Supplementary tables for the paper entitled:

A network analysis of the global cephalopod trade

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Supplementary tables

**Supplementary Table S1** – United Nations COMTRADE Harmonized System Codes and code descriptions that include octopuses, cuttlefish, and squids.

| Species            | Presentation | Code(s)   | Description                                                                 |
|--------------------|--------------|-----------|-----------------------------------------------------------------------------|
| **Octopuses**      | live         | 030751    | Molluscs; octopus (octopus spp.); live, fresh or chilled                   |
|                    | elaborated   | 030752    | Molluscs; octopus (Octopus spp.); frozen, dried, salted, in brine, or smoked, cooked or not before or during the smoking process |
|                    |              | 030759    |                                                                             |
|                    |              | 160555    |                                                                             |
| **Cuttlefish and squids** | live       | 030741    | Molluscs; cuttle fish and squid, whether in shell or not, live, fresh or chilled |
|                    |              | 030742    |                                                                             |
|                    | elaborated   | 030743    | Molluscs; cuttle fish and squid, whether in shell or not, includes flours, meals, and pellets of molluscs, fit for human consumption, frozen, dried, salted, in brine, or smoked, cooked or not before or during the smoking process |
|                    |              | 030749    |                                                                             |
|                    |              | 160554    |                                                                             |
**Supplementary Table S2** – Measures of centrality, definitions, and rationales in a context of a global trade network. See references for additional information.

| Measure       | Reference                | Formal definition and equation | Plain language definition                                                                 | Rationale in a global trade market                                                                 |
|---------------|--------------------------|--------------------------------|------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|
| Strength      | Barrat et al., 2004; Squartini et al., 2013 | The Strength of a node \( i \) is defined as the sum of the weights of the in-coming links and the weights of the out-going links. \[
\text{strength}_i = \sum_{j \neq i} w_{ij} + w_{ji}
\]
where:
- \( w = \) weighted matrix
- \( w_{ij} = \) weight of the directed link from node \( i \) to node \( j \)
- \( w_{ji} = \) weight of the directed link from node \( j \) to node \( i \) | Also named weighted degree. The node degree is the number of relations (edges) of the nodes. In weighted networks, node Strength is the sum of weights of links connected to the node. | Strength could indicate if a trader is involved in important (by weight) trades with other traders. Traders with high Strength can be acting as keystones since they are connected by imports and exports to many neighbouring traders. |
| In-strength   | Squartini et al., 2013   | The In-strength of a node \( i \) is defined as the sum of the weights of the in-coming links. \[
\text{In} - \text{strength}_i = \sum_{j \neq i} w_{ij}
\]
where:
- \( w = \) weighted matrix
- \( w_{ij} = \) weight of the directed link from node \( i \) to node \( j \) | In directed networks, the In-strength is the sum of inward link weights. | Traders with a high In-strength could act as important importers or hubs for the distribution of raw materials. High In-strength could also be targeting traders acting as major consumers of products. |
| Out-strength  | Squartini et al., 2013   | The Out-strength of a node \( i \) is defined as the sum of the weights of the out-going links. \[
\text{Out} - \text{strength}_i = \sum_{j \neq i} w_{ji}
\]
where:
- \( w = \) weighted matrix
- \( w_{ji} = \) weight of the directed link from node \( j \) to node \( i \) | In directed networks, the Out-strength is the sum of outward link weights. | Traders with high Out-strength may be acting as raw producers with high export flows. This may indicate the geographical origin of the commodities and essential habitats for the species. Out-strength can also indicate whether a trader is a major exporter of processed products. |
| Network Measure | Author(s) | Description | Equations |
|-----------------|-----------|-------------|-----------|
| Closeness centrality | Freeman, 1979 | indicates how close a node is to all other nodes in the network. It is calculated as the average of the shortest path length from the node $i$ to every other node in the network. | $C_i = \frac{1}{N-1} \sum_{j=1, j \neq i}^{N} \frac{1}{d_{ij}}$ |
| Betweenness centrality | Freeman, 1979 | is calculated with the number of shortest paths (between any couple of nodes in the networks) that go through the target node $i$. The score is moderated through the total number of shortest paths between any pair of nodes in the network. The target node will have a high betweenness centrality if it appears in many shortest paths. | $B_i = \frac{1}{(N-1)(N-2)} \sum_{s,d=1, s \neq d \neq i}^{N} \frac{\sigma_{sd}(i)}{\sigma_{sd}}$ |
| Edge betweenness centrality | Girvan and Newman, 2002 | is a measure of the centrality of an edge in a network based on the number of shortest paths through the given edge. | $EB_e = \sum_i \sum_j \frac{\sigma_{ij}(e)}{\sigma_{ij}}$ |

