Analysis of trade in illegally harvested timber: Accounting for trade via third party countries

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A B S T R A C T
The paper presents a model to analyse trade in illegally harvested timber with a particular focus on trade via third party countries. The model is deduced from the conventional input–output-analysis. In contrast to this type of analysis, inverse export coefficients are introduced to analyse the effect of a certain amount of country-specific supply, e.g., of illegally harvested timber, to the use of wood and wood products of all other countries, based on trade relationships. A database has been compiled especially for application of the model. It comprises data on industrial round-wood production in terms of industrial wood harvested and removed from the forest; recovered wood fibre in the form of recovered paper and waste wood; bilateral trade of 272 wood-based commodities in m³ raw wood equivalent (rwe), and domestic use of those commodities. Two scenarios expressing high and low estimates of illegal harvesting for all countries have been employed in the model. The model reveals the trade linkages between all countries of the world and allows quantification of the global supply and use arising from illegal harvesting. Furthermore it allows calculation of the import of illegally harvested timber for each country of the world. And finally, the model likewise allows the quantification of domestic use of illegally harvested timber for each country of the world. The results show that international trade increases the global domestic supply of illegally harvested timber by more than 70% in each scenario. In particular industrial round-wood from Papua New Guinea, Malaysia, Indonesia and Myanmar passes through many countries until it ends in form of finished wood products in the country of final destination. Not only due to suggested illegally harvested timber in the own country, but also due to strongly developed trade relationships, China holds the lead in total supply and use of illegally harvested timber. However this result must be seen against the background of the large population in China. This aspect also helps to explain the predominant position of China, Brazil and Russia with regard to the domestic use of illegally harvested timber. A comparison of import of illegally harvested timber on the basis of “simple” (covering only bilateral trade) and inverse export coefficients demonstrates the model’s merit. The hitherto usually simple approach underestimates the “real” trade by a third up to a half.

1. Introduction

Every year, a huge area of about 13 million ha is deforested worldwide, in particular in the tropical and sub-tropical regions (Food and Agriculture Organization of the United Nations (FAO), 2006, p. xii). Although forests are in most cases burned down, causing significant CO₂ emissions and increasing the problem of climate change (IPCC, 2007, p. 543), harvesting activities often contribute to the process of deforestation. Harvesting activities, even if restricted to the removal of single trees, open the forests for successive deforestation and occupation by a land-seeking rural population (Baumert et al., 2005, p. 91; Geist and Lambin, 2001, p. 24). Due to a lack of governance in many cases (e.g. Selänniemi, 2006, p. 327) the initial harvesting activities are often illegal and not subject to a sustainable forest management plan. The effects for mankind are serious: loss of bio-diversity, loss of carbon storage and desertification are only three outstanding examples.

Several countries, in particular those of the European Union (EU), have committed themselves to combatting the problem of illegal harvesting. The EU, for example, has launched the FLEGT (Forest Law Enforcement, Governance and Trade) action plan. A key element of this action plan is the confinement or possible stoppage of imports of illegally harvested timber (European Union (EU), 2005). Beyond appropriate activities to improve the overall legal framework in the respective partner countries, policy-makers need information about the extent of illegal harvesting and its significance in the European and national markets, respectively. One of the basic challenges is the...
identification of illegally harvested timber and its tracing through the international wood trade to its final destination. Tackling this challenge raises three crucial issues: (i) definition of legality, (ii) identification of illegally harvested timber and its share in trade and (iii) coverage of trade via third party countries.

With the following paper, a model is presented to solve the problem of trade via third party countries. Provided that the share of illegally harvested timber is known, the model's application to world trade in wood and wood-based products including pulp, paper and paper products (herein after called wood and wood products) allows the import of illegally harvested timber to be determined for all countries. Since many countries are considerable exporters as well as importers, import should be offset by export in order to result in consumption of illegally harvested timber. By means of the presented model, the consumption of illegally harvested timber can also be determined for all countries. However, it should be highlighted already at this point that the results rely extensively on the quality of input data.

