Future of Forest Products Modelling: Towards a New Generation of Model

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Outline

1. Model Overview
2. Differentiate softwood and hardwood
3. Bilateral trade and calibration
4. Uncertainty: Monte Carlo projections

Model Overview

Model Overview

Theoretical Foundation

- Dynamic spatial price equilibrium model
  - *Samuelson, 1952; Takayama and Judge, 1971*
- Tracks consumption, production, bilateral trade, prices, welfare

Countries and products

- 240 countries/regions
- 14 forest commodity groups including (fuelwood, industrial roundwood, sawnwood, wood-based panels, pulp, newsprint, paper and paperboard)
- Explicitly recognizes ***softwood and hardwood***
- Market evolves according to assumed growth rates of GDP, population, forest area, and forest stock

Software

- Integrated R – GAMS – Excel environment
- Rapid solve time enables ***Monte Carlo simulations***

Softwood and Hardwood

Softwood and Hardwood

Input-output (I-O) coefficients

- Determined empirically from historical data, while correcting for possible reporting errors
- Goal programming approach
  - *Buongiorno and Zhu (2015)*

Minimize | Deviations from reported production | + | Deviations from prior knowledge on I-O coefficients

Corrected **production**

Estimated **manufacturing costs**

Regional **I-O coefficients**

Bilateral trade and calibration

Bilateral trade and calibration

Positive mathematical programming (PMP)

- Calibration constraints can be represented in the objective function
  - *Howitt, 1995; Paris et al., 2011*
- Derived from the shadow prices on the calibration constraints relating to the observed flows of wood products
- The PMP-calibrated ‘transportation’ costs represent the effective transaction costs between trading regions
- Motivated due to discrepancies between the true and observed transaction costs, as determined by shipping, load/unloading, insurance and administrative costs, plus tariffs and non-tariff barriers

Bilateral trade and calibration

Phase I

Max $$W = \sum_{d=1}^{D}\sum_{k=1}^{K} B_d^k - \sum_{s=1}^{S}\sum_{k=1}^{K} C_s^k + \sum_{j=1}^{J} R_j - \sum_{j=1}^{J}\sum_{s=1}^{S}\left(\delta T_{js} + t_{js}\right)Q_{js} - \sum_{s=1}^{S}\sum_{d=1}^{D}\sum_{k=1}^{K}\left(T_{sd}^k + t_{sd}^k\right)q_{sd}^k$$

Subject to:

$$Q_{js} = \overline{Q_{js}}$$

$$q_{sd}^k = \overline{q_{sd}^k}$$

Dual variables:

$$\lambda_{js}$$

$$\lambda_{sd}^k$$

Phase II

Max $$W = \sum_{d=1}^{D}\sum_{k=1}^{K} B_d^k - \sum_{s=1}^{S}\sum_{k=1}^{K} C_s^k + \sum_{j=1}^{J} R_j - \sum_{j=1}^{J}\sum_{s=1}^{S}(\delta T_{js} + t_{js} + \lambda_{js})Q_{js} - \sum_{s=1}^{S}\sum_{d=1}^{D}\sum_{k=1}^{K}(T_{sd}^k + t_{sd}^k + \lambda_{sd}^k)q_{sd}^k$$

Bilateral trade and calibration

Applied to forest product trade modelling:

1. Russian log export taxes
   - *van Kooten and Johnston (2014) Forest Policy and Economics 39: 54-66*
2. Canada-U.S. Softwood Lumber Agreement
   - *van Kooten and Johnston (2014) Forest Policy and Economics 39: 54-66*
   - *Johnston and van Kooten (2016) Forest Policy and Economics* 74: 71-80
3. Bioenergy (wood pellet trade)
   - *Johnston and van Kooten (2016) Journal of Forest Economics* 23: 27-44

Precisely replicates trade flows

Observed softwood lumber trade flows for 20 model regions: mbf, 2011[a].

