Intersectoral and International Energy Linkages: Models and Measurement

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The Big Picture: Energy, I/O Links, and Trade

Intermediate inputs are increasingly important in trade

1. Two-thirds of world trade
2. Value-added trade and global supply chains
3. Can significantly amplify the gains from trade

Energy is a particularly important intermediate input. Changes in energy costs (and therefore changes in policy) have *direct* and *indirect* effects.

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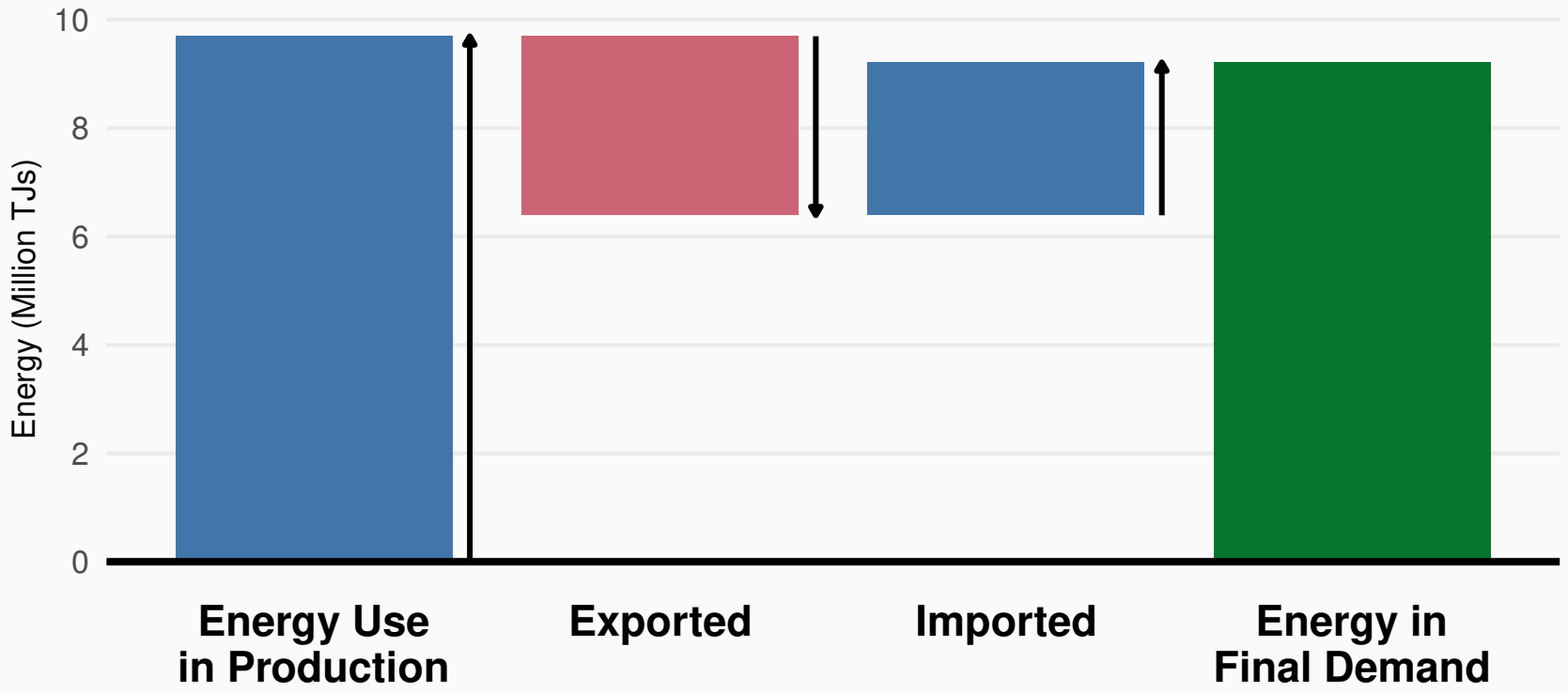
Importance of Trade and I/O for Energy is Clear in the Data

1. Significant energy is embedded in traded goods and services
2. Most energy use is along the supply chain

Significant Energy Embedded in Traded Goods/Services

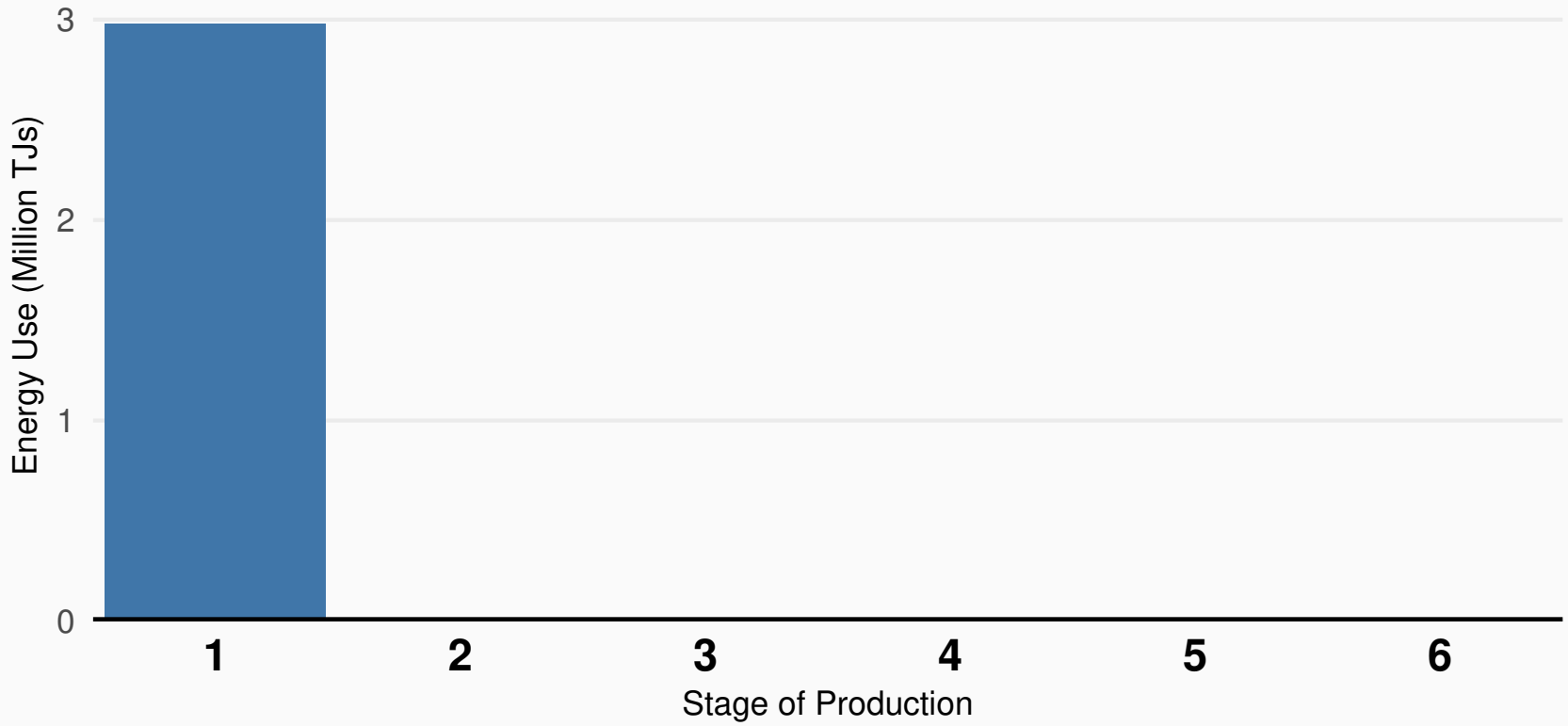
Figure 1: Trade in Energy Use, Production vs Final Demand (2015)



