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Summary

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Keywords: Deforestation, REDD+, Export Tariffs, Public Investments, Two Sector Competing Land Use Model

JEL Classification: O24, Q17, Q23, Q24, Q56

The authors wish to thank Ottmar Edenhofer, Sabine Fuss, Jan Siegmeier, Matthias Kalkuhl, Wolf Heinrich Reuter, and Andri Brenner for helpful comments and discussions.

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Export tariffs combined with public investments as a forest conservation policy instrument*

Gregor Schwerhoff[†‡], Johanna Wehkamp[§]

April 3, 2017

Abstract

The forest conservation policy instrument REDD+ (Reducing Emissions from Deforestation and Forest Degradation) is designed to compensate governments of tropical countries for their efforts to conserve forests. Food insecure countries that are specialized in agriculture and have weak institutions, are likely to face difficulties to enforce forest conservation. This article explores in how far export tariffs on agricultural goods combined with public investments, could be used as a forest conservation policy mix in such contexts. We first show empirically that structural constraints to forest conservation policies are particularly pronounced in one third of countries where REDD+ programs are planned to be rolled out. We then develop a two sector competing land use model with a domestic food producing and an exporting agricultural sector. We show that it is possible to combine export tariffs with public investments such that deforestation decreases, while agricultural production levels and food prices remain constant.

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1 Introduction

The international forest conservation program REDD+ (Reducing Emissions from Deforestation and Forest Degradation) aims at compensating governments or jurisdictions of tropical countries for their efforts to preserve tropical forests. In this context, a variety of policy approaches are discussed, ranging from direct cash or non-cash transfers, technical assistance, stricter monitoring and enforcement of conservation, or sustainable agricultural practice programs (Fishbein and Lee, 2015) to fiscal policies, like introducing land taxes (Kalkuhl and Edenhofer, 2016).

Countries like Brazil (Cisneros et al., 2015; Nepstad et al., 2014), or Costa Rica (Andam et al., 2008) have been able to enforce forest conservation, while experiencing economic growth (FAO, 2015; World Bank, 2013). However, in many tropical countries the implementation of forest conservation policies is challenged by the absence of economic alternatives to deforestation-driving agricultural practices (Barbier, 2004) and weak institutions (Deacon, 1994; Barbier et al., 2005). This situation is further complicated by food insecurity (Ericksen et al., 2011). For this particular type of countries, it seems necessary to identify policies that allow to (i) reduce deforestation, while (ii) at least maintaining the pre-policy level of agricultural output, and (iii) prices of food products.

In this article we propose to combine export tariffs on agricultural goods with agricultural productivity increasing public investments as a forest conservation policy mix for low and lower income countries[1] that are specialized in the agricultural sector, food insecure and equipped with weak political institutions. In a stylized facts section we first explain why these factors are likely to challenge currently discussed policy approaches for REDD+ and show that in one third of the countries in which REDD+ programs are planned to be rolled out (UN-REDD, 2015; FCPF, 2016)[2] these structural constraints are particularly pronounced. Second, we develop an analytical model, which allows to examine the effects of the proposed policy mix on (i) land demand (deforestation), (ii) agricultural output levels, and (iii) price levels of agricultural commodities.

The hypothesis that the proposed combination of export tariffs with public investments could allow to achieve these multiple policy objectives follows from two main insights from economic literature.

First, economic theory suggests that when environmental resources like forests are not adequately protected, opening to trade increases the market for the exploitation of the resource and thus environmental degradation (Copeland and Taylor, 2004). Empirical evidence shows that trade liberalization has indeed increased deforestation rates in the past (Barbier, 2000; Pacheco, 2006; Shandra et al., 2009). Theoretical (Bernhofen, 1997; Rodrik, 1989) and empirical (Solberg et al., 2010; Goodland and Daly, 1996) economic literature finds that export tariffs on unprocessed commodities, can stimulate the structural transformation of an economy. They can also represent a source of public revenue (Bouët and Laborde, 2010). Furthermore, Skinner et al (1991) and Younger et al (1999), show that implementing export tariffs is feasible in countries with weak political institutions, which has also been demonstrated by the increase in export tariffs in least developed countries dur-

[1](with a GNI per capita below $4,125 (World Bank, 2014a). The income classification year corresponds to the data used in this study.

[2]Countries that form part of the UN-REDD or FCPF program as of December 2015

ing the 2007 food price crisis (Kim, 2010). Besides, export tariffs are one of the few explicitly tolerated trade policy instruments under WTO rules.[3]

Second, public investments can contribute to increase agricultural productivity (Craig et al., 1997). Such investments can be financed through tax-revenue recycling. In line with this logic, Jones and O'Neill (1994) have proposed to use tax revenues for deforestation-reducing and economically stimulating public investments. In the context of this study public investments are conceived as publicly provided services that lead to productivity gains and thus intensification in the agricultural sector. Examples for such productivity gains are electrification (Assunção et al., 2015), or the allocation of land tenure rights (Mendelsohn, 1994; Robinson et al., 2014). In Sub-Saharan African countries for example, the national electrification rate is very low with just 35% according to (IEA, 2016). Investments in the electricity grid could reduce the need for land when electricity allows using electric pumps for irrigation, thus making more intensive land use possible. Alternatively, governments could also provide effective property rights on land. Abdulai et al (2011) have for example shown that improved land rights increase the efficiency of land use through better investment incentives. Public investment induced agricultural intensification can have two simultaneous effects on land demand and thus deforestation (Villoria et al., 2014). On the one hand, productivity improvements can entail an increase in natural resource demand - an effect that is commonly referred to as the Jevons-effect (1866). Byerlee et al (2014) find that this effect particularly dominates in cases of market-driven intensification. On the other hand, agricultural intensification can also imply a more efficient (and thus land-sparing) use of the natural resources, which is commonly referred to as a Borlaug effect (2007). In our model both effects can occur and in line with Hertel (2012) we show that the dominating effect depends on the elasticity of demand for the respective agricultural product.

We use a two sector model, in order to capture both, the effect of export tariffs, as well as the two simultaneous effects of public investments on land demand, output levels and price levels. The first sector is a domestically operating food producing sector, which satisfies an inelastic demand of the domestic population. The second sector is an international exporting agricultural sector. It produces crops like palm oil, or soybeans for the international market and is faced with an elastic international market demand. The model allows illustrating the interaction of these two types of agricultural producers.

The model shows that using the proposed policy mix, allows to limit deforestation without reducing output levels both in the exporting and domestic sector, and without increases in domestic food prices. In addition, we find that the policy package can be partly self-funding through the tariff revenues. The level of international REDD+ payments, that would be necessary for the policy to work, thus depends on the amount of export tariff-revenues and the corresponding availability of resources for public investments in the respective country.

We start by presenting stylzed facts. We then introduce the model and show that different assumptions on the elasticity of demand, corresponding to different sectors, lead to different effects of public investments. Next we analyze the effect of export tariffs and public investments simultaneously. In section 5 we show that export tariffs and investments in agricultural productivity can be combined in a way that reduces deforestation and keeps agricultural prices as well as agricultural production stable. We conduct a numerical estimation of the costs pf the policy for

[3] See GATT rule article 2, 11.1 and 11.2 (WTO, 1947)

the international REDD+ donor in section 6. Finally, we discuss our findings and put it into a policy perspective in section 7. We end with a short conclusion.

2 Stylized facts

In this section we present stylized facts, showing that (i) an economic specialization in the agricultural sector, (ii) food insecurity, and (iii) weak political institutions, are likely to function as structural constraints to forest conservation. We further show that all three structural constraints are particularly pronounced in one third of the countries where REDD+ programs are planned to be rolled out.

2.1 Structural constraints to forest conservation policies

First of all, figure 1 illustrates how in countries with the lowest GNI per capita (black line), the contribution of the agricultural sector to GDP (black dashed line) is largest. Furthermore, it shows that the average contribution of the manufacturing sector to GDP is rather low, in most low and lower middle income countries (dark grey in figure 1.

