Potential Economic Impact of Biofuels Industry Expansion in Maine

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Western Forest Economists
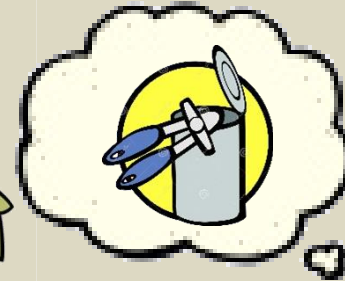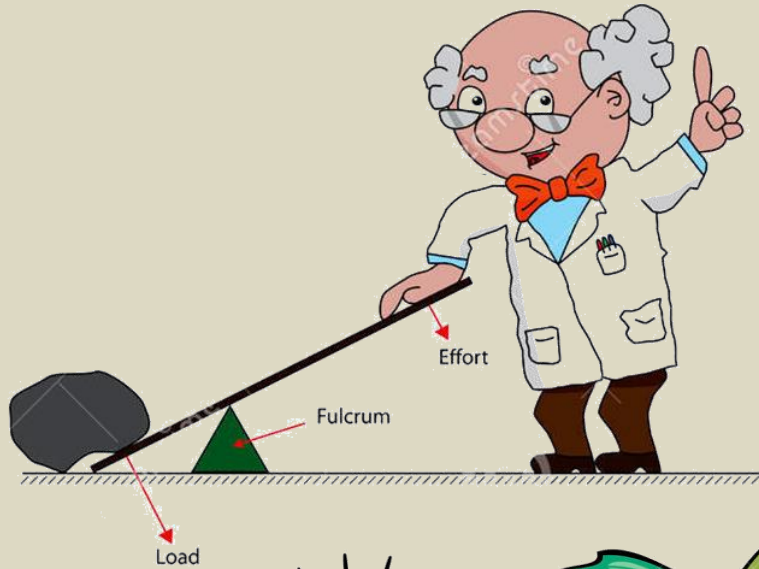Annual Meeting
May 3, 2016
Seattle, Washington

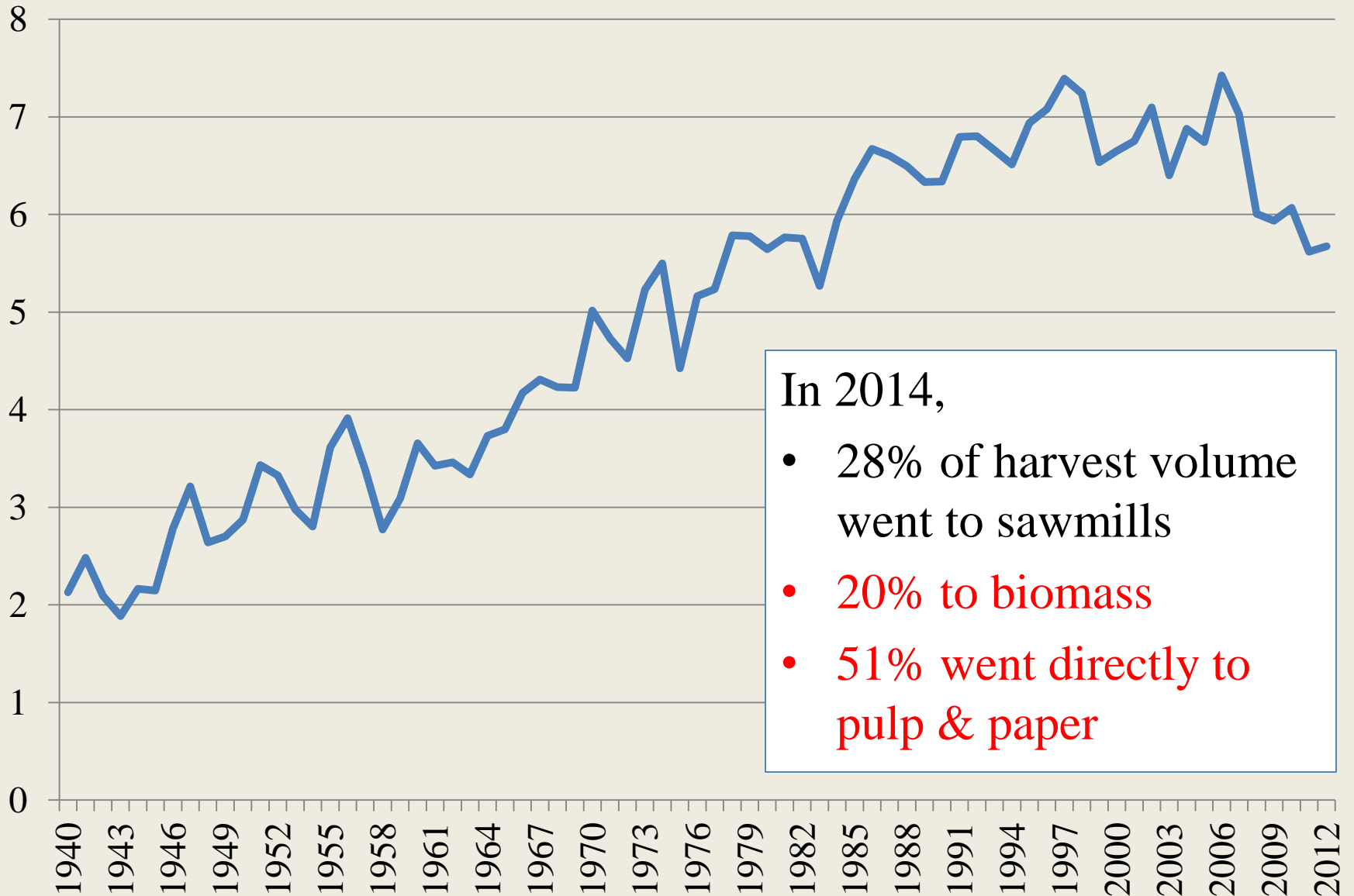# Outline

● ○ ○ Motivation & Background

○ ● ○ Methodology

○ ○ ● 1. IMPLAN 2014
2. Adjustments for known closures
3. Incorporation of Biofuels expansion

