

BETTER OFF DEAD: “VALUE ADDED” IN ECONOMIC POLICY DEBATES

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SUMMARY

Politicians across Canada have come to understand that our economy improves when we develop so-called “value added” industries and jobs. They suppose that turning raw materials into finished goods creates more value added than simply extracting and exporting raw materials directly. That understanding is entirely and often dangerously wrong.

Indeed, the meaning of the phrase “value added” has been so widely misunderstood and distorted that we would all be better off if it were struck from the political rhetoric and public debate entirely. The reality is that almost everything Canadians are being told about which activities add value, and which ones do not, is utterly backwards. Manufacturing has come to be seen as the ultimate source of value added, as though the physical manipulation of matter was somehow responsible. For example, the leader of the federal Opposition, the NDP’s Thomas Mulcair, has insisted that “exporting unrefined heavy oil creates no value-added jobs” and likens exporting raw logs to “a practice typical of undeveloped nations.” It is not just the NDP, similar statements are made across the political spectrum.

Fortunately for us, such views can be put to the test. We will see that they are not just inaccurate, they are the very opposite of the reality: Canada’s raw resource extraction industries actually provide the highest value-added, often by a significant margin. Oil and gas extraction, for example, creates \$1.36 million in value per job per year, 15 times higher than the national average for all sectors and more than triple the value added per job per year in the petroleum products refining sector.

Absent such data, is there a better way to think about value added that would provide a clear and intuitive defense to misleading statements? Thankfully, there is: industries that generate the most income are industries with high value added. To say a sector like oil and gas extraction creates no value-added jobs is to say it creates no income, which is plainly false. If replacing “income” for “value added” leads a claim to not make sense, then it is likely false and the politician or commentator should be dismissed.

Disturbingly, this mixed-up thinking matters a lot for the health of Canada’s economy. Public policy often favours supposedly high value-added industries at the expense of others through subsidies or other supports. Instead of creating value, when governments favour one sector over another they invariably hurt the economy by distorting the allocation of labour and capital, which lowers Canada’s overall GDP. This is true for any subsidy made on the basis of “value added” - subsidizing resource extraction would also be economically damaging. There may be other reasons to provide industry supports - but value added is never one of them.

Canada’s economy, and everyone in it, would be better off if politicians and public commentators put the phrase “value added” to rest.

False and misleading statements are all around us; often, they are believed. This is particularly true in economic policy discussions, where choices rarely benefit everyone and policy debates are understandably contentious. With Canada's resource sectors expanding quickly, there is a growing chorus of commentators claiming that raw resource activities add little or no value to Canada's economy. Consider for example a recent claim by federal NDP leader Thomas Mulcair that "exporting unrefined heavy oil creates *no* value-added jobs [emphasis added]."¹ These claims are widely held and often repeated at both the left and right ends of the political spectrum, and the public largely agrees. A recent poll of Albertans reveals over 90 per cent of respondents support the government's vaguely phrased "value-added strategy" (essentially, subsidizing oil processing activities) and 70 per cent believe raw oil should be upgraded and refined in Alberta.² It is natural and somewhat understandable for people to support policies favouring what they think of as "value-added sectors" or "value-added jobs" as a means of improving the economy. The tricky questions though, are: What is a value-added sector or job? Why does it matter whether a particular project adds value? When people claim that exporting raw oil or unprocessed lumber creates no value-added jobs, are they correct? Even if you can identify which sectors add value, do favours to some sectors at the expense of others benefit an economy? This report seeks to cut through the complexity, lay out the facts, and demonstrate the importance of an accurate understanding of "value added" for Canadian public policy.