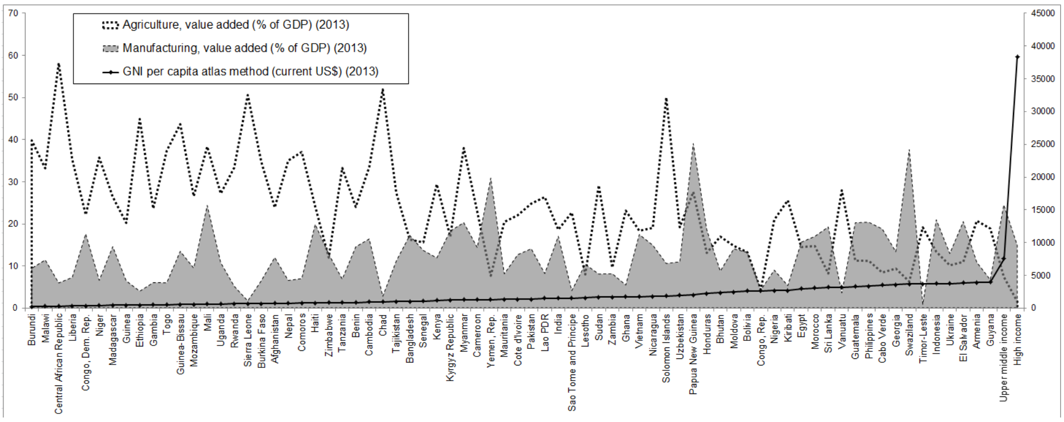

Figure 1: Agriculture and manufacturing value added to GDP and GNI per capita for low and lower middle income countries in 2013. Left axis: Relative value added of agriculture in percent (black dashed line, main source WDI, completed with CIA and AEO data) (World Bank, 2013; African Development Bank, 2013; Central Intelligence Agency, 2013) and manufacturing (dark grey, main source WDI, completed with CIA and AEO data)) in 2014 in percent (based on ISIC divisions 15-37 if available and else on ISIC divisions 10-45 (World Bank, 2013; African Development Bank, 2013; Central Intelligence Agency, 2013)). Right axis: GNI per capita (black) in 2013 (World Bank, 2013). The income groups according to the World Bank classification (World Bank, 2014a) are provided for comparison.

Kongsamut et al (2001) refer to these facts as 'Kuznets facts' and explain them with a model in which the fraction of income that a household spends on agricultural goods declines, once a certain minimum subsistence income level is reached, which triggers the diversification of the economy. From that observation it would follow that it is more likely that an economy begins to diversify after the subsistence level is reached. For countries with more diversified economies and technologically more advanced agricultural sectors it is easier to enforce forest conservation without foregoing economic growth opportunities, because the relative dependence on land as an input factor to production decreases. For example, in spite of the stringent forest conservation enforcement phase and thus policy-induced agricultural land scarcity from 2004-2008 in Brazil, GDP growth rates were high, ranging from 3.14% to 6% (World Bank, 2013) and no decline in agricultural output levels could be observed (Macedo et al., 2012).

Second, figure 2 shows that particularly in low and lower middle income countries the agricultural sector represents a large contribution to exports. On average agricultural raw materials constitute 11% of merchandised exports in low and 5% in lower middle income countries, ranging up to 49.13% for Benin, 48.49% for the Solomon Islands and 46.04% for the Central African Republic (World Bank, 2013). At the same time, figure 2 also shows that the percentage prevalence of undernourishment is higher in low (24%) and lower middle (13%) income countries (FAO, 2013). In contrast, upper middle and high income countries have both a relatively small contribution of agricultural raw materials to their exports and have a very low prevalence of undernourishment.[4]

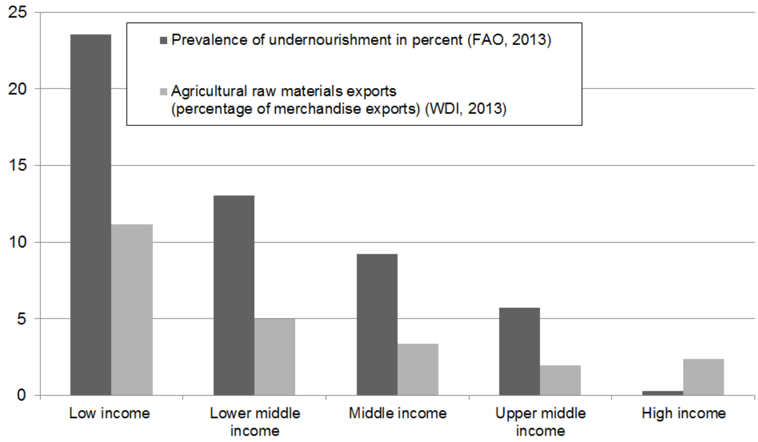

Figure 2: Relative contribution of agricultural raw materials to merchandised exports and relative prevalence of undernourishment in percent. Left axis: Prevalence of undernourishment in dark grey (FAO, 2013) and agricultural raw materials as a contribution to exports in light grey (World Bank, 2014b), respectively for low, lower middle middle, upper middle and high income countries (World Bank, 2014a).

Henson et al (2000) explain this phenomenon by a specialization in export-oriented agricultural supply chains, reliant on high-value markets in developed countries and simultaneously uncoupled and undersupplied local markets. The parallelity of the two types of markets for agricultural commodities creates a high dependence on the land demanding agricultural sector, and vulnerability to changes in local food supplies for the domestic population. This situation thus represents an obstacle to forest conservation, because increasing protected areas - especially in regions with high population density - translates into land scarcity for agricultural goods and consequently public resistance to conservation (Brockington et al., 2006; Pullin et al., 2013; Oldekop et al., 2016).

Finally, low income countries have also the weakest scores in the quality of political institutions. They have an average score of -0.83 in rule of law and of -0.84 in control of corruption on a scale from -2.5 to 2.5 (World Bank, 2014b). In contrast, high income countries have a positive average score of 1.01 in control of corruption and 1.06 in rule of law. Acemoglu (2005), finds that the weak quality of political institutions is a central reason for diverging patterns in long run economic growth in itself. Weak institutions cause countries to be economically locked into sectors that do not require complex contracting institutions (Nunn and Trefler, 2013), such as typically agriculture. Therefore weak institutions also present a structural impediment to economic diversification towards a less land-demanding economy.

Furthermore, a growing body of empirical literature shows that the quality of political institutions is also directly a central structural parameter to forest conservation. Key elements regarding the quality of political institutions, such as the

[4]FAO does not provide data for all countries for which the percentage of prevalence of food insecurity is below 5 %(FAO, 2013), therefore we set the value for all of these countries equal to 0 as a default value.

strength of rule of law (Corderí Novoa, 2008), reliable land tenure rights (Arcand et al., 2008; Bohn and Deacon, 2000), or the absence of corruption (Koyuncu and Yilmaz, 2009) significantly impact, whether a country is likely to be able to conserve its forests or not. It has also been argued that the quality of political institutions can fundamentally undermine the functioning of results-based payments schemes like REDD+. Karsenty and Ongolo (2012) argue that incentive payment-based forest conservation programs are especially likely to confront difficulties in fragile states. Angelsen (2013) points out that there is a high risk of embezzlement of funds in recipient countries with weak institutions, but at the same time little incentive for donating countries to control and potentially sanction the mismanagement of REDD+ funds. This situation can thus undermine the effectiveness of policy instruments in the REDD+ context.

To summarize, effective forest conservation is complicated in economies with a strong specialization in the agricultural sector, because there are less economic alternatives to deforestation driving agricultural practices. It is also challenged by food insecurity, because the population is very vulnerable to conservation induced land scarcity. Finally, it is difficult in countries that lack the political institutions to enforce forest conservation.

2.2 Structural constraints coincide in potential REDD+ countries

We run a Spearman's correlation to assess the relationship between the percentage contribution of agricultural products to GDP (200 observations), rule of law (181 observation) and the prevalence of undernourishment (155 observations). There is a negative and significant correlation between the agricultural share of GDP and rule of law of $\rho = -0.63$, a positive and significant correlation between the agricultural share of GDP and prevalence of undernourishment of ρ=0.62, and a negative and significant correlation between rule of law and prevalence of undernourishment of ρ=-0.6.