Source: Own calculations from UNCTAD-EORA database, following Aslam et al. (2017) for GVCs.

Most Energy Use is Along the Supply Chain

Figure 2: Energy Use in Canada, by Stage of Production (2015)



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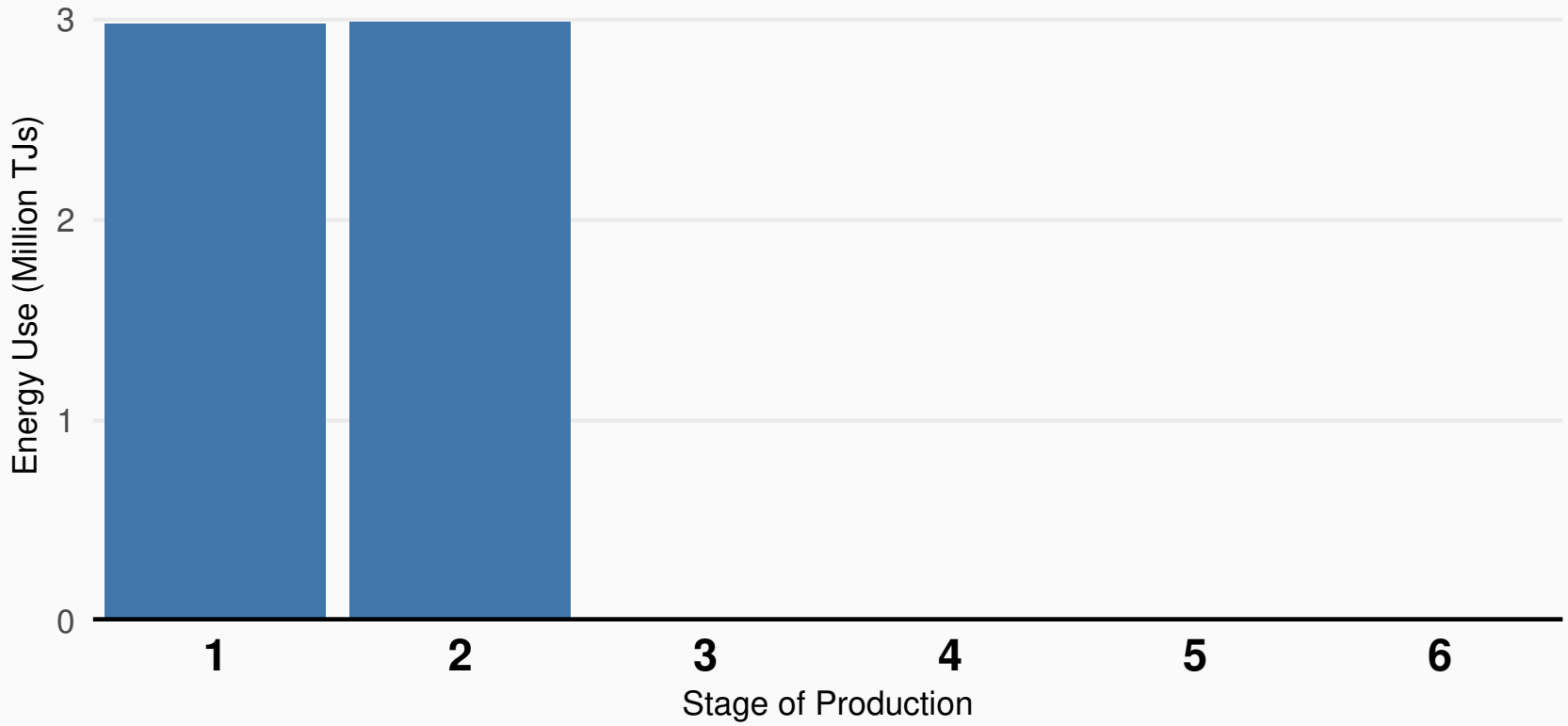