Economists Make Assumptions!
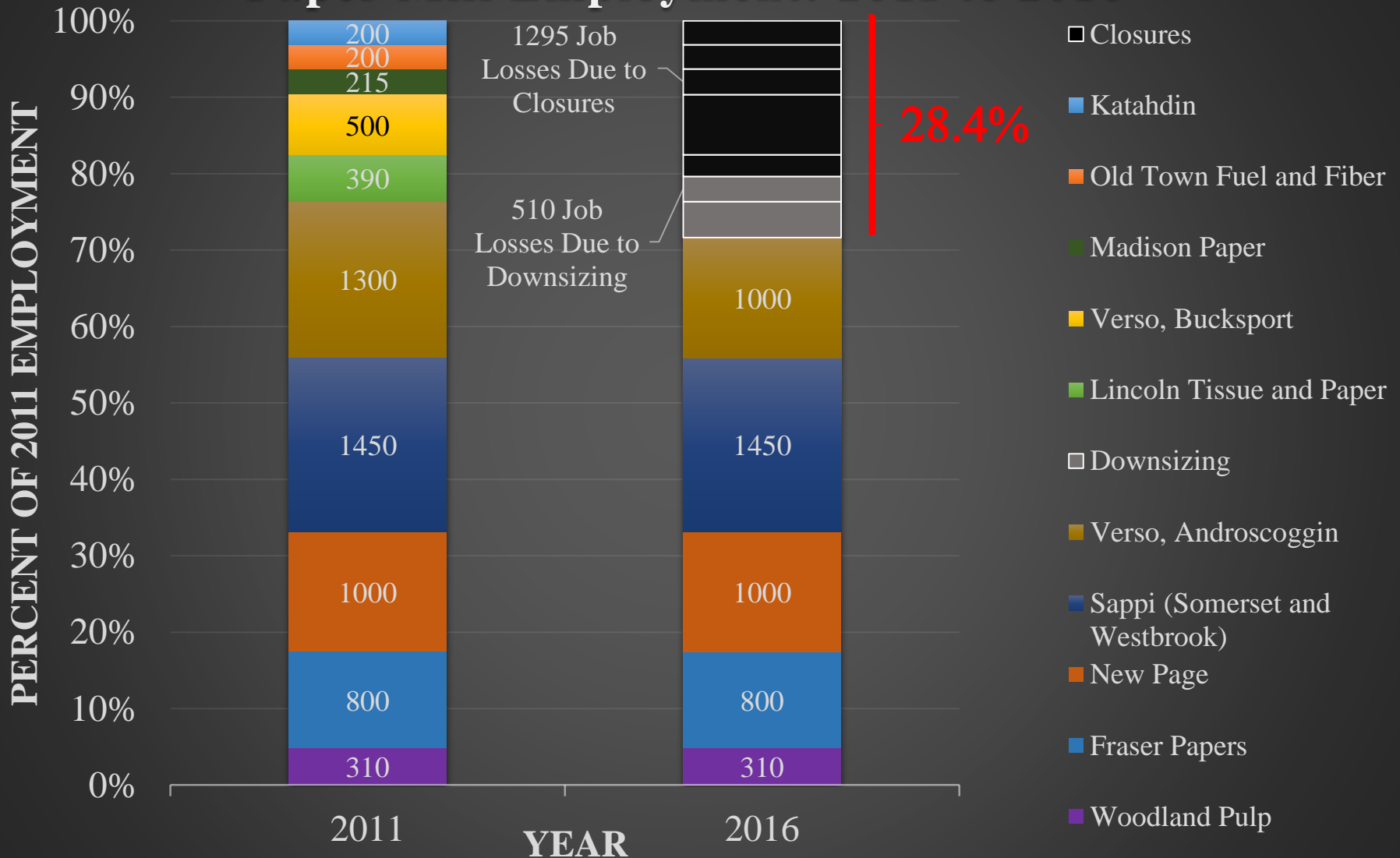
Harvest in Maine, million cords

In 2014,

- 28% of harvest volume went to sawmills

- 20% to biomass

- 51% went directly to pulp & paper

Recent changes in P&P

Paper Mill Employment: 2011 to 2016

Why it matters for more than just jobs

51%

Pulp/Paper

28%
Sawmill

20%
Biomass
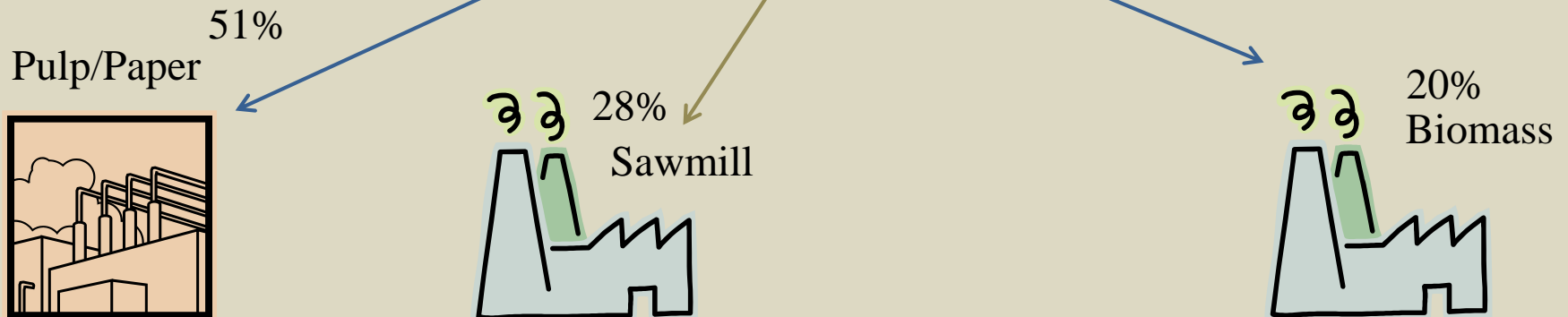
Study Questions

1. What is the current economic impact of the forest products industry in Maine? How has it changed since the last estimate (2011 data)?

