IUU Fishing: Economic Effects of IUU Imports on U.S. Commercial Fishers

Species: Warmwater shrimp, coldwater shrimp

Model Release

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This model accompanies the USITC report, *Seafood Obtained via Illegal, Unreported, and Unregulated Fishing: U.S. Imports and Economic Impact on U.S. Commercial Fisheries*, Inv. 332-575. The report includes a quantitative analysis of the economic impact of IUU imports on U.S. commercial fishers and U.S. commercial fishing production, trade, and prices. Economic effects are modeled by species, with each species-level model customized to fit the unique features of the U.S. domestic industry. Consumers of seafood products choose between domestic marine-capture sources, imports, and in some models, domestic aquaculture products. Imports include both legal and IUU sources that enter the U.S. at the same price, so consumers cannot distinguish an IUU from non-IUU product. 2018 data is used to establish an initial equilibrium with imports of IUU products included in the baseline. The model then removes the IUU imports, as estimated in chapter 3, and solves for a new equilibrium absent those products.

Data inputs in the simulation are in the BLUE-shaded cells (with sources for the input data listed in the cell above). Outputs are in the GREEN-shaded cells. The white cells are intermediate calculations.

This PDF is a printout of the Mathematica file “IUU Fishing Model - shrimp - model release.nb”

In[1]:=
```
ClearAll[f];
```

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1. Model Parameters

1.1 Within-Species Elasticity of Substitution

Source: USITC's econometric estimation using the trade cost method in Riker (2020). More information can be found in the technical appendix (appendix I).

Coldwater shrimp

```
sigmac = 12.49713;
```

Warmwater shrimp

```
sigmaw = 12.81831;
```

1.2 Cross-Species Elasticity of Substitution

Source: USITC Staff Estimate and Interviews with Industry Participants.

```
beta = 3.0;
```

1.3 Industry Price Elasticity of Demand

Source: USITC Staff Estimate.

In[ ]:=
```
eta = -1.0;
```

1.4 Illegal Imports Replacement Rates

Source: USITC Staff Estimate. Further discussion on qualitative factors and rate determination can be found in appendix I of the USITC's report.

Coldwater shrimp

```
replc = 0.5;
```

Warmwater shrimp

```
replw = 0.3 ;
```

1.5 Price Elasticity of Supply

Source: USITC Staff Estimate and Interviews with Industry Participants.

Coldwater shrimp

```
ecd = 2.0;
```

Warmwater shrimp

```
ewd = 5.0;
```

Aquaculture shrimp

```
ewa = 5.0;
```

2. Data Inputs

2.1 U.S. Landings Quantities and Prices

Source: National Oceanic and Atmospheric Administration. National Marine Fisheries Service (NOAA Fisheries). Fisheries of the United States 2018. Current Fishery Statistics No. 2018. U.S. Department of Commerce. Silver Spring MD: NOAA, February 2020. https://www.fisheries.noaa.gov/resource/document/fisheries-united-states-2018-report.

Coldwater shrimp

```
qcd0 = 24,143,000.00; (*kg*)
```

```
pcd0 = 2.1661; (*$/kg*)
```

Warmwater shrimp

```
qwd0 = 107,027,000.00; (*kg*)
```

```
pwd0 = 4.1468; (*$/kg*)
```

Aquaculture Shrimp

```
qwa0 = 1,760,400.00; (*kg*)
```

```
pwa0 = 5.5341; (*$/kg*)
```

2.2 U.S. Processing Production Quantities and Prices

Sources:

National Oceanic and Atmospheric Administration. National Marine Fisheries Service (NOAA Fisheries). Fisheries of the United States 2018. Current Fishery Statistics No. 2018. U.S. Department of Commerce. Silver Spring MD: NOAA, February 2020. https://www.fisheries.noaa.gov/resource/document/fisheries-united-states-2018-report.

National Oceanic and Atmospheric Administration. National Marine Fisheries Service (NOAA Fisheries). NOAA Processed Products database. Accessed September 1, 2020.https://www.fisheries.noaa.gov/foss/f?p=215:3:5412288074334::NO:::

```
qdp0 = 138 720 401; (*kg*)
```

```
pdp0 = 7.1663; (*$/kg*)
```

2.3 Import Quantities and Prices

Source: IUU Estimate Database as described in Chapter 3 of the report.

