Trade Frictions, Development and Agriculture: Do income effects matter?

ECO2704 Research Proposal

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1 Introduction

There is a growing literature that documents the role of trade in addressing the extranormative productivity gap in agriculture between rich and poor countries (Tombe, 2015) (Teignier, 2018). These productivity differences alone suggest the potential for comparative advantage to work its magic, barring frictions that rationalize the lack of trade in the sector. These frictions are especially severe in developing countries (Tombe, 2015).

There has also has been recent emphasis on the role trade frictions play *within* developing countries, and how they can benefit from investment in reducing these frictions (Sotello, 2020) (Asher and Novosad, 2020) (Brooks and Donovan, 2020) (Adampolous, 2011). Often, the rural poor in developing countries remain relatively unintegrated in international markets because of poor *domestic* infrastructure. In addition, the structure of these domestic trade frictions also mediate the uneven gains to trade within these countries in the presence of low spatial and sectoral factor mobility; a point highlighed in Sotello (2020). Due to the availability of trade data, I want to focus this study instead on the distributional effects of agricultural trade across developing countries.

In the context of agriculture, little attention[1] has been paid to the role of income effects in shaping the distribution of the gains to trade across developing countries: whether rightly or wrongly. While trade shocks tend to morph the relative prices of goods in directions that reflect comparative advantages, trade-induced benefits to the standard of living also alter the demand composition of agriculture[2]. In theory, these yield additional implications for the aggregate gains to trade, and how those gains are distributed across sectors and countries. I seek to answer if these income effects matter in practice. Does the assumption of homothetic preferences provide a reasonable estimate in the appraisal of policies that seek to bolster economic integration?

At the outset, the answer to this question isn't obvious. On one hand, the share of agricultural employment in developing countries is high, making them susceptible to international competition if the reallocation of factors across sectors is met with friction[3]. On the other hand, marginally increased trade in agriculture disproportionately benefits the consumption poor, to which they spend a larger fraction of income[4]. The calibrations in Tombe (2015) suggest that the latter channel outweighs the former. What does this mean for the distribution of these gains when income effects are accounted for? In the set of developing countries, do the poorest gain where they might otherwise lose, and by how much?

[1]To my knowledge, Tombe (2015) is the first to document the contribution of non-homothetic preferences in the context of trade, development and welfare. Less related is Fieler (2011), which rationalizes the lack of trade in poor countries by arguing that the Ricardian gains to trade are smaller for goods with smaller income elasticities.

[2]Estimations of the income elasticity of agriculture have shown deviations far below unity. I elaborate on these estimates after introducing non-homothetic CES preferences in the body of the paper.

[3]Frictions in the labour market are responsible for a large portion of the agricultural productivity gap (Restuccia, Yang and Zhu, 2008).

[4]In the context of development, this point is emphasized in Tombe (2015). With Stone-Geary preferences, countries with less disposable income are more responsive to changes in the price of agriculture. Fagelbaum and Khandewal (2016) also find that trade favours the consumption poor in rich countries because they concentrate spending in traded sectors.

The specific application I have in mind was studying the distributional effects of trade shocks between countries in the African Continental Free Trade Zone and the rest of the world. This will be done by counterfactually decreasing trade costs in a calibrated Armington model. This context is particularly interesting because there is significant variation in the agricultural employment shares across African countries[5]. The contribution of income effects to the gains of trade may matter to extent that the variation in employment is rationalized by differences in agricultural productivity and standards of living, or reflect patterns of trade and specialization.

The main contribution I want to make in this proposal is methodological. I attempt to build on the welfare estimates of Tombe (2015) in two ways. Firstly, when preferences are not homothetic, the use of the percentage change in utility as a welfare measure does not correspond tightly with the equivalent and compensating variation. The latter measures are useful when making cross-country comparisons in welfare changes. I outline why, and make a correction in the following section. To my knowledge, such a correction is not made in the trade literature. Secondly, I employ the non-homothetic generalization of the CES utility function, which has been used by Comin et al (2020) and Matsuyama (2019). These preferences have empirical advantages over Stone-Geary and CRIE[6], which are commonly used in trade and development. My final contribution is to show that these preferences are amenable to the "hat algebra" of Eaton, Dekle and Kortum (2007), which provides a basis for all counterfactual exercises I want to perform.