2011 → 2014

2. Can we adjust that for the known closures that have occurred since the most available data?

2014 → 2016

3. What would the economic impact be of the development of new technology to utilize low-value material?

2016 → Future

IMPLAN and Economic Impact
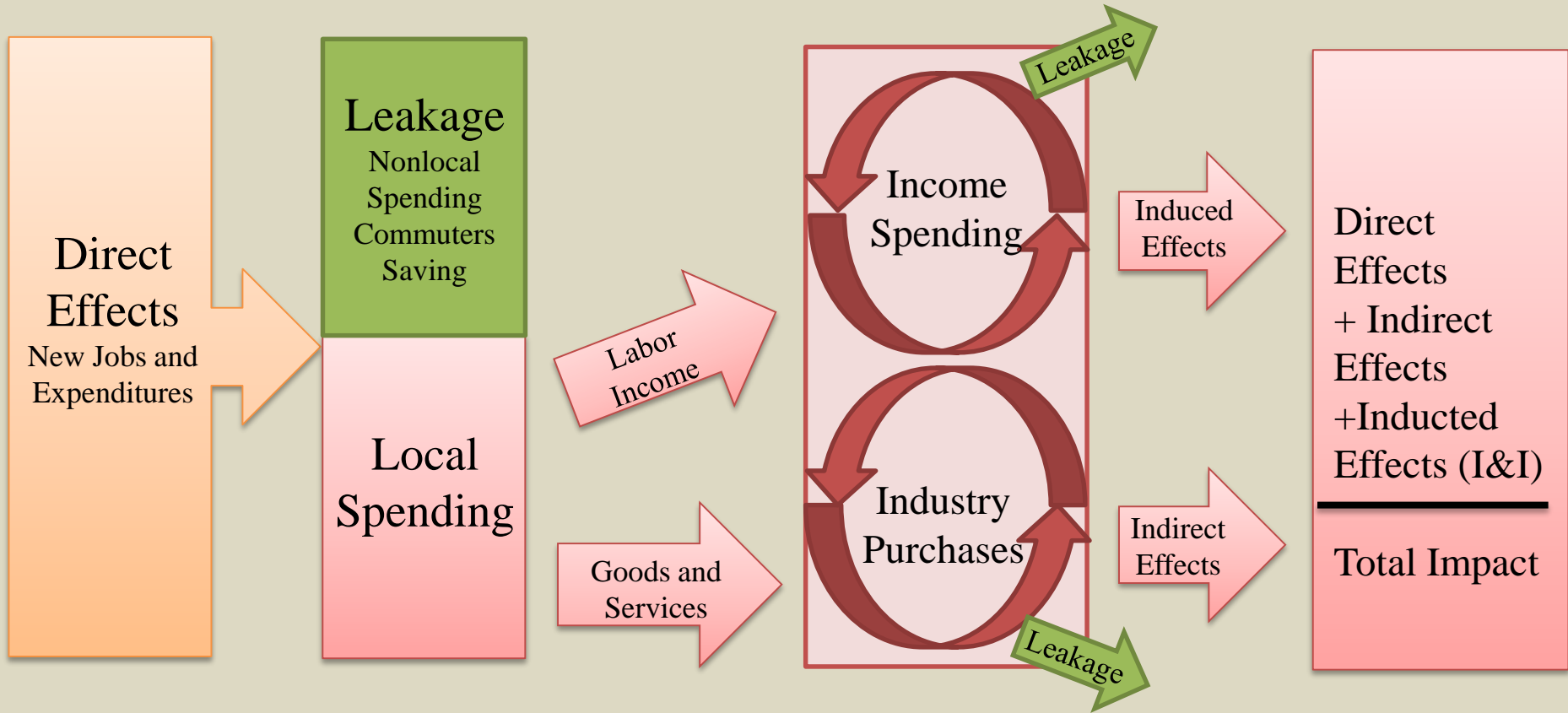
Defining the Forest Products Industry

Forest Products Industries

❑ Harvesting

❑ Biomass Electricity

❑ Sawmills

❑ Plywood and Veneer

❑ Pulp and Paper

❑ Wood Products (Hardwood Specialty)

❑ Wood Furniture

FP Support Industries

❑ Regeneration and Management

❑ Machinery Repair and Lease

❑ Transportation

❑ Research

❑ Land Lease

❑ Non-Forest Product Industries (FPI)/All other Sectors

Methodology
Input-Output Modelling

The Foundation:
the Accounts Matrix

The Workhorse:
the Direct Requirements Matrix

$$\begin{array}{ccc|c|c}
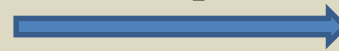z_{11} & \cdots & z_{1p} & y_1 & x_1 \\
\vdots & \ddots & \vdots & \vdots & \vdots \\
z_{p1} & \cdots & z_{pp} & y_p & x_p \\
\hline
v_1 & \cdots & v_p & & \\
\hline
g_1 & \cdots & g_p & &
\end{array}$$

Standardized by input

$$a_{ij} = z_{ij}/g_j$$

$$\begin{array}{ccc|c|c}
a_{11} & \cdots & a_{1p} & e_1 & x_1/g \\
\vdots & \ddots & \vdots & \vdots & \vdots \\
a_{p1} & \cdots & a_{pp} & e_p & x_p/g \\
\hline
m_1 & \cdots & m_p & & \\
\hline
1 & \cdots & 1 & &
\end{array}$$

In equilibrium,
$$x_j = g_j$$

$$\begin{bmatrix} x_1 \\ \vdots \\ x_p \end{bmatrix}_{p \times 1} = \begin{bmatrix} a_{11}x_1 & \cdots & a_{1p}x_p \\ \vdots & \ddots & \vdots \\ a_{p1}x_1 & \cdots & a_{pp}x_p \end{bmatrix}_{p \times p} \begin{bmatrix} 1 \\ \vdots \\ 1 \end{bmatrix}_{p \times 1} + \begin{bmatrix} y_1 \\ \vdots \\ y_p \end{bmatrix}_{p \times 1}$$

$$\boldsymbol{x = Ax + y = (I_p - A)^{-1}y}$$

Multiplier Matrix, $\boldsymbol{R}$ *a.k.a.* Leontief Inverse or Total Requirements Matrix