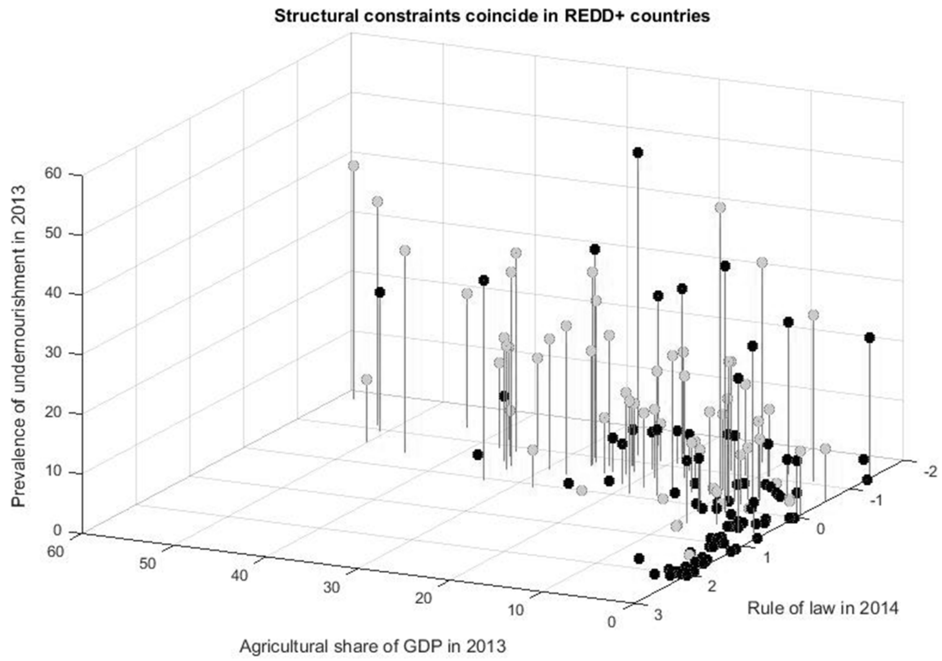

Figure 3: X-axis: contribution of the agricultural sector to GDP (World Bank, 2013), y-axis: relative scores in rule of law on a scale from -2.5 to 2.5 (World Bank, 2014b), z-axis: prevalence of undernourishment (FAO, 2013). The light grey dots indicate countries in which REDD+ programs are planned to be rolled out. Note that insufficient data is available for South Sudan and the Solomon Islands and thus they are not plotted in the graph.

It thus shows that a country with a weak rule of law score in our sample, tends to have a larger share of agricultural products as a contribution to GDP and that the percentage share of undernourrished people in this context tends to be larger.

Furthermore, using a three-dimensional scatterplot (figure 3) shows that (i) a relatively large contribution of the agricultural sector to GDP (displayed in percent on the x-axis (World Bank, 2013)), (ii) weak rule of law scores (displayed on the y-axis using the original scale from -2.5 to 2.5 (World Bank, 2014b)), and (iii) the prevalence of undernourishment (displayed in percent on the z-axis (FAO, 2013)[5]), are likely to coincide in countries in which REDD+ programs (highlighted by light grey points) are planned to be rolled out. Figure 3 shows that REDD+ countries tend to be located in the upper left back of the coordinate. REDD+ countries have an average share of 20% of agricultural products as a contribution to their GDP, prevalence of food insecurity among 15% of their populations, and an average rule of law score of -0.55.

Finally, it is useful to understand in which countries all of the three problems are particularly pronounced to understand what it means for forest conservation. When looking particularly at low and lower middle income countries in which the agricultural sector is larger than the manufacturing sector, the prevalence of undernourishment is above 5% and the rule of law score below -0.54 (average value of lower middle income countries), we identify 36 countries. These countries host 474.7 Mha of forest, which corresponds to 12% of the world's forests, with 168 Mha of primary forest, corresponding to 13% of the world's remaining primary forests (FAO, 2015) (see figure 4 for a list of these countries).

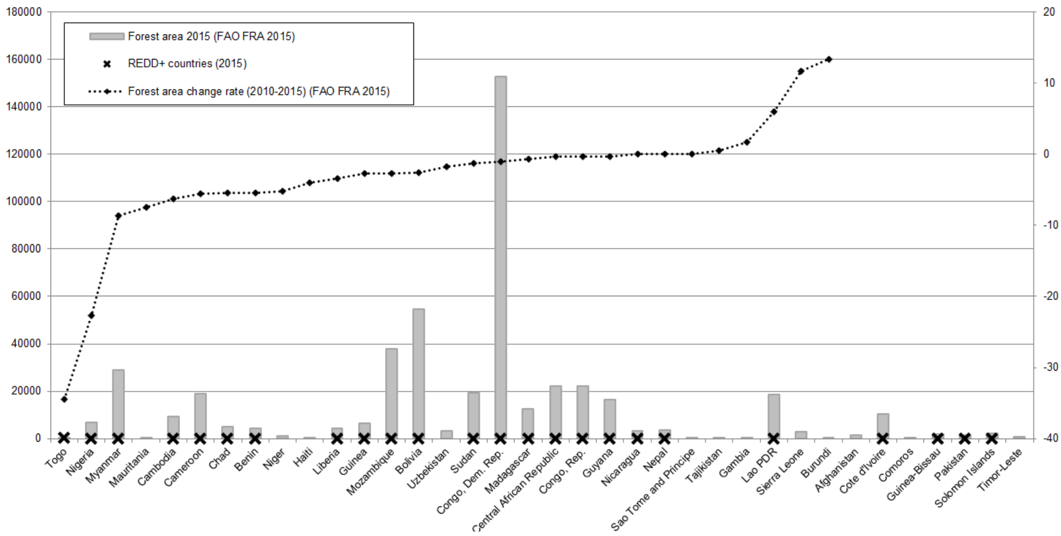

Figure 4: Forest shares for agrarian low income countries with rule of law scores below -0.5 (corresponding to the average value of lower middle income countries). Left axis: Forest area (gray) in ha (FAO, 2015). Right axis: Forest area change (dashed line) in 2015 as a percentage of the forest area in 2010, for Afghanistan, Cote d'Ivoire, Comoros, Guinea-Bissau, Pakistan, Solomon Islands and Timor-Leste no forest area change data is available (FAO, 2015). The black crosses indicate REDD+ countries.

At the same time, as figure 4 shows most of the countries experience deforestation, with an average forest cover loss of 3% over the 2010 to 2015 period (FAO,

[5]The FAO does not provide data for countries with scores below 5%, but indicates for which countries this is the case. We set values for those countries equal to zero.

2015). Togo and Nigeria experienced particularly high deforestation rates with 34% and 22% respectively over the 2010 to 2015 period (FAO, 2015). Figure 4 illustrates the extent of forest cover, as well as the forest area change rates between 2010 and 2015 for the countries in which all of the three problems are particularly pronounced. Only 5 out of 36 of these countries have experienced forest cover gain (Tajikistan (0.5%), Gambia (2%), Laos (6%), Sierra Leone (11%) and Burundi (13%). Out of the 36 countries in which the problems are particularly pronounced, there are 24 countries in which REDD+ programs are planned to be rolled out. In total REDD+ programs are planned to be rolled out in 70 countries, meaning that countries in which the structural constraints to forest conservation are particularly articulated represent one third of all REDD+ countries.

3 The model

We use a competing land use model in order to simulate the decision of a representative farmer. Total land A contains natural forest land W and agricultural land L. Agriculture is one of the most important drivers of deforestation (Gibbs et al., 2010; Ferretti-Gallon and Busch, 2014). We assume that higher demand for agricultural land causes an expansion of agricultural land and simultaneous deforestation. As a consequence, the amount of agricultural land is a function of the price of agricultural land r_L. We model this with a land supply function,

$$L = r_L^{\varepsilon} \, , \tag{1}$$

where $\varepsilon \geq 0$ is the supply elasticity of land. An expansion of agricultural land implies a reduction of forest land, $A - L = W$. Hence, the growth rate of forest land g_W is the negative of the growth rate of agricultural land,

$$g_W = -g_L = -\varepsilon g_{r_L} \, . \tag{2}$$

The agricultural sector uses government infrastructure and institutions G, capital K and land L as inputs for production,

$$F(G, K, L) = G^{\alpha} K^{\beta} L^{\gamma}. \tag{3}$$

We assume $\beta + \gamma = 1$, $\alpha > 0$, $\beta > 0$ and $\gamma > 0$. Capital investment and land use are chosen by the representative land owner. Capital can be rented at an exogenous interest rate r_K. We consider this a realistic assumption since Karlan (2014) finds that farmers in developing countries are typically not liquidity constrained (and lack access to insurance instead). The price for land r_L is endogenous. The level of public investment G is decided by the government. Notice that agricultural producers modeled this way never make negative profits since they have constant returns to scale and land prices are endogenous.