$\sigma_{ij}$ = number of shortest paths between nodes $i$ and $j$

$\sigma_{ij}(e)$ = number of shortest paths between $i$ and $j$ that go through the edge $e$

Traders with a higher closeness centrality have a high probability of exporting to the nearest neighbouring traders. These traders could be important in trade at regional or continental geographic scales.

Traders with high Betweenness centralities have been called "bottlenecks" or "bridges" and prevent network fragmentation. A trader that acts as a bridge between two well differentiated groups of traders usually has a high Betweenness.

An edge with a high edge betweenness centrality score represents a bridge-like connector between two countries or territories in the global market, and whose removal may affect the flow of goods between many pairs of partners through the shortest paths between them.
| PageRank | Brin and Page 1998[^1] |
|----------|-----------------------|
| A variant of Eigenvector Centrality, primarily used for directed networks. PageRank considers (1) the number of in-coming links (i.e., nodes that link to a target node), (2) the quality of the linkers (i.e., the PageRank of nodes that link to the target node), and (3) the link propensity of the linkers (i.e., the number of nodes the linkers link to). |
| Algorithm developed by Larry Page and Sergey Brin, founders of Google. PageRank works by assigning importance to a webpage (node) if important pages (other nodes) point to it. |
| The most important traders are likely to import more products from other traders in the network. The approximate estimation of the importance of a trader is based on the number and quality (weight) of the links pointing to it. It indicates the trading relevance of the country providing the goods to another country. |

\[
PR_i = 1 - \alpha + \alpha \left( \frac{PR_{t1}}{C_{t1}} + \ldots + \frac{PR_{tn}}{C_{tn}} \right)
\]

where:
PR(i) = PageRank of a node i;
\(\alpha\) = factor (estimated to be 0.85)
PR_{t1} to PR_{tn} = PageRank of nodes linking to i
C_{t1} to C_{tn} = number of outgoing links in those nodes
Supplementary Table S3 – International merchandise trade information of octopus for the period 2000-2019 downloaded from United Nations COMTRADE Database. Annual values and net weights (M USD and kg, respectively) for exports by presentation (1) live, fresh and chilled and (2) elaborated, (i.e., frozen, dried, salted or in brine) and country or territory, summarized by five-year periods are showed.

| period       | Octopus live, fresh or chilled |          | Octopus elaborated |          |
|--------------|--------------------------------|----------|--------------------|----------|
|              | Exporter | M USD | Exporter | kg    | Exporter | M USD | Exporter | kg    |
| 2000-2004    | VNM      | 165492 | CHN      | 61977 | MAR      | 1509626 | MAR     | 355718 |
|              | CHN      | 125446 | VNM      | 52940 | MRT      | 547059  | CHN     | 177555 |
|              | PRT      | 36880  | IND      | 7552  | ESP      | 526166  | ESP     | 128029 |
|              | ESP      | 25351  | ESP      | 6955  | CHN      | 433574  | MRT     | 117092 |
|              | FRA      | 18258  | PRT      | 6452  | PHL      | 238368  | VNM     | 102808 |
| 2005-2009    | CHN      | 224653 | CHN      | 71875 | MAR      | 1600080 | MAR     | 236282 |
|              | ESP      | 72799  | VNM      | 20486 | MRT      | 911619  | CHN     | 185217 |
|              | VNM      | 70659  | ESP      | 13781 | ESP      | 871620  | MRT     | 146930 |
|              | PRT      | 68774  | PRT      | 10415 | CHN      | 622088  | ESP     | 144553 |
|              | FRA      | 22882  | IND      | 6260  | VNM      | 436858  | VNM     | 139051 |
| 2010-2014    | CHN      | 304046 | CHN      | 51895 | MAR      | 1850608 | MAR     | 256312 |
|              | ESP      | 103437 | ESP      | 17826 | MRT      | 1484975 | CHN     | 214459 |
|              | PRT      | 96371  | PRT      | 15619 | CHN      | 1233304 | MRT     | 213771 |
|              | FRA      | 26564  | FRA      | 4451  | ESP      | 814462  | VNM     | 129484 |
|              | ITA      | 20936  | THA      | 2885  | VNM      | 604109  | ESP     | 112463 |
| 2015-2019    | CHN      | 505596 | CHN      | 43905 | MRT      | 3673373 | MRT     | 420049 |
|              | ESP      | 131605 | ESP      | 17145 | MAR      | 3236167 | MAR     | 355753 |
|              | MAR      | 72622  | MAR      | 10461 | CHN      | 2324771 | CHN     | 339201 |
|              | PRT      | 62804  | PRT      | 9379  | ESP      | 1867819 | VNM     | 246433 |
|              | THA      | 36102  | THA      | 5821  | VNM      | 1632688 | ESP     | 209583 |
**Supplementary Table S4** – International merchandise trade information of octopus for the period 2000-2019 downloaded from United Nations COMTRADE Database. Annual values and net weights (M USD and kg, respectively) imports by presentation (1) live, fresh and chilled and (2) elaborated, (i.e., frozen, dried, salted or in brine) and country or territory, summarized by five-year periods are showed.

