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

Species: Albacore, bigeye, bluefin, skipjack, yellowfin, bonito, other/NEI tuna

Model Release

Read Me :
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.

In the tuna model, there are domestic and imported varieties of albacore, bigeye, bluefin, skipjack, yellowfin, bonito, and NEI tuna species. The model includes cross-species substitution, so relative price changes in one species affects the other species. Landings of some of the domestic varieties are potentially constrained by catch limits. There are two markets modeled: unprocessed and processed products. Landings flow to three destinations: the unprocessed market, the processed market, or are exported outside the country. The price of the processed product is a constant markup over the price of the unprocessed price index, so increases in prices of unprocessed fish affect the price of processing.

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 - tuna - model release.nb”

```
In[1425]:= 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).

Unprocessed yellowfin: elasticity of substitution across varieties of unprocessed yellowfin

In[1426]:=
```
sigmayu = 2.874731 ;
```

Unprocessed skipjack: elasticity of substitution across varieties of unprocessed skipjack

In[1427]:=
```
sigmasu = 8.450249;
```

Unprocessed albacore: elasticity of substitution across varieties of unprocessed albacore

In[1428]:=
```
sigmaau = 2.006154;
```

Unprocessed bigeye: elasticity of substitution across varieties of unprocessed bigeye

In[1429]:=
```
sigmabu = 2.580973;
```

Unprocessed bluefin: elasticity of substitution across varieties of unprocessed bluefin

In[1430]:=
```
sigmafu = 6.044084;
```

Unprocessed other/NEI tuna: elasticity of substitution across varieties of unprocessed other tuna

In[1431]:=
```
sigmaou = 2.006154;
```

Unprocessed bonito: elasticity of substitution across varieties of unprocessed bonito

In[1432]:=
```
sigmanu = 8.450249;
```

Processed yellowfin: elasticity of substitution across varieties of processed yellowfin

In[1433]:=
```
sigmayp = 2.874731 ;
```

Processed skipjack: elasticity of substitution across varieties of processed skipjack

In[1434]:=
```
sigmasp = 8.450249;
```

Processed albacore: elasticity of substitution across varieties of processed albacore

In[1435]:=
```
sigmaap = 2.006154;
```

Processed bigeye: elasticity of substitution across varieties of processed bigeye

In[1436]:=
```
sigmabp = 2.580973;
```

Processed bluefin: elasticity of substitution across varieties of processed bluefin

In[1437]:=
```
sigmafp = 6.044084;
```

Processed other/NEI tuna: elasticity of substitution across varieties of processed other tuna

In[1438]:=
```
sigmaop = 2.006154;
```

1.2 Cross-Species Elasticity of Substitution

Source: USITC Staff Estimate and Interviews with Industry Participants.

Unprocessed: elasticity of substitution across unprocessed products

In[1439]:=
```
betau = 3.0;
```

Processed: elasticity of substitution across processed products

In[1440]:=
```
betap = 3.0;
```

1.3 Industry Price Elasticity of Demand

Source: USITC Staff Estimate.

Unprocessed

In[1441]:=
```
etau = -1.0;
```

Processed

In[1442]:=
```
etap = -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.

Yellowfin: fraction of illegal imports replaced by legal imports of yellowfin

In[1443]:=
```
reply = 0.30;
```

Skipjack: fraction of illegal imports replaced by legal imports of skipjack

In[1444]:=
```
repls = 0.50;
```

Albacore: fraction of illegal imports replaced by legal imports of albacore

In[1445]:=
```
repla =  0.50;
```

Bigeye: fraction of illegal imports replaced by legal imports of bigeye

In[1446]:=
```
replb = 0.30 ;
```

Bluefin: fraction of illegal imports replaced by legal imports of bluefin

In[1447]:=
```
replf = 0.10;
```

Other/NEI tuna: fraction of illegal imports replaced by legal imports of other/NEI tuna

In[1448]:=
```
replo = 0.30;
```

Bonito: fraction of illegal imports replaced by legal imports of bonito

In[1449]:=
```
repln = 0.30 ;
```

1.5 Price Elasticity of Supply

Source: USITC Staff Estimate and Interviews with Industry Participants.

U.S. landings of yellowfin

In[1450]:=
```
eyu = 5.0;
```

U.S. landings of skipjack

In[1451]:=
```
esu = 5.0;
```

U.S. landings of albacore

In[1452]:=
```
eau = 5.0;
```

U.S. landings of bigeye

In[1453]:=
```
ebu = 2.0;
```

U.S. landings of bluefin

In[1454]:=
```
efu = 2.0;
```

U.S. landings of other/NEI tuna

In[1455]:=
```
eou = 5.0;
```

U.S. landings of bonito

In[1456]:=
```
enu = 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.

Yellowfin tuna

In[1457]:=
```
qydu0 = 5,843,673.00 ; (*kg*)
```

In[1458]:=
```
pydu0 = 6.1081; (*$/kg*)
```

Skipjack tuna

In[1459]:=
```
qsdu0 = 1,448,384.00 ; (*kg*)
```

In[1460]:=
```
psdu0 = 1.4963; (*$/kg*)
```

Albacore tuna

In[1461]:=
```
qadu0 = 8,529,946.00 ; (*kg*)
```

In[1462]:=
```
padu0 = 3.5245; (*$/kg*)
```

Bigeye tuna

In[1463]:=
```
qbdu0 = 8,325,596.00; (*kg*)
```

In[1464]:=
```
pbdu0 = 9.0050; (*$/kg*)
```

Bluefin tuna

In[1465]:=
```
qfdu0 = 958,000.00; (*kg*)
```

In[1466]:=
```
pfdu0 = 11.9081; (*$/kg*)
```

Other/NEI tuna

In[1467]:=
```
qodu0 = 256,773.00; (*kg*)
```

In[1468]:=
```
podu0 = 2.2614; (*$/kg*)
```

Bonito

In[1469]:=
```
qndu0 = 696,000.00; (*kg*)
```

In[1470]:=
```
pndu0 = 0.7888; (*$/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:::