This production function follows a typical approach (Barro, 1990; Barro and Sala-i Martin, 1992; Turnovsky, 2000) when representing returns to scale. There are increasing returns to scale when all production factors are taken together. This means that for the resource constrained domestic government there is an optimal amount of public investment (G), above which it is not optimal to decrease private investment further through taxation. However, there is no absolute optimum. Additional investments in G, financed by outside sources, would increase production.

The government collects a tariff on the export of agricultural products τ. The representative farmer chooses K and L to maximize profits and takes the government's tariff τ and the level of price p as given,

$$\max_{K,L}(1-\tau)p(G^{\alpha}K^{\beta}L^{\gamma}) - r_K K - r_L L \; . \tag{4}$$

The representative farmer's maximization problem (4) results in the following first order conditions,

$$\frac{\partial \mathcal{L}}{\partial K} = (1-\tau)p\beta(G^{\alpha}K^{\beta-1}L^{\gamma}) - r_K = 0 \; , \tag{5}$$

$$\frac{\partial \mathcal{L}}{\partial L} = (1-\tau)p\gamma(G^{\alpha}K^{\beta}L^{\gamma-1}) - r_L = 0 \; . \tag{6}$$

We represent demand for agricultural products with a constant elasticity of demand function,

$$Y = p^{-\theta} \; , \tag{7}$$

where $\theta \geq 0$ is the demand elasticity.

In section 4 we consider the effect of agricultural productivity on deforestation for variations of the elasticity of demand, θ. In section 5 we let a domestic food sector with low θ compete for land with an export sector with high θ. This framework will allow us to study the effect of agricultural productivity on several key agricultural variables like deforestation, food prices and total export sales.

4 The role of the elasticity of demand

In our model, productivity-enhancing public investment can have both, a deforestation increasing a decreasing effect. We capture these two effects through different assumptions about the elasticity of demand in the domestic (inelastic) and exporting sectors (elastic).

In order to understand the interaction of government investments and the demand elasticity for agricultural products, we first analyze the general case

Proposition 1 *The amount of land demanded for agriculture is given by*

$$L = \left(\gamma^{\beta(-\frac{1}{\theta}+1)-1}(1-\tau)^{\frac{1}{\theta}-1}G^{\alpha(\frac{1}{\theta}-1)}\left(\frac{r_K}{\beta}\right)^{\beta(-\frac{1}{\theta}+1)}\right)^{\frac{\varepsilon}{-\beta(\frac{1}{\theta}-1)-1-\varepsilon\frac{1}{\theta}}} \; . \tag{8}$$

An increase in public investments G increases the amount of deforestation if and only if $\theta > 1$.

Proof

We solve food demand (7) for p and land supply (1) for r_L and insert the expressions into the first order conditions (5) and (6). We then solve equation (5) for K and use it to substitute for K in equation (6) and solve for L. □

This proposition shows that an increase in agricultural productivity through public investments can increase the amount of agricultural land at the expense of forests or increase it. There are two effects at work: First of all, for a given amount of production, less inputs, including land, are required. At the same time, the output can be produced at a lower price, so that production can be scaled up. Scaling up production requires to purchase more inputs. When demand is inelastic ($\theta < 1$), the first effect dominates. When demand is elastic ($\theta > 1$), the second effect dominates.

In addition to the case with general demand elasticity, we consider two special cases. In the first special case, we assume that demand is perfectly inelastic $\theta_1 = 0$. It represents a staple food producing sector that satisfies a limited local demand. An example for this could be staple foods consumed by the local population.

Corollary 1 *When demand is perfectly inelastic, public investments decrease deforestation.*

Proof

Using

$$\lim_{\theta \to 0} \frac{\varepsilon((\frac{1}{\theta} - 1))}{-\beta\frac{1}{\theta} + \beta - 1 - \varepsilon\frac{1}{\theta}} = \frac{\varepsilon}{-\beta - \varepsilon} \tag{9}$$

we obtain

$$L_1 = \lim_{\theta \to 0} L = \left(\gamma^{-\beta}(1-\tau)G^{\alpha}\left(\frac{r_K}{\beta}\right)^{-\beta}\right)^{\frac{\varepsilon}{-\beta-\varepsilon}} . \tag{10}$$

From $\frac{\varepsilon}{-\beta-\varepsilon} < 0$ we obtain $\frac{dL_1}{dG} < 0$. □

The food sector with inelastic demand, thus reflects the Borlaug hypothesis (Borlaug, 2007; Meyfroidt and Lambin, 2008; Stevenson et al., 2013; Cohn et al., 2014), which postulates that increased agricultural productivity reduces deforestation. The Borlaug effect is caused by higher productivity (through more public investments in our case) that allows farmers to produce the same amount of food with less land.

In the second special case, we assume that demand is perfectly elastic, $\theta_2 = \infty$. This assumption applies to sector that export agricultural products like palm oil, soybeans, coffee or cotton for the export market. We assume that production is taking place in a small open economy, such that changes in domestic price levles do not influence international market prices.

Corollary 2 *When demand is perfectly elastic, public investments increase deforestation.*

Proof

Using $\lim_{\theta \to \infty} \frac{1}{\theta} = 0$ we obtain

$$L_2 = \lim_{\theta \to \infty} L = \left(\gamma^{1-\beta}(1-\tau)G^{\alpha}\left(\frac{r_K}{\beta}\right)^{-\beta}\right)^{\frac{\varepsilon}{1-\beta}} . \tag{11}$$

Form $\frac{\varepsilon}{1-\beta} > 0$ we obtain $\frac{dL_2}{dG} > 0$. □

The export sector, where demand is elastic, reflects the Jevons paradox. Additional public investments makes it more attractive to use the complementary inputs capital and land. The higher usage of land accelerates deforestation.

This section shows that both the Borlaug hypothesis and the Jevons paradox can be reproduced with the model. When agricultural land is used to produce products with different elasticities of demand, it is thus not straightforward to predict the aggregate effect of investments into productivity on deforestation. In the next section we analyze a simple case of such an interaction in order to show how environmental and economic objectives can be reconciled.

5 The case of a competitive land market

In the model the two sectors compete for land. Total agricultural land is thus the sum of the land used in the two sectors,

$$L = L_1 + L_2 \; . \tag{12}$$

In the food producing sector L_1 we assume that $\theta = 0$. Inserting this into the food demand equation (7) we obtain that total food production is fixed,

$$Y_1 = 1 \; . \tag{13}$$

In the export sector we have $\theta = \infty$. Again, by inserting this into the food demand equation show that the price in the export sector is given by the international market price $\bar{p}_2$,

$$p_2 = \bar{p}_2 \; . \tag{14}$$

5.1 Tariff policy and public investments

We consider the effect of government policy interventions in the form of tariffs and public investments individually. We can describe the equilibrium by equations (5), (6), and (13) for sector 1, equations (5), (6) and (14) for sector 2 as well as the land market given by (1) and (12).