Total imports - unprocessed coldwater shrimp product

```
In[526]:= qct0 = 1 604 214; (*kg*)
```

```
In[]:= pct0 = 10.5378; (*$/kg*)
```

Total imports - unprocessed warmwater shrimp product

```
In[]:= qwt0 = 233 944 812; (*kg*)
```

```
In[]:= pwt0 = 8.94622; (*$/kg*)
```

Total imports - processed product

```
In[]:= qtp0 = 461 145 515; (*kg*)
```

```
In[]:= ptp0 = 9.15764; (*$/kg*)
```

Total illegal imports

```
In[532]:= qci0 = 57 283;  (*kg*)
```

```
In[]:= qwi0 = 20 146 662;(*kg*)
```

```
In[]:= qip0 = 35 619 312;(*kg*)
```

```
In[]:= ql0 = qct0 - qci0;
In[]:= qwl0 = qwt0 - qwi0;
In[]:= qlp0 = qtp0 - qip0;
```

2.4 Export Quantities

Source:National Oceanic and Atmospheric Administration. National Marine Fisheries Service (NOAA Fisheries). NOAA US Trade in Fishery Products database. Accessed September 1, 2020. https://foss.nmfs.noaa.gov/apexfoss/f?p=215:2:14884747663545::NO

```
qce0 = 2,403,276.00; (*kg*)
```

```
qwe0 = 2,056,660.00; (*kg*)
```

```
qdpe0 = 3,656,709; (*kg*)
```

2.5 Catch Limits

No aggregate ACL available, inserted arbitrarily high limit so it doesn't affect calculation.

```
qccap = 500,000,000.00; (*kg*)
```

```
qwcap = 500,000,000.00; (*kg*)
```

```
qacap = 500,000,000.00; (*kg*)
```

2.6 Import Market Share Statistics

```
In[]:= N[qwt0 / (qwt0 + (qwd0 - qwe0))]
Out[]= 0.690275

In[]:= N[qct0 / (qct0 + qcd0 - qce0)]
Out[]= 0.0687208

In[]:= N[qtp0 / (qtp0 + (qdp0 - qdpe0))]
Out[]= 0.773463
```

3. Calibration

Baseline values of domestic apparent consumption and imports

```
In[]:= vcd0 = (qcd0 - qce0) pcd0;
In[]:= vct0 = qct0 pct0;
In[]:= vwd0 = (qwd0 - qwe0) pwd0;
In[]:= vwt0 = qwt0 pwt0;
In[]:= vwa0 = qwa0 pwa0;
```

In[∘]:= $vdp0 = (qdp0 - qdpe0)\ pdp0;$

In[∘]:= $vtp0 = qtp0\ ptp0;$

3.1 Supply Parameters

In[52]:= $$ecde = ecd \frac{qcd0}{(qccap - qcd0)};$$

In[53]:= $$acd = (qccap - qcd0)\ pcd0^{ecde};$$

In[∘]:= $$ewde = ewd \frac{qwd0}{(qwcap - qwd0)};$$

In[∘]:= $$awd = (qwcap - qwd0)\ pwd0^{ewde};$$

In[∘]:= $$ewae = ewa \frac{qwa0}{(qacap - qwa0)};$$

In[∘]:= $$awa = (qacap - qwa0)\ pwa0^{ewae};$$

In[∘]:= $$adp = qdp0\ pdp0^{-ewd};$$

3.2 Demand Parameters

In[∘]:= $$bct = \frac{vct0}{vcd0} \left(\frac{pct0}{pcd0}\right)^{sigmac-1};$$

In[∘]:= $$bwt = \frac{vwt0}{vwd0} \left(\frac{pwt0}{pwd0}\right)^{sigmaw-1};$$

In[∘]:= $$bat = \frac{vwa0}{vwd0} \left(\frac{pwa0}{pwd0}\right)^{sigmaw-1};$$

In[∘]:= $$Pc0 = \left(pcd0^{1-sigmac} + bct\ pct0^{1-sigmac}\right)^{\frac{1}{1-sigmac}};$$

In[∘]:= $$Pw0 = \left(pwd0^{1-sigmaw} + bwt\ pwt0^{1-sigmaw} + bat\ pwa0^{1-sigmaw}\right)^{\frac{1}{1-sigmaw}};$$

In[∘]:= $$bw = \frac{vwd0 + vwt0 + vwa0}{vcd0 + vct0} \left(\frac{Pw0}{Pc0}\right)^{beta-1};$$

In[∘]:= $$P0 = \left(Pc0^{1-beta} + bw\ Pw0^{1-beta}\right)^{\frac{1}{1-beta}};$$

$$k = \frac{qct0\ P0^{-eta-beta}\ Pc0^{beta-sigmac}\ pct0^{sigmac}}{bct};$$

Out[∘]= 2.60195×10^{9}

In[∘]:= $$btp = \frac{vtp0}{vdp0} \left(\frac{ptp0}{pdp0}\right)^{sigmaw-1};$$

In[∘]:= $$Pproc0 = \left(pdp0^{1-sigmaw} + btp\ ptp0^{1-sigmaw}\right)^{\frac{1}{1-sigmaw}};$$

$$kp = qtp0\; Pproc0^{-sigmaw-eta}\, \frac{ptp0^{sigmaw}}{btp};$$

Out[ ]= 5.19091×10^9

4. New Equilibrium Calculation

Unprocessed Shrimp Equilibrium Calculation:

In[ ]:= $Pc = \left(pcd^{1-sigmac} + bct\; pct^{1-sigmac}\right)^{\frac{1}{1-sigmac}};$

In[ ]:= $Pw = \left(pwd^{1-sigmaw} + bwt\; pwt^{1-sigmaw} + bat\; pwa^{1-sigmaw}\right)^{\frac{1}{1-sigmaw}};$

In[ ]:= $P = \left(Pc^{1-beta} + bw\; Pw^{1-beta}\right)^{\frac{1}{1-beta}};$

In[ ]:= $E1 = qccap - acd\; pcd^{-ecde} == qce0 + k\; P^{eta+beta}\; Pc^{sigmac-beta}\; pcd^{-sigmac};$

In[ ]:= $E2 = qcl0 + qci0\; (replc) == k\; bct\; P^{eta+beta}\; Pc^{sigmac-beta}\; pct^{-sigmac};$

In[ ]:= $E3 = qwcap - awd\; pwd^{-ewde} == qwe0 + k\; bw\; P^{eta+beta}\; Pw^{sigmaw-beta}\; pwd^{-sigmaw};$

In[ ]:= $E4 = qwl0 + qwi0\; (replw) == k\; bwt\; bw\; P^{eta+beta}\; Pw^{sigmaw-beta}\; pwt^{-sigmaw};$

In[ ]:= $E5 = qacap - awa\; pwa^{-ewae} == k\; bat\; bw\; P^{eta+beta}\; Pw^{sigmaw-beta}\; pwa^{-sigmaw};$

```
In[ ]:= FindRoot[{E1, E2, E3, E4, E5}, {pcd, pcd0}, {pct, pct0}, {pwd, pwd0},
          {pwt, pwt0}, {pwa, pwa0}, AccuracyGoal → 7, PrecisionGoal → 7]
Out[ ]= {pcd → 2.19593, pct → 10.724, pwd → 4.23427, pwt → 9.25106, pwa → 5.651}

In[ ]:= pcd1 = pcd /. %;

In[ ]:= pct1 = pct /. %%;

In[ ]:= pwd1 = pwd /. %%%;

In[ ]:= pwt1 = pwt /. %%%%;

In[ ]:= pwa1 = pwa /. %%%%%;
```

In[ ]:= $qcd1 = qccap - acd\; pcd1^{-ecde};$

In[ ]:= $qct1 = qcl0 + qci0\; (replc);$

In[ ]:= $qwd1 = qwcap - awd\; pwd1^{-ewde};$

In[ ]:= $qwt1 = qwl0 + qwi0\; (replw);$

In[ ]:= $qwa1 = qacap - awa\; pwa1^{-ewae};$

In[ ]:= $Pc1 = \left(pcd1^{1-sigmac} + bct\; pct1^{1-sigmac}\right)^{\frac{1}{1-sigmac}};$

In[ ]:= $Pw1 = \left(pwd1^{1-sigmaw} + bwt\; pwt1^{1-sigmaw} + bat\; pwa1^{1-sigmaw}\right)^{\frac{1}{1-sigmaw}};$

In[ ]:= $P1 = \left(Pc1^{1-beta} + bw\; Pw1^{1-beta}\right)^{\frac{1}{1-beta}};$

Processed Shrimp Equilibrium Calculation:

In[∘]:= $\text{Pproc} = \left(\text{pdp}^{1-\text{sigmaw}} + \text{btp}\,\text{ptp}^{1-\text{sigmaw}}\right)^{\frac{1}{1-\text{sigmaw}}};$

In[∘]:= $\text{Eqnp1} = \text{adp}\,\text{pdp}^{\text{ewd}} == \text{qdpe0} + \text{kp}\,\text{Pproc}^{\text{sigmaw+eta}}\,\text{pdp}^{-\text{sigmaw}};$

In[∘]:= $\text{Eqnp2} = \text{qlp0} + \text{qip0}\,(\text{replw}) == \text{kp}\,\text{btp}\,\text{Pproc}^{\text{sigmaw+eta}}\,\text{ptp}^{-\text{sigmaw}};$

```
In[∘]:= FindRoot[{Eqnp1, Eqnp2}, {pdp, pdp0}, {ptp, ptp0}]
Out[∘]= {pdp → 7.29391, ptp → 9.42757}

In[∘]:= pdp1 = pdp /. %;

In[∘]:= ptp1 = ptp /. %%;
```