Export/Import Region	Australia	BC Coast	BC Interior	Alberta	Atlantic Canada	Rest of Canada	Chile	China	Finland	Japan	New Zealand	Russia	Sweden	US North	US South	US West	Rest of Latin Am.	Rest of Europe	Rest of Asia	Rest of World
Australia	1913.4	0.0	0.0	0.0	0.0	0.0	0.3	17.8	0.0	2.0	1.2	0.0	0.0	0.0	0.0	0.1	0.0	0.2	15.5	0.2
BC Coast	3.3	88.2	23.4	92.2	57.5	580.2	0.3	200.1	0.1	116.5	1.7	0.0	0.2	153.3	120.8	78.5	0.9	19.1	6.7	9.7
BC Interior	12.0	316.8	84.0	331.2	206.6	2083.5	0.9	718.7	0.3	418.3	6.1	0.0	0.6	1908.2	1505.7	977.7	3.4	68.6	23.9	34.9
Alberta	3.3	88.3	23.4	92.3	57.6	580.9	0.3	200.4	0.1	116.6	1.7	0.0	0.2	390.6	309.2	200.1	0.9	19.1	6.7	9.7
Atlantic Canada	2.3	61.9	16.4	64.7	40.3	406.8	0.2	140.3	0.1	81.7	1.2	0.0	0.1	114.5	90.0	58.5	0.7	13.4	4.7	6.8
Rest of Canada	7.0	186.2	49.4	194.7	121.4	1224.6	0.5	422.4	0.2	245.9	3.6	0.0	0.3	704.1	555.7	361.3	2.0	40.3	14.1	20.5
Chile	7.2	0.4	0.1	0.4	0.3	2.6	1597.4	136.5	0.6	122.5	0.6	0.0	0.0	51.9	41.0	26.6	198.5	40.8	83.7	173.4
China	0.3	0.0	0.0	0.0	0.0	0.0	0.0	10,606.2	0.0	32.8	0.1	0.0	0.0	0.1	0.1	0.1	0.9	1.7	8.9	4.9
Finland	4.2	0.0	0.0	0.0	0.0	0.1	0.0	31.4	1678.3	264.0	0.0	0.1	4.0	0.2	0.1	0.1	0.0	980.4	12.6	841.7
Japan	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.3	0.0	6565.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.5
New Zealand	116.5	0.0	0.0	0.8	0.0	0.8	0.0	289.4	1.0	55.5	710.9	0.0	0.3	35.0	27.6	17.9	0.0	45.3	138.2	233.0
Russia	0.1	0.0	0.0	0.0	0.0	0.0	0.0	1840.9	121.7	357.2	0.0	4789.6	4.7	0.2	0.0	0.6	0.0	1237.4	90.4	1502.1
Sweden	11.0	1.2	0.3	1.3	0.8	7.9	0.1	30.5	10.7	314.9	0.0	0.0	2314.9	6.1	4.8	3.1	0.1	2925.2	6.7	1214.2
US North	0.4	2.4	0.6	2.6	1.6	16.0	0.0	14.2	0.0	10.2	0.0	0.0	0.0	707.8	558.6	362.8	21.9	2.4	2.0	2.7
US South	4.1	22.7	6.0	23.7	14.8	149.0	0.0	131.7	0.0	94.5	0.1	0.3	0.2	6573.0	5187.6	3369.1	203.7	21.9	18.2	25.2
US West	1.8	10.3	2.7	10.7	6.7	67.5	0.0	59.6	0.0	42.8	0.0	0.1	0.1	2976.8	2349.4	1525.8	92.3	9.9	8.2	11.4
Rest of Latin Am.	0.1	0.2	0.0	0.2	0.1	1.2	0.9	54.5	0.0	0.7	0.4	0.1	0.1	78.6	62.0	40.3	5873.2	0.5	1.5	0.1
Rest of Europe	103.9	0.2	0.0	0.2	0.1	1.0	0.0	91.3	28.1	373.7	0.2	2.7	61.3	27.5	21.7	14.1	13.6	25,685.6	2.7	66.2
Rest of Asia	0.2	0.0	0.0	0.0	0.0	0.0	0.0	8.5	0.0	7.5	0.2	0.0	0.0	0.2	0.1	0.1	10.1	55.6	6482.4	2.8
Rest of World	0.1	0.0	0.0	0.0	0.0	0.0	0.0	4.6	0.0	0.4	0.9	0.0	0.6	0.1	0.1	0.1	65.0	1483.4	26.8	8167.4

Makes adjustments to transaction costs

Shadow prices associated with the calibration constraint; used to adjust transaction costs ($/mbf)[a].