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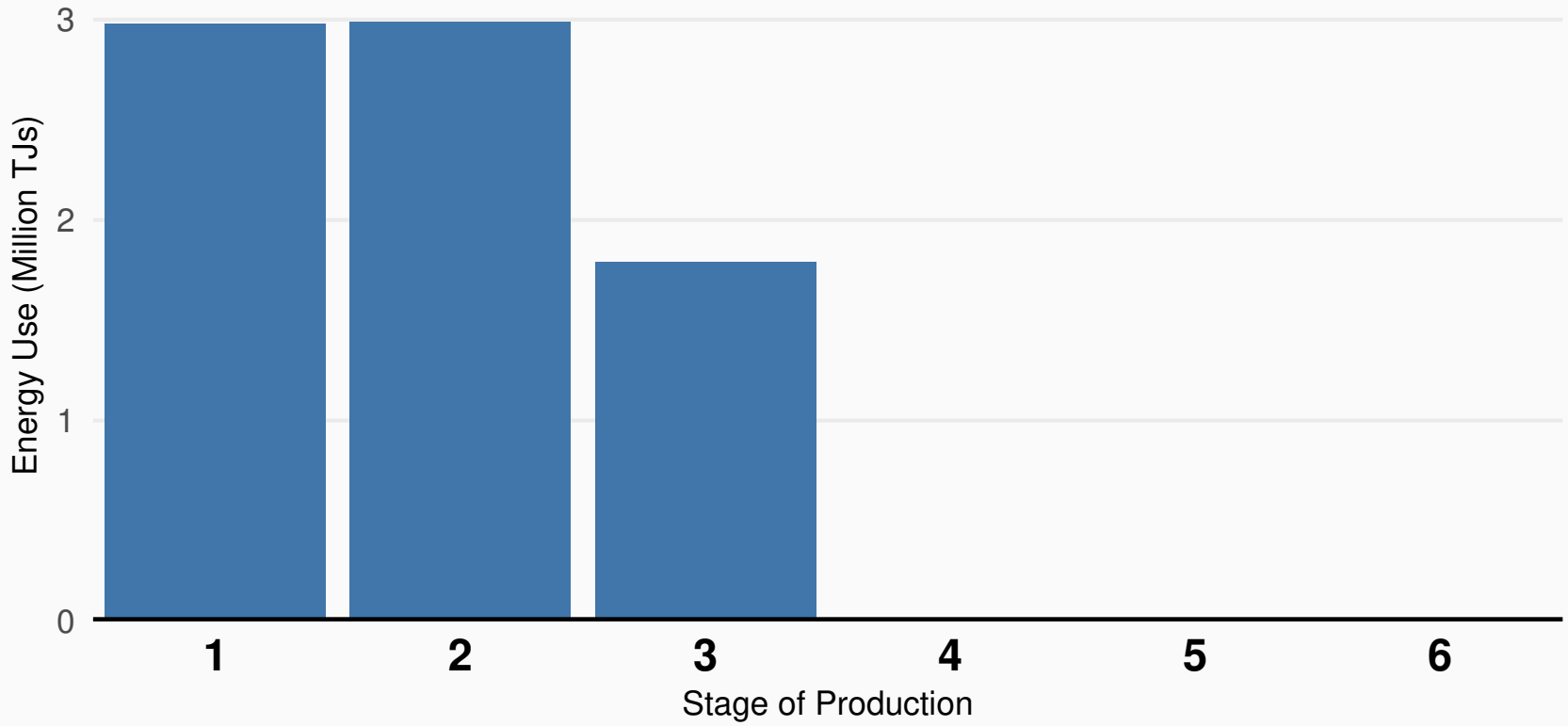

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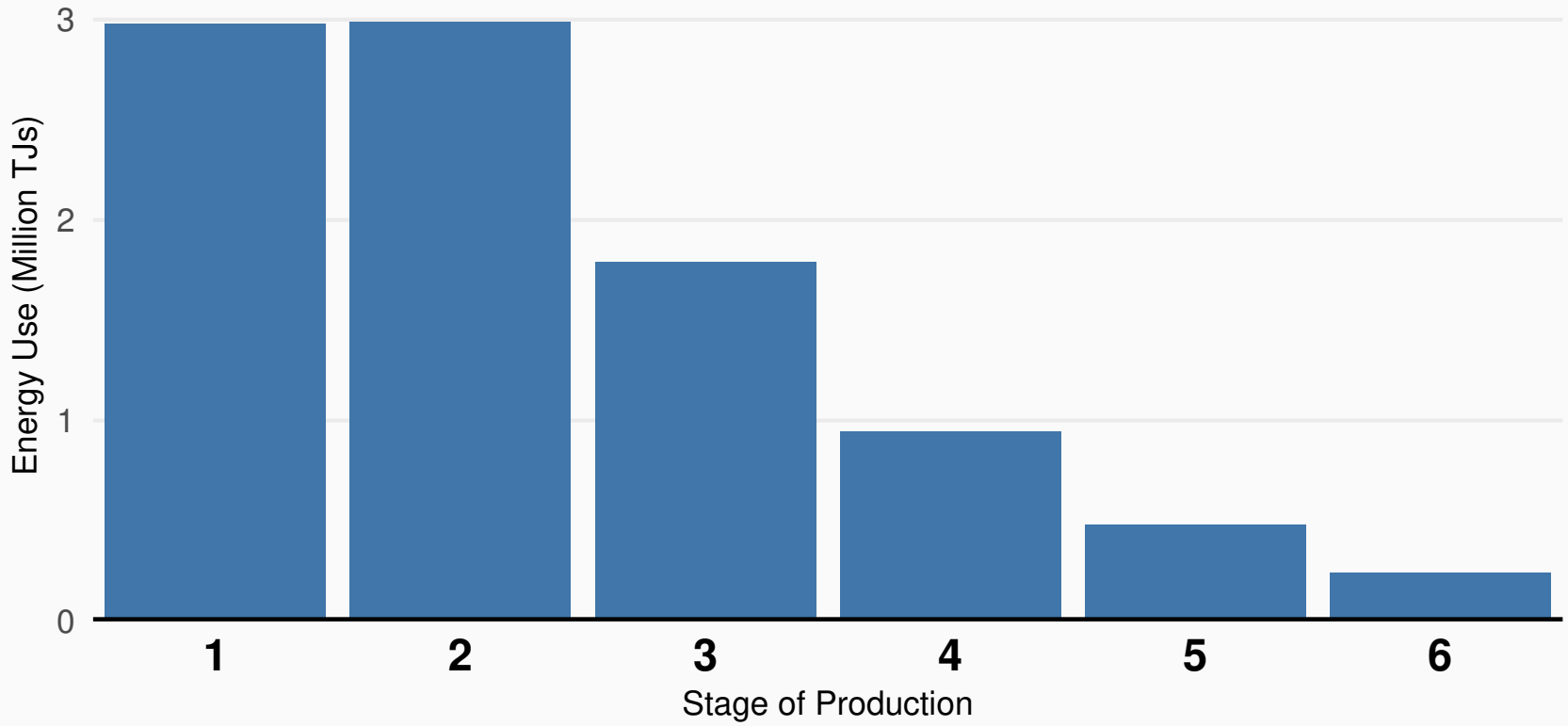

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The Plan for this Book Chapter

The importance of intersectoral and international energy linkages

1. **Empirical:** Properly accounting for indirect energy use
2. **Policy/Model:** Properly quantifying economic implications of energy development and policies that affect energy prices

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Specific Contributions of the Book Chapter:

1. **Data:** Accounting for indirect energy use, sectoral linkages
2. **Empirics:** Energy as a source of comparative advantage
3. **Model:** The effect of resource exports on Canada's aggregate economy, and that of provincial GDP, employment, fiscal transfers

Existing literature: Lan et al. (2016) for energy trade; little overlap.