2. Material studied

Up to now there is no harmonized definition of illegal harvesting. The common denominator is harvesting without permission (licence), and harvesting exceeding permission with regard to volume, region or tree species. Logging rights obtained, for example, through corruption, are regarded as illegal by most parties concerned as well. Beyond this rather common understanding there are also authors and organisations, in particular nature conservation organisations, which define illegal harvesting much more generally. Their definition of illegality comprises all activities of processing, transporting and trading activities which violate governing law (FERN et al., 2004, p. 5; WWF, 2008a; for a comprehensive survey on definitions see Ottitsh et al., 2004, p. 11). Such a broad definition would even include timber transported by a lorry without technical approval. Obviously this broader definition detracts from the basic problem: degradation of forests and deforestation. The application of such general definitions results in illegal harvesting figures which overestimate illegal harvesting in terms of the actual meaning of the word: harvesting activities which do not conform to governing law.

Figures indicating the probable share of illegally harvested timber of all harvested timber volume exist for many countries. However, in most cases it is not possible to trace the figures back to the original studies and therewith to the applied methodology. In particular non-governmental organisations tend to copy from each other without verifying and disclosing the data sources. Reviewable methods and results on illegal logging exist for only a few countries, such as, for example, the analysis for Indonesia by Palmer (2001), for Russia by Ottitch et al. (2005) or the most recent study on Ghana by Hansen and Treue (2008). The most common method applied is material balancing. It is based on the hypothesis that a gap between the overall use of timber in a country and the overall supply can be explained by illegal harvesting. Overall domestic supply can be derived from official harvesting statistics (e.g. Ottitch et al., 2005, p. 29; Palmer, 2001, p. 6) as well as from officially endorsed harvesting allowances (Hansen and Treue, 2008, p. 577). Although the logic of this approach is convincing, one should keep in mind that other causes for such a gap may exist as well, e.g., shortcomings in the national harvesting statistics (for Germany see Dieter and Englert, 2005, p. 2 f.). Methodological alternatives to material balances are, e.g., surveys among key workers (Richards et al., 2003) or among border control authorities (INDUFOR, 2004).

The most recent and comprehensive survey on estimated shares of illegally harvested timber is provided by Li et al. (2008, p. 482 f.). They present low and high estimates for each country of the world and with it the spanning of a global estimate frame for illegally harvested timber. Most of the estimates originate from the comprehensive study on illegal logging and global wood markets by Seneca Creek Associates (2004). Where necessary, Li et al. (2008) supplemented Seneca Creek Associates' data with some other authors' estimates, e.g., Miller et al. (2006) and Contreras-Hermosilla et al. (2007).

In contrast to information on illegal harvesting, estimates on trade with illegally harvested timber hardly exist. Due to the lack of accurate data there is a common agreement in assuming that the share of illegally harvested timber in total harvests equals the share of trade in illegally harvested timber in total wood trade. This proportionality assumption is rather rough. It does not allow for a differentiation by products manufactured predominantly from natural forests and those manufactured predominantly from, e.g., plantation trees. In the case of Brazil this is crucial: pulp accounts for a significant share of the Brazilian wood product exports but it is predominantly produced from plantation trees.

As, for example, Dieter and Englert (2006) show, international trade with wood and wood products is rather complex. There are trade relationships between many countries at different levels of processing. Countries show inter-industry as well as intra-industry specialization. The existing linkages in trade raise the problem that trade via third or fourth-party countries, etc., can be hardly traced back to the origin of trade, which is the place where the timber has been harvested. This implies that the more intensive international trade with wood and wood products is, the lower the bilateral trade figures between countries suspected of illegal harvesting and a focus country represent the real import of illegally harvested timber. Up to now most investigations only cover bilateral trade. No comprehensive method for the full coverage of trade in illegally harvested timber via third party countries has been presented in respective studies. Some approaches at least included trade within a cluster, e.g., the EU (WWF, 2008b), but still on a very global level (overall imports without subdivision into trade between member states).

Although various timber market models exist on the national and international level, only a few have been employed to analyse trade in illegally harvested timber. Li et al. (2008) estimate the effects of progressive elimination of illegal logging on the world markets in terms of prices, production and trade volumes but they do not specifically account for the trade in illegally harvested timber among individual countries. Furthermore their model stops at the semi finished product level which would be a shortcoming for the present question since trade, in particular with tropical timber, has for many years shifted continually towards trade in finished wood products. Other studies on this topic analyse only the trade between individual countries. Ottitch et al. (2005), e.g., assess the possible impacts of reductions in the trade of wood of unknown origin from the Russian Federation to the European Union. But they confine the trade analysis to round-wood and sawn-wood, too.