Export/Import Region	Australia	BC Coast	BC Interior	Alberta	Atlantic Canada	Rest of Canada	Chile	China	Finland	Japan	New Zealand	Russia	Sweden	US North	US South	US West	Rest of Latin Am.	Rest of Europe	Rest of Asia	Rest of World
Australia	20.0	11.9	0.9	1.3	8.2	12.3	1.1	21.3	28.8	15.9	3.3	-0.3	27.8	44.4	36.0	40.2	12.7	-0.9	23.5	14.3
BC Coast	50.2	44.1	33.1	33.2	39.9	39.9	36.0	51.8	61.4	47.7	37.1	35.2	60.3	69.3	61.3	66.1	44.9	31.1	55.9	46.3
BC Interior	55.5	48.6	38.3	38.2	43.7	34.9	41.6	50.5	66.7	49.3	42.5	40.9	65.6	60.7	57.6	68.2	50.0	35.3	60.8	51.0
Alberta	55.4	48.8	38.1	38.5	45.0	45.8	41.4	56.2	66.5	52.5	42.4	40.7	65.4	73.5	65.9	71.3	49.9	36.0	60.9	51.3
Atlantic Canada	52.0	45.2	34.7	34.7	42.2	45.0	37.8	52.7	63.1	49.0	38.9	37.0	62.0	78.1	69.2	73.5	46.6	33.0	57.6	48.1
Rest of Canada	49.9	42.4	32.6	32.1	39.9	44.3	35.7	44.0	61.2	43.3	36.9	35.0	60.1	73.5	63.3	67.3	44.7	30.7	55.5	46.0
Chile	42.3	36.6	25.7	26.0	33.0	37.0	31.7	44.6	53.8	39.7	29.3	26.9	52.8	68.7	60.4	64.7	36.4	23.3	47.5	32.4
China	17.4	12.9	1.9	2.3	9.3	13.3	2.3	22.5	29.9	16.9	4.4	0.8	28.8	45.5	37.0	41.2	13.7	0.1	24.7	15.2
Finland	52.7	46.6	35.6	36.0	43.0	47.0	38.6	55.4	64.3	45.6	39.8	37.9	62.8	79.2	70.7	74.9	47.4	31.1	58.1	38.9
Japan	24.0	19.2	8.2	8.6	15.6	19.6	9.0	28.8	36.2	24.6	11.0	7.7	35.1	51.8	43.3	47.5	20.0	6.5	31.0	21.6
New Zealand	35.1	30.0	19.0	19.4	26.4	30.4	20.7	36.1	47.1	33.8	25.0	19.6	46.0	61.9	53.6	58.0	30.8	16.3	40.2	29.2
Russia	43.8	38.0	27.0	27.4	34.4	38.4	29.4	24.7	55.0	37.8	30.7	33.0	54.1	70.6	62.1	66.3	38.8	20.9	49.3	4.4
Sweden	67.5	60.8	49.8	50.2	57.2	61.1	54.0	69.7	78.3	58.7	54.7	53.5	77.4	93.3	84.9	89.1	61.6	41.3	72.5	48.8
US North	26.9	21.9	11.0	11.3	18.3	22.3	12.0	31.2	39.0	26.0	13.9	10.8	37.9	54.5	43.0	47.0	22.5	9.2	33.7	24.3
US South	26.9	21.8	11.0	11.2	18.2	21.6	12.0	29.1	39.0	24.4	13.9	10.8	37.9	19.1	46.1	32.7	20.9	9.0	33.5	24.1
US West	26.9	21.9	10.9	11.3	18.2	21.8	12.0	30.7	39.0	25.5	13.9	10.8	37.9	27.1	33.8	50.3	21.7	9.0	33.7	24.1
Rest of Latin Am.	50.4	44.3	33.3	33.7	40.6	44.7	36.1	52.8	61.6	48.9	37.3	35.3	60.5	76.0	67.8	72.2	45.1	31.5	56.1	46.7
Rest of Europe	30.1	26.8	15.8	16.2	23.1	27.2	17.2	34.3	43.8	22.6	18.9	16.1	42.7	59.0	50.6	54.9	27.4	14.1	38.5	28.4
Rest of Asia	17.4	12.9	1.9	2.3	9.3	13.3	2.3	22.5	29.9	16.9	4.4	0.8	28.8	45.5	37.0	41.2	13.5	-1.1	24.7	15.2
Rest of World	39.0	33.5	22.5	22.9	29.9	33.9	24.5	43.0	50.7	37.9	26.0	23.5	49.6	66.1	57.6	61.8	33.6	3.9	44.9	35.9