[5] Using publicly available 2020 data from the World Bank. For example, agricultural employment shares range from 0.92 in Burundi to .05 in South Africa.

[6] In particular, CRIE preferences are used in Fieler (2011) and Caron, Fally and Markusen (2014).

2 Welfare measurement.

To answer this question, I need two ingredients. The first is a welfare measure that is comparable across countries. Both compensating and equivalent variation (EV and CV) are good candidates here, as they express welfare changes in terms of measurable quantities. In the context of trade and welfare, both Fagelbaum and Khandewal (2016) and Borusyak and Jaravel (2018) use first order approximations to EV relative to initial income. The formula expresses this as a function of *current* consumer expenditure shares, as well as small changes in prices and wages induced by the trade shock. If there are N goods, this is

$$EV = \frac{dw}{w} - \sum_{i=1}^{N} \alpha_i \frac{dp_i}{p_i}$$

Where α_i is the expenditure share of good i. What is attractive about the formula is that it holds for any differentiable, quasi-concave utility function. However, a drawback is that it is an approximation. It does not account for effects of greater order, such as the adjustment of consumption shares to large trade shocks. This makes it ill-suited for trade in the development context; I want to allow for the possibility that expenditure shares of agriculture adjust in response to increases in the standard of living. This leads to the second ingredient.

I also need a non-homothetic utility that delivers simple statistics for the welfare impacts of *large* trade shocks. Traditionally, these simple statistics fall out of the CES model using the hat algebra of Eaton Dekle and Kortum (2007)[7]. On the other hand, CES preferences can be easily generalized to be non-homothetic; see Comin et. al (2020) and Matsuyama (2019) for a comprehensive examina-

[7]In particular, solving for counterfactual changes in welfare without estimating productivity or certain demand parameters is made possible by hat algebra.

tion of its properties[8]. The small contribution I make in this proposal is to show that algebra is amenable to this new class, with some caveats. When preferences are non-homothetic, price indices fail to be independent of the standard of living (Samuelson and Swamy, 1974). This implies that the EV and CV *relative to income* do not coincide as welfare measures, as they do with homothetic CES. This is an issue in counterfactual exercises that use the percentage change in utility as a measure of welfare, as this measure does not in general equal the CV or EV unless homothetic preferences are assumed. A correction must be made. I have looked hard at the literature to find another paper that makes this observation in the context of trade, and I cannot find any[9].

To see why, let $E(p,u)$ be the expenditure function for some arbitrary well-behaved preference at prices p and utility u. Let $\mathbb{P}(p,u)$ be the price index such that $E(p,u) := \mathbb{P}(p,u)u$. Now consider a trade shock that changes utility from u to u' and prices p to p'. The objective is to calculate the CV associated with this shock (the EV can be calculated with similar logic). I define CV to be the fraction of income after the shock that must be deducted in order to be as well of as in pre-shock levels. In other words,

$$(1 - CV)w' = \mathbb{P}(p',u)u$$

where $w' := E(p',u')$. This can be simplified using the fact that $w := \mathbb{P}(p,u)u$,

$$(1 - CV) = \frac{w}{w'}\frac{\mathbb{P}(p',u)}{\mathbb{P}(p,u)} \tag{1}$$

[8]Borusyak and Jaravel (2018) also employ this utility function, but use the first order approximation of EV to calculate welfare effects.

[9]Fagelbaum and Khandewal (2016), Borusyak and Jaravel (2018) and Arkolakis et. al (2019) all avoid this issue by using first order approximations to the equivalent variation, which holds for all well-behaved preferences. On another note, my intention is not to take credit for this observation; please suggest any references if you are aware of them so I may cite them appropriately.

An inspection of this equation is in order. Measuring the CV requires comparing the change in price indices *holding utility constant at pre-shock levels.* If the preferences in question were homothetic, $\mathbb{P}$ would be independent of well-being u. This makes the CV satisfy

$$(1 - CV) = \frac{w}{w'}\frac{\mathbb{P}(p')}{\mathbb{P}(p)} = \frac{u}{u'}$$

So that the proportional change in utility $\frac{u'}{u}$ would be sufficient to compute welfare changes. This useful property is lost when preferences are not homothetic. In this case the proportional change in utility *cannot* be used to calculate the CV because the change in well-being also affects the price index. In the following sections, I account for this correction when using non-homothetic CES. Using a small open economy framework, Appendix A shows that income effects can increase the gains to trade under these corrected measures.

