activities of industry i that is independent of spillovers.[11] Then, the diversification rate in i is $g_i(t) = \dot{n}_i(t)/n_i(t) = g_i(t) = L_{R,i}(t)/a_i$. From here on, the growth rate of any other variable X is denoted as $g_X = \dot{X}/X$.

Finally, free-entry into production of final goods imposes that, at moment t, the cost of developing a new product in sector i equals the discounted value of being able to sell that product in the final goods market:

$$\frac{w_i(t)a_i}{n_i(t)} = v_i(t) \tag{5}$$

IV.C. Instantaneous equilibrium

Given between-industry preferences (2), the following expression for the share of expenditure in the agricultural sector is obtained:

$$\alpha(t) = \left[\frac{\omega_M}{\omega_A}\left(\frac{n_A(t)^{1/(1-\sigma_A)}p_A(t)}{n_M(t)^{1/(1-\sigma_M)}p_M(t)}\right)^{\beta-1} + 1\right]^{-1} \tag{6}$$

The share $\alpha(t)$ is determined by the proportion of A-products in the set of all consumption goods (weighted by a function of the elasticity of substitution within industry σ_i) and by its relative price. When goods from different industries are substitutes for one another, i.e., $\beta > 1$, a greater number of A-goods available or a lower relative price yields expenditure shift towards A-goods, to the detriment of M. On the other hand, when products of different industries are perceived as complements, i.e., $\beta < 1$, then the same conditions yield an increase in the expenditure share devoted to M, to the detriment of A.

Equilibrium in the labor market imposes that the amount of resources used in the

[11] A very intuitive way to endogenize parameter a_i is to introduce firm heterogeneity in the model, in the vein of Baldwin and Robert-Nicoud (2008) or Ourens (2016). In those works, efficiency in the development of new products depends on average efficiency in the production process in the industry.

development of products and in their production equals its fixed supply at each economy, which gives the following labor market clearing conditions

$$g_A(t)a_A + \frac{\alpha(t)E(t)}{p_A(t)} = L_S \ , \ g_M(t)a_M + \frac{(1-\alpha(t))E(t)}{p_M(t)} = L_N \tag{7}$$

Trade balance at every t requires exports of one region to match exports of the other, i.e., $E_{S,M} = E_{N,A}$, which together with $E_N = 1$, yields the following condition:

$$E_S(t) = \frac{\alpha(t)}{1-\alpha(t)} \tag{8}$$

IV.D. Dynamic Equilibrium

A solution with both positive product creation and final good production requires the following condition to hold:[12]

$$g_i(t) = \frac{\pi_i(t)}{v_i(t)} - \rho \tag{9}$$

Merging (9) together with equation (7) yields:

$$g_i = \frac{L_i}{a_i\sigma_i} - \frac{\sigma_i - 1}{\sigma_i}\rho \tag{10}$$

Products are created at constant rates in both industries. For the model to reproduce positive growth, it is assumed that the allocation of resources towards the development of new products is positive. Equation (10) provides a microfounded explanation of why diversification can differ across sectors. The diversification rate in any industry depends positively on the size of the producing economy (L_i). In other words, the model features a scale effect that is common in the literature.[13] Diversification happens at a higher pace when product creation requires fewer units of labor (lower a_i), i.e., when efficiency in

[12]See Section C.I of the Appendix for a proof and discussion. The section also shows an alternative solution where this condition is not imposed in S. The main results in this paper still hold in this environment.

[13]Scale effects in models of intensive-margin growth have been disputed as unrealistic since they imply that larger economies should grow faster ceteris paribus. While it is possible to eliminate scale effects from the model, their existence is less problematic when growth is in the extensive margin, since the implication of more varieties being created in larger markets is not debated empirically.

the R&D sector is larger. A smaller σ_i also contributes to larger sectoral diversification since lower substitutability increases firms' operating profits, ultimately increasing entry. Intuitively, firms face reduced incentives to develop new products in a given industry when consumers perceive goods in that industry to be highly replaceable by other goods within the same industry.

The model yields uneven growth in the extensive margin when diversification rates are different between sectors. Given the evidence presented in Section III, the analysis that follows is constrained to the case in which $g_A < g_M$ holds, and this amounts to imposing the following assumption:

ASSUMPTION 1 *Assume* $\frac{L_A}{a_A} - \frac{\sigma_A L_M}{\sigma_M a_M} < \rho(\sigma_A - 1)\left[1 - \frac{(\sigma_M - 1)\sigma_A}{(\sigma_A - 1)\sigma_M}\right]$, *so* $g_A < g_M$.

Notice that Assumption 1 is the only asymmetry imposed between sectors and therefore regions. For this assumption to hold, either $\sigma_A > \sigma_M$, $L_A < L_M$, $a_A > a_M$, or a combination of some of these conditions need to hold. None of these conditions is imposed in particular, since the results of the model do not require any more structure to replicate the facts targeted here.