3. Methodological approach

The method for accounting for trade in illegally harvested timber via third party countries is deduced from the input–output-analysis. The input–output-analysis can be attributed to its so-called “father,” Leontief (1936). He analysed inter-industrial relationships of the American economy and could detect not only the direct relations but also the indirect, invisible but real relations, between the sectors (Holub and Schnabel, 1994, p. 30). Meanwhile the input–output-analysis is a common analytical instrument, in particular for practical economic policy. A standard application of the input–output-analysis is the question about the relation between a marginal final use of the products of a certain sector and the corresponding supply of all other sectors, based on inter-industrial relationships. In contrast to this question the problem to be solved in the present study is as follows: what is the relation between a certain amount of a country's supply, e.g., of illegally harvested timber, and the use of all other countries, based on trade relationships? Before presenting the proposed method a crucial assumption shall be pointed out: proportionality in the share
of illegally harvested timber in domestic use and exports. The input–output-analysis requires such a proportionality assumption. However, its theoretical justification is considerably weaker than the justification of the general assumption of input–output-proportionality for a whole economy.

The conventional input–output-analysis has to be adjusted to solve this question. As the fundamental difference, input and output axes are changed in the present case. Another difference is that the input–output-table is built on data on global production, trade and consumption of wood and wood products (Fig. 1). Quadrant I represents the trade flows between the countries, Quadrant II the domestic supply of wood fibre of each country, and Quadrant III the domestic use. In the next step, trade linkages are analysed according to the input–output-model. In contrast to the conventional input–output-analysis, we have to compute the export coefficients to put the table into a matrix-syntax. The export coefficients represent the share of country j’s exports to country i, referred to total use of country j. Since total use equals total supply we can write:

\[
\begin{bmatrix}
  x_{11} & x_{12} & x_{13} & \ldots & x_{1n} \\
  x_{21} & x_{22} & x_{23} & \ldots & x_{2n} \\
  x_{31} & x_{32} & x_{33} & \ldots & x_{3n} \\
  \vdots & \vdots & \vdots & \ddots & \vdots \\
  x_{n1} & x_{n2} & x_{n3} & \ldots & x_{nn}
\end{bmatrix}
\begin{bmatrix}
  q_1 \\
  q_2 \\
  q_3 \\
  \vdots \\
  q_n
\end{bmatrix}
= \begin{bmatrix}
  d_1 \\
  d_2 \\
  d_3 \\
  \vdots \\
  d_n
\end{bmatrix}
\]

(1)

with

\[
x_q = \text{export coefficients of country } j, \text{i.e. } t_j/q_j \text{ (see Fig. 1)}
\]

\[
q_i = \text{total use} = \text{total supply of country } i
\]

\[
d_i = \text{domestic supply of country } i
\]

or in vector syntax

\[
Xq + d = q
\]

(2)

\[
\equiv d = q - Xq
\]

(3)

\[
\equiv d = (I - X)q
\]

(4)

\[
\equiv q = (I - X)^{-1}d
\]

(5)

With (5) we result in an equation which allows computation of the effect of a certain quantity of domestic supply in one country i to the total supply, and, respectively, use in each other country. Ceteris paribus, the increase in total supply for every country unlike i is due only to the trade linkages. So, Eq. (5) gives the relationship between the supply in one country of the world and the imports of all other countries. Disclosing this relationship is the main advantage of the chosen input–output-approach. A simple open model (input–output-model type 1) was applied because (positive) repercussions between imports and domestic supply cannot be argued. There is no indication that an increase in a country’s import of wood and wood products proportionally increases the domestic supply of wood, recovered paper or waste wood. A partly closed model (input–output-model type 2) would be appropriate only if this proportionality assumption were valid.

