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Green public procurement of certified wood

The impact on global welfare and welfare calculation itself

Green Public Procurement of certified wood – the impact on global welfare and welfare calculation itself

By Jan Brusselaers, Jeroen Buysse and Guido Van Huylenbroeck

Ghent University – Department of Agricultural Economics

This paper investigates the impact of green public procurement (governments' purchases) of certified wood in the EU. A spatial price equilibrium model is developed to analyse whether this policy impacts the interregional trade flows of wood and other regions' economic welfare. The model contains an innovative feature which allows the introduction of consumers' willingness to pay for certified wood, and producers' willingness to accept certified wood production. The outcome of the analysis demonstrates that green public procurement of certified wood in one region can create a trade barrier for other regions and decrease their economic welfare. In the worst case scenario, the forced increase of demand for certified wood increases the prices of certified wood. This decreases the relative price of conventional wood which can trigger the production of conventional wood and endanger forest conservation. Cost reductions and adequate financial compensation for certified wood producers can tackle these problems.

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1. Introduction

Governments around the world increasingly apply Green or Sustainable Public Procurement (GPP). GPP implies that governments take green and sustainability criteria into account while procuring goods and services. To what extent SPP encourages demand and supply of sustainable products over conventional products is still subject of debate.

In order to analyse the impact of GPP of green products, this paper presents an extension to traditional welfare analysis. The extension is required for the welfare analysis at markets which are characterized by the presence of 'green' products next to conventional products. The differentiated green products are assumed to be physically equal to their conventional counterparts and fulfil the same primary consumer needs. Possible tools for differentiation are certification, (eco-) labelling, or branding. The presented extension is generic and can be applied on numerous products and markets. This paper describes the welfare implication of GPP at the wood market. Green wood is assumed to be eco-labelled or certified wood.

The extension is required because certified wood and conventional wood cannot be considered as pure substitutes. The reason to assume that they are traded on the same market is twofold. First of all because of the price mechanism leading to the certified wood price. The certified wood price consists of the sum of the conventional wood price and a price premium. Hence a price increase for conventional wood will also increase the certified wood premium. Second, certified and conventional products have the same physical characteristics and fulfil the same primary consumer needs. A certificate only distinguishes conventional products from their environmentally and/or socially more sustainable counterpart.

But the emergence of certified next to conventional products does introduce a third and fourth dimension to the equilibrium state of that market. The original two dimensions are the equilibrium price and equilibrium quantity. In the extended model, the equilibrium price and quantity is still determined for the aggregate demand and supply. Aggregate demand and supply encompasses supply and demand of conventional and certified products together. As a third dimension, an equilibrium price premium is determined. At the demand side of the market, the equilibrium price premium represents the 'Willingness to Pay' (WTP) of consumers for certified products. At the supply side of the market, the equilibrium price premium represents the producers' 'Willingness to Accept' (WTA) certification. The fourth dimension is the share

of consumers and producers who are trading certified products instead of conventional products. This share depends upon the level of the price premium.

The extended model presented in this paper builds upon traditional welfare analysis. Traditional welfare calculation for open economies makes use of Spatial Equilibrium Models (SEM) (Takayama & Judge, 1971). SEMs maximize the quasi-welfare by making use of the equilibrium prices and quantities. By introducing two dimensions, an additional consumer and producer surplus is calculated. The extended model maximises the sum of the traditional quasi-welfare and the additional consumer and producer surplus.

The next part of this paper describes the logic and specifications of the extended SEM. This explanation will also demonstrate why governments' purchases of the cheapest option must not always maximize economic welfare. The third part of the paper explains the case of GPP of certified wood and why it was selected. GPP refers to public procurement processes which take environmental aspects into account. At the supply side of the market GPP must encourage industries to develop green technologies and practices (Erdmenger, 2003; European Commission, 2011). At the demand side, GPP became a promising tool to foster the demand for greener products (Parikka-Alhola, 2008). In the EU, government purchases account for 26.2 % of final consumption of wood (EUROSTAT, 2014). The governments' shares in final consumption represent the magnitude of the demand shock analysed in the extended welfare analysis. The two final parts of the paper presents the limitations of the model, the conclusions and some possible policy recommendations.

2. Extension to the traditional welfare calculation

Traditional welfare analysis in open economies often makes us of Spatial Equilibrium Models (SEM). Takayama and Judge (1971) first developed the SEM approach. A SEM optimizes the global economic quasi-welfare. This global quasi-welfare consists of the sum of all regions' economic welfare. A region's economic welfare consists of the sum of its producer and consumer surplus. Consumer surpluses express the gains of consumers who buy a product at a lower price than the maximum price they are willing to pay. Hence, this is a purely monetary calculation of welfare. Figure 1 displays how a region's economic surplus is determined graphically. The consumer surplus equals area ABD, or the area delimited by the demand curve and the region's equilibrium price and equilibrium quantity.

Accordingly, the producer surplus expresses the gains of producers who sell the product at the equilibrium price which is above the minimum price they are willing to accept. In Figure 1, the producer surplus equals area 0BC, or the area delimited by the supply function and the region's equilibrium price and equilibrium quantity. The entire economic welfare equals the shaded area in Figure 1. Notice that Figure 1 represents the situation for an open market which is importing goods. The world price is lower than the domestic equilibrium price which allows domestic demand to surpass domestic supply.

The traditional welfare calculation is a purely economic approach which does not take environmental or societal aspects into account. Pearson (2000) described how governments' policies can take environmental aspects into account. But this can only be done on the precondition that monetary values are attributed to the environmental cost or benefit of products, services and practices. In reality, the correct monetary value of environmental damage or gains is hard to estimate. A comparable reasoning applies to societal aspects.

The emergence of certification offers the possibility to attribute monetary value to, and internalize environmental and societal aspects. At the demand side of the market, consumers can buy certified products if they pay a price premium on top of the conventional price of the product. This price premium is also known as the 'Willingness to Pay' (WTP). At the supply side of the market, producers demand a price premium to compensate the additional costs related to producing certified products. This demanded price premium is known as the 'Willingness to Accept' (WTA) of producers. Hence, the WTP and WTA are no exact monetary measures of the environmental and societal gains of a product. They are a monetary indication of the consumers' valuation of the environmental gains and the related costs for producers. Crucial is that the conventional wood price is also the basis of the certified wood price. Hence, the price mechanism leading to both products prices is partly the same. Therefore, supply and demand of certified and conventional wood must be considered at one single market. Traditional welfare calculation is applied to analyse the situation at this market.