Empirically, results in Table 1 suggest that the elasticity of substitution within each industry is much higher in the agricultural sector (the median σ_A is around 35% larger than the median σ_M), and this can partially explain the result $g_A < g_M$. Inspection of Figure 1 hints that population in agricultural economies is much lower than in the rest, which provides scale economies that also contribute to this outcome. Even considering the largest list of agricultural economies, the population advantage in non-agricultural economies is greater than 50% in the year 2000. Finally, while there is no direct evidence regarding relative efficiency in product development between sectors, recent empirical evidence has shown that diversification is likely to be easier in labor and knowledge-intensive sectors where production processes may be more flexible in allowing new developments. Hidalgo et al. (2007), suggest a measure of technological proximity between any two products based on the probability that both are exported by the same country. Their proximity indicator is used here as an approximation to the inverse of the cost of diversification. I compute the average proximity that a good belonging to sector $i = A, M$ has with all other goods (see Table A.3 in the Appendix). A lower average proximity is found for A, suggesting that the distance between a representative A-good and any other good in the product space is larger than that of the representative M-good. According to this result, product creation is more costly in the former than in the latter industry. Table A.4 shows results for average proximity between a representative good in industry i and all other goods belonging to the same industry. The fact that the average proximity is lower in A suggests that within industry diversification is also more costly in the agricultural sector. This could constitute primary evidence supporting $a_A > a_M$. Overall, it is not impossible that all three of the conditions on σ's, L's and a's making Assumption 1 hold may be contributing together to explain the relative lag in diversification within the agricultural sector that was documented in Section III.

Analysing the North first, $E_N = 1$ means that $r_N = \rho$. Aggregate profits $\pi_M n_M$ are constant, since the rate at which products are created in M is the same as that at which profits for a firm in that industry fall. Constant product creation in industry M gives $g_{\pi M} = g_{vM} = -g_M$. Using (5), constant wages in N obtains.

Moving to the South, the rate at which expenditure evolves is obtained from the trade balance condition:

$$g_{ES}(t) = \frac{g_\alpha(t)}{1-\alpha(t)} \tag{11}$$

This shows in a very straightforward way that expenditure in S is directly linked to the share of consumption attracted by its firms in world markets. Using the previous result it is possible to solve for the dynamic version of equation (6):

$$g_\alpha(t) = [1-\alpha(t)]\frac{\beta-1}{\beta}\left[\frac{g_A}{\sigma_A-1} - \frac{g_M}{\sigma_M-1}\right] \tag{12}$$

Equation (12) constitutes the main expression of this model as it highlights the straightforward way how the share of consumers' expenditure in A is affected by the difference in product creation between sectors. Note that if industries were symmetric (so $g_A = g_M$ and $\sigma_A = \sigma_M$), then $g_\alpha = 0$. The solution in such a case would resemble one with fixed expenditure shares across sectors, a situation that can also be obtained when $\beta = 1$. In such a scenario, no income nor welfare divergence would follow.

The unbalanced nature of the model prevents the existence of a balanced growth path for the global economy in the absence of too restrictive assumptions. Therefore, in the remainder of the section, results are provided for an Asymptotic Balanced Growth Path defined as follows:

DEFINITION 1 *The Asymptotic Balanced Growth Path (ABGP) is characterized by constant $L_{R,i}$ and g_i, $\forall i = A, M$. Under Assumption 1, $\alpha(t)$ converges to a constant when $t \to +\infty$.*

Fixed allocation of labor between different activities within each sector is consistent with constant product creation, and uneven product creation yields a time varying share of expenditure in the agricultural sector. Following this definition, the asymptotic value of α depends on the sign of the bundle of parameters in the right hand side of equation (12): it is zero if the bundle is negative, or 1 if the bundle is positive. From here on, our analysis focuses exclusively on the case where $g_\alpha < 0$, as this is the empirically relevant scenario. Equation (12) shows that the present model can replicate a declining α in a number of ways. Focus is placed on the case in which uneven diversification is such that the term in brackets is negative, combined with $\beta > 1$.[14] While this is not the only combination of parameter values that could yield $g_\alpha < 0$ in theory, other options are disregarded as empirically ungrounded.[15]

IV.E. Welfare results

The fact that the ratio $g_\alpha(t)/[1-\alpha(t)]$ must be constant according to (12), implies that g_{ES} also is, and as is shown next, most other endogenous variables in the South are

[14] A discussion on the value of β is presented in Section VI.

[15] An interesting novelty in the model lies in the possibility of having $g_\alpha < 0$ even with $\beta < 1$. As is shown in Section V, this is not possible in a similar model of uneven growth in the intensive margin, where the combination of $\beta < 1$ and uneven development yields expenditure shifts in favor of the lagging sector ($g_\alpha > 0$). This new possibility can be achieved if $\beta < 1$, combined with a positive term in brackets. This is compatible with $g_A < g_M$ as long as $(\sigma_A - 1)/(\sigma_M - 1) < g_A/g_M < 1$. In such a situation, even though product creation is smaller in A, consumer valuation of any new product in that sector is very high (because substitutability within that industry is very low). Consumers' valuation of product development is larger in industry A, even when actual diversification is smaller. Although theoretically possible, this scenario does not seem to square with the empirical evidence presented here (Table 1) suggesting that $(\sigma_A - 1)/(\sigma_M - 1) > 1$.

either constant or growing at a constant rate. The rest of the solution in S is given by the Euler equation $r_S = g_{ES} + \rho$ and the no arbitrage condition $g_{vA} = r_S - \pi_A(t)/v_A(t)$. The path followed by the most relevant variables of this model can now be fully determined, allowing us to reach important results.