Uncertainty Monte Carlo

Monte Carlo Simulations

Short solve time

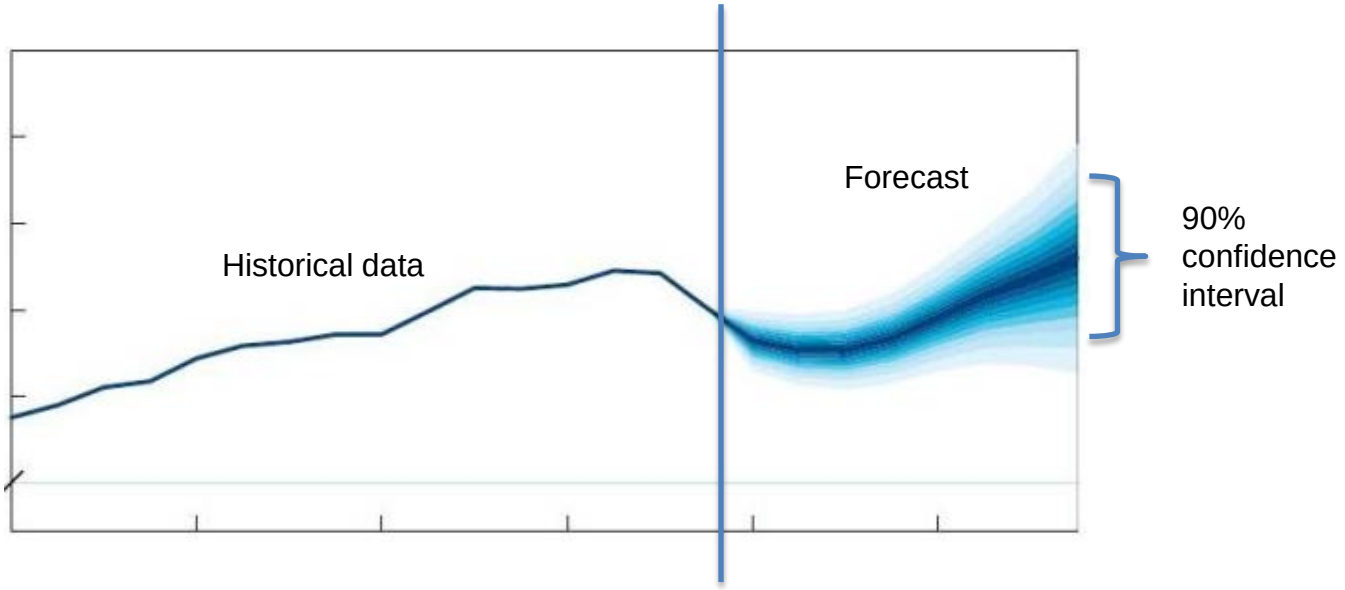
- ~ 2 seconds per yearly node
- solved to 2060 (9, 5 year intervals) takes 10 - 15 seconds