Data: Accounting for Sectoral Energy Linkages and International Trade

Input-Output Data is Useful

Multi-Region Input-Output Table: UNCTAD-EORA Database

- 190 countries, 15,909 sectors (I'll use 26 aggregates)
- Covers 1990-2015 (in some cases back to 1970)
- Full multi-region input-output linkages
- Energy use by sector, 9 fuel types
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Input-Output tables have many uses. Though often abused.

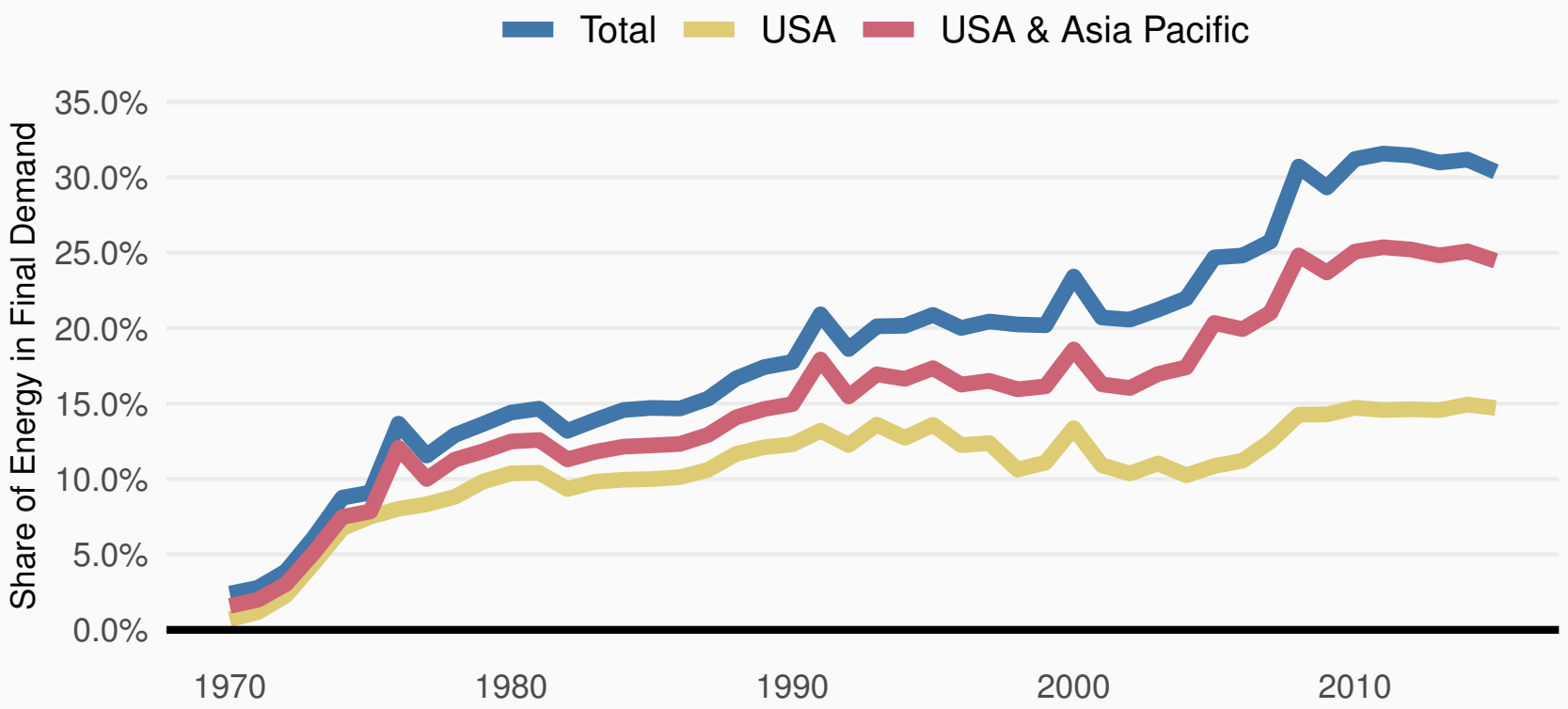
Useful for: Accounting exercises.

Not useful for: Counterfactuals.

Instead, use I/O data to calibrate trade models (Albrecht and Tombe, 2016; Tombe and Winter, 2018)

Import Share of Final Energy Demand in Canada

Figure 3: Import Share of Final Energy Demand in Canada



Source: Own calculations from UNCTAD-EORA Resource Footprints database.

Energy as Source of Comparative Advantage

Estimating the Sources of Comparative Advantage:

Exports x_n^j, country and sector characteristics c_n and s^j, estimate:

$$ln(x_n^j) = \delta_n + \delta^j + \boldsymbol{\beta}\left(s^j \times c_n\right) + \epsilon_n^j$$

If $\boldsymbol{\beta} \neq 0$ then c_n matters for trade and this is evidence of that as a source of comparative advantage

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A large and growing literature takes this approach:

- Importance of contracts $\times$ judicial system (Nunn, 2007 QJE)
- Industry complexity $\times$ judicial system (Levchenko, 2007 ReStud)
- Financing needs $\times$ financial depth (Manova, 2008 ReStud)
- Job complexity $\times$ human capital stock (Costinot, 2009 JIE)
- Volatility $\times$ labour market rules (Cunat and Melitz, 2010 JEEA)

Energy as a Source of Comparative Advantage

Table 1: Regression of Exports on Energy Intensity x Energy Production

	Dep. Var.: log(exports)	
2-3	(1)	(2)
$(\text{Direct Intensity})^j$ x Endowment_n	0.095***	-
	[0.026]	-
$(\text{Total Intensity})^j$ x Endowment_n	-	0.128***
	-	[0.038]
Country FEs	Yes	Yes
Sector FEs	Yes	Yes
Observations	3,524	3,524
R^2	0.737	0.738

Source: Own calculations from UNCTAD-EORA database. Regression follows Nunn (2007), who finds estimates for human capital (0.085) and physical capital (0.105).