Processed Yellowfin

In[1471]:=
```
qydp0 = 18,470,202.00; (*kg*)
```

In[1472]:=
```
pydp0 = 5.6637; (*$/kg*)
```

Processed Skipjack

In[1473]:=
```
qsdp0 = 74,785,963.00; (*kg*)
```

In[1474]:=
```
psdp0 = 4.2374; (*$/kg*)
```

Processed Albacore

In[1475]:=
```
qadp0 = 67 028 892.00; (*kg*)
```

In[1476]:=
```
padp0 = 6.0944; (*$/kg*)
```

Processed Bigeye

In[1477]:=
```
qbdp0 = 1 595 096.00; (*kg*)
```

In[1478]:=
```
pbdp0 = 24.7219; (*$/kg*)
```

Processed Bluefin

In[1479]:=
```
qfdp0 = 714 906.00; (*kg*)
```

In[1480]:=
```
pfdp0 = 28.9190; (*$/kg*)
```

Processed Other/NEI tuna

In[1481]:=
```
qodp0 = 1086.00; (*kg*)
```

In[1482]:=
```
podp0 = 1.1543; (*$/kg*)
```

2.3 Import Quantities and Prices

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

Yellowfin

Total unprocessed imports

In[1483]:=
```
qytu0 = 7 277 295; (*kg*)
```

In[1484]:=
```
pytu0 = 6.10622; (*$/kg*)
```

Total processed imports

In[1485]:=
```
qytp0 = 52 839 763; (*kg*)
```

In[1486]:=
```
pytp0 = 8.04508; (*$/kg*)
```

Illegal imports

In[1487]:=
```
qyiu0 = 990 308; (*kg*)
```

In[1488]:=
```
qyip0 = 7 064 729; (*kg*)
```

Skipjack

Total unprocessed imports

In[1489]:=
```
qstu0 = 28 952 079; (*kg*)
```

In[1490]:=
```
pstu0 = 5.7198; (*$/kg*)
```

Total processed imports

In[1491]:=
```
qstp0 = 97 739 443; (*kg*)
```

In[1492]:=
```
pstp0 = 4.70128; (*$/kg*)
```

Illegal imports

In[1493]:=
```
qsiu0 = 2 630 579; (*kg*)
```

In[1494]:=
```
qsip0 = 10 177 644; (*kg*)
```

Albacore

Total unprocessed imports

In[1495]:=
```
qatu0 = 10 825 988; (*kg*)
```

In[1496]:=
```
patu0 = 5.96477; (*$/kg*)
```

Total processed imports

In[1497]:=
```
qatp0 = 36 456 957; (*kg*)
```

In[1498]:=
```
patp0 = 6.27589; (*$/kg*)
```

Illegal imports

In[1499]:=
```
qaiu0 = 1 649 831; (*kg*)
```

In[1500]:=
```
qaip0 = 5 185 988; (*kg*)
```

Bigeye

Total unprocessed imports

In[1501]:=
```
qbtu0 = 7 562 019;(*kg*)
```

In[1502]:=
```
pbtu0 = 7.38661;(*$/kg*)
```

Total processed imports

In[1503]:=
```
qbtp0 = 8 165 080;(*kg*)
```

In[1504]:=
```
pbtp0 = 8.66838;(*$/kg*)
```

Illegal imports

In[1505]:=
```
qbiu0 = 1 165 447;(*kg*)
```

In[1506]:=
```
qbip0 = 1 393 667;(*kg*)
```

Bluefin

Total unprocessed imports

In[1507]:=
```
qftu0 = 2 326 232;(*kg*)
```

In[1508]:=
```
pftu0 = 21.2879; (*$/kg*)
```

Total processed imports

In[1509]:=
```
qftp0 = 201 152;(*kg*)
```

In[1510]:=
```
pftp0 = 13.509;(*$/kg*)
```

Illegal imports

In[1511]:=
```
qfiu0 = 1 108 413;(*kg*)
```

In[1512]:=
```
qfip0 = 52 704;(*kg*)
```

Other/NEI tuna

Total unprocessed imports

In[1513]:=
```
qotu0 = 259 286;(*kg*)
```

In[1514]:=
```
potu0 = 5.78741; (*$/kg*)
```

Total processed imports

In[1515]:=
```
qotp0 = 981188;(*kg*)
```

In[1516]:=
```
potp0 = 8.0845;(*$/kg*)
```

Illegal imports

In[1517]:=
```
qoiu0 = 46462;(*kg*)
```

In[1518]:=
```
qoip0 = 278737;(*kg*)
```

Bonito

Total unprocessed imports

In[1519]:=
```
qntu0 = 68877;(*kg*)
```

In[1520]:=
```
pntu0 = 3.2723; (*$/kg*)
```

Total processed imports

In[1521]:=
```
qntp0 = 291758;(*kg*)
```

In[1522]:=
```
pntp0 = 5.6819;(*$/kg*)
```

Illegal imports

In[1523]:=
```
qniu0 = 17160;(*kg*)
```

In[1524]:=
```
qnip0 = 72084;(*kg*)
```

Calculation of legal imports

```
In[1525]:= qylu0 = qytu0 - qyiu0;
In[1526]:= qylp0 = qytp0 - qyip0;
In[1527]:= qslu0 = qstu0 - qsiu0;
In[1528]:= qslp0 = qstp0 - qsip0;
In[1529]:= qalu0 = qatu0 - qaiu0;
In[1530]:= qalp0 = qatp0 - qaip0;
In[1531]:= qblu0 = qbtu0 - qbiu0;
In[1532]:= qblp0 = qbtp0 - qbip0;
In[1533]:= qflu0 = qftu0 - qfiu0;
In[1534]:= qflp0 = qftp0 - qfip0;
```

In[1535]:=
```
qolu0 = qotu0 - qoiu0;
```

In[1536]:=
```
qolp0 = qotp0 - qoip0;
```

In[1537]:=
```
qnlu0 = qntu0 - qniu0;
```

In[1538]:=
```
qnlp0 = qntp0 - qnip0;
```

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

In[1539]:=
```
qydue0 = 1 474 827.00; (*kg*)
```

In[1540]:=
```
qydpe0 = 0; (*kg*)
```

In[1541]:=
```
qsdue0 = 666 890.00; (*kg*)
```

In[1542]:=
```
qsdpe0 = 0; (*kg*)
```

In[1543]:=
```
qadue0 = 6 859 332.00; (*kg*)
```

In[1544]:=
```
qadpe0 = 0; (*kg*)
```

In[1545]:=
```
qbdue0 = 164 478.00; (*kg*)
```

In[1546]:=
```
qbdpe0 = 0; (*kg*)
```

In[1547]:=
```
qfdue0 = 548 749.00; (*kg*)
```

In[1548]:=
```
qfdpe0 = 0; (*kg*)
```

In[1549]:=
```
qodue0 = 0; (*kg*)
```

In[1550]:=
```
qodpe0 = 0; (*kg*)
```

In[1551]:=
```
qndue0 = 0; (*kg*)
```

2.5 Catch Limits

Yellowfin tuna

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

In[1552]:=
```
qydcap = 400000000; (*kg*)
```

Skipjack tuna

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

In[1553]:=
```
qsdcap = 400000000;(*kg*)
```

Albacore tuna

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

In[1554]:=
```
qadcap = 400000000;(*kg*)
```

Bigeye tuna

Sources:
International Commission for the Conservation of Atlantic Tunas, "Tropical Tuna Fishery Management Plans," 2018, https://www.iccat.int/com2018/ENG/PA1_501_ENG.pdf.

"Electronic Code of Federal Regulations: Longline Fishing Restrictions," Text, Electronic Code of Federal Regulations (eCFR), accessed October 27, 2020, https://www.ecfr.gov/cgi-bin/text-idx?c=ecfr&SID=c4a02d52df72fb2c44dab04d0a6684a7&rgn=div8&view=text&node=50:11.0.2.11.1.15.21.15&idno=50.

NOAA Fisheries, "Longline Bigeye Tuna Catch Limits in the Pacific," NOAA, August 13, 2019, Pacific Islands, International, https://www.fisheries.noaa.gov/pacific-islands/sustainable-fisheries/longline-bigeye-tuna-catch-limits-pacific.

"Pacific Island Pelagic Fisheries; 2018 U.S. Territorial Longline Bigeye Tuna Catch Limits," Federal Register, October 23, 2018, https://www.federalregister.gov/documents/2018/10/23/2018-23080/pacific-island-pelagic-fisheries-2018-us-territorial-longline-bigeye-tuna-catch-limits.

In[1555]:=
```
qbdcap = 11879000;(*kg*)
```

Bluefin tuna

Sources:
National Marine Fisheries Service, "National Marine Fisheries Service Pacific Bluefin Stakeholder Meeting," May 19, 2020, https://www.pcouncil.org/documents/2020/06/d-1-a-supplemental-nmfs-report-3.pdf/.

Fisheries, "Atlantic Bluefin Tuna and Northern Albacore Quotas and Minor Change in Atlantic Tuna Size Limit," NOAA, August 10, 2020, New England/Mid-Atlantic, Southeast, https://www.fisheries.noaa.gov/bulletin/atlantic-bluefin-tuna-and-northern-albacore-quotas-and-minor-change-atlantic-tuna-size.