Evolution of relative consumption between regions. A shrinking expenditure share in agricultural goods, pushes down aggregate expenditure in S, by (11), so the ratio of expenditure in S over N falls. The following result obtains:

RESULT 1 *When uneven product creation reduces α, consumers from S obtain a decreasing share of world income, translating into expenditure divergence between regions. All consumers face the same price index, so divergence in consumption follows.*

Evolution of relative income between regions. While aggregate profits in N are constant, this is not the case in S. Indeed, aggregate profits in N remain constant due to a combination of an increasing global market share captured by sector M, with an exactly offsetting fall in global expenditure, explained by the decreasing expenditure in S. For S:

$$g_{\pi A} = -g_A + \frac{g_\alpha(t)}{1-\alpha(t)} \tag{13}$$

The above expression shows how firms in A experience an additional source of profit loss not experienced by firms in M: not only they compete with entrants, but on top of that the size of the market is shrinking. So unlike what happens in N, aggregate profits in S fall unequivocally over time (at rate $g_\alpha/[1-\alpha]$).

The time-path of wages is given by

$$g_{wS} = \frac{g_\alpha(t)}{1-\alpha(t)} \tag{14}$$

Wages in S evolve at a constant rate and in the same direction as the share of agricultural products in expenditure. When that share is decreasing, the aggregate value of firms in S falls as a consequence, and wages move downwards in the South.

The following result summarizes the findings regarding relative income movements:

Result 2 *With α falling, income diverges between regions since both aggregate profits and wages fall in S with respect to those in N.*

Income divergence among primary economies is a stylized fact as documented by much of the resource curse literature (see for example Sachs and Warner, 2001). The working paper version of this article provides in-depth evidence in support of such trend specifically for the subset of agricultural economies, as defined here.

Evolution of welfare in each region. Result 1 summarizes the conclusions regarding the evolution of expenditure and real consumption of one country relative to the other. Reaching welfare conclusions requires knowing the time path of the aggregate price index. The evolution of the price index over time may not be trivial. Even if the price of each industry decreases monotonically due to constant product creation ($g_{P,i}(t) < 0$, $\forall i = M, A$ and $\forall t$), the aggregate price index could potentially rise, at least temporarily, driven by weight shifts within the index. Nevertheless, it can be shown that in the case of $\beta \neq 1$, the dynamic price index is given by $g_P(t) = \alpha(t)g_{PA} + [1 - \alpha(t)]g_{PM}$, with $g_{Pi} = g_{wi} - g_i/(\sigma_i - 1)$. The aggregate price level needs to fall over time in our setting. Intuitively, the possibility of a rising aggregate price is ruled out because, as is usual in expanding variety models, real consumption must grow in the anchor economy, so aggregate prices must fall relative to expenditure in N.

For real consumption to increase in the South too, the fall in expenditure in that region needs to be lower than the fall in prices, i.e., $g_{ES} > g_P$ has to hold, occurring if and only if:

$$\frac{\alpha(t)}{1 - \alpha(t)} > \frac{1 - \beta}{\beta} - \frac{g_M(\sigma_A - 1)}{\beta g_A(\sigma_M - 1)} \tag{15}$$

The term in the left-hand side is always positive and goes to zero when α does. The sign of the constant term in the right-hand side depends on the value of β. If $\beta > 1$, the entire term is negative so the condition always holds. Only if $\beta < 1$ and the value of that parameter is low enough, can the constant term be positive and the entire condition could not hold at some t. Conclusions regarding the evolution of real consumption in absolute terms, within each region, can be summarized as follows:

Result 3 *With α falling, the North experiences monotonically increasing welfare. The same is true for the South if condition (15) holds.*

According to this condition, it is theoretically possible that the South experiences growing aggregate consumption during a certain period and this is suddenly reversed when α falls below the threshold established in the previous result.

Evolution of terms of trade for the South. Equation (4) establishes that the only determinant for changes in terms of trade p_A/p_M are movements in relative wages. Having established that the relative wage in S fall, the following result follows:

Result 4 *With α falling, terms of trade deteriorate for S.*

This result underscores that, in a model with uneven growth in the extensive margin, relative prices move to enhance income divergence. This is opposed to what is expected in a model where uneven growth happens in the intensive margin.

V. Relative price movements and the margins of growth

In a framework where uneven growth happens exclusively in the intensive margin relative prices must move to offset income differences. This is easy to illustrate by deriving the FOC of the maximization problem of the consumer and including (3) to obtain:

$$\left[\frac{p_M(t)}{p_A(t)}\right]^{\beta} = \frac{\omega_M q_A(t) n_A(t)^{\frac{\sigma_A-\beta}{\sigma_A-1}}}{\omega_A q_M(t) n_M(t)^{\frac{\sigma_M-\beta}{\sigma_M-1}}} \tag{16}$$

When growth happens exclusively in the intensive margin, i.e., when q_A/q_M moves but n_A/n_M does not, changes in relative prices must go in the opposite direction to changes in quantities, as long as $\beta > 0$. In a context of specialization, this implies that terms of trade offset differences in output growth to some degree. This result was first shown in Acemoglu and Ventura (2002), and the authors highlight the importance of this terms of trade effect (TTE) to prevent income divergence across regions. Terms of trade constitute a central variable in the development process of economies as it establishes how much domestic consumers can purchase in international markets with one unit of exports. Properly understanding how terms of trade react to growth is therefore of major importance.