The extension to the traditional welfare calculation is based upon the distribution (with known mean and standard deviation) of the WTP and WTA per region. If the WTP and WTA are standardly distributed, it is possible to construct a logistic distribution function for each of them. This function determines the share of consumers and producers trading certified products for any given price premium. For a given price premium of demand in region i ($PP_{d,i}$) the share of certified products in total demand ($Share_{d,i}$) is expressed by:

$$\mathbf{Share_{d,i} = 1 - (1 + \ e^{-(PP_{d,i} - mWTP_i)/vWTP_i})^{-1}} \quad \mathbf{1}$$

With $mWTP_i$ and $vWTP_i$ being the mean and standard deviation of the regional WTP for certified products. Accordingly, the share of certified products in total consumption is determined by:

$$\mathbf{Share_{s,i} = (1 + \ e^{-(PP_{s,i} - mWTA_i)/vWTA_i})^{-1}} \quad \mathbf{2}$$

Figure 2 visualizes this concept for the demand side of the market in a given region *i*. If the price premium equals the mean WTP, 50% of the region's consumers buys certified products. Figure 2 depicts the situation for a world price premium below the region's mean WTP. In this situation, more than 50% of this region's consumers buys certified products.

But part of the consumers buying certified products are willing to pay an even higher price premium. These consumers gain economic welfare because their maximum WTP is higher than the equilibrium WTP. In accordance with the traditional consumer surplus calculation this allows to calculate the consumer surplus related to the distribution of the WTP in a region. The consumer surplus is calculated by taking the integral of the distribution of this WTP from the world equilibrium price to infinity. This matches the shaded area in Figure 2.

Accordingly, the producer surplus related to the producers' WTA distribution is calculated. For the producer surplus, the integral from zero to the world equilibrium price is required. This is the shaded area in Figure 3.

2.1. Specifications of extended objective function

The extended SEM maximizes the global welfare W. This results in objective function:

$$\mathbf{Max\ W = \sum_i \left[PS_i + CS_i + PS_i^{WTA} + CS_i^{WTP}\right] - \sum_{i,j} (Q_{i,j}^{T,cer} + Q_{i,j}^{T,con}) * TC_{i,j}} \quad \mathbf{3}$$

The global welfare consists of two summation. The first summation adds all region's economic welfare. The economic welfare of a region r consists of four elements. The first two elements are the traditional consumer surplus CS_i and producer surplus PS_i calculated for the aggregate demand and supply. To determine CS_i and PS_i it is necessary to specify the aggregate demand $Q_{d,i}$ and supply $Q_{s,i}$ per region without distinguishing between certified and conventional products. This research only considers the impact of changing prices on the produced and consumed quantities. The next part of this paper explains how the value for these parameters

are calculated. The introduction of certification will impact equilibrium prices and quantities compared to the baseline situation. At the demand side of the market, the baseline equilibrium price for demand $P^*_{d,i}$ and equilibrium demanded quantity $Q^*_{d,i}$ will reach the level of $P^t_{d,i}$ and $Q^t_{d,i}$ in the SEM. The magnitude of change depends upon the responsiveness of $Q^t_{d,i}$ to price changes expressed by the price elasticity of demand $\sigma_{d,i}$. This results in demand curve:

$$\boldsymbol{Q^t_{d,i} = Q^*_{d,i} * (1 + \sigma_{d,i} * \frac{P^t_{d,i} - P^*_{d,i}}{P^*_{d,i}})} \quad \textbf{4}$$

The demand for certified ($Q^{cer}_{d,i}$) and conventional products ($Q^{con}_{d,i}$) is determined by making use of the share of certified products in total demand and $Q^t_{d,i}$ in equation 4:

$$\mathbf{Q^{cer}_{d,i} = Q^t_{d,i} * Share_{d,i}} \quad \textbf{5}$$

$$\mathbf{Q^{con}_{d,i} = Q^t_{d,i} * (1 - Share_{d,i})} \quad \textbf{6}$$

Simultaneously, the aggregate supply function is specified (equation 7). The supply of certified and conventional products is derived from $Q^t_{s,i}$ in equation 8 and 9:

$$\boldsymbol{Q^t_{s,i} = Q^*_{s,i} * (1 + \sigma_{s,i} * \frac{P^t_{s,i} - P^*_{s,i}}{P^*_{s,i}})} \quad \textbf{7}$$

$$\mathbf{Q^{cer}_{s,i} = Q^t_{s,i} * Share_{s,i}} \quad \textbf{8}$$

$$\mathbf{Q^{con}_{s,i} = Q^t_{s,i} * (1 - Share_{s,i})} \quad \textbf{9}$$

Integration of the aggregate demand and supply curve allows the calculation of the regional consumer surplus CS_i and producer surplus PS_i. This occurs according the traditional approach by Takayama and Judge (1971) and is expressed as:

$$\mathbf{CS_i = Q^t_{d,i} * P^*_{d,i} * \left(1 - 1/\sigma_{d,i}\right) + \frac{1}{2} * {Q^t_{d,i}}^2 * \frac{P^*_{d,i}}{\sigma_{d,i} * Q^*_{d,i}} - Q^t_{d,i} * P^t_{d,i}} \quad \textit{10}$$

$$\mathbf{PS_i = Q^t_{s,i} * P^t_{s,i} - Q^t_{s,i} * P^*_{s,i} * \left(1 - 1/\sigma_{s,i}\right) - \frac{1}{2} * {Q^t_{s,i}}^2 * \frac{P^*_{s,i}}{\sigma_{s,i} * Q^*_{s,i}}} \quad \textit{11}$$

In the objective function (3), CS^{WTP}_i and PS^{WTA}_i stand for the consumer and producer surplus related to the distribution of respectively the WTP and WTA in region i. Both the WTP and WTA are assumed to be standardly distributed around a given mean per region. This allows to construct logistic distribution functions determining the share of the certified product in the

total demand and supply. These functions are described by equations 1 and 2. Integration of these functions leads to the additional consumer and producer surplus related to the WTP and WTA.