Proper Counterfactuals and “Economic Impacts”

Quantifying The Value of Energy Exports

In 2014, resource exports (mostly energy) totalled $150 billion

Question: What is the value of these exports on Canada's economy?

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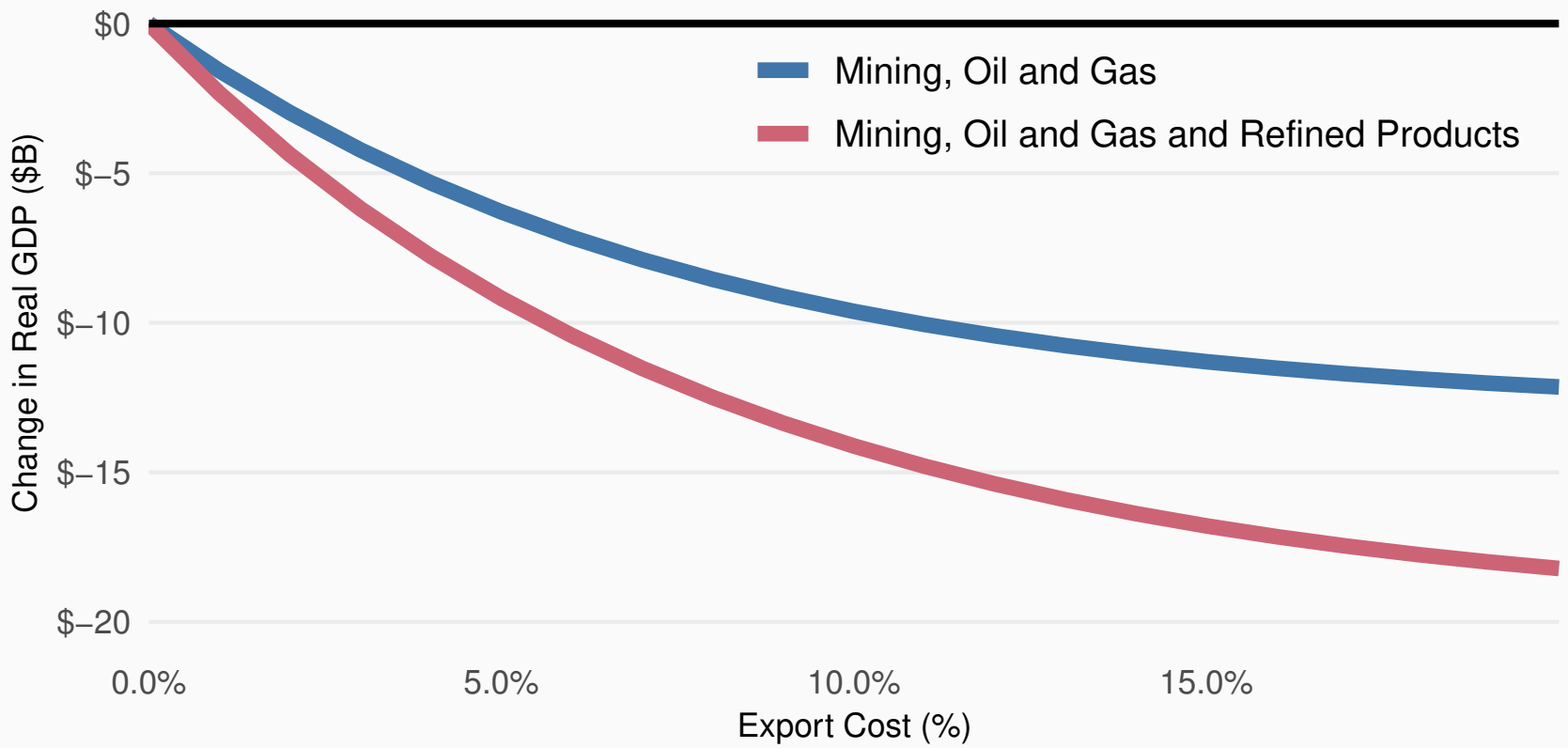
Proper Counterfactuals: The Effect of Trade Cost Changes

- Increase export costs modestly.
- Increase export costs to prohibitive levels.
- Carefully map out all the resulting reallocations/adjustments