In[1556]:=
```
qfdcap = 1878000;(*kg*)
```

Other/NEI tuna

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

In[1557]:=
```
qodcap = 400000000;(*kg*)
```

Bonito

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

In[1558]:=
```
qndcap = 400 000 000; (*kg*)
```

2.6 Import Market Share Statistics

In[1559]:=
```
N[qatu0 / (qatu0 + qadu0 - qadue0)]
```
Out[1559]= 0.866315

In[1560]:=
```
N[qbtu0 / (qbtu0 + qbdu0 - qbdue0)]
```
Out[1560]= 0.480948

In[1561]:=
```
N[qftu0 / (qftu0 + qfdu0 - qfdue0)]
```
Out[1561]= 0.850392

In[1562]:=
```
N[qstu0 / (qstu0 + qsdu0 - qsdue0)]
```
Out[1562]= 0.973717

In[1563]:=
```
N[qytu0 / (qytu0 + qydu0 - qydue0)]
```
Out[1563]= 0.624867

In[1564]:=
```
N[qntu0 / (qntu0 + qndu0 - qndue0)]
```
Out[1564]= 0.0900498

In[1565]:=
```
N[qatp0 / (qatp0 + qadp0 - qadpe0)]
```
Out[1565]= 0.352289

In[1566]:=
```
N[qbtp0 / (qbtp0 + qbdp0 - qbdpe0)]
```
Out[1566]= 0.836571

In[1567]:=
```
N[qftp0 / (qftp0 + qfdp0 - qfdpe0)]
```
Out[1567]= 0.219584

In[1568]:=
```
N[qstp0 / (qstp0 + qsdp0 - qsdpe0)]
```
Out[1568]= 0.566522

In[1569]:=
```
N[qytp0 / (qytp0 + qydp0 - qydpe0)]
```
Out[1569]= 0.740987

3. Calibration

In[1570]:=
```
vytu0 = qytu0 pytu0;
```

In[1571]:=
```
vytp0 = qytp0 pytp0;
```

```
In[1572]:= vstu0 = qstu0 pstu0;
In[1573]:= vstp0 = qstp0 pstp0;
In[1574]:= vatu0 = qatu0 patu0;
In[1575]:= vatp0 = qatp0 patp0;
In[1576]:= vbtu0 = qbtu0 pbtu0;
In[1577]:= vbtp0 = qbtp0 pbtp0;
In[1578]:= vftu0 = qftu0 pftu0;
In[1579]:= vftp0 = qftp0 pftp0;
In[1580]:= votu0 = qotu0 potu0;
In[1581]:= votp0 = qotp0 potp0;
In[1582]:= vntu0 = qntu0 pntu0;
In[1583]:= vntp0 = qntp0 pntp0;
In[1584]:= vydu0 = (qydu0 - qydue0) pydu0;
In[1585]:= vydp0 = (qydp0 - qydpe0) pydp0;
In[1586]:= vsdu0 = (qsdu0 - qsdue0) psdu0;
In[1587]:= vsdp0 = (qsdp0 - qsdpe0) psdp0;
In[1588]:= vadu0 = (qadu0 - qadue0) padu0;
In[1589]:= vadp0 = (qadp0 - qadpe0) padp0;
In[1590]:= vbdu0 = (qbdu0 - qbdue0 ) pbdu0;
In[1591]:= vbdp0 = (qbdp0 - qbdpe0) pbdp0;
In[1592]:= vfdu0 = (qfdu0 - qfdue0) pfdu0;
In[1593]:= vfdp0 = (qfdp0 - qfdpe0) pfdp0;
In[1594]:= vodu0 = (qodu0 - qodue0) podu0;
In[1595]:= vodp0 = (qodp0 - qodpe0) podp0;
In[1596]:= vndu0 = (qndu0 - qndue0) pndu0;
```

In[∘]:=

3.1 Supply Parameters

In[1597]:= $$\text{eydu} = N\left[\text{eyu}\,\frac{\text{qydu0}}{(\text{qydcap} - \text{qydu0})}\right];$$

In[1598]:= $$\text{aydu} = (\text{qydcap} - \text{qydu0})\ \text{pydu0}^{\text{eydu}};$$

In[1599]:= $$\text{esdu} = N\left[\text{esu}\,\frac{\text{qsdu0}}{(\text{qsdcap} - \text{qsdu0})}\right];$$

In[1600]:= $asdu = (qsdcap - qsdu0)\ psdu0^{esdu};$

In[1601]:= $eadu = N\left[eau \frac{qadu0}{(qadcap - qadu0)}\right];$

In[1602]:= $aadu = (qadcap - qadu0)\ padu0^{eadu};$

In[1603]:= $ebdu = N\left[ebu \frac{qbdu0}{(qbdcap - qbdu0)}\right];$

In[1604]:= $abdu = (qbdcap - qbdu0)\ pbdu0^{ebdu};$

In[1605]:= $efdu = N\left[efu \frac{qfdu0}{(qfdcap - qfdu0)}\right];$

In[1606]:= $afdu = (qfdcap - qfdu0)\ pfdu0^{efdu};$

In[1607]:= $eodu = N\left[eou \frac{qodu0}{(qodcap - qodu0)}\right];$

In[1608]:= $aodu = (qodcap - qodu0)\ podu0^{eodu};$

In[1609]:= $endu = N\left[enu \frac{qndu0}{(qndcap - qndu0)}\right];$

In[1610]:= $andu = (qndcap - qndu0)\ pndu0^{endu};$

3.2 Demand Parameters

In[1611]:= $bytu = \frac{vytu0}{vydu0} \left(\frac{pytu0}{pydu0}\right)^{sigmayu-1};$

In[1612]:= $Pyu0 = \left(pydu0^{1-sigmayu} + bytu\ pytu0^{1-sigmayu}\right)^{\frac{1}{1-sigmayu}};$

In[1613]:= $bstu = \frac{vstu0}{vsdu0} \left(\frac{pstu0}{psdu0}\right)^{sigmasu-1};$

In[1614]:= $Psu0 = \left(psdu0^{1-sigmasu} + bstu\ pstu0^{1-sigmasu}\right)^{\frac{1}{1-sigmasu}};$

In[1615]:= $batu = \frac{vatu0}{vadu0} \left(\frac{patu0}{padu0}\right)^{sigmaau-1};$

In[1616]:= $Pau0 = \left(padu0^{1-sigmaau} + batu\ patu0^{1-sigmaau}\right)^{\frac{1}{1-sigmaau}};$

In[1617]:= $bbtu = \frac{vbtu0}{vbdu0} \left(\frac{pbtu0}{pbdu0}\right)^{sigmabu-1};$

In[1618]:= $Pbu0 = \left(pbdu0^{1-sigmabu} + bbtu\ pbtu0^{1-sigmabu}\right)^{\frac{1}{1-sigmabu}};$

In[1619]:= $bftu = \frac{vftu0}{vfdu0} \left(\frac{pftu0}{pfdu0}\right)^{sigmafu-1};$

In[1620]:= $Pfu0 = \left(pfdu0^{1-sigmafu} + bftu\ pftu0^{1-sigmafu}\right)^{\frac{1}{1-sigmafu}};$

In[1621]:= $$\text{botu} = \frac{\text{votu0}}{\text{vodu0}}\left(\frac{\text{potu0}}{\text{podu0}}\right)^{\text{sigmaou}-1};$$

In[1622]:= $$\text{Pou0} = \left(\text{podu0}^{1-\text{sigmaou}} + \text{botu}\,\text{potu0}^{1-\text{sigmaou}}\right)^{\frac{1}{1-\text{sigmaou}}};$$

In[1623]:= $$\text{bntu} = \frac{\text{vntu0}}{\text{vndu0}}\left(\frac{\text{pntu0}}{\text{pndu0}}\right)^{\text{sigmanu}-1};$$

In[1624]:= $$\text{Pnu0} = \left(\text{pndu0}^{1-\text{sigmanu}} + \text{bntu}\,\text{pntu0}^{1-\text{sigmanu}}\right)^{\frac{1}{1-\text{sigmanu}}};$$

In[1625]:= $$\text{bsu} = \frac{\text{vsdu0} + \text{vstu0}}{\text{vydu0} + \text{vytu0}}\left(\frac{\text{Psu0}}{\text{Pyu0}}\right)^{\text{betau}-1};$$

In[1626]:= $$\text{bau} = \frac{\text{vadu0} + \text{vatu0}}{\text{vydu0} + \text{vytu0}}\left(\frac{\text{Pau0}}{\text{Pyu0}}\right)^{\text{betau}-1};$$

In[1627]:= $$\text{bou} = \frac{\text{vodu0} + \text{votu0}}{\text{vydu0} + \text{vytu0}}\left(\frac{\text{Pou0}}{\text{Pyu0}}\right)^{\text{betau}-1};$$

In[1628]:= $$\text{bnu} = \frac{\text{vndu0} + \text{vntu0}}{\text{vydu0} + \text{vytu0}}\left(\frac{\text{Pnu0}}{\text{Pyu0}}\right)^{\text{betau}-1};$$