Enables a confidence interval of projections

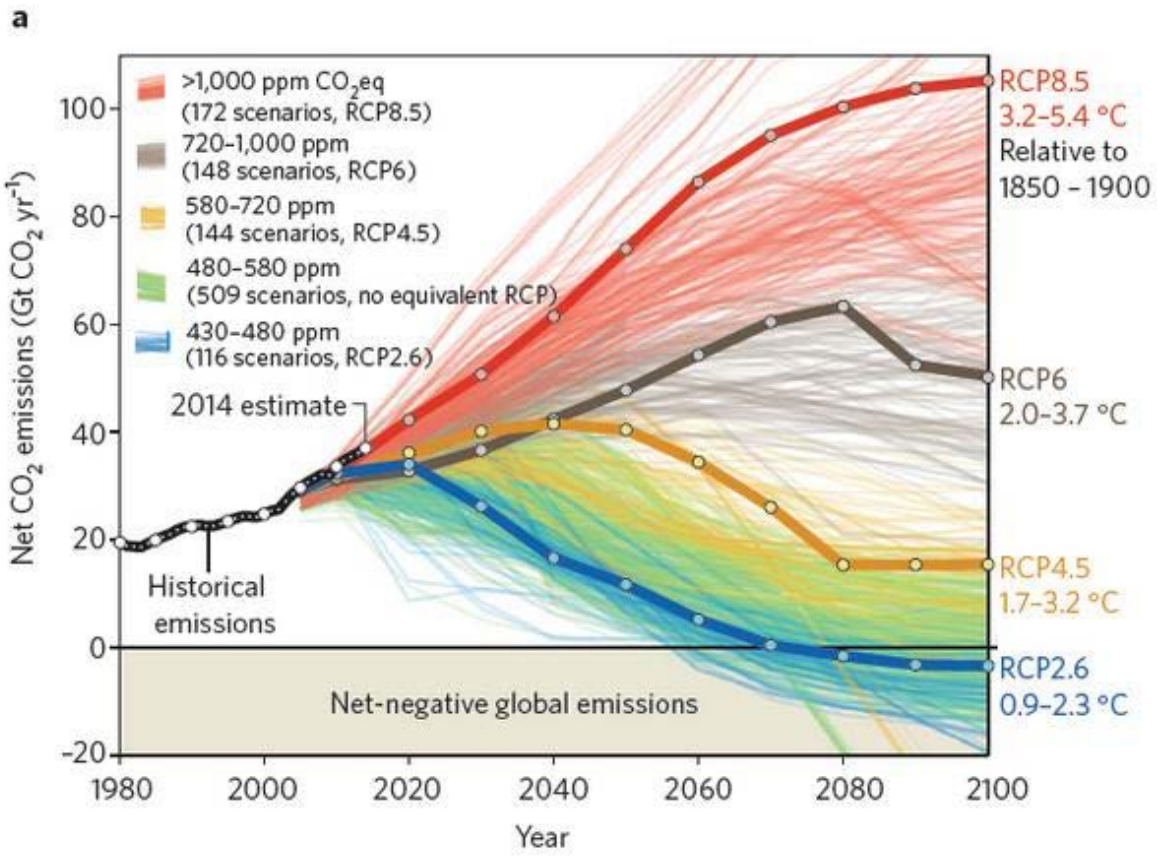
- For example, we can ***relax our reliance on exogenous inputs***
  - GDP, population estimates
  - elasticity estimates
  - forest growth/area
  - climate change impacts

Monte Carlo Simulations

How to deal with uncertainty



Uncertainty IPCC Representative Concentration Pathways (RCP)



Highlights

1. Model Overview
   - 200+ countries/regions, 14 forest product groups, softwood & hardwood, bilateral trade, economic indicators

2. Differentiate softwood and hardwood
   - I-O logs to lumber
   - proportion of species type contained in panels, pulp

3. Bilateral trade and calibration
   - PMP promising technique

4. Monte Carlo confidence interval projections
   - Dealing with Uncertainty

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STREAMLINING THE NEXT ROUND OF FOREST SECTOR OUTLOOK STUDIES IN THE UNECE REGION

PUSHKINO, MOSCOW REGION, THE RUSSIAN FEDERATION 12-13 DECEMBER 2016

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