Proposition 2 *Higher tariffs reduce deforestation, but also production in the export sector. They also lead to a reduction in food prices. Higher public investments lead to an increase in deforestation and an increase in production in the export sector. The effect of higher public investments on food prices depends on the relative size of the output elasticity of public investments in the two sectors.*

Proof

From (5) and (6) we obtain $\frac{K_1}{L_1} = \frac{\beta_1}{\gamma_1}\frac{r_L}{r_K}$. Using (13) and the production function we have that $1 = G^{\alpha_1} K_1^{\beta_1} L_1^{\gamma_1}$. Combining these two expressions and solving for r_L we obtain

$$G^{-\frac{\alpha_1}{\beta_1}} L_1^{-\frac{1}{\beta_1}} \frac{\gamma_1}{\beta_1} r_K = r_L \tag{15}$$

Solving (5) for K_2, inserting into (6) and using (14) we have

$$\gamma_2 \left(\left(\frac{\beta_2}{r_K} \right)^{\beta_2} (1-\tau)\bar{p}_2 G^{\alpha_2} \right)^{\frac{1}{1-\beta_2}} = r_L. \tag{16}$$

Combining (15) and (16) and solving for L_1 we obtain

$$L_1 = \left(\frac{\gamma_1}{\gamma_2 \beta_1} \right)^{\beta_1} G^{-\frac{\alpha_1\gamma_2 + \alpha_2\beta_1}{\gamma_2}} r_K^{\frac{\beta_1}{\gamma_2}} \beta_2^{-\frac{\beta_1\beta_2}{\gamma_2}} \left((1-\tau)\bar{p}_2\right)^{-\frac{\beta_1}{\gamma_2}} \; . \tag{17}$$

From this expression we obtain $\frac{dL_1}{d\tau} > 0$ and $\frac{dL_1}{dG} < 0$. Using (16) we obtain $\frac{dr_L}{d\tau} < 0$ and $\frac{dr_L}{dG} > 0$. Combining (1) and (12) we have $\frac{dL_2}{d\tau} = \varepsilon r_L^{\varepsilon-1}\frac{dr_L}{d\tau} - \frac{dL_1}{d\tau} < 0$ and $\frac{dL_2}{dG} > 0$. Furthermore, solving (5) for K_2 and plugging L_2 into the equation, we obtain $\frac{dK_2}{d\tau} < 0$ and $\frac{dK_2}{dG} > 0$. Using the production function we have $\frac{dY_2}{d\tau} < 0$

and $\frac{dY_2}{dG} > 0$. Using (2) we have that deforestation decreases with a tariff increase and increases with an increase in public investment.

Using the capital-labor ratio in sector 1 we have $K_1 = \frac{\beta_1}{\gamma_1}\frac{r_L}{r_K}L_1$. Since we assumed that firms produce with constant returns to scale, they make zero profits. Therefore, $p_1 = (r_K K_1 + r_L L_1) = (r_K \frac{\beta_1}{\gamma_1}\frac{r_L}{r_K}L_1 + r_L L_1) = \frac{r_K}{\beta_1}G^{-\frac{\alpha_1}{\beta_1}}L_1^{-\frac{\gamma_1}{\beta_1}} = r_K^{\frac{\gamma_2-\gamma_1}{\gamma_2}}\beta_1^{\beta_1}G^{\frac{-\alpha_1\gamma_2+\alpha_2\gamma_1}{\gamma_2}}\left(\frac{\gamma_2}{\gamma_1}\right)^{\gamma_1}\beta_2^{\frac{\beta_2\gamma_1}{\gamma_2}}((1-\tau)\bar{p}_2)^{\frac{\gamma_1}{\gamma_2}}$. With this we have $\frac{dp_1}{d\tau} < 0$ and $\frac{dp_1}{dG} < 0 \Leftrightarrow \frac{\alpha_2}{\gamma_2} < \frac{\alpha_1}{\gamma_1}$. □

The intuition for the tariff increase is straightforward. Export tariffs reduce the net price received by the producer. The sector thus uses less inputs and produces less. The lower demand for land reduces the land price and thus deforestation.

Concerning the effect of the tariff increase on the food price, there are two opposing effects. The food sector uses more land, but it pays less per unit of land. The price drop is however stronger, meaning that the food sector pays less for the total amount of land after the tariff increase even though it uses more land.

Public investments by contrast benefit both sectors. They bid up the price for land and therefore cause more deforestation. Only the export sector can expand production. The food sector thus uses the land more intensively by substituting land with capital (as well as public infrastructure and institutions). The export sector takes over some land from the food sector. Concerning the food price, there are two effects. The public investments benefit the food sector directly, but indirectly they harm the food sector by making land more expensive. The net effect on food prices thus depends on which sector benefits more from the direct effect of the investment.

5.2 Revenue recycling

In Corollary 2 we have seen that public investments can produce a Jevons paradox: the export sector benefits and expands production, but at the same time more forest is lost to agricultural production. Proposition 2 shows that export tariffs can be used to reduce deforestation, but since the export tariff also reduces production of the export sector it remains unclear what the net effect the two policy tools in combination is.

In order to identify a beneficial policy we first identify the interests of the different stakeholders. An international REDD+ donor is willing to make a payment to the country government, if the government introduces a policy, which reduces deforestation. We assume that the government is already undertaking maximal forest conservation given its multiple constraints. The government is thus only willing to undertake additional efforts, if they represent zero net additional cost to the government budget. We assume that the export sector is willing to accept its country's participation in the REDD+ program only, if it is not forced to downsize its operation. We assume that the size of the sector reflects the interests of the business owners through factor income, since technically profits are zero. Finally, we assume that the country's population is willing to participate in the REDD+ program only if the participation does not increase food prices.

The challenge is thus to design the REDD+ policy mix in such that all stakeholders are willing to participate. We find that indeed, it is possible to design the policy such that no stakeholder loses:

Proposition 3 *For any amount of public investment it is possible to raise export tariffs such that (i) production in the export sector remains constant, (ii) deforestation reduces, and (iii) food prices decline.*

Proof

Let $\bar{Y}_2$ be the level of production in the export sector before the REDD policy mix is implemented. Then condition (i) can be expressed as

$$\bar{Y}_2 = G^{\alpha_2} K_2^{\beta_2} L_2^{\gamma_2} \ . \tag{18}$$

Solving (5) for L_2 and plugging it into (12) we have

$$K_2 = \left(\frac{r_K}{(1-\tau)\bar{p}_2\beta_2} \right)^{-\frac{1}{\gamma_2}} G^{\frac{\alpha_2}{\gamma_2}} (L - L_1) \ . \tag{19}$$

Inserting (19) into (18) we can express $1-\tau$ as a function of $L - L_1$,

$$1 - \tau = \bar{Y}_2^{\frac{\gamma_2}{\beta_2}} G^{-\frac{\alpha_2}{\beta_2}} \frac{r_K}{\bar{p}_2\beta_2} (L - L_1)^{-\frac{\gamma_2}{\beta_2}} \ . \tag{20}$$

This is the level of tariffs the government would need to set in order to induce the export sector (sector 2) to produce $\bar{Y}_2$, the same amount they produced before the policy intervention.

We can now insert this choice of tariffs by the government into the market equilibrium value for L_1 given in equation (17):

$$L_1 = \left(\frac{\gamma_1}{\gamma_2\beta_1} \right)^{\beta_1} G^{\frac{-\alpha_1\beta_2+\alpha_2\beta_1}{\beta_2}} \beta_2^{\beta_1} \bar{Y}_2^{-\frac{\beta_1}{\beta_2}} (L - L_1)^{\frac{\beta_1}{\beta_2}} \ . \tag{21}$$

Using (1) and (15) we have

$$L = r_L^{\varepsilon} = G^{-\frac{\alpha_1\varepsilon}{\beta_1}} L_1^{-\frac{\varepsilon}{\beta_1}} \left(\frac{\gamma_1}{\beta_1} r_K \right)^{\varepsilon} \ . \tag{22}$$

Inserting this into (21) we have

$$L_1 = \left(\frac{\gamma_1}{\gamma_2\beta_1} \right)^{\beta_1} G^{\frac{-\alpha_1\beta_2+\alpha_2\beta_1}{\beta_2}} \beta_2^{\beta_1} \bar{Y}_2^{-\frac{\beta_1}{\beta_2}} \left(G^{-\frac{\alpha_1\varepsilon}{\beta_1}} L_1^{-\frac{\varepsilon}{\beta_1}} \left(\frac{\gamma_1}{\beta_1} r_K \right)^{\varepsilon} - L_1 \right)^{\frac{\beta_1}{\beta_2}} \ . \tag{23}$$

Using this we define

$$H = \left(\frac{\gamma_1}{\gamma_2\beta_1} \right)^{\beta_1} G^{\frac{-\alpha_1\beta_2+\alpha_2\beta_1}{\beta_2}} \beta_2^{\beta_1} \bar{Y}_2^{-\frac{\beta_1}{\beta_2}} \left(G^{-\frac{\alpha_1\varepsilon}{\beta_1}} L_1^{-\frac{\varepsilon}{\beta_1}} \left(\frac{\gamma_1}{\beta_1} r_K \right)^{\varepsilon} - L_1 \right)^{\frac{\beta_1}{\beta_2}} - L_1 \ . \tag{24}$$

Employing (23) we can write $\frac{\partial H}{\partial G} = \frac{-\alpha_1\beta_2+\alpha_2\beta_1}{\beta_2} \frac{L_1}{G} - \frac{\alpha_1\varepsilon}{\beta_2} \frac{L_1}{L-L_1} \frac{L}{G}$ and $\frac{\partial H}{\partial L_1} = \frac{\beta_1}{\beta_2} \frac{L_1}{L-L_1} \left(-\frac{\varepsilon}{\beta_1} \frac{L}{L_1} - 1 \right) - 1$.