| period          | Octopus live, fresh or chilled | Octopus elaborated |
|-----------------|-------------------------------|--------------------|
|                 | Importer | M USD | Importer | kg  | Importer | M USD | Importer | kg  |
| 2000-2004       | KOR      | 175704| KOR      | 77741| JPN      | 1553028| JPN      | 371690|
|                 | JPN      | 74740 | JPN      | 23836| ESP      | 784420 | ITA      | 216423|
|                 | ITA      | 52451 | ITA      | 17896| ITA      | 770489 | KOR      | 188493|
|                 | ESP      | 51094 | ESP      | 12033| KOR      | 325354 | ESP      | 160514|
|                 | DEU      | 13466 | USA      | 3783 | USA      | 282802 | USA      | 91573 |
| 2005-2009       | KOR      | 260707| KOR      | 81405| JPN      | 1431980| ITA      | 257271|
|                 | ITA      | 84522 | ITA      | 19921| ESP      | 1270921| JPN      | 244071|
|                 | ESP      | 81187 | ESP      | 14582| ITA      | 1268764| KOR      | 229791|
|                 | PRT      | 27986 | JPN      | 6452 | KOR      | 607200 | ESP      | 197773|
|                 | JPN      | 22255 | PRT      | 5426 | PRT      | 367077 | USA      | 97058 |
| 2010-2014       | KOR      | 323381| KOR      | 55243| JPN      | 2717785| JPN      | 357586|
|                 | ITA      | 103908| ITA      | 17376| ESP      | 2161674| KOR      | 321149|
|                 | ESP      | 88137 | ESP      | 15171| ITA      | 1768354| ESP      | 308557|
|                 | PRT      | 30493 | PRT      | 6197 | KOR      | 1419080| ITA      | 285916|
|                 | FRA      | 11659 | THA      | 2531 | PRT      | 539837 | USA      | 86226 |
| 2015-2019       | KOR      | 547532| KOR      | 50122| ESP      | 3498286| ESP      | 375435|
|                 | ITA      | 145475| ITA      | 20193| JPN      | 2677873| KOR      | 361905|
|                 | ESP      | 80986 | ESP      | 11755| KOR      | 2218955| JPN      | 313709|
|                 | PRT      | 39323 | PRT      | 5779 | ITA      | 2054556| ITA      | 282538|
|                 | JPN      | 21469 | THA      | 3693 | USA      | 976601 | USA      | 134805|
**Supplementary Table S5** – International merchandise trade flow information of octopus for the period 2000-2019 downloaded from United Nations COMTRADE Database⁶. Annual values and net weights (M USD and kg, respectively) *flows* by presentation (1) live, fresh and chilled and (2) elaborated, (i.e., frozen, dried, salted or in brine), summarized by five-year periods are showed.