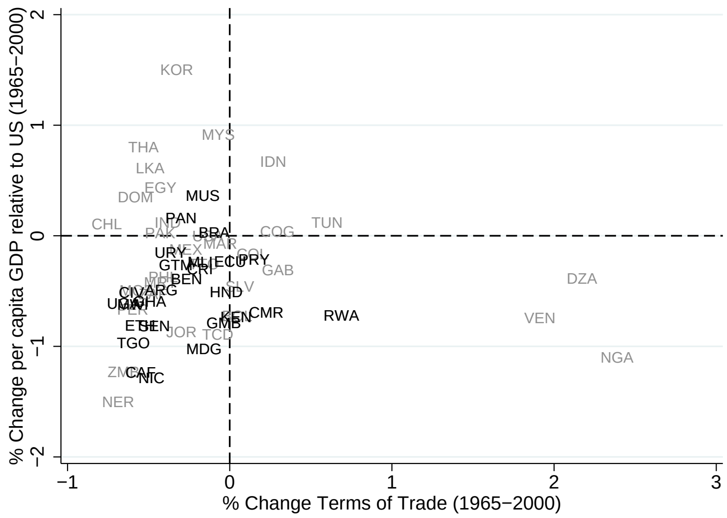
As shown in the previous section, a model of uneven diversification is capable of reproducing the opposite relative price movement because it processes a different adjustment mechanism. A time-varying ratio of varieties in each sector means that relative prices in equation (16) do not necessarily compensate for changes in relative quantities. In the present model, changes in relative prices follow shifts in relative wages, as efficiency in the production of final goods remains unchanged. Relative wages are in turn determined by the aggregate value of firms in each sector and ultimately by the movements in the share of expenditure devoted to each sector in (12). Since a falling share of expenditure in A reduces the value of A-firms relative to M-firms, the relative wage of workers in S also falls and terms of trade deteriorate for that region. Differences in product creation between sectors are adjusted by changes in sales for individual firms so the equality in (16) holds.

In sum, unbalanced growth between sectors have opposing effects on relative prices when it happens in the intensive or the extensive margin. In a context of specialization, this translates into opposing changes in terms of trade. The data shows that in the real world, both margins of growth may be contributing in shaping terms of trade movements, with each margin having relatively more importance for different sets of economies. Figure 4 plots the change in terms of trade against the change in real income (relative to the US) for each economy over a period of roughly 40 years.[16]

A fully operational TTE, pushed by uneven growth in the intensive margin alone, would yield a negative relationship between these two variables. While the correlation for the full sample of countries is negative (-0.07), it is clear that the group of countries with large shares of agricultural exports (in bold) contribute to a great extent against

[16]Section D in the Appendix replicates and extends the exercise in Acemoglu and Ventura (2002), which implies controlling for steady state determinants, and highlighting the particular position of agricultural economies. It also shows that the TTE is independent of the size of the economy. This is compatible with an Armington world, as the one set by Acemoglu and Ventura (2002), where consumers differentiate goods by country of origin. The result is robust to alternative time periods. Moreover, it is shown that a larger weight of agricultural goods in export values is positively correlated with a larger fall in terms of trade.

Figure 4:
Change in real income and terms of trade (1965-2000)



Notes: Change in terms of trade for the period 1965-1985 from Barro and Lee (1993) and for the remaining period from WDI. Data on per capita GDP (constant prices) from PWT. Agricultural countries are signaled in bold and are defined as those for which exports of agricultural goods (A1 list in Appendix A.I) exceed 30% in 2000. Export data from Feenstra et al. (2005).

a stronger TTE, since almost all of them are located in the lower-left quadrant (the correlation for a sample ignoring these countries rises to -0.20). These economies have experienced relatively low growth in real income and their terms of trade have fallen instead of increasing. Moreover, the correlation for this sub-sample is actually positive. This suggests that the extensive margin of growth may be playing a role in terms of trade movements for these economies.

VI. Quantification

The main argument in this paper is that uneven product creation contributes to shaping expenditure shares across sectors. The existing literature has underlined growth in the intensive margin and income effects stemming from non-homothetic preferences as main drivers of expenditure shifts. This section proposes a quantitative exercise to measure the contribution of each of these sources. A general version of the model in Section IV is proposed, where the main simplifying assumptions are lifted. After estimating the required preference parameters, the model is put to use and counter-factual exercises are presented to quantify the importance of uneven product diversification for expenditure shifts.

VI.A. A general version of the model

The model comprises C economies (indexed c), each freely deciding how much to produce of two goods ($i = M, A$). Trade is now costly which means that prices consumers face are country specific. Preferences of consumers in country c over consumption of A and M (both domestically produced or imported) are now represented by

$$Q_c(t) = \left[\omega_M^{\frac{1}{\beta}} Q_{cM}^{\frac{\beta-1}{\beta}}(t) + \omega_A^{\frac{1}{\beta}} (Q_{cA}(t) + \bar{Q}_A)^{\frac{\beta-1}{\beta}}\right]^{\frac{\beta}{\beta-1}} \tag{17}$$

Here, $\bar{Q}_A$ is a constant that can take any real value. Agricultural goods are inferior if $\bar{Q}_A < 0$ and preferences are homothetic only if $\bar{Q}_A = 0$. Again, preference parameters are common to consumers in all regions. Given these preferences, equation (6) is now replaced by:

$$\alpha_c(t) = 1 - \left[1 + \frac{P_{cA}(t)\bar{Q}_A}{E_c(t)}\right]\left[1 + \frac{\omega_A}{\omega_M}\left(\frac{P_{cM}(t)}{P_{cM}(t)}\right)^{\beta-1}\right]^{-1} \tag{18}$$

The structure of firms decisions is the same as before, but now technology in sector i improves at an exogenous constant rate $g_{\phi i} = \dot{\phi}_i/\phi_i$. This introduces growth in the intensive margin, which is going to create the standard price effect usually explored in the literature.