Using (15) the effect of an increase in government spending is thus given by

$$\frac{dr_L}{dG} = r_L \left(-\frac{\alpha_1}{\beta_1} \frac{1}{G} - \frac{1}{\beta_1} \frac{1}{L_1} \frac{dL_1}{dG} \right) \ , \tag{25}$$

where $\frac{dL_1}{dG} = -\frac{\frac{\partial H}{\partial G}}{\frac{\partial H}{\partial L_1}}$. Inserting $\frac{dL_1}{dG}$ into (25) it can be shown that $\frac{dr_L}{dG} < 0$. Using (1) we have $\frac{dL}{dG} = \varepsilon r_L^{\varepsilon-1} \frac{dr_L}{dG} < 0$.

In the proof of Proposition 2 we have seen that $p_1 = \frac{r_K}{\beta_1} G^{-\frac{\alpha_1}{\beta_1}} L_1^{-\frac{\gamma_1}{\beta_1}}$, so that

$$\frac{dp_1}{dG} = p_1 \left(-\frac{\alpha_1}{\beta_1} \frac{1}{G} - \frac{\gamma_1}{\beta_1} \frac{1}{L_1} \frac{dL_1}{dG} \right) . \tag{26}$$

Again resorting to $\frac{dL_1}{dG} = -\frac{\frac{\partial H}{\partial G}}{\frac{\partial H}{\partial L_1}}$ we obtain $\frac{dp_1}{dG} < 0$. □

As the policy of simultaneous export tariff increases and public good investments the production of the export sector remains constant. This implies that the same amount of agricultural products is exported after implementing the policy than before. The policy thus does not cause negative effects, in terms of higher food prices for example, to the trade partners of the implementing country.

The proposition shows that a combination of tariffs and government spending, which keeps production in the export sector constant, would reduce deforestation and lower food prices. However, the amount spent by the government on public investments might exceed the additional revenue from the export tariffs. In order to get the government on board, the international REDD+ donor could pay this balance to the government.

The international REDD+ donor has a limited budget and will not be willing to spend any amount on the outlined policy. It would thus need to trade off the amount of forest saved through the policy with the amount needed to maintain a zero net effect on the government budget. The government revenue with the policy package is given by $\tau \bar{Y}_2$, where τ is given by equation (20). The expenditure of the government would be given by the amount of additional public investment of the policy package multiplied with the cost per unit of government investment. If government revenue from the policy exceeds or equals policy, it would be self-financing. Otherwise REDD+-money would be required.

6 Numerical estimation

Proposition 3 suggests a combination of export tariffs and government investments, which would be acceptable to the export industry and domestic food consumers. It also implicitly contains a supply function for forest conservation: The more government investments there are, the more forest will be protected. In this section we make this trade-off explicit and empirically estimate it.

6.1 Cost benefit analysis of forest conservation

For the empirical estimate we assume $\alpha_1 = \alpha_2, \beta_1 = \beta_2$ and $\gamma_1 = \gamma_2$, which will allow us to write equation (23) as

$$L_1 = \left(\left(\bar{Y}_2 + 1 \right) G^{\frac{\alpha\varepsilon}{\beta}} \left(\frac{\gamma}{\beta} r_K \right)^{-\varepsilon} \right)^{-\frac{\beta}{\varepsilon+\beta}} . \tag{27}$$

By equation (22) we have

$$L = G^{-\frac{\alpha\varepsilon}{\beta}} L_1^{-\frac{\varepsilon}{\beta}} \left(\frac{\gamma}{\beta} r_K \right)^{\varepsilon} . \tag{28}$$

Equation (20) gives the level of τ which keeps total production of the export sector at $\bar{Y}_2$:

$$\tau = 1 - \bar{Y}_2^{\frac{\gamma}{\beta}} G^{-\frac{\alpha}{\beta}} \frac{r_K}{\bar{p}_2 \beta} (L - L_1)^{-\frac{\gamma}{\beta}} \ . \tag{29}$$

Inserting equations (28) and (27) we obtain τ as a function of exogenous parameters. Let $\bar{G}$ be the "initial" amount of government investment. It is the amount which allows firms in the export sector to produce the amount $\bar{Y}_2$ when export tariffs are equal to zero. This $\bar{G}$ can be obtained by solving (29) with $\tau = 0$ for G.

By introducing agricultural export tariffs the government generates a revenue of $\tau\bar{Y}_2$. At the same time it has expenses for increasing the government investment from $\bar{G}$ to a higher level. Labeling the price for one unit of government investment as p_G the expenses amount to $p_G(G - \bar{G})$. If the government is not willing to accept a net loss due to the forest conservation policy, the international REDD+ donor will have to support the program by an amount of

$$E = p_G(G - \bar{G}) - \tau\bar{Y}_2 \ . \tag{30}$$

Finally, we can calculate the amount of forest which corresponds to a given level of government investment. Using again equation (22) we have

$$W = A - L = A - G^{-\frac{\alpha\varepsilon}{\beta}} L_1^{-\frac{\varepsilon}{\beta}} \left(\frac{\gamma}{\beta} r_K \right)^{\varepsilon} \ . \tag{31}$$

Together with equation (27) this yields the amount of forest as a function of G.

6.2 An example

It is not possible to solve equation (29) for G analytically. Therefore we cannot combine equations (30) and (31) to obtain a the amount of forest as a function of the expenditure for the international REDD+ donor. However, we can produce a graph of the relationship of costs and forest numerically.

We choose the model parameters according to empirical estimates from the literature. Warner (2014) conducts a review of the empirical work on the effect of public capital on output for lower income countries and concludes that a value of 0.15 is a realistic assumption for low income countries, so that we set $\alpha = 0.15$. The factor share of non-reproducible capital (which is mainly land) is between 20% and 30% in developing countries in Table II of Caselli and Feyrer (2007), so that we set $\gamma = 0.25$. We require the production function to have constant returns to scale, so that we obtain $\beta = 1 - \gamma = 0.75$. Udry and Anagol (2006) describe that the interest rate faced by farmers in developing countries, Ghana in particular, varies strongly and can attain very high rates, exceeding 100% in some cases. For "well-established food crop cultivation" they give a range of 30% to 50%, so that we work with $r_K = 0.3$. For the supply elasticity of land, Gouel et al. (2006) give a range of 0.37 for Asia and Latin America and 0.75 for Africa. We thus choose $\varepsilon = 0.37$ for the reference case. We normalize the values for land area A, output in the exporting sector $\bar{Y}_2$, and the costs of public investments p_G to 1.

For these value, we have a resulting $\bar{G}$ value of 0.045. Increasing G above $\bar{G}$ generates costs given by $p_G(G - \bar{G})$, see the dotted line in Figure 5, left panel. At the same time the export tariff increases since τ is chosen such that agricultural exports stay constant. The revenues are given by $\tau\bar{Y}_2$ and are plotted as a solid line. Eventually, the cost exceed the revenue so that the government would make a loss.

This would be the net expense by the international REDD+ donor. The net expense is plotted in Figure 5 in the right panel on the vertical axis. As the G continues to increase agricultural producers intensify their land use without expanding production. This allows them to save on land and the amount of forest spared increases. The amount of forest spared is plotted on the horizontal axis.