Let's begin by taking stock of the typical uses and abuses of "value added" in public policy discussions. It is unfortunately rare to see anyone use the phrase "value added" in a way that is not false or misleading. Frequently — perhaps always — "value added" is invoked to garner support for a particular policy objective. Consider the \$300 million in funding provided by the Alberta government to the North West Redwater Partnership (also known as the Sturgeon Refinery or the North West Upgrader).³ Political and popular support for these policies is strongly influenced by the belief that refining adds value while raw extraction does not. At a legislative committee hearing in April 2014, the minister responsible (Diana McQueen) defended support to refining along these very lines, stating "it's important that we continue to do value-added here."⁴ She goes on to say "the value-added industry... it's very important that we continue to grow that." Alberta's Progressive Conservative premier, Jim Prentice, — in referring to increased refinery activity in Alberta — said: "clearly... we need to have maximum value added here in Alberta."⁵ Across the country, Brian Gallant, now Liberal premier of New Brunswick, campaigned partly on a push to build more refineries. Specifically: "if New Brunswick does not build the refining capacity to process the volume of oil that will come here through the Energy East pipeline, the vast majority of this oil would be exported to other markets where the value-added refinement process will create thousands of jobs."⁶

Invoking "value added" is not something confined to policy discussions about the oil and gas industry. In the most recent provincial election in British Columbia for example, Adrian Dix, leader of the New Democratic Party, advocated a policy of restricting raw log exports in favour of a "value-added forestry economy."⁷ This call for domestic processing is broadly held; even think tanks such as the Canadian

¹ Thomas Mulcair, "Tar Sands: Dirty Oil and The Future of a Country," *Policy Options* (March 2012).

² Sheila Pratt, "Majority of Albertans support bitumen upgrading incentives: poll," *Edmonton Journal*, July 2, 2014. For the original poll results, see http://industrialheartland.com/images/stories/aiha_news_releases/AIHA_ROi_poll_on_processing_oil_and_gas_in_Alberta_FINAL.pdf

³ For detail related to this project and the funding provided, interested readers may enjoy the transcript of the Legislative Assembly of Alberta's Standing Committee on Resource Stewardship on April 9, 2014 (Transcript No. 28-2-6).

⁴ *ibid.*

⁵ Karen Kleiss, "Alberta Conservative leadership candidate Jim Prentice promises to cap debt," *Edmonton Journal*, May 28, 2014.

⁶ See New Brunswick Liberal Party, "Liberals would push for downstream oil industry," press release, September 11, 2014, <http://nbliberal.ca/post-news/liberals-would-push-for-downstream-oil-industry/>.

⁷ Tyler Harbottle, "NDP's plan to reduce log exports could hurt B.C.'s forest industry: observers," *Global News*, May 3, 2013, <http://globalnews.ca/news/532698/ndps-plan-to-reduce-log-exports-could-hurt-b-c-s-forest-industry-observers-2/>.

Centre for Policy Alternatives advocate such a policy⁸ and its own Scott Sinclair goes even further, opposing trade liberalization between Canada and South Korea on the grounds that “the deal is likely to cement Canada’s global role as a natural resource supplier, to the detriment of higher value-added sectors, such as the auto industry.”⁹ David Suzuki provides another example. He regularly touts the harm that energy exports, through currency appreciation, do to Canada’s “manufacturing and other value-added industries.”¹⁰ Implicitly, the claim is that manufacturing industries are value added but the resource sector in general, and raw resource exports in particular, are not.

Are these views correct? Answering this question is the entire purpose of this report. We will do so precisely, with detailed data from Statistics Canada.¹¹ We will see that raw resource extraction often creates more value added than other sectors, regardless of how one measures it: in total, per worker, per hour, and so on. If such data is not at your fingertips however, there is a useful rule of thumb to help you evaluate the accuracy of most claims:

Rule of Thumb: Value added is *income*, plain and simple

Why does this rule of thumb work?¹² The ultimate source of added value is productivity — the ability to generate output from inputs. Output is sold for revenue. The cost of materials and other intermediate inputs are subtracted from that.¹³ What’s left is income split between the firm’s employees, owners, lenders, landlords, and so on. *To create income is to add value.* It is the ability to create income that allows firms to secure the resources (workers, buildings, land) to operate. Those that create less income, relative to the resources they require, will find it difficult to compete. Of course, there are complexities and subtleties that we will explore, but thinking of “value added” as a synonym for “income” is sufficient in the vast majority of situations. So, to evaluate public claims involving “value added,” remember:

Replace “value added” with “income.” If the statement still makes sense, then it is likely correct.