Using the direct requirements matrix, A_1

Direct Requirements, Output	Harvest	Paper	Regen	Truck	AOS	Direct Output ($)	Final Output ($), x_1
Harvesting	.226	.050	.011	.005	.015	$y_{H,1}$	$484,452
Paper	.030	.260	.020	.013	.054	$y_{P,1}$	$4,327,428
Regen	.115	.010	.036	.015	.008		$659,603
Trucking	.027	.040	.016	.022	.008		$1,400,222
AOS	.108	.465	.302	.518	.415		$9,076,448

Partial Multipliers, $R_1 = (I - A_1)^{-1}$

Partial Multiplier, Output	Harvest	Paper	Regen	Truck	AOS	Direct Output ($)	Final Output ($), x_1
Harvesting	1.3089	.1192	.0322	.0328	.0455	$y_{H,1}$	$484,452
Paper	.0902	1.4506	.0761	.0943	.1385	$y_{P,1}$	$4,327,428
Regen	.1614	.0409	1.0476	.0294	.0226		$659,603
Trucking	.0460	.0736	.0263	1.0360	.0225		$1,400,222
AOS	.4374	1.2616	.6305	1.0136	1.8595		$9,076,448

$R_1{}'$

Partial Multipliers, Output	Harvesting	Paper	Direct Output ($)	Final Output ($), x_1
Harvesting	1.3089	.1192	$y_{H,1}$	$484,452
Paper	.0902	1.4506	$y_{P,1}$	$4,327,428

$$R_i' y_i = x_i \qquad \Longrightarrow \qquad y_i = R_i'^{-1} x_i = (I_p - A_i)' x_i$$

Here,

$$y_1 = \begin{bmatrix} .7684 & -.0631 \\ -.0478 & .6933 \end{bmatrix} \begin{pmatrix} \$484,452 \\ \$4,327,428 \end{pmatrix} = \begin{pmatrix} \$99,005.69 \\ \$2,977,042.39 \end{pmatrix}$$

Where does the value end up?

Once we estimate the direct contribution, we can follow how that direct impact flows between sectors of interest

$$R'_i y_i = x_i \quad \Longrightarrow \quad [I + (R'_i - I)]diag(y_i) = mat(x_i)$$

$$mat(x_1) = \left[\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} + \begin{bmatrix} .3089 & .1192 \\ .0902 & .4506 \end{bmatrix}\right]\begin{bmatrix} 99005.69 & 0 \\ 0 & 2977042.39 \end{bmatrix}$$

$$= \begin{bmatrix} \$99,005.69 & 0 \\ 0 & \$2,977,042.39 \end{bmatrix} + \begin{bmatrix} \$30,582.90 & \$354,863.50 \\ \$8,930.31 & \$1,341,455.30 \end{bmatrix}$$

Direct Effects   Within Industry Multiplier
Effects/Potential Double Counting

** In this example, if we look at Harvesting alone, the estimate of the direct impact would be \$372,253. Within the context of the entire economy, Harvesting contributes only \$8,191 directly.

What does this look like?

Other Sectors/
External Economy

$99,006

$2,977,042

$8,930

Harvesting

Pulp and Paper

$354,864

$30,583

$1,341,455
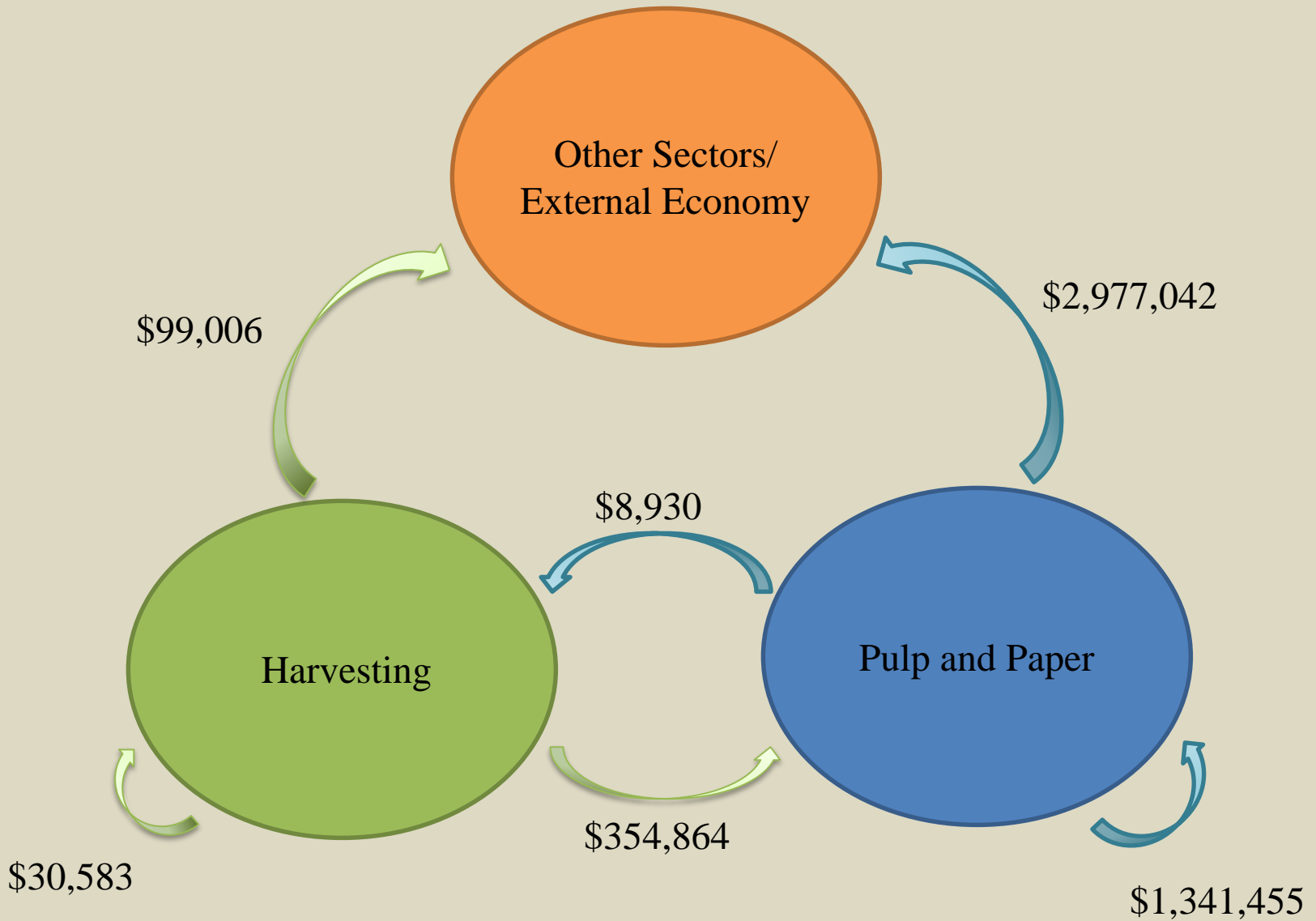
Method Evaluation
First Round Estimate (FRE) v. Observed Values (BLS+NES)