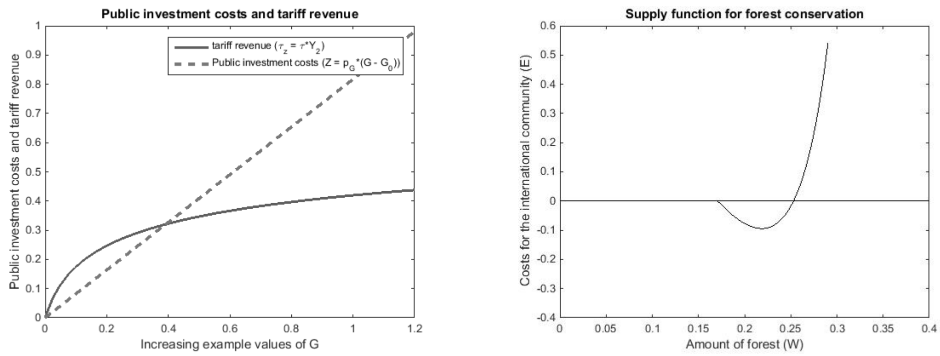

Figure 5: Cost and revenue of forest conservation (left) and net cost compared to conserved forest (right).

While the cost per unit of government investment increase linearly, revenue is a concave function. A country with a low initial stock of government investment will become more productive when more is invested. The export tariff needed to keep production constant is thus increasing steeply. As the economy gets saturated with government investments, additional investments will increase productivity only to a small degree, thus producing only small increases in additional tariff revenue.

The numerical example is chosen in order to allow to show the progression of the curve. Initially, 0.171 units of land are covered with forests. The example is optimistic, because it is probably rather unlikely - even though possible - that the revenue of the policy initially exceeds the cost. 0.075 units of land can be afforested with zero net cost. Eventually, however, this reverses. As a consequence, we initially have a win-win situation: the policy generates additional government revenue and protects more forest land. For higher levels of G, the costs increase until the total cost of the policy exceeds the revenue. This is the point, where the international REDD+ donor would need to support the public investments of country financially. At some point, the marginal value for additional government benefits decreases and hardly and additional forest can be protected. In a less optimistic scenario, the cost could exceed revenue from the beginning, thus creating a trade-off between higher net costs and more forest from the start.

The cost curve in the right panel of Figure 5 can be read as a “forest supply curve” faced by the international REDD+ donor: A higher transfer to the country would increase the amount of forest offered. The curve shows that, as expected, the marginal cost for protecting additional units of forest increases. Defining a utility function on expenditure and forest conservation for the international REDD+ donor would allow us to obtain the optimal optimal combination of cost and conservation.

6.3 Parameter sensitivity

In order to analyze how different parameter assumptions influence the effect of the policy mix, we next vary the parameter values of A, p_G, Y_2, α, ε, and r_K. This sensitivity analysis also provides an intuition for how well the proposed policy mix could work in different countries.

An increase in the cost of public investments, p_G, obviously decreases the amount of forest which can be saved with the policy mix. If we vary the economy described in Section 6.2 by the area of the country A, the initial amount of forest, W, will increase. The cost of saving forest remain the same.

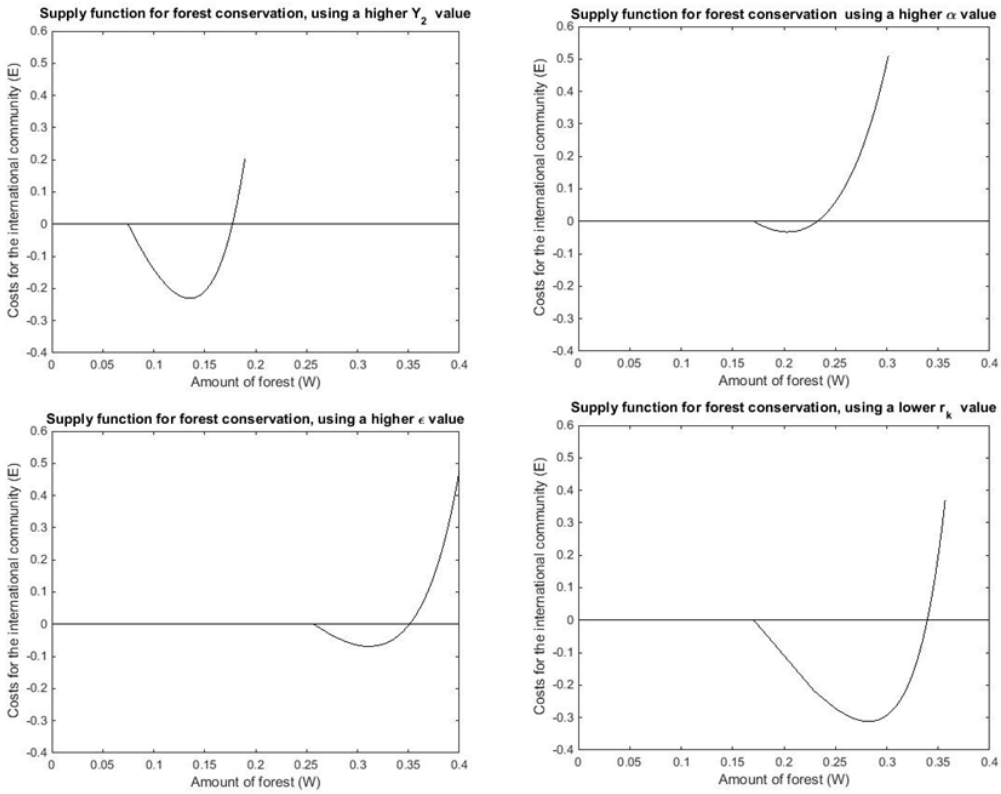

Figure 6: The four graphics above show the effect of a variation of different parameters Y_2(upper left panel), α (upper right panel), ϵ (lower left panel), r_K (lower right panel)

.

Further parameter variations require a more detailed analysis. Consider a change in the output of the export sector to $\bar{Y}_2 = 2$. This case reflects an economy with a higher level of public investments such that $\bar{G} = 0.073$. As the export sector produces more, it also uses more forest land such that initially only 0.075 units of land are left for conservation. When the policy mix is introduced, it initially generates higher profits since the amount of output in the exporting sector, based on which tariffs are collected, is higher. Due to this higher revenue, 0.10 units of land can be afforested with zero net cost. The upper left panel of Figure 6 illustrates the effect.

When the output elasticity of public investments is higher, $\alpha = 0.3$, more public investments are used initially, $\bar{G} = 0.211$. The initial forest area is almost unchanged compared to the reference scenario at 0.171 . As much more public investments are used initially, less land, (0.060 units) can be afforested due to decreasing returns to further investments. The upper right panel of Figure 6 illustrates this case.

Next we consider the case where the supply elasticity of land is at the upper end of the interval given by Gouel et al. (2006) and use a value of $\varepsilon = 0.75$. The initial level of public investments is $\bar{G} = 0.053$. 0.091 units of land can be afforested with zero net cost in this scenario. The lower left panel of Figure 6 illustrates this case.

Finally, we also consider a scenario with a lower interest rate, $r_K = 0.2$. The reduced price for capital means that more capital is used while a lower initial level of public investments are used, $\bar{G} = 0.006$. The amount of land used is not affected much, such that there is an initial forest cover area of $W = 0.170$ units of land. Given that a lot of capital is available initially, complementary public investments are taken up productively, so more land, 0.167 units, can be afforested with zero net cost. The lower right panel of Figure 6 illustrates this point.

Summarizing, we find that forest protection with the suggested mix of higher export tariffs and more public investments is more cost effective when public investments are more affordable (p_G), when more is exported already ($\bar{Y}_2$), when the supply elasticity of land is higher (ε) and when the interest rate is lower (r_K). An economy with higher output elasticity of public investments (ε) can be expected to have a relatively high level of public investments already, so that further additions increase productivity less and thus make the policy mix less cost effective.