Lastly, these CES preferences also bring with them empirical advantages in the context of measuring the gains to trade with income effects. As noted recently by Matsuyama (2019) and Comin et. al (2020), Stone-Geary and CRIE preferences impose an arbitrary relationship between income and price elasticities; known as Pigou's Law. Pigou's Law has been rejected empirically by Deaton (1974). Non-homothetic CES avoids this problem, as it treats income and substitution effects as separate free parameters. This allows for the meaningful comparison between the gains to trade when there are income effects and when there are not, as such a comparison involves leaving the elasticity of substitution unchanged. The elasticity of substitution is especially important for determining the gains to trade (Arkolakis et al, 2012) as well as sectoral labour allocations (Herrendorf et. al, 2013).

With these advantages in mind, I outline a workhorse model and a preliminary strategy to run counterfactuals in the following sections.

3 A workhorse Armington model.

In what follows, assume there are two sectors $s \in \{a, n\}$, agriculture and non-agriculture respectively. There are N trading countries, along with a foreign country F; let Ω denote the set of these countries. Utility U in country $k \in \Omega \setminus \{F\}$ for workers in sector h is defined implicitly by the relation

$$\sum_{s \in \{a,n\}} \gamma_s^{\frac{1}{\eta}} \left[\frac{C_{h,k}^s}{U_{h,k}^{\epsilon_s}} \right]^{\frac{\eta-1}{\eta}} = 1 \tag{2}$$

where I follow Comin et. al (2020) in normalizing $\gamma_n = 1$ and $\epsilon_n = 1$, as well as restricting the elasticity of substitution $\eta \in \mathbb{R}_{++} \setminus \{1\}$. Given sector-location prices $p_{a,k}$ and $p_{n,k}$, (Hicksian) expenditures on a relative to n can be written in log-linear form

$$log\left(\frac{\alpha_{h,k}^a}{\alpha_{h,k}^n}\right) = (1-\eta) log\left(\frac{p_{a,k}}{p_{n,k}}\right) + (1-\eta)(\epsilon_a - 1) log(U_{h,k}) + log(\gamma_a) \tag{3}$$

The second term makes clear that relative expenditures also depend on the standard of living U_k. If $\epsilon_a < 1$ and $\eta < 1$, relative expenditures on agriculture decline in $U_{h,k}$[10]. The case where $\epsilon_a = 1$ nests homothetic CES. Lastly, the price index $\mathbb{P}_{h,k}$ can be written as

$$\mathbb{P}_{h,k} = \left[\sum_{s \in \{a,n\}} \gamma_s U_{h,k}^{(1-\eta)(\epsilon_s - 1)} p_{s,k}^{1-\eta} \right]^{\frac{1}{1-\eta}} \tag{4}$$

[10] Comin et. al (2020) use OECD data, among other sources, to estimate η and ϵ_a in a model that disaggregates non-agriculture into services and manufacturing. One of these estimates puts η and ϵ_a in the ballpark of 0.25 and 0.01, respectively. All estimates suggest that these sectors are highly complementary, with the welfare elasticity of agriculture just shy of -1; see Table (3), column (3).

where by definition $\mathbb{P}_{h,k} U_{h,k} = E_{h,k}$, where E is minimum expenditure yielding utility $U_{h,k}$ at sector prices $p_{s,k}$. Note that it is also a function of the standard of living $U_{h,k}$ whenever $\epsilon_a \neq 1$.

I close the model with standard Armington assumptions over trade. Within each sector, goods $C^s_{h,k}$ are defined as in terms of homothetic CES aggregators over location-specific output with elasticity of substitution σ_s[11]. There are sector specific "iceberg" trade costs τ^s_{ik}. I also assume that this location-specific output is produced at constant returns to scale with a single spatially immobile factor, labour, with productivity $A_{s,k}$. Wages are allowed to differ across sectors within locations up to a factor $w_{a,k} = (1 - \theta_k) w_{n,k}$; keeping with the quantitatively important labour market distortions that contribute to the agricultural productivity gap highlighted by both Restuccia, Yang and Zhu (2008)[12] and Tombe (2015). The latter demonstrates that these labour market distortions impact the gains to trade directly.