Referring the model to our problem, trade in illegally harvested timber, we can focus on those quantities harvested illegally in each country, and zero legally harvested timber as well as supply of recovered paper and waste wood. Vector d then contains the quantity of illegally harvested timber and the coefficients of matrix \((I - X)^{-1}\) allow the determination of the imports of illegally harvested timber for each country. A fictive numerical example (Fig. 2) shall illustrate interpretation of the coefficients. For the sake of clarity, the world is reduced to five countries in the example. Transforming the supply according to Eq. (1) and applying the vector algorithms according to Eqs. (2)–(5), we result in \((I - X)^{-1}\) as shown in the core of Fig. 3. The coefficients shall be interpreted by a very simple example: there is only illegal harvesting in country M, amounting to 1 unit. In this example, e.g., import-induced total supply of country D rises by 0.045 units. Due to trade linkages, the total supply in country M itself grows by 1.021 units. The global supply of all countries rises by 1.137 units (column sum of country M and, in this special case, of total supply). A comparison of the countries’ column sums shows that global supply would be at maximum if country F rather than country M would be the producer of the 1 unit illegally harvested timber. This is due to the much higher export share of country F compared to country M. In the context of this example, the row sum would be a rather theoretical figure and hence is not shown. It would indicate a country’s increase in total supply if every country increased illegally harvested timber up to 1 unit.

It is obvious that intensifying trade will lead to an increase in imports even if there is no increase in wood harvests. Hence, an increasing import of illegally harvested timber must not be interpreted as anything else but an increasing import. It is not an indication for increasing illegal harvest. In this regard, analysing the consumption instead of the import of illegally harvested timber could be rewarding from an importing country’s perspective. For this purpose we have to define s, as the share of domestic use in reference to total use of country i. Multiplying the share of domestic use \((s_j)\) with the total use \((q_j)\) of country i leads to the consumption of illegally harvested timber. Accordingly, the overall sum of illegally harvested timber \(d\) (sum of values building d) finds its counterpart on the global consumption side with the following multiplication:

\[
d = s^Tq
\]

(6)

Applied to the example in Fig. 2, \(s^T\) results in the figures in the upper footer of Fig. 3. Multiplying total supply by domestic use share

\[
\begin{array}{cccccc}
\text{Supply} & \text{Import from country / Exporters (i)} & \text{Domestic supply} & \text{total supply} \\
\hline
\text{Use} & 1 & 2 & 3 & \ldots & n & h & r & w & q_1 \\
1 & t_{11} & t_{12} & t_{13} & \ldots & t_{1n} & h_1 & r_1 & w_1 & q_1 \\
2 & t_{21} & t_{22} & t_{23} & \ldots & t_{2n} & h_2 & r_2 & w_2 & q_2 \\
3 & t_{31} & t_{32} & t_{33} & \ldots & t_{3n} & h_3 & r_3 & w_3 & q_3 \\
\vdots & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots & \vdots & \vdots & \vdots \\
N & t_{n1} & t_{n2} & t_{n3} & \ldots & t_{nn} & h_n & r_n & w_n & q_n \\
\hline
\text{Domestic use} & u_1 & u_2 & u_3 & \ldots & u_n \\
\text{total use} & q_1 & q_2 & q_3 & \ldots & q_n
\end{array}
\]

Fig. 1. Global production, trade and consumption of wood and wood products, formed into an input–output-table. \(t = \text{bilateral trade}\), \(h = \text{harvested wood}\), \(r = \text{recovered paper}\), \(w = \text{waste wood}\), \(u = \text{domestic use}\), and \(q = \text{total supply}\) total use of country.
for each country leads to the specific domestic use of the regarded 1 unit (lower footer in Fig. 3), which logically sums up to 1. In the presented example, the 1 unit illegally harvested timber is for the most part used domestically by the producing country M. Although import linkages increase the total supply, e.g., of country D by 0.045 units, domestic use only grows by about half, or 0.024 units.

4. Empirical database

Two main data sources have been employed for coverage of supply and use of wood and wood products: trade data have been taken from the UN Comtrade database (United Nations, 2009a) and domestic wood supply data are derived from the FAO database (Food and Agriculture Organization of the United Nations (FAO), 2009). Domestic use of wood and wood products is computed by deducting exports from a country’s total use. The analysis was conducted for the year 2005 as the most recent data is available for this year.