At the demand side of the market, the WTP's logistic distribution function is integrated from the price premium of demand ($PP_{d,i}$) to infinity (Figure 2). This paper assumes that consumers will not pay more than double of the conventional price $P_{d,i}$. Hence, the maximum price premium of demand is 100 %. The integral is multiplied with the aggregate equilibrium quantity $Q^{t}_{d,\mathrm{i}}$ and price $P^{t}_{d,\mathrm{i}}$ in order to measure the additional surplus at the same scale as the surplus of aggregate demand:

$$\mathbf{CS_i^{WTP}} = \left[\mathbf{1 - PP_{d,i} - vWTP_i} * \left[\ln\left(\mathbf{e}^{\mathbf{mWTP_i}/\mathbf{vWTP_i}} + \mathbf{e}^{\mathbf{1}/\mathbf{vWTP_i}}\right) - \ln\left(\mathbf{e}^{\mathbf{mWTP_i}/\mathbf{vWTP_i}} + \mathbf{e}^{\mathbf{PP_{d,i}}/\mathbf{vWTP_i}}\right)\right]\right] * \mathbf{Q^t_{d,i}} * \mathbf{P^t_{d,i}} \qquad \mathbf{12}$$

Accordingly, the integral of the logistic distribution function for the WTA is defined and multiplied with the aggregate equilibrium quantity $Q^{t}_{s,\mathrm{i}}$ and price $P^{t}_{s,\mathrm{i}}$ of supply. This results in the additional producer surplus related to the WTA's distribution:

$$\mathbf{PS_i^{WTA}} = \left[\mathbf{vWTA_i} * \ln\left(\mathbf{e}^{\mathbf{mWTA_i}/\mathbf{vWTA_i}} + \mathbf{e}^{\mathbf{PP_{s,i}}/\mathbf{vWTA_i}}\right) - \mathbf{mWTA_i}\right] * \mathbf{Q^t_{s,i}} * \mathbf{P^t_{s,i}} \qquad \mathbf{13}$$

The objective function (3) also takes the transport costs of the internationally traded products into account. These costs negatively impact the global economic welfare. The transported quantity between any given region *i* and *j* is defined as $Q^{T,cer}_{i,j}$ and $Q^{T,con}_{i,j}$. The total costs of trade between two regions *i* and *j* is found by multiplying the traded quantity with the per unit transport costs between the two regions ($TC_{i,j}$). A region *i* can supply itself. But this papers assumes that no transport costs occur for domestic trade flows. Hence, $TC_{i,i}$ is set at zero for each region *i*. Trade will only occur under certain circumstances. This is explained in the following part.

2.2. Constraints of the SEM

The maximization of the objective function is subject to a number of constraints. First, all quantities and prices must be non-negative:

$$\mathbf{P_{d,i} \geq 0, P_{s,i} \geq 0, Q_{d,i} \geq 0, Q_{s,i} \geq 0, Q_{i,j}^{T,cer} \geq 0, Q_{i,j}^{T,con}} \quad \mathbf{14}$$

From these constraints it follows that $Q_{d,i}^{cer}$, $Q_{d,i}^{con}$, $Q_{s,i}^{cer}$, and $Q_{s,i}^{con}$ are non-negative.

This paper assumes that certified products are environmentally and/or socially more sustainable than conventional products. Because certified products offer this additional services to environment and society, this paper assumes that the price of certified products cannot fall under the price of conventional products. Consequently, the price premiums must be non-negative. In addition, this paper assumes that no consumer is willing to pay more than double of the price of conventional products for a certified product:

$$\mathbf{0 \leq PP_{d,i} \leq 1, 0 \leq PP_{s,i}} \quad 15$$

Trade balances are defined in accordance with traditional SEMs. These balances ensure that the trade flows stemming from a region *i* (including the trade flow to that region itself) do not exceed the production in region *i.* At the demand side of the market, the balances ensure that a region *i* is not consuming more than the sum of all incoming trade flows (including domestic supply). Since the extended SEM distinguishes between certified and conventional products, the number of trade balances at the demand (16) and supply (17) side of the market is doubled:

$$\mathbf{Q_{d,j}^{cer} \leq \sum_i Q_{i,j}^{T,cer}, Q_{d,j}^{con} \leq \sum_i Q_{i,j}^{T,con}} \quad \mathbf{16}$$

$$\mathbf{Q_{s,i}^{cer} \geq \sum_j Q_{i,j}^{T,cer}, Q_{d,i}^{cer} \geq \sum_j Q_{i,j}^{T,cer}} \quad \mathbf{17}$$

The final set of constraints determines when trade between two regions occurs. In traditional SEMs, trade occurs if the demand price in the receiving region *i* is higher than the sum of the supply price of sending region *j* and the transport costs between both regions. If this is not the case, it is not beneficial to import products. No trade will occur. For the conventional products, the traditional trade balances are applied:

$$\mathbf{P_{d,j}^t < P_{s,i}^t + TC_{i,j} \Leftrightarrow \neg\, Q_{i,j}^{T,con} > 0} \quad \mathbf{18}$$

The price premiums for demand ($PP_{d,i}$) and supply ($PP_{s,i}$) are taken into account in the trade balance for certified products:

$$\mathbf{P_{d,j}^t + PP_{d,i} < P_{s,i}^t + PP_{s,i} + TC_{i,j} \Leftrightarrow \neg\, Q_{i,j}^{T,cer} > 0} \quad \mathbf{19}$$

Due to the non-negativity of the traded quantities (*14*), the traded quantities $Q_{i,j}^{T,con}$ and $Q_{i,j}^{T,cer}$ will equal zero if the demand price in receiving region *i* does not compensate the supply price in region *j* added to the transport costs between both regions $TC_{i,j}$. The transport costs in this research the ad valorem taxes between two regions, and the costs of physically shipping a product.

2.3. Possible negative welfare consequences of traditional procurement practises

Traditionally, the price criterion is one of the most important award criteria applied by procuring governments (Uttam & Roos, 2015). This paper assumes that certified and conventional products serve the same primary need and have the same physical characteristics. Hence, they are equivalent options. Due to the positive price premium, certified products will never be cheaper than conventional products. The traditional price criteria consequently rarely select certified products. The internationalization of the environmental and societal aspects of certified products in the equilibrium of the extended SEM suggests that the purchase of the cheaper conventional products must not necessarily maximize welfare however.

Suppose that a government accounts for a specific share of final consumption in region *i*: $Govshare_i$. If the governments decides to opt for cheaper conventional products, the logistical distribution function does not cross the y-axis at 100% (Figure 2) but at the lower point (100-$Govshare_i$)%. This is displayed in Figure 4.