In this version of the model, it is easy to show how changes in the share of expenditure of agricultural goods are driven by an income effect, a standard price effect produced by growth in the intensive margin, and the effect proposed in this paper created by growth in the extensive margin. We can write a dynamic version of (18) as follows

$$g_{\alpha c}(t) = \frac{1-\alpha_c(t)}{\alpha_c(t)}\left[\frac{(\beta-1)\mathcal{P}_c(t)}{1+\mathcal{P}_c(t)}\left(\underbrace{\frac{g_{cA}}{\sigma_A - 1} - \frac{g_{cM}}{\sigma_M - 1}}_{extensive} + \underbrace{\frac{\dot{p_{cM}}}{p_{cM}} - \frac{\dot{p_{cA}}}{p_{cA}}}_{intensive}\right) - \underbrace{\frac{\dot{\mathcal{Y}}_c(t)}{1+\mathcal{Y}_c(t)}}_{income}\right] \tag{19}$$

with $\mathcal{P}_c(t) = (\omega_A/\omega_M)(P_{cM}(t)/P_{cA}(t))^{\beta-1}$ and $\mathcal{Y}_c(t) = P_{cA}(t)\bar{Q}_A/E_c(t)$. According to the previous equation, obtaining accurate values for preference parameters is key in our quantification as the importance of uneven growth in both margins is affected by parameter β and the coefficient ω_A/ω_M, while the value of $\bar{Q}_A$ is crucial for assessing the importance of the income effect.

VI.B. Estimation of preference parameters

Values for the preference parameters can be estimated using consumption data. In recent papers evaluating structural change in closed economies, similar estimations are performed, for a wide range of specifications in preferences. Among these papers, Herrendorf et al. (2013) uses the preference structure that is closer to the one used here, so it constitutes a reasonable benchmark for the exercise. However, the quantitative exercise performed here refrains from directly using the point estimations found in that paper, since their setting includes a service sector (S), that our framework omits due to the impossibility of assessing growth in the extensive margin for that sector. In particular, the consumption aggregator is defined in that paper as a generalized version of (17), that can be referred to as a Generalized Stone-Geary (GSG) structure:

$$Q_c = \left[\sum_i \omega_i^{\frac{1}{\beta}} (Q_{ci} + \bar{Q}_i)^{\frac{\beta-1}{\beta}}\right]^{\frac{\beta}{\beta-1}} \text{ with } i = A, M, S, \quad \sum_i \omega_i = 1, \text{ and } \bar{Q}_M = 0 \tag{20}$$

Maximizing this with the usual budget constraint gives the following share system:

$$\alpha_{ci} = \omega_i \left(\frac{P_i}{P}\right)^{1-\beta} \left(1 + \sum_{j=A,M,S} \frac{P_j \bar{Q}_j}{E_c}\right) - \frac{P_i \bar{Q}_i}{E_c}$$

where α_{ci} represents the expenditure share in sector i ($i = A, M, S$) at country c, and P is the corresponding aggregate price index of all three sectors. To deal with the issue of these parameters being constrained, the estimation is done in terms of unrestricted parameters b_0, b_1, $b_2 \in (-\infty, +\infty)$, where:

$$\beta = e^{b_0}, \quad \omega_A = \frac{1}{1 + e^{b_1} + e^{b_2}}, \quad \omega_M = \frac{e^{b_1}}{1 + e^{b_1} + e^{b_2}} \text{ and } \omega_S = \frac{e^{b_2}}{1 + e^{b_1} + e^{b_2}}$$

To obtain parameter estimations that are consistent with the framework of the present paper, but at the same time are comparable to the literature, we use the same database on US household final expenditure from the US Bureau of Economic Analysis (BEA). For robustness, results are also reported on a country-sample that includes Western European economies, by making use of *Table 5, Final consumption expenditure of households*, of the OECD Annual National Accounts Detailed Tables. Uy et al. (2013) is followed here.[17] While this source includes data on other countries, the estimation of preference parameters is restricted to Western Europe where consumption patterns are closer to those in the US.

Table 4 shows the results using the same non-linear seemingly unrelated regression estimator as Herrendorf et al. (2013), a particular form of the feasible generalized non-linear least square estimation. Column 1 shows the results for the baseline estimation of the share system that results from the GSG utility function with all three sectors (equation 20), using US data, and therefore replicating the results in the first column in Table I of Herrendorf et al. (2013). Column 2 removes the service sector and considers only expenditure in goods (A and M) as total expenditure, a framework in line with equation (17). Note that in all specifications $\bar{Q}_M = 0$ is assumed, and $\bar{Q}_A < 0$ and $\bar{Q}_S > 0$ are obtained, a standard outcome in the literature. More importantly, notice the coefficient for β turns out to be higher than unity in this exercise, suggesting that A and M could be considered substitutes. Columns 3 and 4 replicate the exercise on data for expenditure of Western European households showing similar results: while sectors appear as complements when all three sectors are considered, the degree of substitutability is larger between M and A, suggesting these are substitutes.