The UN Comtrade database is applied in its classification according to the Harmonized System, an internationally standardized system with a six digit nomenclature. UN Comtrade comprises bilateral trade data in both, physical and monetary terms. For the purpose of the present study we refer to the physical values. All trade with wood and wood products is included, i.e., in particular round-wood, sawn-wood, wood-based panels, further processed wood products (Chapter 44, of the Harmonized System), furniture from wood and wood buildings (parts of Chapter 94) as well as pulp (Chapter 47), paper and paperboard and products from those (Chapter 48) and printed matter (Chapter 49). In addition some sub-positions representing regenerated cellulose (parts of Chapters 39, 54 and 55) are included also. In total, trade with wood and wood products is represented by 272 commodity groups on the six digit level.

The physical values of the 272 commodity groups are recorded in different units, in particular in m³, kg or pieces. In order to allow the aggregation of the traded volume of wood and wood products, the original units have been converted into m³ raw wood equivalent (rwe) as a common unit. The m³ rwe factors express the volume of raw wood needed for the production of one unit of the regarded commodity. Up to now there are no internationally agreed-upon m³ rwe factors available. For this reason the m³ rwe factors used for the German timber balance reports (e.g., Dieter, 2007) are applied. They exist as factors on the eight digit level of the Combined Nomenclature. The six digit conversion factors are computed as an average of the respective eight digit factors. In most cases they refer to kg, in some to m³. There are no factors referring to pieces.

UN Comtrade data are not recorded in all cases in (appropriate) physical values. In these cases trade in m³ rwe is estimated on the basis of the monetary values. In the case of individual bilateral trade only, flows are recorded without physical values, a world average factor m³ rwe/1000 USD is computed on the basis of all other recorded trade flows and applied to the respective monetary trade value. In case there are no appropriate physical values (kg or m³) for a certain commodity group at all (3% of the cases) the relation m³ rwe/1000 USD is calculated according to German foreign trade structure and applied to the global trade figures. In order to exclude outliers in both cases, the average is computed as a 70% trimmed mean, which implies that the upper and the lower 15% of the factors m³ rwe/1000 USD are discarded.

135 countries attend to UN Comtrade data base as reporting countries. The bilateral trade between these countries accounts for 90–95% of the overall global trade (United Nations, 2009b). However, comparison of import and export physical values reveals data shortcomings. In several cases the same trade flow is reported in a different amount by the importing and the exporting country. Costs, insurance and freight cannot help to explain these differences with regard to physical values. A potential reason for this finding is different reporting thresholds in the countries. The reported imports are preferred due to the fact that tariffs and taxes are usually imposed on imports, and hence countries should have a vital interest in the best possible import recording. Beyond trade among the 135 reporting countries (Quadrant I in Fig. 4) there is also trade among non-reporting countries (Quadrant II and III in Fig. 4) and among non-reporting countries only (Quadrant IV in Fig. 4). All trade involving at least one reporting country is covered by UN Comtrade. Trade among non-reporting countries only is not included in the data base. However, its relevance is rather low, as the representation of Quadrant I (90–95%, see above) indicates.

Domestic wood supply data are derived from the FAO database. They comprise produced round-wood in terms of wood harvested and removed from the forests and recovered wood fibre. The analysis is confined to industrial round-wood since trade with fuel-wood is negligible, and estimates on illegally harvested fuel-wood are not available. Recovered paper is a separate category of the FAO database, given in tons. In contrast, waste wood is not a separate sub-category of the FAO database, but mixed together with other wood residues from industrial wood processing exclusive of wood chips and particles. There are no reliable indications about the share of waste wood in the category wood residues for most of the countries of the world. For Germany, e.g., FAO data for wood residues corresponds quite well with national estimates on recovered waste wood. Therefore the entire amount of wood residues is taken as recovered wood waste in
the following calculations, bearing in mind that this might be an overestimation for some countries.

To some extent, the combination of different data sources offers the opportunity to check the datasets, which in some cases requires an adjustment. If necessary, trade adjustments were conducted on basis of specific databases, i.e., Eurostat and FAO trade data. Furthermore the final domestic use of wood and wood products is used for verification in terms of per capita use of wood and wood products for each country. In 10 cases negative use values occurred. Since statistical recording of harvested wood is considered less exact compared to trade data, harvested wood figures are adapted so that per capita use of wood and wood products reaches 0.05 m³ rwe. This is the order of magnitude of regionally comparable countries of those 10 countries with negative use values.