In[1629]:= $$\text{bfu} = \frac{\text{vfdu0} + \text{vftu0}}{\text{vbdu0} + \text{vbtu0}}\left(\frac{\text{Pfu0}}{\text{Pbu0}}\right)^{\text{betau}-1};$$

In[1630]:= $$\text{P1u0} = \left(\text{Pyu0}^{1-\text{betau}} + \text{bsu}\,\text{Psu0}^{1-\text{betau}} + \text{bau}\,\text{Pau0}^{1-\text{betau}} + \text{bou}\,\text{Pou0}^{1-\text{betau}} + \text{bnu}\,\text{Pnu0}^{1-\text{betau}}\right)^{\frac{1}{1-\text{betau}}};$$

In[1631]:= $$\text{P2u0} = \left(\text{Pbu0}^{1-\text{betau}} + \text{bfu}\,\text{Pfu0}^{1-\text{betau}}\right)^{\frac{1}{1-\text{betau}}};$$

In[1632]:= $$\text{bytp} = \frac{\text{vytp0}}{\text{vydp0}}\left(\frac{\text{pytp0}}{\text{pydp0}}\right)^{\text{sigmayp}-1};$$

In[1633]:= $$\text{Pyp0} = \left(\text{pydp0}^{1-\text{sigmayp}} + \text{bytp}\,\text{pytp0}^{1-\text{sigmayp}}\right)^{\frac{1}{1-\text{sigmayp}}};$$

In[1634]:= $$\text{bstp} = \frac{\text{vstp0}}{\text{vsdp0}}\left(\frac{\text{pstp0}}{\text{psdp0}}\right)^{\text{sigmasp}-1};$$

In[1635]:= $$\text{Psp0} = \left(\text{psdp0}^{1-\text{sigmasp}} + \text{bstp}\,\text{pstp0}^{1-\text{sigmasp}}\right)^{\frac{1}{1-\text{sigmasp}}};$$

In[1636]:= $$\text{batp} = \frac{\text{vatp0}}{\text{vadp0}}\left(\frac{\text{patp0}}{\text{padp0}}\right)^{\text{sigmaap}-1};$$

In[1637]:= $$\text{Pap0} = \left(\text{padp0}^{1-\text{sigmaap}} + \text{batp}\,\text{patp0}^{1-\text{sigmaap}}\right)^{\frac{1}{1-\text{sigmaap}}};$$

In[1638]:= $$\text{bbtp} = \frac{\text{vbtp0}}{\text{vbdp0}}\left(\frac{\text{pbtp0}}{\text{pbdp0}}\right)^{\text{sigmabp}-1};$$

In[1639]:= $$\text{Pbp0} = \left(\text{pbdp0}^{1-\text{sigmabp}} + \text{bbtp}\,\text{pbtp0}^{1-\text{sigmabp}}\right)^{\frac{1}{1-\text{sigmabp}}};$$

In[1640]:= $$\text{bftp} = \frac{\text{vftp0}}{\text{vfdp0}}\left(\frac{\text{pftp0}}{\text{pfdp0}}\right)^{\text{sigmafp}-1};$$

In[1641]:= $$\text{Pfp0} = \left(\text{pfdp0}^{1-\text{sigmafp}} + \text{bftp}\,\text{pftp0}^{1-\text{sigmafp}}\right)^{\frac{1}{1-\text{sigmafp}}};$$

In[1642]:= $$\text{botp} = \frac{\text{votp0}}{\text{vodp0}}\left(\frac{\text{potp0}}{\text{podp0}}\right)^{\text{sigmaop}-1};$$

In[1643]:= $$\text{Pop0} = \left(\text{podp0}^{1-\text{sigmaop}} + \text{botp potp0}^{1-\text{sigmaop}}\right)^{\frac{1}{1-\text{sigmaop}}};$$

In[1644]:= $$\text{bsp} = \frac{\text{vsdp0} + \text{vstp0}}{\text{vydp0} + \text{vytp0}}\left(\frac{\text{Psp0}}{\text{Pyp0}}\right)^{\text{betap}-1};$$

In[1645]:= $$\text{bap} = \frac{\text{vadp0} + \text{vatp0}}{\text{vydp0} + \text{vytp0}}\left(\frac{\text{Pap0}}{\text{Pyp0}}\right)^{\text{betap}-1};$$

In[1646]:= $$\text{bop} = \frac{\text{vodp0} + \text{votp0}}{\text{vydp0} + \text{vytp0}}\left(\frac{\text{Pop0}}{\text{Pyp0}}\right)^{\text{betap}-1};$$

In[1647]:= $$\text{bnp} = \frac{\text{vntp0}}{\text{vydp0} + \text{vytp0}}\left(\frac{\text{pntp0}}{\text{Pyp0}}\right)^{\text{betap}-1};$$

In[1648]:= $$\text{bfp} = \frac{\text{vfdp0} + \text{vftp0}}{\text{vbdp0} + \text{vbtp0}}\left(\frac{\text{Pfp0}}{\text{Pbp0}}\right)^{\text{betap}-1};$$

In[1649]:= $$\text{P1p0} = \left(\text{Pyp0}^{1-\text{betap}} + \text{bsp Psp0}^{1-\text{betap}} + \text{bap Pap0}^{1-\text{betap}} + \text{bop Pop0}^{1-\text{betap}} + \text{bnp pntp0}^{1-\text{betap}}\right)^{\frac{1}{1-\text{betap}}};$$

In[1650]:= $$\text{P2p0} = \left(\text{Pbp0}^{1-\text{betap}} + \text{bfp Pfp0}^{1-\text{betap}}\right)^{\frac{1}{1-\text{betap}}};$$

In[1651]:= $$\text{ku1} = \frac{\text{qytu0 P1u0}^{-\text{etau}-\text{betau}}\ \text{Pyu0}^{\text{betau}-\text{sigmayu}}\ \text{pytu0}^{\text{sigmayu}}}{\text{bytu}};$$

In[1652]:= $$\text{ku2} = \frac{\text{qbtu0 P2u0}^{-\text{etau}-\text{betau}}\ \text{Pbu0}^{\text{betau}-\text{sigmabu}}\ \text{pbtu0}^{\text{sigmabu}}}{\text{bbtu}};$$

In[1653]:= $$\text{kp1} = \frac{\text{qytp0 P1p0}^{-\text{etap}-\text{betap}}\ \text{Pyp0}^{\text{betap}-\text{sigmayp}}\ \text{pytp0}^{\text{sigmayp}}}{\text{bytp}};$$

In[1654]:= $$\text{kp2} = \frac{\text{qbtp0 P2p0}^{-\text{etap}-\text{betap}}\ \text{Pbp0}^{\text{betap}-\text{sigmabp}}\ \text{pbtp0}^{\text{sigmabp}}}{\text{bbtp}};$$

4. New Equilibrium Calculation

In[1655]:= $$\text{Pyu} = \left(\text{pydu}^{1-\text{sigmayu}} + \text{bytu pytu}^{1-\text{sigmayu}}\right)^{\frac{1}{1-\text{sigmayu}}};$$

In[1656]:= $$\text{Psu} = \left(\text{psdu}^{1-\text{sigmasu}} + \text{bstu pstu}^{1-\text{sigmasu}}\right)^{\frac{1}{1-\text{sigmasu}}};$$

In[1657]:= $$\text{Pau} = \left(\text{padu}^{1-\text{sigmaau}} + \text{batu patu}^{1-\text{sigmaau}}\right)^{\frac{1}{1-\text{sigmaau}}};$$

In[1658]:= $$\text{Pbu} = \left(\text{pbdu}^{1-\text{sigmabu}} + \text{bbtu pbtu}^{1-\text{sigmabu}}\right)^{\frac{1}{1-\text{sigmabu}}};$$

In[1659]:= $$\text{Pfu} = \left(\text{pfdu}^{1-\text{sigmafu}} + \text{bftu pftu}^{1-\text{sigmafu}}\right)^{\frac{1}{1-\text{sigmafu}}};$$

In[1660]:= $$\text{Pou} = \left(\text{podu}^{1-\text{sigmaou}} + \text{botu potu}^{1-\text{sigmaou}}\right)^{\frac{1}{1-\text{sigmaou}}};$$