Modest Export Costs Have Large Effects

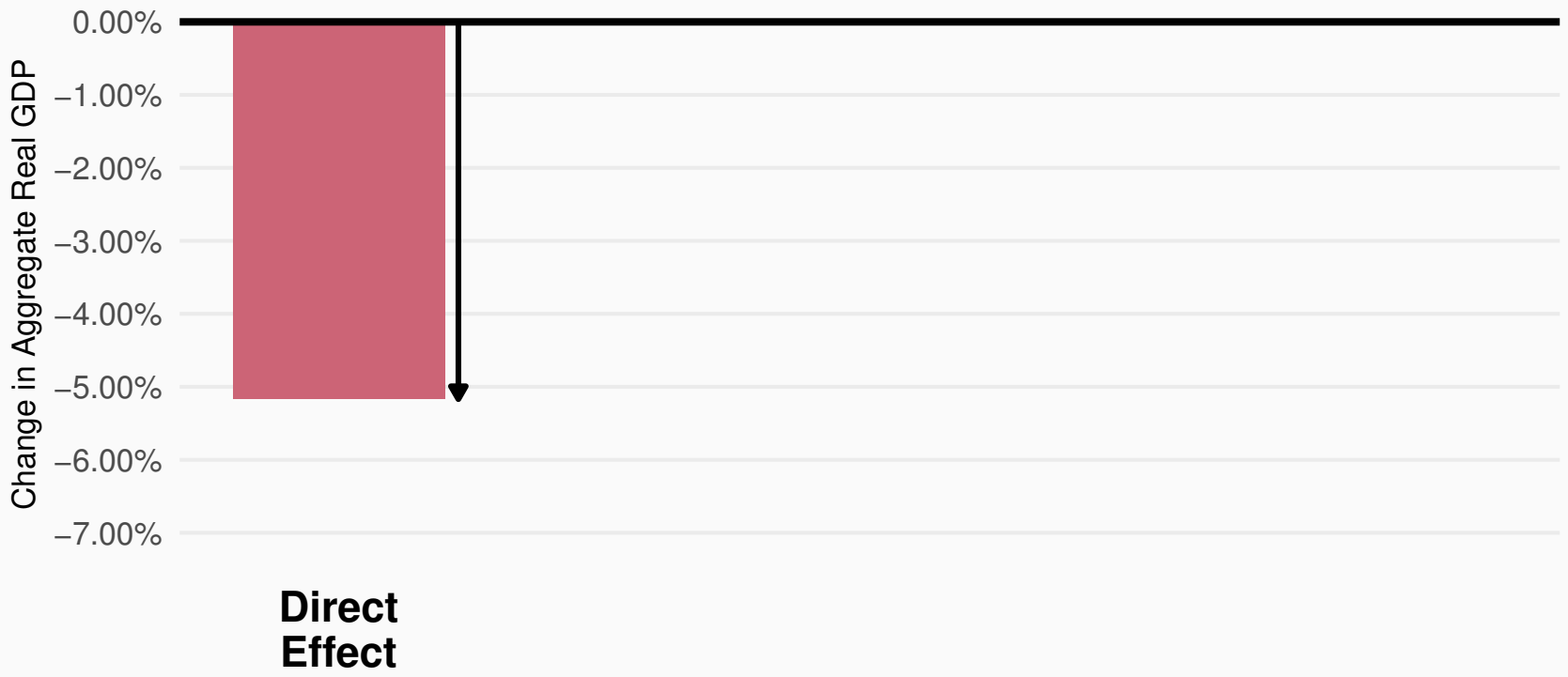
Figure 4: Change in Real GDP due to Various Export Costs



Source: Own calculations from an Eaton-Kortum model based on Caliendo and Parro (2015) and the World Input-Output Database.

The Effect of Blocking the $150B in Resource Exports

Figure 5: Change in Real GDP from Blocking Canada's Resource Exports



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Reconciling the Model with Input-Output Estimates

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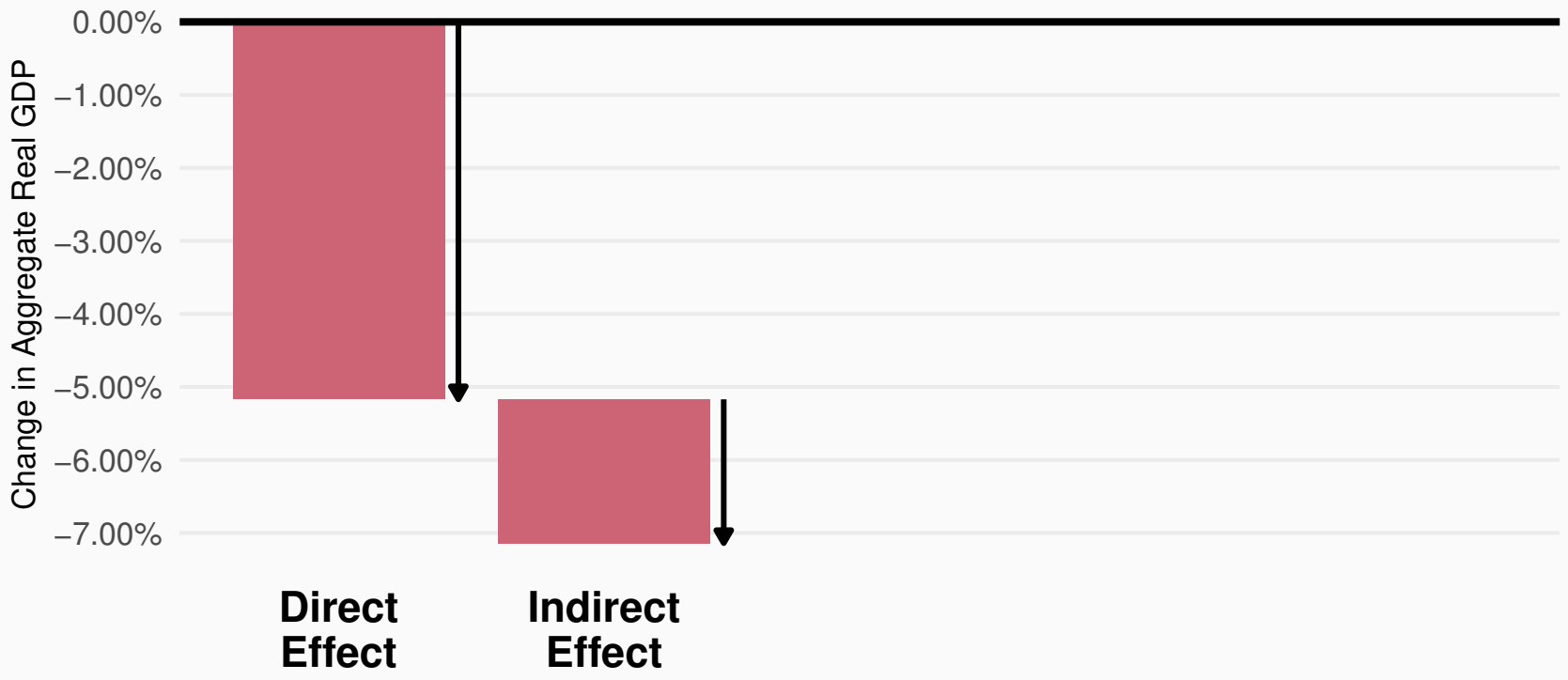