Li et al. (2008) present estimated shares of illegally logged industrial round-wood subdivided into saw-logs and pulpwood. Since in the present study no distinction is made, the illegality share estimates for both industrial round-wood products were merged together weighted by their production quantity in the respective country. The illegality share estimates refer to a rather narrow definition of illegality as “theft of timber or logs, cutting in parks, reserves or similar areas, and cutting where government approvals are obtained by corrupt practices” (Seneca Creek Associates, 2004, p. 4).

5. Results

Before trade in illegally harvested timber is analysed, a very brief description of the global supply and use of wood and wood products shall be provided. Global industrial round-wood production amounts to 1756 million m³; in the case of round-wood it is equal to the value in m³ rwe. Due to a rather less developed global recycling culture, the global supply of recovered fibre is clearly lower than round-wood production. Recovered paper accounts for the majority of recovered fibre. Converted into m³ rwe it adds up to 519 million m³ rwe. 187 million m³ rwe waste wood was recovered globally in the year 2005. The overall trade with wood and wood products amounts to 1716 million m³ rwe. Trade holds a share of 41% as referred to the global supply and use of wood and wood products, amounting to 4177 million m³ rwe. Applying the low and high estimates for illegally harvested timber from Li et al. (2008) to each country, illegal logging adds up to 115 (low) to 222 (high) million m³ rwe, which is 7% (low) and 13% (high), respectively, of the global industrial round-wood production.

Analysis of trade in illegally harvested timber was conducted according to Eq. (5) and on basis of the specified data. The results of both scenarios, application of the high and low share of illegally harvested timber, are shown in Fig. 5. Their structure corresponds with the structure of the example in Fig. 3. Since data for 234 countries are analysed, and the resulting 234 × 234 matrix is not presentable in the whole, the presentation in Fig. 5 is confined to the 27 countries with the highest total supply/use of illegally harvested timber. They account for 80% of the global total supply/use and 78% of the global domestic use.

Regarding the effects of 1 unit illegally harvested timber on the global total supply/use (column sum), Papua New Guinea is at the top. Due to trade relationships, global total supply/use rises by 2.2 units. Malaysia (2.1), Indonesia (2.0) and Myanmar (1.9) follow closely. These figures indicate that industrial round-wood from those countries passes through many other countries until it ends in the form of finished wood products in the country of final destination. The total supply must be discussed (second and third column of Fig. 5) with regard to the effects of not only 1 unit, but of the estimated real illegally harvested timber volume. China faces the highest total supply/use of illegally harvested timber, not only due to illegally harvested timber in the own country but also due to intensive trade relationships. In the high estimates scenario it amounts to 69 million-

m³ rwe and in the low estimates scenario to 39 million m³ rwe. China is followed by the Russian Federation (36 and 25 million m³ rwe, respectively) and Indonesia (36 and 22 million m³ rwe, respectively). Brazil reaches a superior position in the “high” scenario (38 million m³ rwe) but only an inferior position in the “low” scenario (3 million m³ rwe) because of strongly differing high and low illegal harvest estimates. Among the countries with zero estimates for illegally harvested timber, the United States show the highest total supply/use of illegally harvested timber (15 m³ rwe). Japan (13 million m³ rwe) and Germany (6 million m³ rwe) follow. Altogether international trade increases the domestic supply of illegally harvested timber by more than 70% in each scenario.

In the next step, the domestic use of illegally harvested timber shall be regarded. 22 of the 27 countries with the highest total supply/use are also major domestic users of illegally harvested timber. In many cases their range doesn’t change very much in descending order. China, Brazil and the Russian Federation are the top users of illegally harvested timber due to their high domestic use shares. Thus these three of the four so-called BRIC countries are distinguished from other countries through their (i) high domestic supply, (ii) high total supply/use and (iii) high domestic use of illegally harvested timber. However this result must be seen against the background of the high population in these three countries. They are followed by the United States and Japan which account for more than 10% of the global domestic use. Against its rather high position in total supply/use, Germany drops down in domestic use of illegally harvested timber, accounting for only 1.1% of the global value.