If governments do not have the same preferences as regular consumers but buy the cheaper conventional products only, the original logistical distribution function (equation 1) becomes:

$$\mathbf{Share_{d,i}} = (\mathbf{1} - \mathbf{Govshare_i}) - (\mathbf{1} - \mathbf{Govshare_i})/(\mathbf{1} + \mathbf{e}^{-\frac{\mathbf{PP_{d,i}} - \mathbf{mWTP_i}}{\mathbf{vWTP_i}}}) \qquad \mathbf{20}$$

The potential maximum consumer surplus derived from the logistical distribution function in equation (20) is lower than the surplus derived from equation (1). Hence, governments procuring the cheaper conventional products do not necessarily increase welfare. Indirectly, this policy might also negatively impact the potential maximum producer surplus related to the WTA's distribution.

3. Selection of a case: GPP of wood

The extension to the traditional welfare calculation is described by making use of a case study: green public procurement (GPP) of certified industrial roundwood, hereafter referred to as *wood*. At first stage, this paper analyses the impact of the occurrence of certification on the international wood market. The parameters' values for the baseline demand and supply quantities and prices are retrieved from the GFPM. The GFPM does not distinguish certified wood from conventional wood. At second stage, the impact of GPP is analysed.

The case of wood is selected for a number of reasons:

- *Importance of certification*: In Northern America and Western Europe, the supply of industrial certified roundwood accounts for 36% to 63.4% of total supply (FAO, 2014a).
- *International dimension of the wood market*: forest industries in different regions are 'increasingly linked through international trade and global environmental policies' (Buongiorno, 2003). Consequently, demand and supply shocks in one region can impact other regions' markets. In addition, Gan and McCarl (2007) described how forest conservation and the accompanying drop of production in one country can result in deforestation in other countries. Also Sedjo and Sohngen (2013) (1999) (1995) described the global consequences of regional forest policies. This makes the international wood market increasingly interesting for analysis by a SEM. Five regions are taken into account: Northern America, Europe & Russia, Asia & Oceania, Latin America, and Africa.
- *Green Public Procurement acknowledges certification*: numerous countries implement GPP of wood and wood-based products[1] (FAO, 2014c; FSC, 2013). This paper assumes that if governments opt for GPP, they will buy certified wood only[2]. This is a valid assumption. Market mechanisms became an appealing alternative for governments who could not properly manage forests (Auld, Gulbrandsen, & McDermott, 2008). In addition, FSC even became part of the Due Diligence System (DDS) provisions of the EU's Timber Regulation. DDSs demonstrate that imported

[1] E.g.: Austria, Australia, Belgium, China, Denmark, Finland, France, Germany, India, Japan, Republic of Korea, Mexico, the Netherlands, New Zealand, Norway, Switzerland, and the UK.

[2] This is currently happening in some countries already. In Belgium for example, the federal government restricts itself to buying certified wood only since 2006 (Belgian Government, 2013).

wood is legally harvested[3]. Some of the EU's public procurement criteria are even based upon certificates and eco-labels (European Commission, 2008). Public procurement accounts for a considerable share of final consumption in most regions. This paper analyses the procurement practises in the EU. The aggregate share of all governments in the EU accounts for 26.2% of final wood consumption in the EU (EUROSTAT, 2015).

3.1. Certification in the wood market

Forest and wood certification is a transnational, non-governmental approach to environmental regulation and development. The approach is currently gaining momentum as tool for forest conservation, especially for tropical forests (Ebeling & Yasué, 2009). Traditional conservation interventions such as international forest conservation agreements, national forest policy reform, and the creation of additional protected areas were not able to significantly reduce unsustainable logging in tropical forests (Auld, et al., 2008). This was partly because the governments responsible for the tropical forests lack the capacity to adequately manage natural resources, enforce pertinent forestry and land-use regulations (Ebeling & Yasué, 2009) and to provide secure land tenure (Smith, Muir, Walpole, Balmford, & Leader-Williams, 2003). As a result, in the last two decades, market-based instruments involving non state actors, such as forest certification, have been promoted as economically attractive alternatives that are less dependent on public resources and governance capacity and therefore potentially more effective in tropical developing countries (Auld, et al., 2008; Gullison, 2003). Unfortunately, certification is not very present in the tropical regions. Nearly 90 percent of the FSC and PEFC certified forests are situated in the northern hemisphere. FSC and PEFC are the two main certification schemes. In contrast, only 2 percent of under-regulated southern tropical forest is certified (FAO, 2014a).

[3] Importers can develop a DDS themselves or work with a monitoring organisation for permanent control and support of their compliance with the regulation. NEPCon is the only monitoring organisation which is recognised in each Member State. NEPCon recognises FSC material as having a low (negligible) risk (FSC, 2014). Both PEFC and FSC made changes to their schemes in order to meet the EUTR's requirements (UNECE, 2013).

3.2. Defining parameters

The Global Forest Products Model (GFPM) by Buongiorno (2014) provides data to determine the following parameters' values: $Q^*_{d,i}, Q^*_{s,i}$, $P^*_{d,i}$, $P^*_{s,i}, \sigma_{d,i}, \sigma_{s,i}$ and $TC_{i,j}$. The remaining parameters are the mean and standard deviation of the WTP's and WTA's distribution per region: $mWTP_i$, $mWTA_i$ $vWTP_i$, $vWTA_i$. Equation (1) and (2) describe how the last four parameters determine the share of certified wood in the aggregate wood demand and supply.

The value of $mWTP$ and $vWTP$ is retrieved from research by Cai and Aguilar (2013). They conducted a meta-analysis on the consumers' WTP for certified wood products in different regions. At global level, they found a mean WTP for wood products of 12.2% on top of the conventional wood price (St. Dev. 8%). Cai and Aguilar (2013) assume regional differences in WTP. This is explained by the longer presence of certification in Northern America and Europe which leads to higher reported WTP in these regions. Research by Jacobsen and Hanley (2009) provide an alternative explanation for regional differences. They developed a logistic regression model which demonstrates that the WTP for eco-labels and ecosystem services is positively related to GDP per capita. This results in a higher WTP in developed countries. The positive relationship indicates that 'Willingness to Pay' is probably a wrong choice of words. It rather reflects the 'Capacity to Pay' for certified products. The model by Jacobsen and Hanley (2009) is used in order to determine the mean WTP per continent based upon the global mean WTP and standard deviation found by Cai and Aguilar (2013).