In[1661]:= $$\text{Pnu} = \left(\text{pndu}^{1-\text{sigmanu}} + \text{bntu pntu}^{1-\text{sigmanu}}\right)^{\frac{1}{1-\text{sigmanu}}};$$

In[1662]:= $P1u = \left(Pyu^{1-betau} + bsu\ Psu^{1-betau} + bau\ Pau^{1-betau} + bou\ Pou^{1-betau} + bnu\ Pnu^{1-betau}\right)^{\frac{1}{1-betau}};$

In[1663]:= $P2u = \left(Pbu^{1-betau} + bfu\ Pfu^{1-betau}\right)^{\frac{1}{1-betau}};$

In[1664]:= $pydp = Pyu \frac{pydp0}{Pyu0};$

In[1665]:= $psdp = Psu \frac{psdp0}{Psu0};$

In[1666]:= $padp = Pau \frac{padp0}{Pau0};$

In[1667]:= $podp = Pou \frac{podp0}{Pou0};$

In[1668]:= $pbdp = Pbu \frac{pbdp0}{Pbu0};$

In[1669]:= $pfdp = Pfu \frac{pfdp0}{Pfu0};$

In[1670]:= $Pyp = \left(pydp^{1-sigmayp} + bytp\ pytp^{1-sigmayp}\right)^{\frac{1}{1-sigmayp}};$

In[1671]:= $Psp = \left(psdp^{1-sigmasp} + bstp\ pstp^{1-sigmasp}\right)^{\frac{1}{1-sigmasp}};$

In[1672]:= $Pap = \left(padp^{1-sigmaap} + batp\ patp^{1-sigmaap}\right)^{\frac{1}{1-sigmaap}};$

In[1673]:= $Pbp = \left(pbdp^{1-sigmabp} + bbtp\ pbtp^{1-sigmabp}\right)^{\frac{1}{1-sigmabp}};$

In[1674]:= $Pfp = \left(pfdp^{1-sigmafp} + bftp\ pftp^{1-sigmafp}\right)^{\frac{1}{1-sigmafp}};$

In[1675]:= $Pop = \left(podp^{1-sigmaop} + botp\ potp^{1-sigmaop}\right)^{\frac{1}{1-sigmaop}};$

In[1676]:= $P1p = \left(Pyp^{1-betap} + bsp\ Psp^{1-betap} + bap\ Pap^{1-betap} + bop\ Pop^{1-betap} + bnp\ pntp^{1-betap}\right)^{\frac{1}{1-betap}};$

In[1677]:= $P2p = \left(Pbp^{1-betap} + bfp\ Pfp^{1-betap}\right)^{\frac{1}{1-betap}};$

Equilibrium equations

Total supply (landings) of wild caught = exports + consumer demand

In[1678]:= $E1 = qydcap - aydu\ pydu^{-eydu} == qydue0 + ku1\ P1u^{etau+betau}\ Pyu^{sigmayu-betau}\ pydu^{-sigmayu};$

In[1679]:= $E2 = qsdcap - asdu\ psdu^{-esdu} == qsdue0 + ku1\ bsu\ P1u^{etau+betau}\ Psu^{sigmasu-betau}\ psdu^{-sigmasu};$

In[1680]:= $E3 = qadcap - aadu\ padu^{-eadu} == qadue0 + ku1\ bau\ P1u^{etau+betau}\ Pau^{sigmaau-betau}\ padu^{-sigmaau};$

In[1681]:= $E4 = qbdcap - abdu\ pbdu^{-ebdu} == qbdue0 + ku2\ P2u^{etau+betau}\ Pbu^{sigmabu-betau}\ pbdu^{-sigmabu};$

In[1682]:= $E5 = qfdcap - afdu\ pfdu^{-efdu} == qfdue0 + ku2\ bfu\ P2u^{etau+betau}\ Pfu^{sigmafu-betau}\ pfdu^{-sigmafu};$

In[1683]:= $E6 = qodcap - aodu\ podu^{-eodu} == qodue0 + ku1\ bou\ P1u^{etau+betau}\ Pou^{sigmaou-betau}\ podu^{-sigmaou};$

In[1684]:= $E19 = qndcap - andu\ pndu^{-endu} == qndue0 + ku1\ bnu\ P1u^{etau+betau}\ Pnu^{sigmanu-betau}\ pndu^{-sigmanu};$

Supply of imported unprocessed product = Demand for imported unprocessed product

In[1685]:= **E7 = qylu0 + reply qyiu0 == ku1 bytu P1u^etau+betau Pyu^sigmayu-betau pytu^-sigmayu;**

In[1686]:= **E8 = qslu0 + repls qsiu0 == ku1 bstu bsu P1u^etau+betau Psu^sigmasu-betau pstu^-sigmasu;**

In[1687]:= **E9 = qalu0 + repla qaiu0 == ku1 batu bau P1u^etau+betau Pau^sigmaau-betau patu^-sigmaau;**

In[1688]:= **E10 = qblu0 + replb qbiu0 == ku2 bbtu P2u^etau+betau Pbu^sigmabu-betau pbtu^-sigmabu;**

In[1689]:= **E11 = qflu0 + replf qfiu0 == ku2 bftu bfu P2u^etau+betau Pfu^sigmafu-betau pftu^-sigmafu;**

In[1690]:= **E12 = qolu0 + replo qoiu0 == ku1 botu bou P1u^etau+betau Pou^sigmaou-betau potu^-sigmaou;**

In[1691]:= **E20 = qnlu0 + repln qniu0 == ku1 bntu bnu P1u^etau+betau Pnu^sigmanu-betau pntu^-sigmanu;**

Supply of imported processed product = Demand for imported processed product

In[1692]:= **E13 = qylp0 + reply qyip0 == kp1 bytp P1p^etap+betap Pyp^sigmayp-betap pytp^-sigmayp;**

In[1693]:= **E14 = qslp0 + repls qsip0 == kp1 bstp bsp P1p^etap+betap Psp^sigmasp-betap pstp^-sigmasp;**

In[1694]:= **E15 = qalp0 + repla qaip0 == kp1 batp bap P1p^etap+betap Pap^sigmaap-betap patp^-sigmaap;**

In[1695]:= **E16 = qblp0 + replb qbip0 == kp2 bbtp P2p^etap+betap Pbp^sigmabp-betap pbtp^-sigmabp;**

In[1696]:= **E17 = qflp0 + replf qfip0 == kp2 bftp bfp P2p^etap+betap Pfp^sigmafp-betap pftp^-sigmafp;**

In[1697]:= **E18 = qolp0 + replo qoip0 == kp1 botp bop P1p^etap+betap Pop^sigmaop-betap potp^-sigmaop;**