The previous evidence suggests that the degree of substitutability within different categories of goods (G, including A and M) might differ from the existing between G and S, and that the difference is relevant qualitatively. Following this intuition, the next

[17]Agriculture (A) expenditure corresponds to the categories P31CP010 (Food and non-alcoholic beverages) and P31CP020 (Alcoholic beverages, tobacco and narcotics). Manufacturing (M) includes categories P311B (Durable Goods), P312B (Semi-durable goods) and P313B (Non-durable goods) net of A-expenditures. Finally, Services (S) are composed of category P314B (Services).

Table 4:
ESTIMATION OF PREFERENCE PARAMETERS

	(1) US GSG	(2) US GSG (no S)	(3) W-Europe GSG	(4) W-Europe GSG (no S)	(5) US Nested GSG	(6) W-Europe Nested GSG
β	0.848***	1.663***	0.776***	1.224***	1.621***	1.192***
	(0.060)	(0.093)	(0.083)	(0.091)	(0.103)	(0.112)
$\bar{Q}_A$	-1350.382***	-1140.740***	-1369.761***	-1318.224***	-1136.875***	-1358.252***
	(31.177)	(48.194)	(107.980)	(93.989)	(57.118)	(91.008)
$\bar{Q}_S$	11237.402***		2764.868***		8725.382***	1246.069*
	(2840.770)		(684.125)		(2252.515)	(625.206)
ω_A	0.021***	0.118***	0.092***	0.231***	0.120***	0.228***
	(0.001)	(0.004)	(0.007)	(0.011)	(0.005)	(0.011)
ω_M	0.169***	0.882***	0.303***	0.769***	0.880***	0.772***
	(0.010)	(0.004)	(0.010)	(0.011)	(0.005)	(0.011)
ω_S	0.810***		0.605***		0.817***	0.719***
	(0.011)		(0.014)		(0.008)	(0.066)
ω_G					0.183***	0.281***
					(0.008)	(0.066)
ϵ					0.768***	0.447***
					(0.057)	(0.117)
N	64	64	410	410	64	410
AIC	-932.549	-436.714	-3515.743	-1518.805	-963.495	-3569.736
$RMSE_A$	0.004	0.008	0.024	0.038	0.003	0.023
$RMSE_M$	0.009	0.008	0.033	0.038	0.000	0.033
$RMSE_S$	0.010		0.042		0.000	0.040
$RMSE_{\sum_i}$	0.023	0.015	0.099	0.075	0.003	0.096

Notes: *, ** and ***, significant at a 10, 5 and 1% confidence level respectively. Robust standard errors in parenthesis. AIC is the Akaike information criterion, $RMSE_i$ is the root mean squared error for i.

step is to test a nested preference structure as follows

$$Q_c = \left[\omega_G^{\frac{1}{\epsilon}} Q_{cG}^{\frac{\epsilon-1}{\epsilon}} + \omega_S^{\frac{1}{\epsilon}} (Q_{cS} + \bar{Q}_S)^{\frac{\epsilon-1}{\epsilon}}\right]^{\frac{\epsilon}{\epsilon-1}} \tag{21}$$

with

$$Q_{cG} = \left[\omega_M^{\frac{1}{\beta}} Q_{cM}^{\frac{\beta-1}{\beta}} + \omega_A^{\frac{1}{\beta}} (Q_{cA} + \bar{Q}_A)^{\frac{\beta-1}{\beta}}\right]^{\frac{\beta}{\beta-1}}$$

where parameter ϵ guides the substitutability between G and S, while β does so between M and A.[18] Evidently, this specification is more general than (20), as it can be reduced to it by imposing $\epsilon = \beta$ and $\omega_G = 1$. Results are reported in the remaining columns of Table 4: Column 5 shows results for the US, and Column 6 does so for Western Europe.[19] As can be seen, the evidence indicates that β is significantly greater than one, while ϵ is significantly lower than that value.

[18] A similar structure can be found in Moro et al. (2017), albeit defined over different sectors.

[19] Herrendorf et al. (2013) highlights that estimations for between-industry substitutability parameters might differ when using data on value added instead of final expenditure data. Although not relevant for the present paper, for the sake of completeness of the estimation exercise, the latter specification is also estimated using value added data. This, again, gives significant coefficients for β larger than unity. Results are available in Section E of the Appendix.

VI.C. Quantitative results

The following Table summarizes the parameter values used in our main quantitative exercise:

Table 5:
CHOICES FOR PARAMETERS

β	1.44
$\bar{Q}_A$	-1136.86
ω_A/ω_M	0.22
σ_A	3.44
σ_M	2.53
g_A	0.210 and 0.428
g_M	0.681 and 0.754

According to the results presented in Table 4, reasonable values for β should be in the interval $(1.22, 1.66)$, while values for ω_A/ω_M are estimated to belong to $(0.14, 0.3)$. Intermediate values are used as reference here. Table 1 indicates that 3.44 and 2.53 are reasonable values for σ_A and σ_M respectively. Finally, Table 2 contains plausible values for g_A and g_M. For robustness, two scenarios are considered here. Scenario #1 uses a pair of values for the vector (g_A,g_M) computed upon 4-digit data and using our narrower definition of agricultural goods $A1$. This corresponds to values in the first column of Table 2. Scenario #2 takes vales from the last column of the same table, those calculated on 6-digit data and for the broader definition $A3$.