Test this out on Thomas Mulcair’s statement quoted earlier: “exporting unrefined heavy oil creates *no* value-added jobs [emphasis added].”¹⁴ I suspect many (perhaps most) people would find it difficult to argue against this claim. Consider alternatively the claim that “exporting unrefined heavy oil creates *no income.*” This claim would likely find few adherents; workers in the extraction sector earn high incomes and royalty payments to governments are large, as are profits and all other types of income. It is clearly a sector that generates significant income. By the end of the report, I hope that most readers will agree the former statement is as false as the latter.

⁸ See, for example, Dale Marshall, “Down the Value-Chain: The Politics and Economics of Raw Log Exports,” *CCPA-BC Policy Brief* (November 20, 2002) http://policyalternatives.ca/sites/default/files/uploads/publications/BC_Office_Pubs/bc_rawlogexports.pdf.

⁹ Quoted in “Stephen Harper heads to South Korea to ink long-awaited free-trade pact,” CBC News, March 9, 2014, <http://www.cbc.ca/news/politics/stephen-harper-heads-to-south-korea-to-ink-long-awaited-free-trade-pact-1.2565781>.

¹⁰ David Suzuki, “They say radical; we say rational,” David Suzuki Foundation website, February 16, 2012, <http://www.davidsuzuki.org/blogs/science-matters/2012/02/they-say-radical-we-say-rational/>.

¹¹ All data, heavily sourced throughout this report, is freely and publicly available from Statistics Canada. Results are common across years and also from alternative sources, such as the OECD Structural Analysis Database.

¹² For the readers with an economics background, this should not be surprising: total value-added equals total payments to primary factors follows directly from Euler’s theorem. It can also be thought of as the “value-added approach” of national income accounting.

¹³ Intermediate inputs are goods or services *used up* in the production process, such as wood in a table. They are distinct from workers, buildings, machinery and so on, which are not used up. Workers and capital are called “primary factors” of production.

¹⁴ Mulcair, “Tar Sands.”

Indeed, to say that that something creates *no* value added is a very strong claim. Imagine a manufacturing operation that doesn't add any value; better yet, imagine one that subtracts value. What would this look like? Pennsylvania State University professor Jan Prybyla provided perhaps the starkest illustration of such a situation. Writing on the East German economy during unification, he tells the story of the Trabant (a cheap East German car). Volkswagen, prior to taking over many East German facilities, sent inspectors to review the operations. They found:¹⁵

The Trabant operation was value-subtracting: valuable material, labor, and capital inputs went in at one end; shabby Trabies came out at the other, their bodies made from compacted trash. The final output was worth less than the sum of the inputs.

Clearly, manufacturing operations and other production activities that do not create value are damaging to the health of any economy. Most operations, however, are obviously not value-subtracting. Instead, we must evaluate different projects that all create value, though in different amounts. In the next section, we go beyond the simple “value added as income” rule of thumb and examine detailed data across a variety of sectors. We will be able to precisely measure how much value added there is, who generates it, and which sectors create the most value added per job.

Before we turn to precise measurements, let me finally provide a comparison between our rule-of-thumb measure and a fully accurate definition of value added that some readers may be familiar with. The following information box presents three alternative ways of thinking about the meaning of value added, ranging between a plain-English definition to a more technical definition. The value-added-as-income definition is by far the best way to understand value added. Keep it in mind throughout the report.

What is Value Added? A Range of Meanings			
	Plain-English		Technical Definition
What is it?	Income	Income, plus depreciation of fixed capital	Wages and salaries, plus supplementary labour income, plus gross mixed income, plus gross operating surplus, plus net indirect taxes on products and production
Who gets it?	Workers (including benefits), capital owners	Workers (including benefits), capital owners	Workers, capital owners, government
When to use it in public?	Often	Sometimes	Never
Helpful?	Yes	Sometimes	Only for works

But, knowing whether a project or a sector creates value or not is often not helpful. The discussion usually surrounds whether to provide subsidies, favourable tax treatment, or other special considerations to certain industries and not others. In the last section of this report, we will take a close look at the effect these policies have on Canada's economy. We will see that policies aimed at increasing value added in Canada by supporting certain projects or sectors at the expense of others — even if those projects add much value, such as in the resource sector — are often counterproductive. What matters is whether a given project creates more value than the alternatives. The value created by a new lumber mill, for example, may actually be *less* than what *would have been* created had the workers and capital investments gone into something else, such as a chain of hair salons). Special favours for one sector often come at the expense of all others. Near the end of the report we will see subsidies to specific sectors (even high-value-added ones) can have large negative consequences for total value added in Canada.