Putting these components of the model together, sector-location prices $p_{s,k}$ can be written as

$$p_{s,k} = \left[\sum_{j \in \Omega} \phi_{s,j} w_{s,j}^{1-\sigma_s} (\tau^s_{jk})^{1-\sigma_s} \right]^{\frac{1}{1-\sigma_s}}$$

where $w_{a,j} = (1 - \theta_j) w_{n,j}$, and $\phi_{s,j}$ are arbitrary demand parameters. Equilibrium is defined in a standard way; as a set of wages w_k and sector-location labour allocations L_{sk} such that trade is balanced given consumption and production decisions, as well as labour market distortions. In addition, the labour

[11] The elasticity of substitution can be estimated in gravity equations, which are standard in the literature. Moreover, the Armington assumption is innocuous because the model is isomorphic to Eaton and Kortum; see Arkolakis et. al (2012).

[12] This model can easily be extended to include traded agricultural inputs, which would make the barriers to input use documented in Restuccia, Yang and Zhu (2008) relevant in a trade context. Sotello (2020) and Tombe (2015) also emphasize the role of trade in the access to agricultural inputs.

market clears given the inelastic labour supply L_k for each country. I defer the complete specification for future drafts.

4 Hat Algebra with non-homothetic CES

To end the proposal, I provide a framework that enables the counterfactual exercise I want to perform, drawing heavily from the hat algebra of Eaton, Dekle and Kortum (2007). Suppose a shock occurs that changes trade costs τ^s_{ik} to $\tau^s_{ik}{}'$. Let $\hat{\tau^s_{ik}}$ denote the ratio of trade costs before and after the change. Using this framework, I can solve for equilibrium changes in wages $\hat{w}_k$ and eventually welfare changes $CV_{s,k}$ and $EV_{s,k}$. This framework uses estimates of ϵ_a, η, σ_a, σ_n and θ_k, whose estimation techniques have been flushed out in the trade, structural change and misallocation literatures. Demand and productivity parameters γ_a, $\phi_{s,j}$ and $A_{s,j}$ do not need to be directly estimated in this procedure, as they can be targeted with other moments.

Suppose we know, before the shock, the fraction of income that workers in sector-location (h, k) spend on goods in sector s, as well as the fraction of expenditure on sector s that country k sources from j. Denote these as $\alpha^s_{h,k}$ and $\beta^s_{j,k}$, respectively. As performed numerous times in the literature with homothetic preferences, the new expenditure shares $\beta^s_{i,k}{}'$ can be written as

$$\beta^s_{i,k}{}' = \frac{\beta^s_{i,k}\hat{w_i}^{1-\sigma_s}(\hat{\tau^s_{ik}})^{1-\sigma_s}}{\sum_{j\in\Omega}\beta^s_{j,k}\hat{w_j}^{1-\sigma_s}(\hat{\tau^s_{jk}})^{1-\sigma_s}}$$

Which does not depend on the demand or productivity parameters. It turns out that a similar formula holds for sector shares $\alpha^s_{h,k}{}'$,

$$\alpha^s_{h,k}{}' = \frac{\alpha^s_{h,k}\hat{p_{s,k}}^{1-\eta}\hat{U_{h,k}}^{(1-\eta)(\epsilon_s-1)}}{\sum_{o\in\{s,n\}}\alpha^o_{h,k}\hat{p_{o,k}}^{1-\eta}\hat{U_{h,k}}^{(1-\eta)(\epsilon_o-1)}} \tag{5}$$

where $\hat{p_{s,k}}$ can be written as a function of $\hat{w}_i$ and $\hat{\tau^s_{ik}}$,

$$\hat{p_{s,k}} = \big[\sum_{j\in\Omega} \beta^s_{jk} \hat{w_j}^{1-\sigma_s} \hat{\tau^s_{jk}}^{1-\sigma_s}\big]^{\frac{1}{1-\sigma_s}}$$

and $\hat{U_{h,k}}$ can be written as the unique solution to the equation

$$\hat{U_{h,k}} = \hat{w}_k \big[\sum_{o\in\{s,n\}} \alpha^o_{h,k} \hat{p_{o,k}}^{1-\eta} \hat{U_{h,k}}^{(1-\eta)(\epsilon_o-1)}\big]^{-\frac{1}{1-\eta}} \tag{6}$$