	Employment		Compensation		Output	
	FRE	BLS +NES	FRE	BLS +NES	FRE	BLS +NES
Harvesting	3,795	4,607	$172,847,438	$198,907,339	$488,970,804	$484,452,356
Biomass Electricity	151	142	$9,384,251	$8,808,278	$141,517,202	$132,238,647
Sawmills	2,080	2,171	$82,208,853	$92,072,579	$671,614,383	$677,790,419
Plywood and Veneer	733	736	$23,046,748	$25,829,156	$234,471,972	$234,896,130
Wood Products	1,822	1,833	$56,279,838	$61,992,576	$336,492,189	$336,778,801
Pulp and Paper Products	6,133	6,155	$434,054,815	$436,213,697	$4,331,099,700	$4,327,427,704
Wood Furniture	756	757	$27,938,533	$30,161,457	$119,091,637	$119,202,354

1. 2014 and 2011 Results

2014 (in 2016 $USD)	Direct Contribution	Multiplier Effects			Total Impact
	FPI	FPI	FPI Support	non-FPI	Total
Output	$5,642,301,136	$670,422,871	$470,984,069	$2,991,050,947	$9,774,759,023
Employment	14,439	2,112	1,180	20,419	38,151
Compensation	$763,642,804	$100,182,070	$57,778,742	$853,456,559	$1,775,060,175
Prop Income	$94,750,162	$56,820,463	$37,124,959	$108,549,094	$297,244,678

2011 (in 2016 $USD)	Direct Contribution	Multiplier Effects		
	Forest Products	Forest Products	Non-Forest Products	Total Contribution
Output	$5,063,915,031	$643,676,568	$2,267,788,190	$7,975,457,789
Employment	12,003	5,072	21,714	38,789
Labor Income*	$721,541,907	$184,150,509	$960,935,289	$1,866,637,705

* Labor Income = Employee Compensation + Proprietor Income

1. Comparison of results
Tuned Results v. First Round Estimate (FRE)

Tuned Results

2014 (in 2016 $USD)	Direct Contribution	Multiplier Effects			Total Impact
	FPI	FPI	FPI Support	non-FPI	Total
Output	$5,642,301,136	$670,422,871	$470,984,069	$2,991,050,947	$9,774,759,023
Employment	14,439	2,112	1,180	20,419	38,151
Compensation	$763,642,804	$100,182,070	$57,778,742	$853,456,559	$1,775,060,175
Prop Income	$94,750,162	$56,820,463	$37,124,959	$108,549,094	$297,244,678

First Round Estimate (FRE)

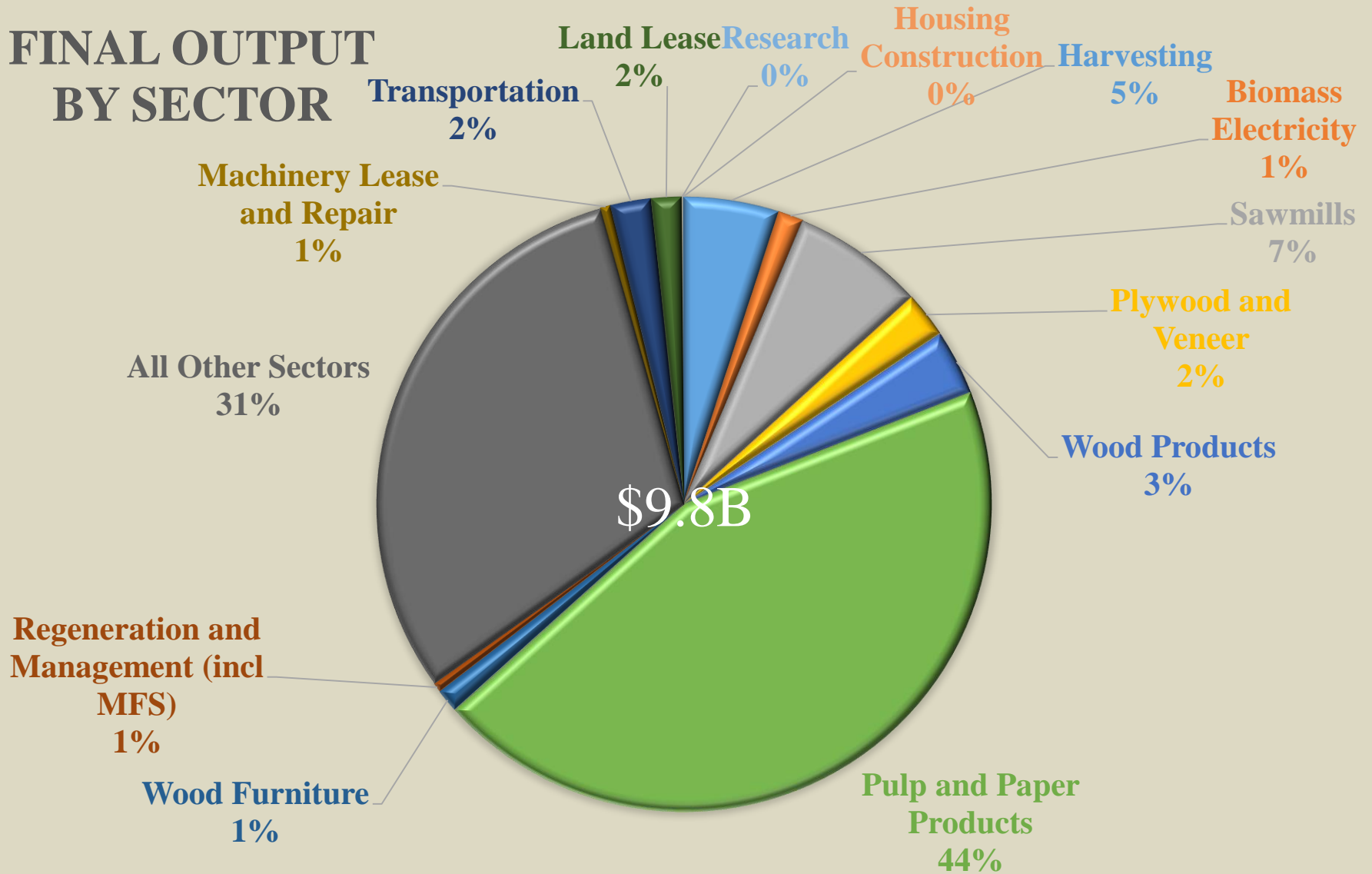| 2014 (in 2016 $USD)	Direct Contribution	Multiplier Effects			Total Impact
	FPI	FPI	FPI Support	non-FPI	Total
Output	$5,652,650,920	$670,616,969	$467,969,710	$2,954,664,362	$9,745,901,961
Employment	13,504	2,115	1,180	20,128	36,926
Compensation	$715,408,866	$100,289,981	$57,732,649	$842,547,905	$1,715,979,401
Prop Income	$91,383,613	$56,995,902	$36,919,525	$107,317,453	$292,616,493