The WTA is the WTP's equivalent at the supply side of the market. The WTA is a measure of the minimum requested price premium by wood producers before they switch from conventional to certified production. This price premium must compensate the additional direct and indirect costs related to certification. The direct costs are the costs of the certification process: audit costs, certification fees, and costs of meeting *corrective action requests*. The indirect costs comprise all costs required to change the management to meet the certification's standards (Bass, 2001)[4]. The certification bodies themselves declare that wood producers receive price premiums between 15 to 25 % on top of the conventional wood price. This research uses these price premiums as the mean WTA in a standardised distribution (St. Dev.

[4] Examples of indirect costs: investment in infrastructure and machinery in order to be able to harvest more efficiently with lower impacts, higher wage costs by paying legally specified wages and providing social benefits, and opportunity costs of reducing wood production to sustainable levels.

0.08). This allows to determine the WTA per region by combining the standardised distribution with the share of certified forests in the total forest area per continent derived from UNECE/FAO (2014).

From the data provided by UNECE/FAO (2014) it appears that less forests are certified in developing regions. This is explained by a higher WTA in these regions. The WTA is higher in developing countries than in developed countries for two reasons. First, 'the magnitude of the indirect costs depend upon the current quality of the management of conventional forests and the context in which forestry is taking place' (Gullison, 2003). This is also confirmed by the ITTC (2004). Because current management techniques in developing countries are less appropriate for certification, the WTA in developing countries will be higher. Second, only a small part of certification costs are variable costs. Consequently, certification costs are easier to bear for bigger producers. The bigger producers can – in general – be found in developed countries.

3.3 Specificities of the demand and supply function of wood

In reality, $Q_{d,i}$ and $Q_{s,i}$ will not only change due to changes of $P_{d,i}$ and $P_{s,i}$. Many other factors influence demand and supply as well. Wagner (2011) described how $Q_{d,i}$ also depends on the consumers' income level, the substitutes' prices, and the related income and price elasticity. The parameters in equation (4) take the income level and demand for roundwood as inputs indirectly into account however. The parameters are derived from the data by Buongiorno and Shushuai (2014). In their model $Q^*_{d,i}$ is determined by the income level and the demand for roundwood from the processing sector. Only substitutes for roundwood are not taken into account in the SEM.

Accordingly, Wagner (2011) described how the supply of wood in region i ($Q_{s,i}$) is determined by the price of wood ($P_{s,i}$), the price of substitutes of roundwood, the price of inputs (including labour), the technical efficiency of the production system, and the price elasticity[5]. Again, substitutes are not taken into account. But the technical efficiency of production systems is taken into account in Buongiorno's GFPM as input-output coefficients which lead to the

[5] The efficiency of the production system is partially explained by the modernity and density of the forest infrastructure. E.g. "forest road system and adequate harvesting systems for steep terrain are seen as essential for cost-effective and competitive wood production and market access". As a consequence, the supply curve directly depends upon production costs. (Kraxner, Yang, & Yamagata)

baseline quantities. Consequently, this factor indirectly is incorporated in the SEM. The price elasticity enters the SEM directly.

4. Results

The base line quantities and prices are derived from the GFPM by Buongiorno (2014). This model does not distinguish between certified and conventional wood. The first section of this part therefor describes the extended SEM's output after the introduction of certification on the international wood market. The second section describes the impact of GPP of certified wood in the EU.

4.1. Certification in the extended SEM

Table 1 displays the situation per region after the introduction of certification on the international wood market. Most of the economic welfare stemming from the production and consumption of industrial roundwood originates from *Northern America* and *Europe & Russia*. This is straightforward since those regions also account for most of the wood production and consumption. The produced and consumed quantities of wood are considerably determined by the baseline quantities retrieved from the GFPM (Buongiorno, 2014).

From Table 1 it also becomes apparent that not every region is equally involved in consumption and production of certified wood. Especially *Northern America* and *Europe & Russia* are producing certified wood. Respectively 42.9% and 39.5% of their supply consists of certified wood supply. Those two regions also account for most of the consumed certified wood. Respectively 60.1% and 59.7% of their aggregate consumption consists of certified wood. Certification is less important in the 3 other regions.

This research takes 5 regions into account which encompass virtually the entire globe. This will result in specialisation of production in a number of regions and limited set of trade flows. This is displayed in Table 2. All countries are able to supply their own demand for certified and conventional wood. The only exception is *Asia & Oceania*. This region cannot fulfil its own demand for conventional wood. It must import conventional wood from *Northern America*. *Asia & Oceania* is also not capable to fulfil its own demand for certified wood. They import certified wood from all 4 remaining regions.

4.2. Welfare implication of GPP of certified wood in Europe & Russia

This paper investigates the impact of GPP of certified wood in region *Europe & Russia*. It is assumed that all governments in this region together account for 26.2 % of final consumption (EUROSTAT, 2015). This is the size of the demand shock investigated. For *Europe & Russia*, equation (20) becomes:

$$\boldsymbol{Share_{d,i} = 1 - (1 - 0.262)/(1 + e^{-\frac{PP_{d,i} - mWTP_i}{vWTP_i}})} \qquad \textbf{21}$$

Table 3 displays the situation after GPP in *Europe & Russia*. It becomes apparent that the demand shock (GPP) has global consequences. Most importantly, global welfare increased from 123.98 to 125.61 standardised units. At first sight this supports the statement that public procurement of the cheaper conventional products does not maximize economic welfare. But the increase of the global welfare is not a Pareto optimal improvement. The regional welfare of *Latin America* and *Asia & Oceania* decreased. Those regions are worse off after the GPP in *Europe & Russia*. All other regions benefited from the demand shock.

Distinction can be made between the consumer and producer surplus as well. Table 4 decomposes the regional economic welfare. This table demonstrates that the producer surplus related to the aggregate supply decreases in all regions except for *Northern America* and *Africa*. In *Africa* this is due to an increased production of conventional wood in combination with a higher price for conventional wood. In *Northern America,* the production of conventional wood decreased but also for this region the prices received for this conventional wood increased (Table 5). As such both regions experience an increased producer surplus. This observation is strongly related to the observation that *Africa* and *Northern America* are the sole regions exporting conventional wood (Table 6). The price received for conventional wood decreased in all other regions. In combination with a decreased production of conventional wood in these regions this leads to a lower producer surplus in those regions.