These relations can be used in the calculation of the new equilibrium induced by the counterfactual trade shock. The trade balance equation can be written as, for every sector location (s, j),

$$(1-\theta_{s,j})w'_j L'_{s,j} = \sum_{k\in\Omega}\sum_{h\in\{a,n\}} \alpha^s_{h,k}{}' \beta^s_{j,k}{}'(1-\theta_{h,k})w'_k L'_{h,k} \tag{7}$$

where $\theta_{h,k} = \theta_k$ if $h = a$, and 0 otherwise. Note that equation (7) can be written strictly as a function of $\hat{w}_i$, $\hat{\tau^s_{jk}}$, observable quantities, and post-shock labour allocations. This equation can be cleaned up to avoid calculations of post-shock labour allocations directly. To this end, define $\tilde{Y}_{h,k} = w_k L_{h,k}$ and $Y_k = w_k L_k$, and let

$$\hat{y_{s,k}} = \frac{\tilde{Y_{s,k}}'}{Y_k}$$

so that, by definition, $\hat{y_{a,k}} + \hat{y_{n,k}} = \hat{w}_k$. Then, equation (7) can be rewritten as

$$(1-\theta_{s,j})\hat{y_{s,j}} Y_j = \sum_{k\in\Omega}\sum_{h\in\{a,n\}} \alpha^s_{h,k}{}' \beta^s_{j,k}{}'(1-\theta_{h,k})\hat{y_{h,k}} Y_k \tag{8}$$

(8) can be transformed into an excess demand function using similar methods in Alvarez and Lucas (2008), which guarantees a solution to the system in $\hat{y_{h,k}}$ given counterfactual changes in trade costs. We can use these solutions to immediately back out $\hat{w}_j$, which can be used to compute the compensating

variation. Using equation (1), the formula for the price index and some hat algebra, we can write the CV as

$$1 - CV_{h,k} = \hat{w_k} \Big[\sum_{o \in \{s,n\}} \alpha_{h,k}^{o} \hat{p_{o,k}}^{1-\eta} \Big]^{-\frac{1}{1-\eta}}$$

The calculation of EV is slightly more involved, because it requires computing standards of living after the trade shock. I defer this procedure for future drafts.

Appendix A: Ricardian welfare gains under non-homothetic CES.

The purpose of this appendix is to show that income effects and differing advantages in agriculture increase the gains to trade for the consumption poor. This result holds for exact CV measure under the corrections in Section 2.

As an abstraction, suppose we have a small open economy with two sectors. Suppose also that $\sigma_s \to \infty$ so that this model corresponds to a vanilla Ricardian model where internationally traded goods within each sector are perfect substitutes. Assume there are also no labour market frictions.

I start by computing wages and the price index in autarky[13]. Normalize the price of non-agriculture to one, so that wages $w = A_n$ and prices $p_a = \frac{A_n}{A_a}$. Using the formula for the price index, this implies that welfare in autarky U_a solves

$$U_a = \frac{A_n}{\left[\gamma_a U_a^{(1-\eta)(\epsilon_a-1)} \frac{A_n}{A_s}^{1-\eta} + 1\right]^{\frac{1}{1-\eta}}}$$

Now suppose, under trade, the price of agriculture falls to p_a^w while $p_n = 1$ remains unchanged as a normalization. There is complete specialization in the non-agricultural sector at wages $w = A_n$. Using equation (1), the CV is monotone in the quantity

$$\frac{\left[\gamma_a U_a^{(1-\eta)(\epsilon_a-1)} \frac{A_n}{A_s}^{1-\eta} + 1\right]^{\frac{1}{1-\eta}}}{\left[\gamma_a U_a^{(1-\eta)(\epsilon_a-1)} p_a^{w\,1-\eta} + 1\right]^{\frac{1}{1-\eta}}}$$

This equation compares price indeces before and after trade at autarky levels of the standard of living. The objective is to now compare the CV measure when there are income effects and when there are not. The latter case corresponds to

[13] These welfare formulas hold for a reduction in trade frictions, but I use an autarky-to-trade example for simplicity.

$\epsilon_a = 1$. Upon inspection of the equation, it can easily be shown that the CV will be larger in the presence of income effects if and only if

$$U_a^{(1-\eta)(1-\epsilon_a)} < \gamma_a$$

For $\epsilon_a < 1$ and $\eta < 1$. This equation tells us that if the initial standard of living is sufficiently low, income effects independently increase the gains to trade.

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