1. 2014 Results: FPI's Contribution to Maine
2011 to 2014

	2011 (in 2011 $USD)	2014 (in 2011 $USD)
Maine GDP	$52.0B	$53.1B (+2.1)
FPI Value Added	$3.3B	$2.9B (-13.3%)
Percent of GDP	6.38% (1 out of 15.7)	5.38% (1 out of 18.6) (-15.7%)
Total Economic Impact	$8.0B	$9.0B (+12.5%)
All Maine Jobs	794,279	810,672 (+2.1%)
FPI Jobs	38,789	38,152 (-1.6%)
Percent of Employment	4.88% (1 out of 20.5)	4.71% (1 out of 21.2) (-3.7%)
Total Payroll	$1,866.6M	$1,896.2M (+1.6%)
Total State and Local Taxes	$302.0M	$292.2M (-3.2%)

1. 2014 Results: Pulp & Paper still dominant

FINAL OUTPUT BY SECTOR

$9.8B

- Transportation 2%
- Land Lease 2%
- Research 0%
- Housing Construction 0%
- Harvesting 5%
- Biomass Electricity 1%
- Sawmills 7%
- Plywood and Veneer 2%
- Wood Products 3%
- Pulp and Paper Products 44%
- Wood Furniture 1%
- Regeneration and Management (incl MFS) 1%
- All Other Sectors 31%
- Machinery Lease and Repair 1%

2014 Results: Pulp & Paper still dominant

**PERCENT OF OUTPUT
IMPACT SUPPORTED
BY EACH FPI SECTOR**
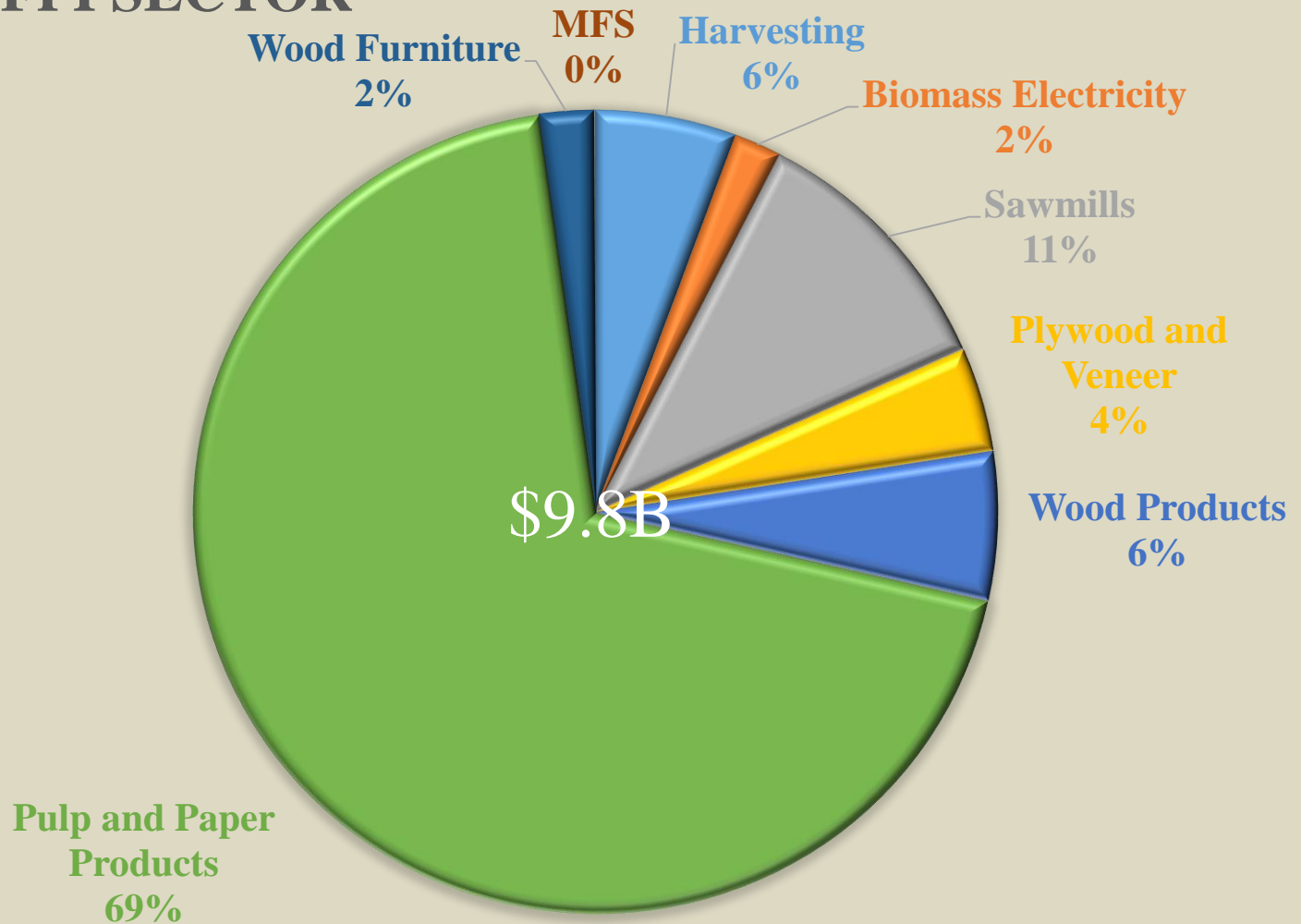
1. Impacts in Maine relative to other states