To evaluate the merit of the presented model, the “simple” export coefficients (covering bilateral trade) of the countries suspected of illegal harvesting can be compared with the inverse coefficients (covering trade via third party countries as well). A direct comparison of all individual coefficients is not feasible, however, because of their high number. Since the “simple” export coefficients determine the import of the partner countries and the import of illegally harvested timber is the main focus of the respective studies, import of illegally harvested timber calculated on base of the “simple” and inverse coefficients shall be compared. Multiplying the export coefficients (row vector) by the volume of illegally harvested timber (column vector) for each (importing) country results in the import of illegally harvested timber based on the “simple” coefficients. The import of illegally harvested timber based on the inverse coefficients is calculated by subtracting the volume of illegally harvested timber from total supply/use for each country.

It can be stated that for most of the 27 selected countries, the ratio of imports calculated by inverse coefficients to imports by “simple” coefficients is about 1.5 to 2 (Fig. 6). A coefficient of 2 means that the bilateral trade only accounts for half of the “real” import and thus underestimates the “real” trade in illegally harvested timber. For individual countries like Indonesia, the ratio is even much higher.

6. Conclusion

The presented model allows an accounting of trade in illegally harvested timber via third party countries, and hence proves to be a helpful instrument in answering some key questions with regard to this topic. Firstly, it reveals the trade linkages between all countries of the world and thus allows quantification of the global supply/use arising from illegal harvesting. Secondly, it likewise allows a calculation of the import of illegally harvested timber for each country of the world. In this context, the model’s merit has been quantified compared with the hitherto usual approach. And thirdly, domestic use of illegally harvested timber can be quantified as well. This can be seen as an important result of the model because both imports and consumption are key figures in political discussions. A restriction on imports seems not to be appropriate since the overall import of illegally harvested timber increases with more intensive
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<th>Country</th>
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<th>Low Harvest Estimate</th>
<th>Trade Coefficient</th>
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Fig. 5. High and low illegal harvest estimates, inverse trade coefficients and resulting total supply and domestic use of the 27 countries with the highest total supply/use of illegally harvested timber.
An UNECE/FAO workshop between wood supply and wood consumption in the EU/EFTA region has been dedicated to these data gaps and the empirical research has not been not revealed for many studies, the results should not be taken as exact estimates. Finally, the definition issue and the sensitivity of the results to the respective definition of illegality must be considered.

7. Discussion

The study is dedicated to a global problem with various long-lasting effects on mankind: losses of forests due to illegal harvesting. The amount of illegally harvested timber which an individual country imports and uses domestically is, in addition to integration into world trade, subject to the estimates of the amount of illegally harvested timber. One key factor on these estimates is the definition of illegality. The definition used by Seneca Creek Associates (2004, p. 4), and thus underlying the present study, is rather narrow, but broader definitions exist as well and other studies refer to them. As part of a critical discussion, the implication of a consequent transfer of a broader definition to all kind of trade should be touched. There is a significant permanent violation of laws in industrialized countries also. The underground economy share in 21 OECD countries of about 16.7% related to gross national income (Schneider, 2003, p. 53), shows the violation dimension, e.g., with regard to work and tax laws. Obviously a transfer of the high moral standard applied to the products of the wood-working industry to all traded products could easily terminate international trade. However, such a transfer is not projected. Hence, given the existing initiatives to stop imports of illegally harvested timber (e.g. FLEGT), reference to a broader definition (covering any kind of illegality in the wood-working industry and hence requiring legality certification for all steps of further wood processing) would result in a distortion of the competitive position of timber products compared with products made from other competing materials. This should be kept in mind when discussing appropriate definitions on political level.

As an outlook it can be stated that it would be worthwhile to further develop the presented model and the underlying database to better take into account country-specific features like import restrictions for wood products suspected to be of illegal origin, or unequal representation of legal and illegal wood products in production and export. For this purpose methodological adjustments would be needed with regard to a stepwise calculation of supply and use of

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**Fig. 6.** Ratio of imports of illegally harvested timber calculated by inverse coefficients to imports by “simple” coefficients for the selected 27 countries; illegally harvested timber according to a high and a low estimate, respectively.
wood and wood products on different processing levels. Such a refinement requires a much more specific database with regard to the individual countries’ import and export policies and wood processing and consuming features. Establishing this specific database would be a project on its own.

References


WWF, 2008b: Illegaler Holzeinschlag und Deutschland. WWF, Frankfurt am Main.