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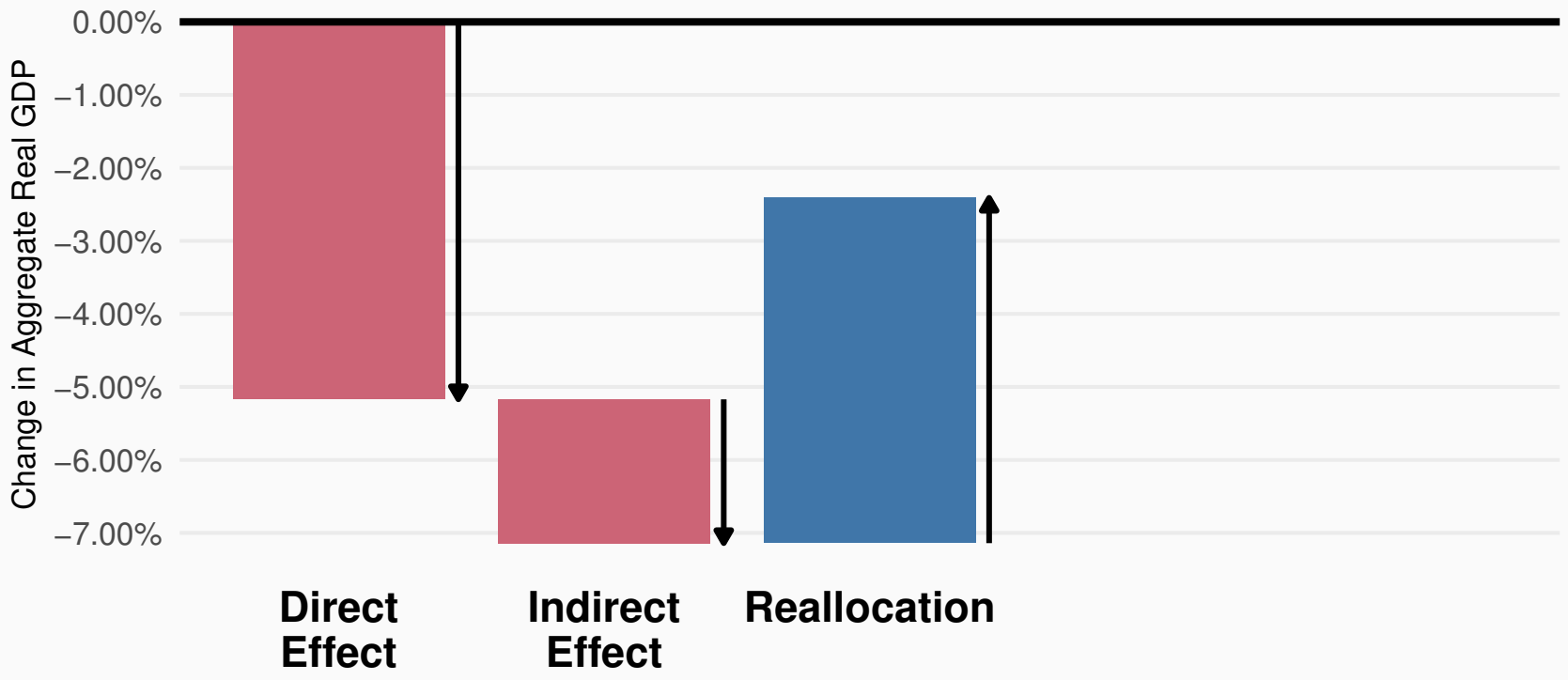

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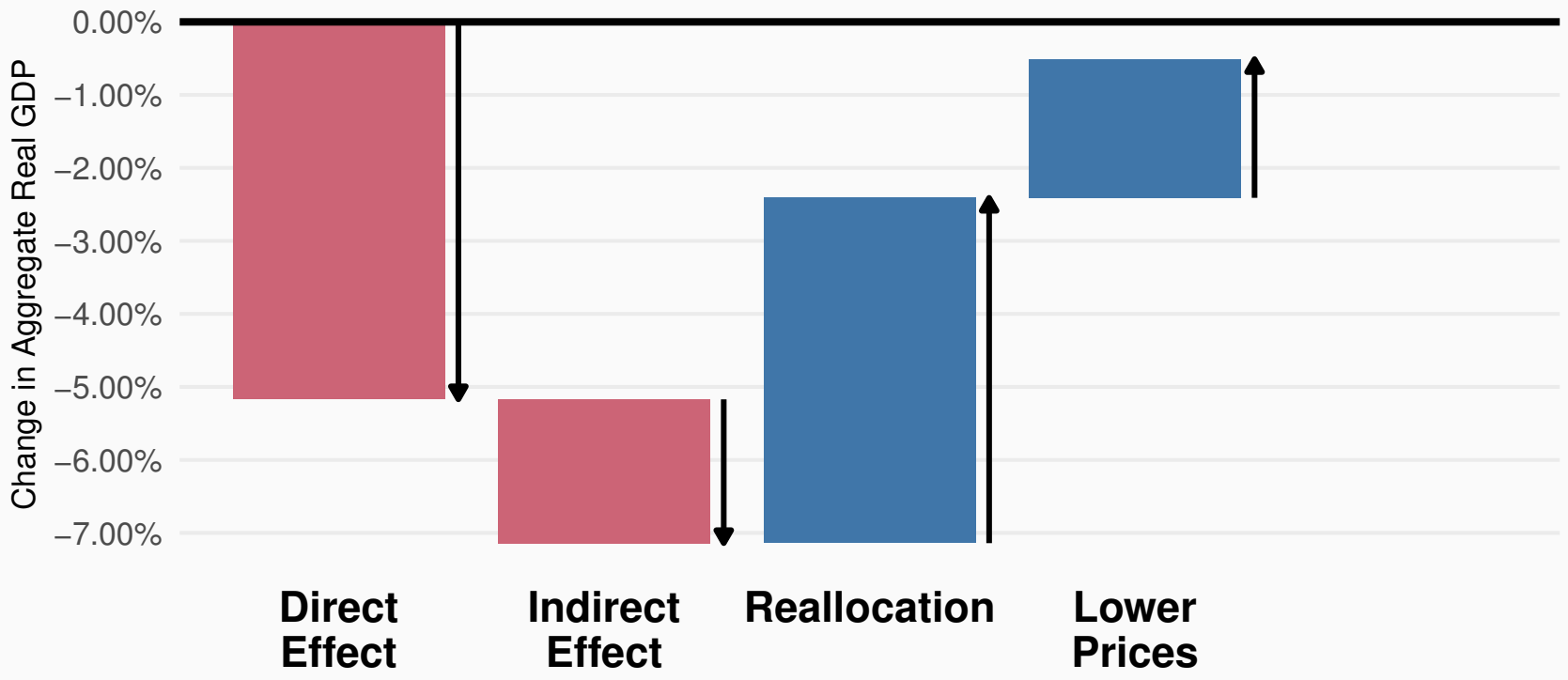