| Period       | Octopus live, fresh or chilled | Octopus elaborated |
|--------------|-------------------------------|--------------------|
|              | From | To   | M USD | From | To   | kg   | From | To   | M USD | From | to   | kg   |
| 2000-2004    | CHN  | KOR  | 161745| CHN  | KOR  | 74595| MAR  | JPN  | 862546| MAR  | JPN  | 202302|
|              | VNM  | JPN  | 91524 | VNM  | JPN  | 28796| MAR  | ESP  | 733516| CHN  | KOR  | 180411|
|              | VNM  | KOR  | 77894 | VNM  | KOR  | 24093| MRT  | JPN  | 555171| MAR  | ESP  | 127801|
|              | PRT  | ESP  | 45635 | PRT  | ESP  | 7922 | CHN  | KOR  | 325997| MRT  | JPN  | 101454|
|              | VNM  | ITA  | 19915 | VNM  | ITA  | 6177 | MAR  | ITA  | 292246| PHL  | USA  | 80626 |
| 2005-2009    | CHN  | KOR  | 234785| CHN  | KOR  | 68135| MAR  | ESP  | 1065527| CHN  | KOR  | 175640|
|              | PRT  | ESP  | 72919 | PRT  | ESP  | 11300| MRT  | JPN  | 1033992| MAR  | ESP  | 127167|
|              | ESP  | ITA  | 38496 | ESP  | ITA  | 6810 | CHN  | KOR  | 602106| MAR  | ESP  | 123739|
|              | ESP  | PRT  | 30552 | ESP  | PRT  | 5889 | MAR  | ITA  | 504015| VNM  | KOR  | 111947|
|              | FRA  | ITA  | 17602 | FRA  | ITA  | 3618 | MAR  | JPN  | 498350| MAR  | ITA  | 72336 |
| 2010-2014    | CHN  | KOR  | 251726| CHN  | KOR  | 40822| MAR  | ESP  | 1004817| CHN  | KOR  | 145122|
|              | PRT  | ESP  | 60217 | PRT  | ESP  | 9989 | MRT  | JPN  | 765279| MAR  | ESP  | 132459|
|              | ESP  | ITA  | 52263 | ESP  | ITA  | 8436 | CHN  | KOR  | 669114| MRT  | JPN  | 114401|
|              | ESP  | PRT  | 21575 | ESP  | PRT  | 4176 | MAR  | JPN  | 590790| MAR  | JPN  | 93747 |
|              | FRA  | ITA  | 17416 | THA  | KOR  | 2722 | CHN  | JPN  | 502503| VNM  | KOR  | 85193 |
| 2015-2019    | CHN  | KOR  | 504888| CHN  | KOR  | 43698| MRT  | ESP  | 1206486| MRT  | ESP  | 116638|
|              | ESP  | ITA  | 78577 | ESP  | ITA  | 10266| MAR  | ESP  | 901392| VNM  | KOR  | 90599 |
|              | PRT  | ESP  | 53243 | PRT  | ESP  | 8275 | MRT  | JPN  | 750224| MRT  | JPN  | 77704 |
|              | THA  | KOR  | 35526 | VNM  | KOR  | 659975| CHN  | KOR  | 77015 |
|              | ESP  | PRT  | 26236 | CHN  | KOR  | 477015| MAR  | ESP  | 71617 |
Supplementary Table S6 – International merchandise trade information of squid and cuttlefish for the period 2000-2019 downloaded from United Nations COMTRADE Database. Annual values and net weights (M USD and kg, respectively) exports by presentation (1) live, fresh and chilled and (2) elaborated, (i.e., frozen, dried, salted or in brine) and country or territory, summarized by five-year periods are showed.