In[1698]:= **E21 = qnlp0 + repln qnip0 == kp1 bnp P1p^etap+betap pntp^-betap;**

```
In[1699]:= FindRoot[{E1, E2, E3, E4, E5, E6, E7, E8, E9, E10, E11, E12, E13, E14, E15,
    E16, E17, E18, E19, E20, E21}, {pydu, pydu0}, {pytu, pytu0}, {psdu, psdu0},
   {pstu, pstu0}, {padu, padu0}, {patu, patu0}, {pbdu, pbdu0}, {pbtu, pbtu0},
   {pytp, pytp0}, {pstp, pstp0}, {patp, patp0}, {pbtp, pbtp0}, {pfdu, pfdu0},
   {pftu, pftu0}, {pftp, pftp0}, {podu, podu0}, {potu, potu0}, {potp, potp0},
   {pndu, pndu0}, {pntu, pntu0}, {pntp, pntp0}, AccuracyGoal → 7, PrecisionGoal → 7]

Out[1699]= {pydu → 6.16814, pytu → 6.527, psdu → 1.528, pstu → 5.9979, padu → 3.52998, patu → 6.33643,
   pbdu → 9.43743, pbtu → 8.35397, pytp → 8.6401, pstp → 4.95405, patp → 6.69747,
   pbtp → 9.89076, pfdu → 13.1168, pftu → 27.2299, pftp → 16.5047, podu → 2.27305,
   potu → 6.29823, potp → 9.04516, pndu → 0.803673, pntu → 3.4467, pntp → 6.28996}

In[1700]:= pydu1 = pydu /. %;

In[1701]:= pytu1 = pytu /. %%;

In[1702]:= pytp1 = pytp /. %%%;

In[1703]:= psdu1 = psdu /. %%%%;

In[1704]:= pstu1 = pstu /. %%%%%;

In[1705]:= pstp1 = pstp /. %%%%%%;

In[1706]:= padu1 = padu /. %%%%%%%;

In[1707]:= patu1 = patu /. %%%%%%%%;
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In[1708]:= patp1 = patp /. %%%%%%%%%;

In[1709]:= pbdu1 = pbdu /. %%%%%%%%%%;

In[1710]:= pbtu1 = pbtu /. %%%%%%%%%%%;

In[1711]:= pbtp1 = pbtp /. %%%%%%%%%%%%;

In[1712]:= pfdu1 = pfdu /. %%%%%%%%%%%%%;

In[1713]:= pftu1 = pftu /. %%%%%%%%%%%%%%;

In[1714]:= pftp1 = pftp /. %%%%%%%%%%%%%%%;

In[1715]:= podu1 = podu /. %%%%%%%%%%%%%%%%;

In[1716]:= potu1 = potu /. %%%%%%%%%%%%%%%%%;

In[1717]:= potp1 = potp /. %%%%%%%%%%%%%%%%%%;

In[1718]:= pndu1 = pndu /. %%%%%%%%%%%%%%%%%%%;

In[1719]:= pntu1 = pntu /. %%%%%%%%%%%%%%%%%%%%;

In[1720]:= pntp1 = pntp /. %%%%%%%%%%%%%%%%%%%%%;
```

In[1721]:= $\text{Pyu1} = \left(\text{pydu1}^{1-\text{sigmayu}} + \text{bytu}\ \text{pytu1}^{1-\text{sigmayu}}\right)^{\frac{1}{1-\text{sigmayu}}};$

In[1722]:= $\text{Psu1} = \left(\text{psdu1}^{1-\text{sigmasu}} + \text{bstu}\ \text{pstu1}^{1-\text{sigmasu}}\right)^{\frac{1}{1-\text{sigmasu}}};$

In[1723]:= $\text{Pau1} = \left(\text{padu1}^{1-\text{sigmaau}} + \text{batu}\ \text{patu1}^{1-\text{sigmaau}}\right)^{\frac{1}{1-\text{sigmaau}}};$

In[1724]:= $\text{Pbu1} = \left(\text{pbdu1}^{1-\text{sigmabu}} + \text{bbtu}\ \text{pbtu1}^{1-\text{sigmabu}}\right)^{\frac{1}{1-\text{sigmabu}}};$

In[1725]:= $\text{Pfu1} = \left(\text{pfdu1}^{1-\text{sigmafu}} + \text{bftu}\ \text{pftu1}^{1-\text{sigmafu}}\right)^{\frac{1}{1-\text{sigmafu}}};$

In[1726]:= $\text{Pou1} = \left(\text{podu1}^{1-\text{sigmaou}} + \text{botu}\ \text{potu1}^{1-\text{sigmaou}}\right)^{\frac{1}{1-\text{sigmaou}}};$

In[1727]:= $\text{Pnu1} = \left(\text{pndu1}^{1-\text{sigmanu}} + \text{bntu}\ \text{pntu1}^{1-\text{sigmanu}}\right)^{\frac{1}{1-\text{sigmanu}}};$

In[1728]:= $\text{P1u1} = \left(\text{Pyu1}^{1-\text{betau}} + \text{bsu}\ \text{Psu1}^{1-\text{betau}} + \text{bau}\ \text{Pau1}^{1-\text{betau}} + \text{bou}\ \text{Pou1}^{1-\text{betau}} + \text{bnu}\ \text{Pnu1}^{1-\text{betau}}\right)^{\frac{1}{1-\text{betau}}};$

In[1729]:= $\text{P2u1} = \left(\text{Pbu1}^{1-\text{betau}} + \text{bfu}\ \text{Pfu1}^{1-\text{betau}}\right)^{\frac{1}{1-\text{betau}}};$

In[1730]:= $\text{Pyp1} = \left(\text{pydp1}^{1-\text{sigmayp}} + \text{bytp}\ \text{pytp1}^{1-\text{sigmayp}}\right)^{\frac{1}{1-\text{sigmayp}}};$

In[1731]:= $\text{Psp1} = \left(\text{psdp1}^{1-\text{sigmasp}} + \text{bstp}\ \text{pstp1}^{1-\text{sigmasp}}\right)^{\frac{1}{1-\text{sigmasp}}};$

In[1732]:= $\text{Pap1} = \left(\text{padp1}^{1-\text{sigmaap}} + \text{batp}\ \text{patp1}^{1-\text{sigmaap}}\right)^{\frac{1}{1-\text{sigmaap}}};$

In[1733]:= $\text{Pbp1} = \left(\text{pbdp1}^{1-\text{sigmabp}} + \text{bbtp}\ \text{pbtp1}^{1-\text{sigmabp}}\right)^{\frac{1}{1-\text{sigmabp}}};$

In[1734]:= $\text{Pfp1} = \left(\text{pfdp1}^{1-\text{sigmafp}} + \text{bftp}\ \text{pftp1}^{1-\text{sigmafp}}\right)^{\frac{1}{1-\text{sigmafp}}};$

In[1735]:= $\text{Pop1} = \left(\text{podp1}^{1-\text{sigmaop}} + \text{botp potp1}^{1-\text{sigmaop}}\right)^{\frac{1}{1-\text{sigmaop}}};$

In[1736]:= $\text{P1p1} = \left(\text{Pyp1}^{1-\text{betap}} + \text{bsp Psp1}^{1-\text{betap}} + \text{bap Pap1}^{1-\text{betap}} + \text{bop Pop1}^{1-\text{betap}} + \text{bnp pntp1}^{1-\text{betap}}\right)^{\frac{1}{1-\text{betap}}};$

In[1737]:= $\text{P2p1} = \left(\text{Pbp1}^{1-\text{betap}} + \text{bfp Pfp1}^{1-\text{betap}}\right)^{\frac{1}{1-\text{betap}}};$

In[1738]:= $\text{pydp1} = \text{Pyu1} \frac{\text{pydp0}}{\text{Pyu0}};$

In[1739]:= $\text{psdp1} = \text{Psu1} \frac{\text{psdp0}}{\text{Psu0}};$

In[1740]:= $\text{padp1} = \text{Pau1} \frac{\text{padp0}}{\text{Pau0}};$

In[1741]:= $\text{podp1} = \text{Pou1} \frac{\text{podp0}}{\text{Pou0}};$

In[1742]:= $\text{pbdp1} = \text{Pbu1} \frac{\text{pbdp0}}{\text{Pbu0}};$

In[1743]:= $\text{pfdp1} = \text{Pfu1} \frac{\text{pfdp0}}{\text{Pfu0}};$

In[1744]:= $\text{qydu1} = \text{qydcap} - \text{aydu pydu1}^{-\text{eydu}};$

In[1745]:= $\text{qytu1} = \text{qylu0} + \text{reply qyiu0};$

In[1746]:= $\text{qytp1} = \text{qylp0} + \text{reply qyip0};$

In[1747]:= $\text{qydp1} = \text{qydpe0} + \text{kp1 P1p1}^{\text{etap+betap}}\ \text{Pyp1}^{\text{sigmayp-betap}}\ \text{pydp1}^{-\text{sigmayp}};$

In[1748]:= $\text{qsdu1} = \text{qsdcap} - \text{asdu psdu1}^{-\text{esdu}};$

In[1749]:= $\text{qstu1} = \text{qslu0} + \text{repls qsiu0};$

In[1750]:= $\text{qstp1} = \text{qslp0} + \text{repls qsip0};$

In[1751]:= $\text{qsdp1} = \text{qsdpe0} + \text{kp1 bsp P1p1}^{\text{etap+betap}}\ \text{Psp1}^{\text{sigmasp-betap}}\ \text{psdp1}^{-\text{sigmasp}};$