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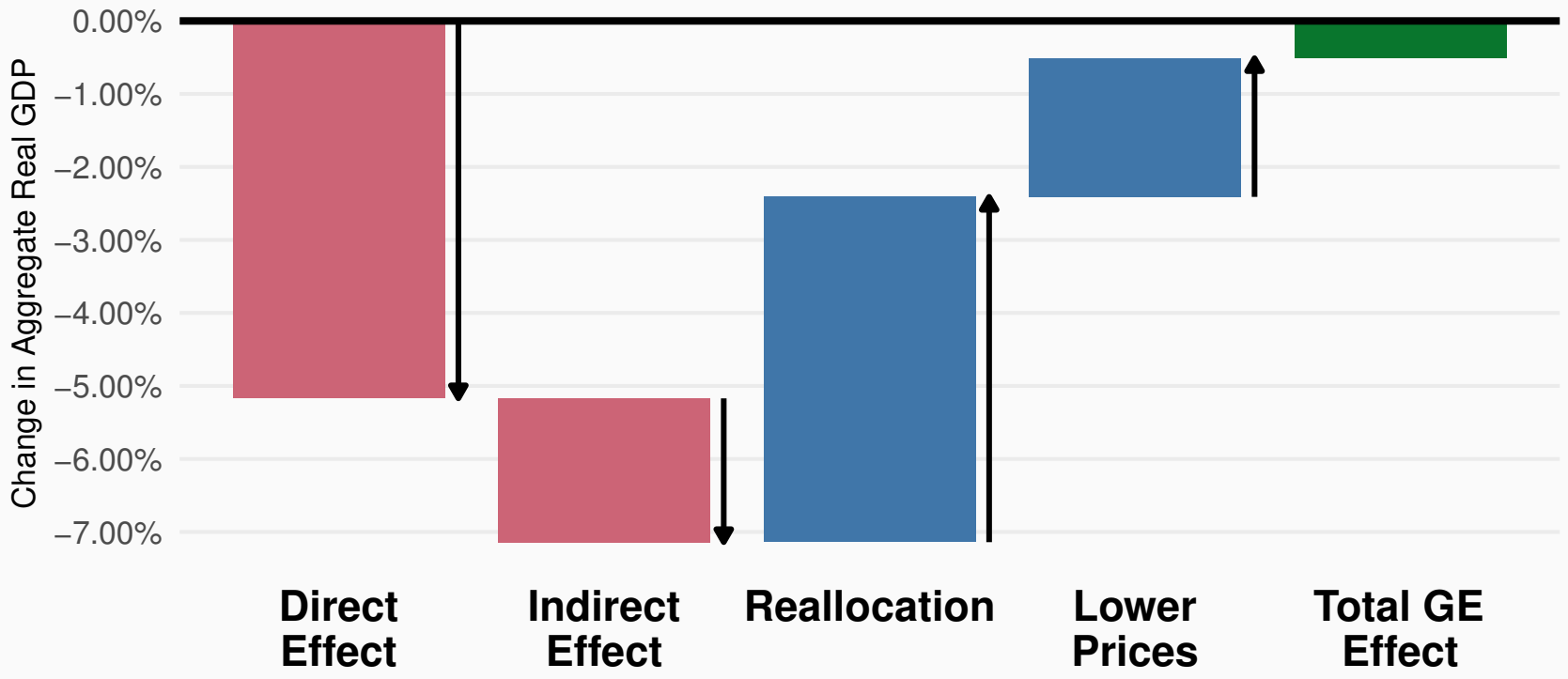

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Quantifying The Value of Energy Exports

In 2014, resource exports (mostly energy) totalled $150 billion

Counterfactual: No resource exports (infinite export cost)

Selection of Aggregate Results

- **Real GDP:** Declines 0.6% or $13 billion
- **Employment:** Resources drops two-thirds. Half to services (mainly transport, wholesale/retail), half to manuf. activities (metals, refining, pulp & paper)
- **Trade:** Refining exports rise significantly, as do metals. All other sectors also increase (exchange rate effect)

Substitution matters: mining, oil and gas, *and* refined products exports total $170 billion. Blocking both decreases real GDP 0.9% or $20 billion.

Within-Canada Effects of Resource Exports

Employment and economic activity can reallocate across regions as well as sectors.

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Propagating Economic Shocks Across Provinces

- **Real GDP Effects:** trade linkages
- **Real Income Effects:** fiscal transfers
- **Migration Effects:** employment, worker mobility

Tombe and Winter (2018) provides a tractable, quantitative model to conduct such an analysis. Includes endogenous inter-provincial trade, migration, and fiscal transfers!

Within-Canada Effects of Resource Exports

Table 2: Effect of Blocking Resource* Exports, by Province

	Per Cent Change in			Transfers (% of GDP)	
	Real GDP	Emp.	Real Income	Before	After
BC	-0.81	0.16	-0.64	1.8	1.9
AB	-1.88	-0.11	-0.82	8.8	7.4
SK	-3.86	-1.02	-1.43	0.7	-2.7
MB	-0.53	0.46	-0.44	-7.0	-7.0
ON	-0.08	0.07	-0.7	0.8	1.4
QC	-0.22	-0.05	-0.78	-3.3	-2.7
NB	**0.09**	0.43	-0.47	-13.4	-12.9
NS	-0.35	0.44	-0.46	-15.7	-15.5
PE	-0.59	0.12	-0.67	-22.0	-22.0
NL	-3.1	-2.32	-2.29	-7.0	-9.6

* And agricultural exports. Future work will disaggregate if possible. This is for 2010. Work updating to 2014 is ongoing.

Concluding Thoughts

Conclusion and Next Steps

- **Sharpen the Contribution:** Measuring the size and consequences of energy trade, between sectors and countries
- **Potential IV for the Empirics:** Country endowments (oil and gas reserves, for example) affect prices $\rightarrow$ trade
- **Add Model Detail:** Further disaggregate sectors for the inter-provincial analysis