| Period       | Squid and cuttlefish live, fresh or chilled | Squid and cuttlefish elaborated |
|--------------|---------------------------------------------|---------------------------------|
|              | Exporter | M USD | Exporter | kg   | Exporter | M USD | Exporter | kg   |
| 2000-2004    | VNM      | 263274 | VNM      | 111305 | THA      | 1218713 | CHN      | 353754 |
|              | FRA      | 208438 | IND      | 81698  | CHN      | 853376  | VNM      | 352478 |
|              | IND      | 186148 | FRA      | 50396  | VNM      | 840921  | THA      | 348019 |
|              | ESP      | 106946 | ESP      | 38524  | ESP      | 644729  | PER      | 321395 |
|              | GBR      | 37699  | MYS      | 24398  | IND      | 633827  | KOR      | 314145 |
| 2005-2009    | IND      | 381356 | IND      | 119806 | THA      | 1544010 | PER      | 840925 |
|              | FRA      | 217535 | ESP      | 38752  | CHN      | 1521777 | CHN      | 580167 |
|              | ESP      | 137293 | FRA      | 35714  | IND      | 1159411 | KOR      | 487542 |
|              | YEM      | 91532  | YEM      | 32386  | VNM      | 1144073 | IND      | 403873 |
|              | MAR      | 70877  | MMR      | 27662  | MAR      | 851123  | VNM      | 348854 |
| 2010-2014    | IND      | 660746 | IND      | 176121 | CHN      | 4422557 | CHN      | 992110 |
|              | FRA      | 324540 | YEM      | 58010  | IND      | 1571034 | PER      | 712759 |
|              | ESP      | 206466 | ESP      | 49039  | THA      | 1354423 | USA      | 521380 |
|              | YEM      | 171032 | FRA      | 47530  | MAR      | 1267262 | IND      | 460789 |
|              | MAR      | 108062 | MYS      | 24510  | PER      | 1067929 | ESP      | 265760 |
| 2015-2019    | IND      | 550503 | IND      | 140866 | CHN      | 13031464 | CHN      | 2659384 |
|              | FRA      | 401225 | ESP      | 69874  | PER      | 2973330 | PER      | 1312285 |
|              | ESP      | 335056 | MMR      | 60954  | IND      | 2909330 | IND      | 733147 |
|              | MAR      | 112520 | FRA      | 55420  | ESP      | 2409776 | ESP      | 591112 |
|              | GBR      | 111487 | ARE      | 29528  | VNM      | 1896376 | IDN      | 510551 |
Supplementary Table S7 – International merchandise trade information of squid and cuttlefish for the period 2000-2019 downloaded from United Nations COMTRADE Database. Annual values and net weights (M USD and kg, respectively) imports by presentation (1) live, fresh and chilled and (2) elaborated, (i.e., frozen, dried, salted or in brine) and country or territory, summarized by five-year periods are showed.

| Period       | Squid and cuttlefish live, fresh or chilled | Squid and cuttlefish elaborated |
|--------------|--------------------------------------------|---------------------------------|
|              | Importer | M USD | Importer | kg    | Importer | M USD | Importer | kg    |
| 2000-2004    | ESP      | 246587 | ESP      | 76874 | ESP      | 1665014 | CHN      | 869754 |
|              | ITA      | 220339 | JPN      | 65308 | JPN      | 1644186 | ESP      | 744793 |
|              | JPN      | 149236 | ITA      | 62506 | ITA      | 1369386 | ITA      | 536940 |
|              | CHN      | 78701  | CHN      | 51732 | CHN      | 857777  | JPN      | 473081 |
|              | PRT      | 54815  | PRT      | 23237 | USA      | 476655  | USA      | 227518 |
| 2005-2009    | ESP      | 537952 | ESP      | 114909 | ESP      | 2699191 | CHN      | 1325208 |
|              | ITA      | 343014 | ITA      | 71734 | ITA      | 2102858 | ESP      | 930600 |
|              | CHN      | 104544 | THA      | 53331 | JPN      | 1727261 | ITA      | 621562 |
|              | FRA      | 76725  | CHN      | 48298 | CHN      | 1370368 | JPN      | 453326 |
|              | PRT      | 61852  | SGP      | 26958 | USA      | 793441  | USA      | 278719 |
| 2010-2014    | ESP      | 570329 | VNM      | 115843 | ESP      | 3520585 | CHN      | 1592914 |
|              | ITA      | 477699 | ESP      | 101359 | ITA      | 2653687 | ESP      | 956054 |
|              | VNM      | 369784 | ITA      | 86497 | CHN      | 2467566 | ITA      | 585550 |
|              | FRA      | 97691  | THA      | 25227 | JPN      | 2394740 | THA      | 508099 |
|              | PRT      | 70699  | FRA      | 25093 | USA      | 1554431 | JPN      | 437191 |
| 2015-2019    | ITA      | 473583 | ITA      | 79904 | ESP      | 4833683 | CHN      | 1348976 |
|              | ESP      | 441469 | ESP      | 70031 | JPN      | 3637286 | ESP      | 1182812 |
|              | VNM      | 156951 | THA      | 57778 | ITA      | 3484044 | THA      | 703432 |
|              | FRA      | 130257 | VNM      | 49741 | CHN      | 3074877 | JPN      | 662119 |
|              | THA      | 86803  | FRA      | 26932 | THA      | 2839169 | ITA      | 660693 |
Supplementary Table S8 – International merchandise trade flow information of squid and cuttlefish for the period 2000-2019 downloaded from United Nations COMTRADE Database. Annual values and net weights (M USD and kg, respectively) flows by presentation (1) live, fresh and chilled and (2) elaborated, (i.e., frozen, dried, salted or in brine), summarized by five-year periods are showed.