For all regions except Africa, the loss of producer surplus related to the aggregate supply is compensated by an increase of the producer surplus related to the WTA. African producers produce less certified wood and the price premium received for African certified wood decreased with 23.65% (Table 5). All other regions witnessed a rise of the price premium for certified wood due to GPP in *Europe and Russia*. In combination with an increased production of certified wood this leads to an increased producer surplus related to the WTA for all remaining regions.

The consumer surplus calculated for the aggregate demand only decreased in *Latin America*. This is due to an increased demand price for conventional products and a decreased aggregate demand for wood. In all other regions, the demand prices for conventional wood decreased due to GPP of conventional wood. In *Northern America* and *Europa & Russia*, this lower price compensated the decreased volume of consumed wood. As a consequence the aggregate consumer surpluses in these regions increased. The consumer surplus related to the WTP's distribution only decreased in *Africa* and *Asia & Oceania*. For both regions this is explained by a decreased consumption of certified wood. Due to rising price premiums, consumers in both regions lost interest for certified wood (Table 5). The situation is opposite for the 3 other regions.

4.3. Impact on trade flows

GPP has global consequences because the different regions' wood markets are (possibly) interlinked through trade. Table 6 demonstrates how the bilateral trade flows changed due to GPP in *Europe & Russia*. At global level, the traded volume of wood increased by 9.25%. Surprisingly, this is due to an increased volume of interregionally traded conventional wood (+304.5%). The volume of traded certified wood decreased (-93.5%).

In *Europe & Russia*, the demand shock in favour of certified wood created a shortage for this type of wood. Their domestic certified wood production cannot fulfil domestic demand. *Europe & Russia* is obliged to import certified wood from *Africa* and *Northern America*. But imports of certified wood in this region only account for 1.1% of certified consumption. Notice that before the GPP demand shock, all regions where exporting certified wood. Global production (and consumption) of certified wood increased, but this certified wood is increasingly produced for the domestic market. This has negative consequences for some of the regions situated in the Southern hemisphere. The decrease of exports of certified wood out of *Africa* is related to the decreased production of certified wood in this region. Instead, more conventional wood is produced in *Africa*.

Exports of conventional wood increased. *Africa*, *Latin America*, and *Northern America* are exporting conventional wood. *Asia & Oceania* is receiving most of this wood. This region imports 17.8 % of its conventional wood needs.

This analysis demonstrates how certified producers are competed out of the international wood market due to GPP. For less competitive producers, GPP created a trade barrier. Instead they

switch back to conventional wood production. A contradictory outcome of the initial policy's goal.

4.4 Leverage effect of certification

At the demand side of the market, GPP boosted the share of certified wood in aggregate demand in *Northern America* and *Latin America*. Also in *Europe & Russia* the share of certified wood in demand increased, but the governments account for this increase. In fact, the households are consuming less certified wood than before GPP. Due to the increased price premiums, a number of the households is not willing to pay for certified wood anymore. The governments' purchases in *Europe & Russia* are less determined by the price level due to the GPP policy stipulations in this paper. This stipulation obliges governments to buy certified wood. In *Africa* and *Asia & Oceania* the purchases of certified wood decreased due to the higher price premiums.

At the productions side of the market, the increased demand for certified wood in *Europe & Russia* stimulated production of certified wood in all regions except Africa. The increased price premiums do not compensate most of Africa's producers additional costs. Due to the increased competition on the certified segment of the market, Africa's producers are competed out of this segment and switch to conventional production.

This trend described by the SEM is also observed in reality by Auld, et al. (2008). Simula, Astana, Ishmael, Santana, and Schmidt (2004) even warn for the problematic implications of this development: if 'producers are forced to drop out from traditional markets as has already happened in some cases, product prices are driven down. There is a risk that this can lead in some countries to reduction of the value of the resource, encouraging its conversion into other uses.' In this case, forest certification could stimulate forest degradation due to the slow progress of certification in tropical countries. Simula, et al. (2004) share this opinion and claim that without 'tangible benefits deriving from certification in terms of profitability or competitiveness, enterprises will have little incentive to improve forest management with higher costs. The problem is particularly serious in the case of tropical timber producing countries'. The results of our SEM seem to confirm this statement.

5. Limitation of the extended SEM

Although the SEM describes trends which have also been described by other authors, the results must be interpreted carefully. It must be kept in mind that the possibilities of the model are restricted due to the following limitations:

- *Regional aggregation*: this research takes 5 regions into account only. Obviously, this is a simplified representation of reality as those regions encompass countries with considerably different characteristics. The model aims to reveal possible mechanism and outcomes of GPP however. It does not claim to predict the future situation exactly.
- *Focussed case study*: no substitutes for industrial roundwood, nor other explanatory variables of the demand for industrial roundwood are taken into account. The SEM does also neglects the origin of the industrial roundwood. Industrial roundwood from one region might have better characteristics than wood from other regions. Consequently, consumers might be willing to pay a higher price for higher-quality industrial roundwood. The SEM is not able to capture all aspects of reality.
- *Internalisation of willingness to pay and accept*: only the economic aspects of certification are taken into account: the willingness to pay and accept a specific product. No economic value has been allocated to the real environmental and social benefits related to certification. The ITTC (2004) stated that the producers are not or hardly compensated for the costs required to create these considerable social, environmental and economic benefits. Nevertheless these benefits can considerably impact the SEM's outcomes.
- *Parameters*: the WTP and WTA for certified wood is investigated by numerous studies but no global studies are available. Consequently, the WTP and WTA in this study are based upon findings in meta-analyses, which by definition are imperfect.

Due to these limitations, this model cannot be used as a perfectly predictive tool. Instead it reveals the mechanisms which explain the impact of the interference of certified wood on global markets. Understanding these mechanisms allows policy makers to tackle the obstacles which prevent the instruments of certification and GPP to positively impact the globe's forests.