7 Discussion

A total volume of 18 billion US$ has been comitted for REDD+ payments (FAO, 2016). At the same time, this article shows that political realities in one third of the countries in which REDD+ programs are planned to be rolled out, are shaped by three structural constraints to forest conservation: a strong specialization in the agricultural sector, food insecurity, and weak political institutions. It is thus important to develop forest conservation policies, which allow to reduce deforestation effectively in spite of these structural constraints.

In this article we have analyzed in how far export tariffs in combination with public investments can represent such a policy mix. We find that the policy mix can (i) reduce deforestation, while (ii) maintaining agricultural output levels, (iii) without increasing the prices of agricultural products. By satisfying these central requirements, the policy mix provides incentives for all relevant stakeholders, namely the international donor, the exporting sector, the government, and the domestic population to accept its implementation.

When examining the political feasibility of the policy mix, four aspects require further discussion: (i) possible secondary economic impacts, (ii) the implementability of export tariffs, (iii) the type of public investments, and (iv) the political economy challenges for the policy mix to becoming effective.

First of all, the potential secondary effect of the introduction of export tariffs have been critically discussed in the literature. Warr (2001) looks at the case of Thailand's rice exports. He points out that while export tariffs reduce consumer prices, they also reduce the producer prices and thus the real wages of unskilled labor. A similar observation is made by Dennis and Iscan (2011), who find that distortionary trade policies on agricultural products reduce the real wage and bring it closer to the subsistence level, whereby the structural transformation of the economy is retarded. In our model consumer prices also decline as a consequence of the proposed policy mix. However, given the public investments, production costs also decline. Therefore production levels and thus the required labor input can be assumed to remain constant, even if the model does not explicitly analyze labor market effects. The crucial difference here, is the reinvestment of tariff revenues into productivity enhancing public infrastructures or institutions. The policy mix provides disincentives to deforest and incentives to substitute the input factor deforested land with public infrastructures and institutions. The representative farmer switches from a land intensive towards a public infrastructure and institutions intensive production. In the long run, higher growth can be expected since the policy induces a more quality oriented model of development. Long run growth is driven by technology and institutional quality, both of which can be boosted with the suggested policy mix. REDD+ funds can be used to support the government budget for the required level of public investments.

Second, past experiences with export tariffs show that they have been used more frequently during the last decade (OECD, 2014), in contrast to other restrictive trade policy instruments that are less and less deployed, due to WTO rules. The use of export tariffs had been significantly reduced during the Washington Consensus period, where Bretton Woods institutions advised developing countries to liberalize trade policies (Williamson, 1993), see the appendix for examplary data.[6] The OECD explains the new rise in export tariffs by volatility on international commodity price markets and in particular by the food price crisis in 2007. Such a trade policy reaction can for instance be observed in Bangladesh, Brazil, Cambodia, Egypt, China, Madagascar, India, Nepal, Thailand and Vietnam on Rice and India, Argentina, Kazakhstan, Nepal and Pakistan on wheat (Bouët and Laborde, 2010). Nevertheless, export tariffs are currently still at rather low levels compared to historic values.

Third, not all types of public investments are likely to have the same positive effect on forest cover. We therefore conceive public investments as types of investment that lead to an increase in productivity in the agricultural sector, without having simultaneously a negative impact on forest cover. Electrification and land right allocations are likely to have such effects. Assuncao et al. (2015) have empirically investigated the impact of electrification on productivity and on forest cover in Brazil. They find that electrification leads to investments into irrigation systems, mechanization, fertilizers and pesticides and thus increases land productivity. Furthermore, Robinson et al (2014) have conducted a meta-analysis of empirical studies on the relationship between land tenure rights and tropical deforestation. Based on evidence from 118 cases, they find that land tenure security is associated with less deforestation. In contrast, the construction of roads through forest areas (as another form of public investments), entails productivity gains in the agricultural sector, due to a reduction in transport costs, but empirical and theoretical evidence show that it also bears a high risk for additional deforestation (Ferretti-Gallon and Busch, 2014; Angelsen, 2007). This illustrates that the policy design needs to consider the type of public investment to effectively increase productivity without increasing deforestation.

Finally, most of the usually discussed REDD+ policy approaches, such as compensation payments to farmers require complex implementing institutions on all levels and are thus challenging to implement in institutionally weak countries. In contrast, a combination of export tariffs with public investments is more implementable, because it is sufficient to collect export tariffs at the export hubs (such as ports or airports, railways or highways out of the country), which can build on existing custom offices and thus limits the administrative cost of the tariff collection. Furthermore, this does not require rural institutions for forest conservation for the policy to work. Nevertheless, the risk of corruption may undermine the effectiveness

[6] In Malaysia, the Philippines, Sri Lanka, Ethiopia, Tanzania, Chile, Columbia, Costa Rica, and Mexico they revenues from export tariffs contributed to up to 5% to public income (FAO, 1994). In Madagascar, income from export tariffs constituted 30% of the government revenue in 1983 (Anderson and Masters, 2009).

of the proposed policy mix. However, combining export tariff revenue with REDD+ funding has two potential sources of scrutiny: First domestic public scrutiny, which is likely to be higher due to the domestic tax collection (Ross, 2004) and second international monitoring and control of the disbursement of REDD+ funds.

8 Conclusion

The conventional approach to REDD+ takes the form of conditional payments for conservation projects. In countries with a low degree of institutional development there are substantial concerns that they can be implemented successfully. In this paper we propose an alternative approach to REDD+ policy, which is designed to have minimal requirements on institutional quality. We identify 36 countries, with a combination of a strong economic specialization in the agricultural sector, food insecurity and weak political institutions.

For these countries we suggest the imposition of export tariffs on agricultural products. The intention of this tariff increase is to reduce the incentive for unsustainable deforestation for the export market. We show that this does not need to have a negative effect on the exporting industry if the government simultaneously invests in agricultural productivity, in particular by improving land tenure security and by supplying electricity. The increased productivity would intensify agriculture, so that the same output can be generated with less land.

The proposed policy mix has costs (for the government investments) and revenues (from the export tariffs) and is thus partially self-financing. As costs are expected to exceed the revenue at least initially, the policy would need to be supported with REDD+ funds. However, the suggested forms of government investments are in line with existing policy objectives by the international community, so that there would be strong synergy effects with development objectives.

We acknowledge that investing in agricultural productivity is a challenging and long-term project and also vulnerable to the problems arising from weak governance. At the same time it offers the prospect of resolving the trade-off between development and forest conservation in a sustainable manner.

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9 Appendix

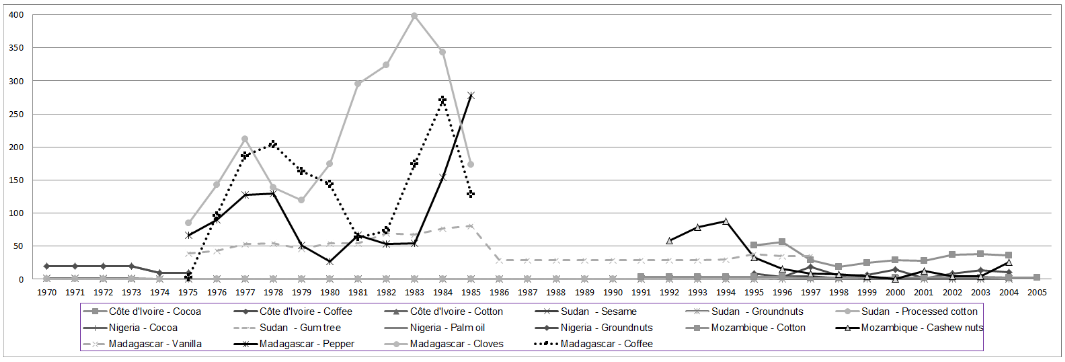

Figure 7: The evolution of the use of export tariffs for some exemplary crops in Cote d'Ivoire, Sudan, Nigeria, Mozambique and Madagascar in percent of the export value (Anderson and Masters, 2009)

.

As figure 7 illustrates in an exemplary manner (time series are unavailable for most countries), the Washington Consensus (Williamson, 1990) marked a period, where Bretton Woods institutions advised developing countries to liberalize their trade policies and consequently significantly reduced most of existing export tariffs (Williamson, 1993). In Benin for instance, most export tariffs were suppressed in 1993 (WTO, 2004).

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