Industry	ME 2014 Output Multiplier	ME 2014 Employment Multiplier
Harvesting	2.050	2.356
Pulp and Paper	1.810	3.729
Wood Furniture	1.754	1.808
Bio-Electricity	1.592	4.551
Sawmills	2.162	3.486
Plywood and Veneer	1.837	2.420
Wood Products	1.620	1.943

Industry	Output Mult	Employ Mult	State	Year	Source	(adj)
Forestry and Logging	1.62 (adj)	1.57 (adj)	OH	2011	Coronado et al.	1.211
Paper Mfg.	1.6 (adj)	2.9 (adj)	OH	2011	Coronado et al.	1.041
Pulp and Paper	1.74	3.63	Southern States	2009	Dahal et al.	
Wood Furniture	1.88	2.06	Southern States	2009	Dahal et al.	
Wood Furniture Mfg.	1.78 (adj)	2.11 (adj)	OH	2011	Coronado et al.	1.000

2. Accounting for closures

❏ Five pulp and paper mills and two biomass plants have closed since late 2013

❏ The results presented are based on the loss of 1,805 and 44 employees from these sectors, respectively

    ❏ We assume output is constant across all employees in a sector

❏ Beginning work on output based paper results

    ❏ 4.5M tons of pulpwood and biomass capacity lost → $74M reduction in input purchases

2. Inefficient mills have been the first to close

Paper Mills and Total Employment
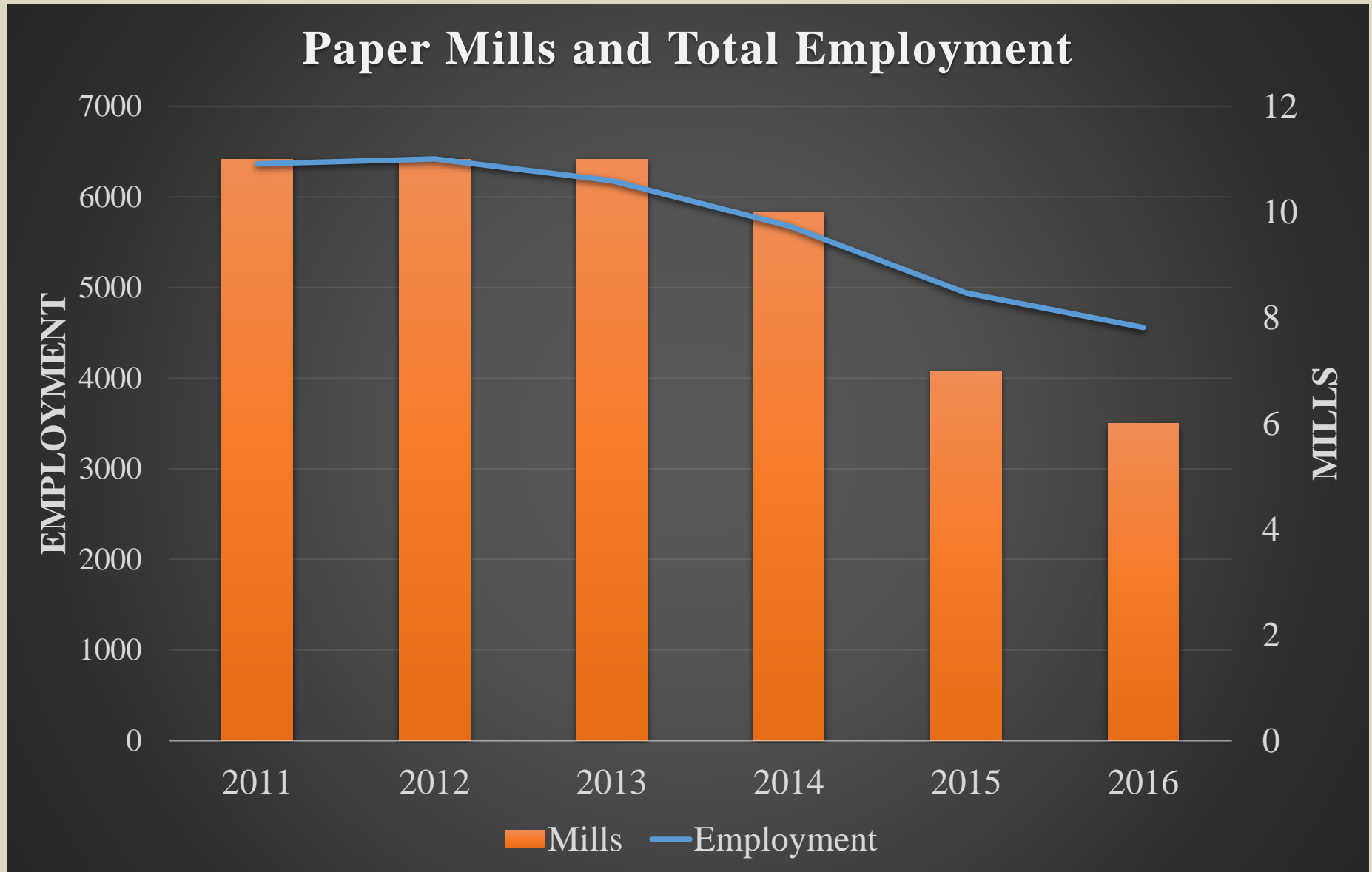
2. Results with recent closures (draft)