6. Conclusion and policy recommendation

The GPP of certified wood in the EU has global consequences. Although the policy is developed in favour of the conservation (or at least sustainable exploitation) of forests, this policy does not achieve the intended result in all regions. The production of certified wood declined in Africa. In addition, less trade of certified wood occurs. GPP creates a trade barrier for producers who face a higher WTA. Those producers are often found in the Southern Hemisphere. At the demand side of the market, GPP seems to stimulate demand for certified wood. This is

especially the case in *Northern America* and *Latin America*. Consumption of certified wood also increased in *Europe &* Russia, but in this region governments account for the increase. In fact, the increased demand for certified wood boosts the price premiums which leads to a decreased interest of household to buy certified wood. These results are seemingly contradictory to the initial goal of the policy. Obviously, the developed SEM has its limitations and must not be used for precise forecasting. Nevertheless it reveals some of the mechanisms leading to a potentially negative outcome of the governments' purchase of certified wood.

The small share of certified wood in the supply of wood in the continents below the equator is also observed in reality: only 2 percent of the tropical forests is certified at present (Dauvergne & Lister, 2013). This suggests that also in reality certification costs are higher than the received price premium in the developing countries where the tropical forests are located. Government policies could aim to reduce these costs. This can make certification more inclusive at global level. The certification cost in a particular region depends upon several factors: the legislative framework in support of certification (Putz, Dykstra, & Heinrich, 2000), the level of vertical integration of the forest industry along the production chain (Atyi & Simula, 2002), the distance certifiers have to travel (Gullison, 2003), the available financial means (ITTC, 2004), and the size of the forest (Ebeling & Yasué, 2009). The costs are relatively low for large-scale producers and relatively high for small-scale producers (Gullison, 2003). In addition, large-scale wood producers are also favoured over small-scale wood producers by the buyers of certified wood. Demand for certified wood is mainly driven by retail which demands large volumes, uniform physical quality, and low prices. Large-scale wood producers are better able to meet these requirements (Klooster, 2005; Molnar & Trends, 2003; Rametsteiner & Simula, 2003; Taylor, 2005). Because large-scale producers and operators are more present in the Northern hemisphere, the average certification cost in this hemisphere also has the tendency to be lower. Producers in the Southern hemisphere could be assisted in their certification process. If this assistance decreases the costs of certification, it is more likely that the share of certified wood producers in these areas increases. According to Simula, et al. (2004), a phased approach is required. In addition, a comprehensive strategy must be developed in which certification plays a complementary role in sustainable forest management.

Besides working on the costs of non-certified producers, it is also worthwhile to look at the price premium received for certified wood. In reality, producers hardly receive a price premium. Retailers are the most powerful actors in wood commodity chains, and they have little interest in either increasing the cost of the products to consumers or in passing any increased revenue

back to their certified suppliers (Bass, 2001; Klooster, 2005; Madrid & Chapela, 2003; Morris & Dunne, 2004; Taylor, 2005). Nevertheless, price premiums and an increased or protected market share are generally perceived as the main motivation for certification (Simula, et al., 2004)[6].

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Tables

	Welfare	Share in global welfare	Supply	Share in global supply	Supply conventional	Supply certified	Demand	Share in global demand	Demand conventional	Demand certified
Africa	0.613877	0.004952	0.350382	0.023358	0.241977	0.108406	0.281782	0.022761	0.24197667	0.039805
Latin America	4.205444	0.033921	1.980589	0.132035	1.818979	0.16161	1.913908	0.171095	1.818979002	0.094929
Asia & Oceania	14.83768	0.119681	3.385311	0.22568	3.109081	0.276231	3.986395	0.292444	3.263943175	0.722452
Europe & Russia	54.67131	0.440981	4.672053	0.311461	2.825684	1.846369	4.633073	0.265787	2.825683797	1.807389
Northern America	49.64836	0.400465	4.61213	0.307466	2.635648	1.976483	4.185309	0.247912	2.480785404	1.704523
Total world	123.9767		15.00047		10.63137	4.369098	15.00047		10.63136805	4.369098

Table 1: Welfare, supply and demand after the introduction of certification in the extended SEM (quantities in 1000 tonnes)

	Receiving									
	Africa		**Latin America**		**Asia & Oceania**		**Europe & Russia**		**Northern America**	
Exporting	Con	Cer	Con	Cer	Con	Cer	Con	Cer	Con	Cer
Africa	0.241977	0.039805				0.068601				
Latin America			1.818979	0.094929		0.066681				
Asia & Oceania					3.109081	0.276231				
Europe & Russia						0.038981	2.82568380	1.807389		
Northern America					0.154862	0.271959			2.480785	1.704523

Table 2: Interregional trade after the introduction of certification in the extended SEM (quantities in 1000 tonnes)

	Welfare	Share in global welfare	Supply	Share in global supply	Supply conventional	Supply certified	Demand	Share in global demand	Demand conventional	Demand certified
Africa	0.727321	0.00579	0.378842	0.025369	0.350173	0.028669	0.311117	0.039939	0.29357	0.017547
Latin America	3.935508	0.031331	1.96815	0.131797	1.576504	0.391646	1.808639	0.17981	1.416994	0.391646
Asia & Oceania	14.81658	0.117956	3.364334	0.225292	2.890742	0.473593	3.991713	0.329708	3.518121	0.473593
Europe & Russia	56.0284	0.446048	4.605558	0.308411	1.869184	2.736374	4.634833	0.213192	1.869184	2.765649
Northern America	50.10298	0.398875	4.616316	0.309131	2.080985	2.535331	4.186898	0.23735	1.66972	2.517178
Total world	125.6108		14.9332		8.767588	6.165612	14.9332		8.767588	6.165612

Table 3: Welfare, supply and demand after GPP of certified wood in Europe &Russia (quantities in 1000 tonnes)

	Percentage change				
	Africa	**Latin America**	**Asia & Oceania**	**Europe & Russia**	**Northern America**
Consumer surplus aggregate demand	0.219046	-0.10698	0.002269	0.000644	0.00076
Consumer surplus price premium certification	-0.67615	4.464612	-0.38343	4.700108	1.232088
Producer surplus aggregate supply	0.169046	-0.01252	-0.01235	-0.02826	0.001816
Producer surplus price premium certification	-0.74652	1.570146	0.757529	0.736095	0.426788

Table 4: Percentage changes in regional consumer and producer surpluses after GPP in Europe & Russia

		Africa	Latin America	Asia & Oceania	Europe & Russia	Northern America
Price of demand	Before GPP	1.350324	1.114706	1.27868	1.273228	1.273228
	After GPP	1.062856	1.279524	1.270266	1.264856	1.264856
Price of supply	Before GPP	0.963743	1.071228	1.071228	1.071228	1.061663
	After GPP	1.062856	1.062856	1.062856	1.052025	1.062856
Price premium demand	Before GPP	0.189605	0.372689	0.187736	0.187585	0.187585
	After GPP	0.27437	0.231055	0.230739	0.230552	0.06953
Price premium supply	Before GPP	0.359352	0.222958	0.222958	0.222958	0.233975
	After GPP	0.27437	0.27437	0.253554	0.287491	0.272799

Table 5: Evolution of demand and supply prices and price premiums (before and after GPP in Europe & Russia). Standardised prices.