| Period     | Squid and cuttlefish live, fresh or chilled | Squid and cuttlefish elaborated |
|------------|--------------------------------------------|---------------------------------|
|            | from | to | M USD | from | to | kg | from | to | M USD | from | to | kg |
| 2000-2004  | VNM  | JPN | 139700 | VNM  | JPN | 58286 | THA  | JPN | 877954 | FLK  | ESP | 266591 |
|            | FRA  | ITA | 103108 | IND  | ESP | 33003 | FLK  | ESP | 523186 | KOR  | CHN | 195707 |
|            | FRA  | ESP | 91729  | FRA  | ITA | 24009 | ESP  | ITA | 516108 | ESP  | ITA | 192089 |
|            | IND  | ESP | 88851  | FRA  | ESP | 23147 | CHN  | JPN | 498743 | THA  | ITA | 157968 |
|            | ESP  | ITA | 37014  | MYS  | SGP | 19675 | MAR  | ESP | 447100 | CHN  | JPN | 157299 |
| 2005-2009  | IND  | ESP | 257496 | IND  | ESP | 68183 | MAR  | ESP | 896992 | KOR  | CHN | 279419 |
|            | FRA  | ITA | 128389 | MMR  | THA | 36090 | THA  | JPN | 621124 | USA  | CHN | 265627 |
|            | FRA  | ESP | 121727 | MYS  | SGP | 25374 | IND  | ESP | 602311 | PER  | CHN | 249362 |
|            | MAR  | ESP | 94135  | FRA  | ITA | 22034 | FLK  | ESP | 532354 | FLK  | ESP | 195523 |
|            | ESP  | ITA | 80041  | IND  | ITA | 19816 | CHN  | USA | 515489 | MAR  | ESP | 168430 |
| 2010-2014  | IND  | ESP | 251142 | IND  | VNM | 68329 | CHN  | JPN | 954841 | PER  | CHN | 333451 |
|            | IND  | VNM | 212893 | IND  | ESP | 54152 | CHN  | USA | 904261 | USA  | CHN | 251325 |
|            | FRA  | ITA | 163393 | YEM  | VNM | 27798 | MAR  | ESP | 854224 | PRK  | CHN | 199927 |
|            | FRA  | ESP | 144221 | IND  | ITA | 27540 | CHN  | THA | 827695 | CHN  | JPN | 188013 |
|            | ESP  | ITA | 124271 | ESP  | ITA | 23678 | CHN  | HKG | 764117 | CHN  | THA | 183718 |
| 2015-2019  | ESP  | ITA | 156190 | MMR  | THA | 52612 | CHN  | JPN | 1859101 | CHN  | JPN | 322779 |
|            | FRA  | ITA | 154255 | IND  | VNM | 35392 | CHN  | THA | 1212316 | IDN  | CHN | 260943 |
|            | FRA  | ESP | 153324 | ESP  | ITA | 29896 | CHN  | USA | 1115636 | FLK  | ESP | 235551 |
|            | IND  | ESP | 124374 | IND  | ESP | 26842 | CHN  | PHL | 831339 | CHN  | THA | 217230 |
|            | IND  | VNM | 120331 | FRA  | ITA | 21609 | FLK  | ESP | 794218 | PER  | CHN | 209072 |
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