Armed with these parameter values, it is possible to quantify the importance of the extensive margin of growth in the decline of the expenditure share to agricultural goods. Introducing the previous values into (19) gives model predictions for the decline in α. Again, this share is computed as expenditure in these goods over total expenditure in all goods. Services are excluded so the exercise matches the structure proposed by the model. Results are presented for the two alternative scenarios (#1 and #2), each using a different set of values for the pair (g_A,g_M). Table 6 shows the corresponding results along with a final column where uneven product diversification is shut down, i.e., $g_A = g_M = 0$ is assumed. This allows to put a number to the magnitude of the missing effect. Results are presented for countries in North America and Western Europe, for which expenditure and price data are available for long periods of time, and for which relative price movements go in the same direction as in the US. Keeping economies with long series for these key variables is important since the model is constructed to reproduce long-term trends, i.e., the model features no adjustment mechanism to the different shocks that could affect expenditure shares in the short term. While parameters take the same value for every country, initial values of the relevant variables are extracted from the country specific data.

Table 6:
DECLINE IN α OBSERVED VS PREDICTED

Country	period	$\%\Delta\alpha$			
		observed	full #1	full #2	no extensive
		(1)	(2)	(3)	(4)
Canada	1981-2014	-32.96	-36.83	-35.29	-23.57
France	1970-2014	-31.45	-27.23	-26.16	-17.98
Norway	1970-2014	-43.34	-28.11	-27.22	-20.44
United States	1947-2010	-71.05	-72.65	-71.16	-59.79

Notes: Results presented for the sample of countries with a timespan longer than 30 years, in North America and Western Europe. $\Delta\alpha$ is the percentage change in the share of expenditure to agricultural products over all goods (services not included). Full model #1 corresponds to the prediction of the model including all effects and where changes in the extensive margin are g_A=0.21 and g_M=0.68. Full model #2 gives results for alternative values g_A=0.428 and g_M=0.754.

The table highlights the sharp decline observed in agricultural expenditure shares for all countries. As has been documented before this share fell 71% in the US over the period 1947-2010. For the other countries, the fall is similarly sharp, at least for the shorter time periods for which data is available. The decline predicted by our model does not differ much across the two presented scenarios. In both cases, the predicted decline approaches very closely the actual fall observed in the US. The fall in α that is predicted when ignoring changes in the extensive margin leaves unexplained 15.85% of the total decline, but introducing uneven product diversification closes the gap almost completely. In France, the observed decline is 31% for the period 1970-2014. The prediction ignoring product diversification only accounts for 57% of that, but including action in the extensive margin improves the prediction by over 28% of the total fall, raising the explained percentage to over 85%.

Overall, these results indicate that the extensive margin of growth can play a quantitatively relevant role in explaining expenditure shifts. This has important implications for industrial policy design, as it provides new support to product diversification incentives. The recommendation becomes particularly crucial for economies with strong specialization in agricultural goods. Shrinking expenditure shares in exported goods can greatly compromise the development process of these economies. Moreover, as shown in Section V, a declining expenditure share in agricultural goods can contribute to falling terms of trade for these economies, even when growth in the intensive margin is relatively lagging, further aggravating the problem. According to the above results, fostering product diversification could contribute to alleviating the fall in terms of trade in these cases, which would certainly contribute to prevent real income divergence for these economies.

VII. Conclusion

This work joins a large literature in pointing at specialization as a cause of welfare divergence. Focus is placed on the extensive margin of development to highlight the role that uneven diversification between sectors can play to account for the declining share of agricultural goods in aggregate expenditure. The first contribution of this paper is to document that product diversification is unbalanced between sectors: diversification happens at lower rates in the agricultural sector than in the rest of goods-producing activities. This finding is in line with recent work showing that technological linkages are rarer, and the elasticity of substitution is higher, among goods belonging to the primary sector.

The second contribution is to show in a simple model, how uneven diversification can account for expenditure shifts. The model highlights interesting macroeconomic trends that are not to be expected in models where uneven growth happens in the intensive margin only. Most notably, it proves that relative prices can move to enhance, rather than offset growth differences, even absent non-homothetic preferences. The mechanism proposed here is quantitatively relevant as it accounts for over 15% of the decline in expenditure shares on agricultural goods in the US. The contribution can be much larger in other economies such as France.

This paper focuses on agricultural economies since the most relevant facts targeted here have been highlighted for those economies in the past. Nevertheless, the same mechanism is potentially valid in other contexts, as long as different parts of the product space exhibit unbalanced diversification. Future research in this matter should be welcomed.

Declarations

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References

Acemoglu, Daron and Veronica Guerrieri, "Capital Deepening and Nonbalanced Economic Growth," *Journal of Political Economy*, 116 (2008), 467–498.

Acemoglu, Daron and Jaume Ventura, "The World Income Distribution," *Quarterly Journal of Economics*, 117 (2002), 659–694.

Baldwin, Richard E. and Frédéric Robert-Nicoud, "Trade and Growth with Heterogeneous Firms," *Journal of International Economics*, 74 (2008), 21–34.