	Receiving									
	Africa		**Latin America**		**Asia & Oceania**		**Europe & Russia**		**Northern America**	
Exporting	Con	Cer	Con	Cer	Con	Cer	Con	Cer	Con	Cer
Africa	0.2936	0.0176			0.0566			0.0111		
Latin America			1.4170	0.3917	0.1595					
Asia & Oceania					2.8907	0.4736				
Europe & Russia							1.8692	2.7364		
Northern America					0.4113			0.0182	1.6697	2.5172

Table 6: Interregional trade after GPP of certified wood in Europe &Russia (quantities in 1000 tonnes)

Figures

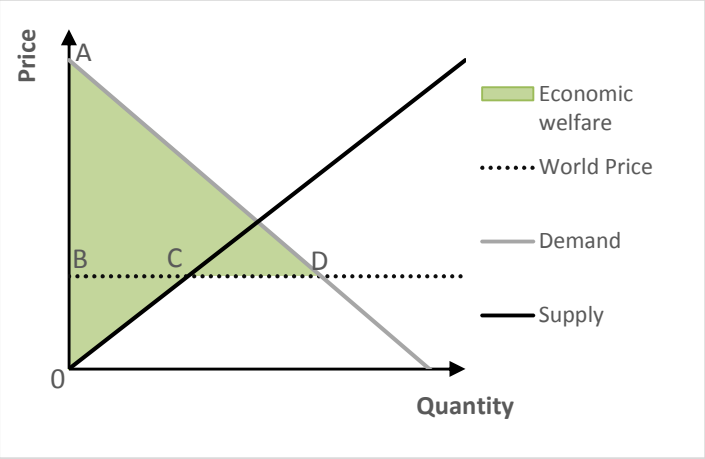

Figure 1: Economic Welfare calculation for an open economy (net-importer)
Economic Welfare = Consumer Surplus + Producer Surplus. Consumer Surplus = area ABD. Producer Surplus = area 0BC

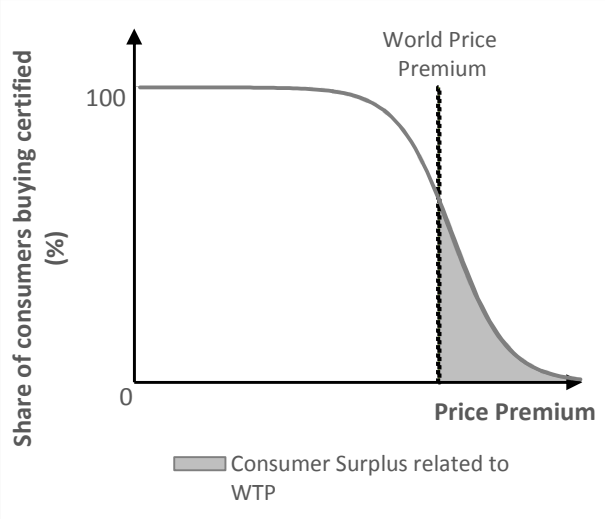

Figure 2: Distribution of the WTP, accompanying share of certified products in total consumption per price premium

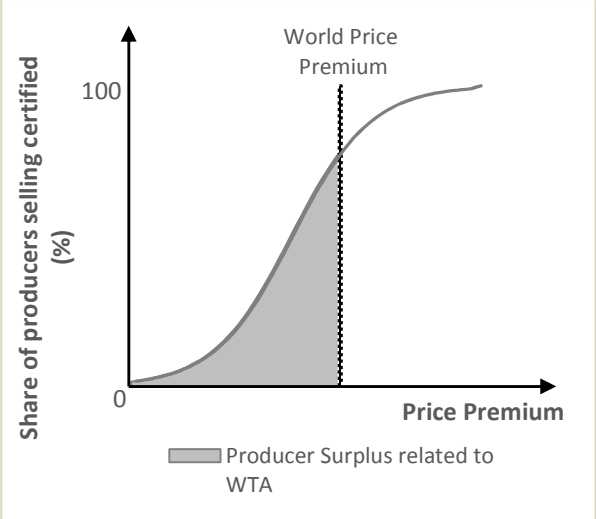

Figure 3: Distribution of the WTA, accompanying share of certified products in total production per price premium

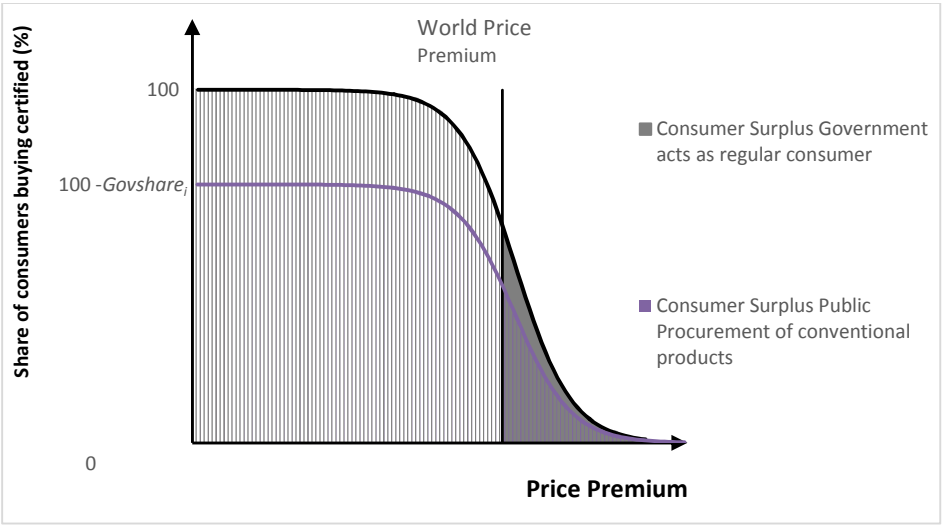

Figure 4: Difference between consumer surplus when the government acts as a regular consumer and when governments only buys conventional products