In[1752]:= $\text{qadu1} = \text{qadcap} - \text{aadu padu1}^{-\text{eadu}};$

In[1753]:= $\text{qatu1} = \text{qalu0} + \text{repla qaiu0};$

In[1754]:= $\text{qatp1} = \text{qalp0} + \text{repla qaip0};$

In[1755]:= $\text{qadp1} = \text{qadpe0} + \text{kp1 bap P1p1}^{\text{etap+betap}}\ \text{Pap1}^{\text{sigmaap-betap}}\ \text{padp1}^{-\text{sigmaap}};$

In[1756]:= $\text{qbdu1} = \text{qbdcap} - \text{abdu pbdu1}^{-\text{ebdu}};$

In[1757]:= $\text{qbtu1} = \text{qblu0} + \text{replb qbiu0};$

In[1758]:= $\text{qbtp1} = \text{qblp0} + \text{replb qbip0};$

In[1759]:= $\text{qbdp1} = \text{qbdpe0} + \text{kp2 P2p1}^{\text{etap+betap}}\ \text{Pbp1}^{\text{sigmabp-betap}}\ \text{pbdp1}^{-\text{sigmabp}};$

In[1760]:= $\text{qfdu1} = \text{qfdcap} - \text{afdu pfdu1}^{-\text{efdu}};$

In[1761]:= $\text{qftu1} = \text{qflu0} + \text{replf qfiu0};$

In[1762]:=
```
qftp1 = qflp0 + replf qfip0;
```

In[1763]:= $qfdp1 = qfdpe0 + kp2\ bfp\ P2p1^{etap+betap}\ Pfp1^{sigmafp-betap}\ pfdp1^{-sigmafp};$

In[1764]:= $qodu1 = qodcap - aodu\ podu1^{-eodu};$

In[1765]:=
```
qotu1 = qolu0 + replo qoiu0;
```

In[1766]:=
```
qotp1 = qolp0 + replo qoip0;
```

In[1767]:= $qodp1 = qodpe0 + kp1\ bop\ P1p1^{etap+betap}\ Pop1^{sigmaop-betap}\ podp1^{-sigmaop};$

In[1768]:= $qndu1 = qndcap - andu\ pndu1^{-endu};$

In[1769]:=
```
qntu1 = qnlu0 + repln qniu0;
```

In[1770]:=
```
qntp1 = qnlp0 + repln qnip0;
```

5. Results

Albacore Tuna

Percent change in price of unprocessed domestic production

In[1771]:= $$\frac{(padu1 - padu0)\ 100}{padu0}$$

Out[1771]= 0.155467

Percent change in quantity of landings

In[1772]:= $$\frac{(qadu1 - qadu0)\ 100}{qadu0}$$

Out[1772]= 0.776665

Percent change in price of processed domestic production

In[1773]:= $$\frac{(padp1 - padp0)\ 100}{padp0}$$

Out[1773]= 5.69512

Percent change in quantity of processed domestic product

In[1774]:= $$\frac{(qadp1 - qadp0)\ 100}{qadp0}$$

Out[1774]= -5.30126

Change ($) in operating income, unprocessed product

In[1775]:=
```
(1 / sigmaau) (padu1 (qadu1 - qadue0) - padu0 (qadu0 - qadue0))
```

Out[1775]=
```
121 133.
```

Change ($) in operating income, processed product

In[1776]:=
```
(1 / sigmaap) (padp1 (qadp1 - qadpe0) - padp0 (qadp0 - qadpe0))
```

Out[1776]=
```
187 232.
```

Percent change in price of unprocessed imports

In[1777]:=
$$\frac{(patu1 - patu0)\ 100}{patu0}$$

Out[1777]=
```
6.23098
```

Percent change in quantity of unprocessed imports

In[1778]:=
$$\frac{(qatu1 - qatu0)\ 100}{qatu0}$$

Out[1778]=
```
-7.61977
```

Percent change in price of processed imports

In[1779]:=
$$\frac{(patp1 - patp0)\ 100}{patp0}$$

Out[1779]=
```
6.71746
```

Percent change in quantity of processed imports

In[1780]:=
$$\frac{(qatp1 - qatp0)\ 100}{qatp0}$$

Out[1780]=
```
-7.11248
```

Bigeye Tuna

Percent change in price of unprocessed domestic production

In[1781]:=
$$\frac{(pbdu1 - pbdu0)\ 100}{pbdu0}$$

Out[1781]=
```
4.80216
```

Percent change in quantity of landings

In[1782]:= $\frac{(\text{qbdu1} - \text{qbdu0})\ 100}{\text{qbdu0}}$

Out[1782]= 8.42147

Percent change in price of processed domestic production

In[1783]:= $\frac{(\text{pbdp1} - \text{pbdp0})\ 100}{\text{pbdp0}}$

Out[1783]= 8.18543

Percent change in quantity of processed domestic product

In[1784]:= $\frac{(\text{qbdp1} - \text{qbdp0})\ 100}{\text{qbdp0}}$

Out[1784]= 1.0226

Change ($) in operating income, unprocessed product

In[1785]:= $(1 / \text{sigmabu})\ (\text{pbdu1}\ (\text{qbdu1} - \text{qbdue0}) - \text{pbdu0}\ (\text{qbdu0} - \text{qbdue0}))$

Out[1785]= 3.93111×10^{6}

Change ($) in operating income, processed product

In[1786]:= $(1 / \text{sigmabp})\ (\text{pbdp1}\ (\text{qbdp1} - \text{qbdpe0}) - \text{pbdp0}\ (\text{qbdp0} - \text{qbdpe0}))$

Out[1786]= 1.41965×10^{6}

Percent change in price of unprocessed imports

In[1787]:= $\frac{(\text{pbtu1} - \text{pbtu0})\ 100}{\text{pbtu0}}$

Out[1787]= 13.0962

Percent change in quantity of unprocessed imports

In[1788]:= $\frac{(\text{qbtu1} - \text{qbtu0})\ 100}{\text{qbtu0}}$

Out[1788]= -10.7883

Percent change in price of processed imports

In[1789]:=
$$\frac{(\text{pbtp1} - \text{pbtp0})\ 100}{\text{pbtp0}}$$

Out[1789]= 14.1016

Percent change in quantity of processed imports

In[1790]:=
$$\frac{(\text{qbtp1} - \text{qbtp0})\ 100}{\text{qbtp0}}$$

Out[1790]= -11.948

Bluefin Tuna

Percent change in price of unprocessed domestic production

In[1791]:=
$$\frac{(\text{pfdu1} - \text{pfdu0})\ 100}{\text{pfdu0}}$$

Out[1791]= 10.1499

Percent change in quantity of landings

In[1792]:=
$$\frac{(\text{qfdu1} - \text{qfdu0})\ 100}{\text{qfdu0}}$$

Out[1792]= 17.5124

Percent change in price of processed domestic production

In[1793]:=
$$\frac{(\text{pfdp1} - \text{pfdp0})\ 100}{\text{pfdp0}}$$

Out[1793]= 25.499

Percent change in quantity of processed domestic product

In[1794]:=
$$\frac{(\text{qfdp1} - \text{qfdp0})\ 100}{\text{qfdp0}}$$

Out[1794]= -35.0237

Change ($) in operating income, unprocessed product

In[1795]:= (1 / sigmafu) (pfdu1 (qfdu1 - qfdue0) - pfdu0 (qfdu0 - qfdue0))

Out[1795]= 445928.

Change ($) in operating income, processed product

In[1796]:= (1 / sigmafp) (pfdp1 (qfdp1 - qfdpe0) - pfdp0 (qfdp0 - qfdpe0))

Out[1796]= -631 283.