Boppart, Timo, "Structural change and the Kaldor facts in a growth model with relative price effects and non-Gorman preferences," *Econometrica*, 82 (2014), 2167–2196.

Broda, Christian and David E. Weinstein, "Globalization and the gains from variety," *Quarterly Journal of Economics*, 121 (2006), 541 – 585.

Buera, Francisco J. and Joseph P. Kaboski, "Can traditional theories of structural change fit the data?," *Journal of the European Economic Association*, 7 (2009), 469–477.

Caron, Justin, Thibault Fally, and James R. Markusen, "International trade puzzles: A solution linking production and preferences," *Quarterly Journal of Economics*, 129 (2014), 1501–1552.

Caselli, Francesco, "Accounting for Cross-Country Income Differences," in Aghion, Philippe and Steven N Durlauf eds. *Handbook of Economic Growth*: North-Holland, 1st edition, Chap. 9, 679–741 (2005).

Comin, Diego, Danial Lashkari, and Martí Mestieri, "Structural Change With LongRun Income and Price Effects," *Econometrica*, 89 (2021), 311–374.

Corsetti, Giancarlo, Philippe Martin, and Paolo Pesenti, "Varieties and the transfer problem," *Journal of International Economics*, 89 (2013), 1–12.

Duarte, Margarida and Diego Restuccia, "Relative Prices and Sectoral Productivity," *Journal of the European Economic Association*, 00 (2019), 1–44.

Epifani, Paolo and Gino Gancia, "The skill bias of world trade," *Economic Journal*, 118 (2008), 927–960.

Feenstra, Robert C. "New Product Varieties and the Measurement of International Prices," *American Economic Review*, 84 (1994), 157–77.

Feenstra, Robert C., Robert E. Lipsey, Haiyan Deng, Alyson C. Ma, and Hengyong Mo, "World Trade Flows: 1962-2000," (2005).

Fieler, Ana Cecília, "Nonhomotheticity and Bilateral Trade: Evidence and a Quantitative Explanation," *Econometrica*, 79 (2011), 1069–1101.

Foellmi, Reto and Josef Zweimüller, "Structural change, Engel's consumption cycles and Kaldor's facts of economic growth," *Journal of Monetary Economics*, 55 (2008), 1317–1328.

Gaulier, Guillaume and Soledad Zignago, "BACI: International Trade Database at the Product-Level. The 1994-2007 Version," (2010).

Gollin, Douglas, Stephen L. Parente, and Richard Rogerson, "Farm work, home work and international productivity differences," *Review of Economic Dynamics*, 7 (2004), 827–850.

Grossman, Gene M. and Elhanan Helpman, *Innovation and Growth in the Global Economy*, Cambridge, Massachusetts. London, England: The MIT Press, 6th edition (1991).

Hausmann, Ricardo and César A. Hidalgo, "The network structure of economic output," *Journal of Economic Growth*, 16 (2011), 309–342.

Herrendorf, Berthold, Richard Rogerson, and Ákos Valentinyi, "Two perspectives on preferences and structural transformation," *American Economic Review*, 103 (2013), 2752–2789.

Hidalgo, César A., Bailey Klinger, A-L Barabási, and Ricardo Hausmann, "The product space conditions the development of nations," *Science*, 317 (2007), 482–7.

Kongsamut, Piyabha, Sergio Rebelo, and Danyang Xie, "Beyond Balanced Growth," *Review of Economic Studies*, 68 (2001), 869–882.

Koren, Miklós and Silvana Tenreyro, "Volatility and Development," *Quarterly Journal of Economics*, 122 (2007), 243–287.

Krugman, Paul R. "Differences in income elasticities and trends in real exchange rates," *European Economic Review*, 33 (1989), 1031–1046.

Matsuyama, Kiminori, "Structural change in an interdependent world: A global view of manufacturing decline," *Journal of the European Economic Association*, 7 (2009), 478–486.

McMillan, Margaret, Dani Rodrik, and Íñigo Verduzco-Gallo, "Globalization, structural change and productivity growth, with an update on Africa," *World Development*, 63 (2014), 11–32.

Moro, Alessio, Solmaz Moslehi, and Satoshi Tanaka, "Does home production drive structural transformation?," *American Economic Journal: Macroeconomics*, 9 (2017), 116–146.

Ngai, Rachel L. and Christopher A. Pissarides, "Structural Change in a Multi-Sector Model of Growth," *American Economic Review*, 97 (2007), 429–443.

Ourens, Guzmán, "Trade and growth with heterogeneous firms revisited," *Journal of International Economics*, 100 (2016), 194–202.

Rauch, James E. "Networks versus markets in international trade," *Journal of International Economics*, 48 (1999), 7–35.

Rodrik, Dani, "Unconditional Convergence in Manufacturing," *Quarterly Journal of Economics*, 128 (2013), 165–204.

Sachs, Jeffrey D. and Andrew M. Warner, "The curse of natural resources," *European Economic Review*, 45 (2001), 827–838.

Swiecki, Tomasz, "Determinants of structural change," *Review of Economic Dynamics*, 24 (2017), 95–131.

Uy, Timothy, Kei-Mu Yi, and Jing Zhang, "Structural change in an open economy," *Journal of Monetary Economics*, 60 (2013), 667–682.