2016 (in 2016 $USD)	Direct Contribution	Multiplier Effects			Total Impact
	Pulp and Paper	**FPI**	**FPI Support**	**non-FPI**	**Total**
Output	($1,421,306,422)	($108,139,908)	($105,417,531)	($666,658,573)	($2,301,522,434)
Employment	-1,805	-253	-272	-4,400	-6,730
Compensation	($124,965,264)	($13,163,117)	($13,114,742)	($188,232,314)	($339,475,437)
Prop Income	($8,218,943)	($5,076,774)	($7,815,335)	($23,677,397)	($44,788,449)

2016 (in 2016 $USD)	Direct Contribution	Multiplier Effects			Total Impact
	Bioelectric	**FPI**	**FPI Support**	**non-FPI**	**Total**
Output	($42,524,966)	($5,458,307)	($2,164,327)	($17,389,587)	($67,537,187)
Employment	-44	-26	-4	-127	-200
Compensation	($2,834,684)	($1,157,728)	($219,684)	($4,561,935)	($8,774,031)
Prop Income	$0	($1,069,575)	($186,216)	($835,174)	($2,090,965)

2016 (in 2016 $USD)	Direct Contribution	Multiplier Effects			Total Impact
	FPI	**FPI**	**FPI Support**	**non-FPI**	**Total**
Output	$4,178,469,748	$556,824,656	$363,402,211	$2,307,002,787	$7,405,699,402
Employment	12,590	1,833	904	15,892	31,221
Compensation	$635,842,856	$85,861,225	$44,444,316	$660,662,310	$1,426,810,707
Prop Income	$86,531,219	$50,674,114	$29,123,408	$84,036,523	$250,365,264

2. 2016 Results: FPI's Contribution to Maine 2014 to 2016 (draft)

	2014 (in 2016 $USD)	2016 (in 2016 $USD)
Maine GDP	$55.8 B	$55.4 B (-0.7%)
FPI Value Added	$3.1 B	$2.5 B (-19.4%)
Percent of GDP	5.59% (1 out of 17.9)	4.51% (1 out of 22.2) (-19.3%)
Total Economic Impact	$9.8 B	$7.4 B (-24.5%)
All Maine Jobs	810,672	811,672 (+0.1%)
FPI Jobs	38,152	31,221 (-18.2%)
Percent of Employment	4.71% (1 out of 21.2)	3.85% (1 out of 26.3) (-19.1%)
Total Payroll	$2,072.3 M	$1,677.2 M (-19.1%)
Total State and Local Taxes	$319.3 M	$245.7 M (-23.1%)

3. Incorporating new technology

❑ The economic impacts of a new industry in the state: a bio refinery producing biofuels and organic chemicals
❑ This plant is assumed to employ 40 workers and consume 2000 tons of biomass a day
❑ We anticipate this demand for biomass will support the equivalent of 437 harvesting jobs, potentially those lost from the pulp and paper sector
❑ The harvesting jobs may not be realized as currently employed harvesters may simply expand the selection of products they will remove from the forest
❑ This would result in more income for currently employed harvesters, but no additional positions

3. Incorporating new technology

❑ The plant produces large quantities of low value product (i.e. biofuel) and low volumes of high value product (i.e. furfural)

❑ The success of the plant is highly dependent on the sale price of its outputs

❑ We analyze the plant under a varying profit scenario to address the variability in output prices

❑ The following linear regression equations define the economic impacts of the plant per million dollars of profit:

$$Induced\ Employment = 179.60_{(.0238)} + 6.474_{(.0008)}Profit(\$Mil)$$
$$Labor\ Income(\$Mil) = 35.11_{(.0005)} + 1.265_{(.0000)}Profit(\$Mil)$$
$$Value\ Added(\$Mil) = 51.46_{(.0008)} + 1.477_{(.0000)}Profit(\$Mil)$$
$$Variable\ Output(\$Mil) = 150.55_{(.0014)} + 1.835_{(.0005)}Profit(\$Mil)$$

Conclusions

2014

- [ ] We are in a similar situation to 2011, some aspects have declined but a few have improved
- [ ] Production has declined slightly, but output is up
- [ ] Employment has declined, but total income impact, total FPI income, and FPI wages rates are up

2016

- [ ] The loss of seven consumers of pulp biomass has been devastating economically, ~20% decline since 2011
- [ ] Reduced demand for pulp and biomass creates incentives to leave these residuals and take only sawtimber → high-grading

Going Forward

- [ ] Bio fuels could potentially rebalance the market for low quality products
- [ ] Each plant employing 40 people and processing 2000 tons of biomass/day may be able to indirectly support as many as 437 harvesters
- [ ] A base of 180 induced jobs plus 6.5 additional induced jobs per million in profit

Conclusions

❑ FPI is still an important and integrated part of Maine's economy

❑ $7.4B in total output impact

❑ The share of FPI as part of the total state GDP has slightly declined

   ❑ $1 out of every $22 of state GDP is associated with the FPI

❑ 1 out of every 26 jobs in Maine is associated with the FPI

   ❑ 2,580 FPI jobs lost overall

   ❑ Employment in sawmills, plywood/veneer, and other wood products **increased** by 363 (from 4376.6 to 4739.6)

Thank You!

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Comparison with Bureau of Labor Statistics

Total Jobs and Compensation

	2011	2014		2011	2014
Harvesting	4700	4607		$ 185,991,359.70	$ 198,907,339.04
Biomass	218	142		$ 12,794,359.00	$ 8,808,278.00
Sawmills	2011.9	2171.0		$ 76,638,206.99	$ 92,072,579.39
Plywood/Veneer	694.7	735.6		$ 24,446,481.89	$ 25,829,156.46
Wood Products	1670.0	1833.0		$ 51,753,260.50	$ 61,992,576.12
Pulp and Paper	7303	6155		$ 473,144,027.50	$ 436,213,697.75
Wood Furniture	803.7	757.0		$ 30,191,004.06	$ 30,161,457.01
Forest Service	150	150		$ 9,138,370.00	$ 9,938,370.00
BLS and NES Total	17551.3	16550.6		$ 864,097,069.63	$ 863,923,453.78
IMPLAN	17003	16552		$ 769,838,553.60	$ 863,824,874.00