Percent change in price of unprocessed imports

In[1797]:= $\frac{(\text{pftu1} - \text{pftu0})\ 100}{\text{pftu0}}$

Out[1797]= 27.9127

Percent change in quantity of unprocessed imports

In[1798]:= $\frac{(\text{qftu1} - \text{qftu0})\ 100}{\text{qftu0}}$

Out[1798]= -42.8836

Percent change in price of processed imports

In[1799]:= $\frac{(\text{pftp1} - \text{pftp0})\ 100}{\text{pftp0}}$

Out[1799]= 22.1757

Percent change in quantity of processed imports

In[1800]:= $\frac{(\text{qftp1} - \text{qftp0})\ 100}{\text{qftp0}}$

Out[1800]= -23.581

Skipjack Tuna

Percent change in price of unprocessed domestic production

In[1801]:= $\frac{(\text{psdu1} - \text{psdu0})\ 100}{\text{psdu0}}$

Out[1801]= 2.11877

Percent change in quantity of landings

In[1802]:= $\frac{(\text{qsdu1} - \text{qsdu0})\ 100}{\text{qsdu0}}$

Out[1802]= 10.4812

Percent change in price of processed domestic production

In[1803]:=
$$\frac{(\text{psdp1} - \text{psdp0})\ 100}{\text{psdp0}}$$

Out[1803]= 4.84059

Percent change in quantity of processed domestic product

In[1804]:=
$$\frac{(\text{qsdp1} - \text{qsdp0})\ 100}{\text{qsdp0}}$$

Out[1804]= -1.03135

Change ($) in operating income, unprocessed product

In[1805]:=
```
(1 / sigmasu) (psdu1 (qsdu1 - qsdue0) - psdu0 (qsdu0 - qsdue0))
```

Out[1805]= 30,382.3

Change ($) in operating income, processed product

In[1806]:=
```
(1 / sigmasp) (psdp1 (qsdp1 - qsdpe0) - psdp0 (qsdp0 - qsdpe0))
```

Out[1806]= 1.4098×10^6

Percent change in price of unprocessed imports

In[1807]:=
$$\frac{(\text{pstu1} - \text{pstu0})\ 100}{\text{pstu0}}$$

Out[1807]= 4.86212

Percent change in quantity of unprocessed imports

In[1808]:=
$$\frac{(\text{qstu1} - \text{qstu0})\ 100}{\text{qstu0}}$$

Out[1808]= -4.54299

Percent change in price of processed imports

In[1809]:=
$$\frac{(\text{pstp1} - \text{pstp0})\ 100}{\text{pstp0}}$$

Out[1809]= 5.37672

Percent change in quantity of processed imports

In[1810]:= $\frac{(\text{qstp1} - \text{qstp0})\ 100}{\text{qstp0}}$

Out[1810]= -5.20652

Yellowfin Tuna

Percent change in price of unprocessed domestic production

In[1811]:= $\frac{(\text{pydu1} - \text{pydu0})\ 100}{\text{pydu0}}$

Out[1811]= 0.982994

Percent change in quantity of landings

In[1812]:= $\frac{(\text{qydu1} - \text{qydu0})\ 100}{\text{qydu0}}$

Out[1812]= 4.8892

Percent change in price of processed domestic production

In[1813]:= $\frac{(\text{pydp1} - \text{pydp0})\ 100}{\text{pydp0}}$

Out[1813]= 4.55994

Percent change in quantity of processed domestic product

In[1814]:= $\frac{(\text{qydp1} - \text{qydp0})\ 100}{\text{qydp0}}$

Out[1814]= -2.11019

Change ($) in operating income, unprocessed product

In[1815]:= (1 / sigmayu) (pydu1 (qydu1 - qydue0) - pydu0 (qydu0 - qydue0))

Out[1815]= 704,277.

Change ($) in operating income, processed product

In[1816]:= (1 / sigmayp) (pydp1 (qydp1 - qydpe0) - pydp0 (qydp0 - qydpe0))

Out[1816]= 856,432.

Percent change in price of unprocessed imports

In[1817]:=
$$\frac{(\text{pytu1} - \text{pytu0})\ 100}{\text{pytu0}}$$

Out[1817]= 6.89108

Percent change in quantity of unprocessed imports

In[1818]:=
$$\frac{(\text{qytu1} - \text{qytu0})\ 100}{\text{qytu0}}$$

Out[1818]= -9.52573

Percent change in price of processed imports

In[1819]:=
$$\frac{(\text{pytp1} - \text{pytp0})\ 100}{\text{pytp0}}$$

Out[1819]= 7.39606

Percent change in quantity of processed imports

In[1820]:=
$$\frac{(\text{qytp1} - \text{qytp0})\ 100}{\text{qytp0}}$$

Out[1820]= -9.35907

Other Tuna

Percent change in price of unprocessed domestic production

In[1821]:=
$$\frac{(\text{podu1} - \text{podu0})\ 100}{\text{podu0}}$$

Out[1821]= 0.514952

Percent change in quantity of landings

In[1822]:=
$$\frac{(\text{qodu1} - \text{qodu0})\ 100}{\text{qodu0}}$$

Out[1822]= 2.56813

Percent change in price of processed domestic production

In[1823]:=
$$\frac{(\text{podp1} - \text{podp0})\ 100}{\text{podp0}}$$

Out[1823]= 6.37202

Percent change in quantity of processed domestic product

In[1824]:=
$$\frac{(qodp1 - qodp0)\ 100}{qodp0}$$

Out[1824]= -11.3423

Change ($) in operating income, unprocessed product

In[1825]:=
```
(1 / sigmaou) (podu1 (qodu1 - qodue0) - podu0 (qodu0 - qodue0))
```

Out[1825]= 8962.04

Change ($) in operating income, processed product

In[1826]:=
```
(1 / sigmaop) (podp1 (qodp1 - qodpe0) - podp0 (qodp0 - qodpe0))
```

Out[1826]= -35.5733

Percent change in price of unprocessed imports

In[1827]:=
$$\frac{(potu1 - potu0)\ 100}{potu0}$$

Out[1827]= 8.82647

Percent change in quantity of unprocessed imports

In[1828]:=
$$\frac{(qotu1 - qotu0)\ 100}{qotu0}$$

Out[1828]= -12.5434

Percent change in price of processed imports

In[1829]:=
$$\frac{(potp1 - potp0)\ 100}{potp0}$$

Out[1829]= 11.8828

Percent change in quantity of processed imports

In[1830]:=
$$\frac{(qotp1 - qotp0)\ 100}{qotp0}$$

Out[1830]= -19.8857

Bonito

Percent change in price of unprocessed domestic production

In[1831]:= $$\frac{(\text{pndu1} - \text{pndu0})\ 100}{\text{pndu0}}$$

Out[1831]= 1.88554

Percent change in quantity of landings

In[1832]:= $$\frac{(\text{qndu1} - \text{qndu0})\ 100}{\text{qndu0}}$$

Out[1832]= 9.33917

Change ($) in operating income, unprocessed product

In[1833]:= $(1 / \text{sigmanu})\ (\text{pndu1}\ (\text{qndu1} - \text{qndue0}) - \text{pndu0}\ (\text{qndu0} - \text{qndue0}))$

Out[1833]= 7407.

Percent change in price of unprocessed imports

In[1834]:= $$\frac{(\text{pntu1} - \text{pntu0})\ 100}{\text{pntu0}}$$

Out[1834]= 5.32964

Percent change in quantity of unprocessed imports

In[1835]:= $$\frac{(\text{qntu1} - \text{qntu0})\ 100}{\text{qntu0}}$$

Out[1835]= -17.4398

Percent change in price of processed imports

In[1836]:= $$\frac{(\text{pntp1} - \text{pntp0})\ 100}{\text{pntp0}}$$

Out[1836]= 10.7017

Percent change in quantity of processed imports

In[1837]:= $$\frac{(\text{qntp1} - \text{qntp0})\ 100}{\text{qntp0}}$$

Out[1837]= -17.2947

Price index

Unprocessed products - yellowfin, skipjack, albacore, bonito, NEI nest

In[1838]:=

$$\frac{100\ (P1u1 - P1u0)}{P1u0}$$

Out[1838]= 4.97235

Unprocessed products - bigeye, bluefin nest

In[1839]:=

$$\frac{100\ (P2u1 - P2u0)}{P2u0}$$

Out[1839]= 12.5495

Canning price index

In[1840]:=

$$\frac{100\ (P1p1 - P1p0)}{P1p0}$$

Out[1840]= 5.92489

Bigeye-bluefin processed products price index

In[1841]:=

$$\frac{100\ (P2p1 - P2p0)}{P2p0}$$

Out[1841]= 13.9007