In[∘]:= $\text{qdp1} = \text{adp}\,\text{pdp1}^{\text{ewd}};$

In[∘]:= $\text{qtp1} = \text{qlp0} + \text{qip0}\,(\text{replw});$

In[∘]:= $\text{Pproc1} = \left(\text{pdp1}^{1-\text{sigmaw}} + \text{btp}\,\text{ptp1}^{1-\text{sigmaw}}\right)^{\frac{1}{1-\text{sigmaw}}};$

5. Results

Coldwater Shrimp

Percent change in price of domestic landings of coldwater shrimp

In[∘]:= $(\text{pcd1} - \text{pcd0})\,\frac{100}{\text{pcd0}}$

Out[∘]= 1.37726

Percent change in domestic landings of coldwater shrimp

In[∘]:= $(\text{qcd1} - \text{qcd0})\,\frac{100}{\text{qcd0}}$

Out[∘]= 2.73383

Change ($) in Operating Income, unprocessed coldwater shrimp

$1/\text{sigmac}\,(\text{pcd1}\,(\text{qcd1} - \text{qce0}) - \text{pcd0}\,(\text{qcd0} - \text{qce0}))$

Out[∘]= 167,873

Percent change in import price of coldwater shrimp

In[∘]:= $(\text{pct1} - \text{pct0})\,\frac{100}{\text{pct0}}$

Out[∘]= 1.76677

Percent change in total imports of coldwater shrimp

In[ ]:= $(\text{qct1} - \text{qct0}) \frac{100}{\text{qct0}}$

Out[ ]= -1.78539

Warmwater Shrimp

Percent change in price of domestic landings of warmwater shrimp

In[ ]:= $(\text{pwd1} - \text{pwd0}) \frac{100}{\text{pwd0}}$

Out[ ]= 2.1093

Percent change in domestic landings of warmwater shrimp

In[ ]:= $(\text{qwd1} - \text{qwd0}) \frac{100}{\text{qwd0}}$

Out[ ]= 10.2899

Change ($) in Operating Income, unprocessed warmwater shrimp

$1 / \text{sigmaw} \left(\text{pwd1} (\text{qwd1} - \text{qwe0}) - \text{pwd0} (\text{qwd0} - \text{qwe0})\right)$

Out[ ]= 4,354,188

Percent change in import price of warmwater shrimp

In[ ]:= $(\text{pwt1} - \text{pwt0}) \frac{100}{\text{pwt0}}$

Out[ ]= 3.40751

Percent change in total imports of warmwater shrimp

In[ ]:= $(\text{qwt1} - \text{qwt0}) \frac{100}{\text{qwt0}}$

Out[ ]= -6.0282

Percent change in price of aquaculture shrimp

In[ ]:= $(\text{pwa1} - \text{pwa0}) \frac{100}{\text{pwa0}}$

Out[ ]= 2.11232

Percent change in aquaculture shrimp production

In[∘]:= $\left(\text{qwa1} - \text{qwa0}\right) \frac{100}{\text{qwa0}}$

Out[∘]= 10.4496

Change ($) in Operating Income, aquaculture

```
1 / sigmaw (pwa1 (qwa1) - pwa0 (qwa0))
```

Out[∘]= 97,151

Processed Shrimp

Percent change in price of processed shrimp production

In[∘]:= $\frac{100 \left(\text{pdp1} - \text{pdp0}\right)}{\text{pdp0}}$

Out[∘]= 1.78068

Percent change in processed shrimp production

In[∘]:= $\frac{100 \left(\text{qdp1} - \text{qdp0}\right)}{\text{qdp0}}$

Out[∘]= 9.22618

Percent change in price of imports of processed shrimp

In[∘]:= $\frac{100 \left(\text{ptp1} - \text{ptp0}\right)}{\text{ptp0}}$

Out[∘]= 2.94755

Percent change in total imports of processed shrimp

In[∘]:= $\frac{100 \left(\text{qtp1} - \text{qtp0}\right)}{\text{qtp0}}$

Out[∘]= -5.40687

Change ($) in Operating Income, processed shrimp

```
1 / sigmaw (pdp1 (qdp1 - qdpe0) - pdp0 (qdp0 - qdpe0))
```

Out[∘]= 8,627,281

Price Index

Percent change in unprocessed price index

In[ ]:=
```
(P1 - P0) 100/P0
```

Out[ ]=
```
3.12169
```

Percent change in processed price index

In[ ]:=
```
100 (Pproc1 - Pproc0)/Pproc0
```

Out[ ]=
```
2.71666
```