¹⁵ Jan Prybyla, “The German Cure for Trabies and Lesser Ills,” PSU Working Paper 11-95-11 (1995), as quoted in the World Bank's *Beyond Transition* Newsletter, available online at <http://go.worldbank.org/0H1BPY07H0>.

While I will strive to present the facts in as accessible and intuitive a manner as possible, examining some detailed data will be unavoidable. This report, however, is not a reference guide. Instead, it is an appeal to some basic facts and a call to improve the quality of economic policy discussions. High-quality public policy is necessary for Canada's economic prosperity; debates surrounding the development of such policy must therefore inform, not mislead. Vague and poorly defined language is no basis for constructive discussions on any subject. Our views should be based on evidence; when they are not, there are undesirable consequences. To arrive at fair and effective policy, we must be clear and honest about the choices put before us. This report attempts a small step in that direction. Let's get started.

MEASURING TOTAL VALUE ADDED IN CANADA

We saw that value added is a simple economic concept that is best understood as a measure of income. It is not *exactly* income, as there is an important difference between the two concepts, but they are so closely related that it is sufficient for our current purposes to think in terms of value added as income. Let's build upon this intuition with a few concrete examples before presenting the actual data.

Apple's iTunes provides a great example. For each song purchased through iTunes for, say, one dollar, Apple keeps 30 per cent and 70 per cent is returned to the content provider. The income created by iTunes for Apple is then approximately 30 cents. Put another way, the income (30 cents) is the difference between sales (one dollar) and the cost of the input used to generate the sale (70 cents). So, we conclude the value added to the song by iTunes is 30 cents. The same calculation is true for any business. Ford's Oakville Assembly Complex produces the 2014 Lincoln MKT, which costs roughly \$50,000 for a basic model. To measure the value added created by Ford and its dealers selling the vehicle, we subtract from the \$50,000 the total cost of all intermediate inputs used to produce and deliver the vehicle, from the cost of parts and shipping to the cost of the coffee provided at the dealership. Overall, the motor-vehicle manufacturing industry in Canada creates 16 cents of income for each dollar of total output.¹⁶

An important lesson from these examples is that total revenue is *not* income and therefore *not* value added. Much of the revenue is used to directly pay for inputs used in the production process. As noted earlier, we call those inputs *intermediate* inputs. We can measure the total value of output, the total spending on intermediate inputs, and therefore the total value added and income created by each sector in Canada using what are called input-output tables. These tables are so important to economic analysis that their creator, Wassily Leontief, was awarded the Nobel Prize in Economics in 1973.¹⁷ Throughout the remainder of this section, I rely heavily on the input-output tables produced by Statistics Canada.¹⁸

Who or what creates the added value? A related but equivalent question is: Who or what receives the income? In general, we can divide the recipients into two categories: labour and capital. Intuitively, some of the value is created by workers and some is created by machines, brands, location, and so on. Wages, salaries and other benefits paid to workers represent labour income, while dividends, rental or interest payments represent examples of capital income. The income received by each group will — roughly and on average — equal its contribution to value created by the firm.¹⁹ In the Apple iTunes example, some of the 30 cents goes to workers who maintain and develop the system, but most of it likely goes to capital

¹⁶ Calculated from the input-output data to be introduced later in the report.

¹⁷ For details of Leontief's contributions, see Nobel Prize website, The Prize in Economic Sciences in Memory of Alfred Nobel to the Father of Input-Output Analysis," Press Release, October 18, 1973, http://www.nobelprize.org/nobel_prizes/economic-sciences/laureates/1973/press.html.

¹⁸ Specifically, the 2010 National Symmetric Input-Output Tables; Catalogue 15-208-XCB.

¹⁹ To the extent that markets are not competitive, labour and capital incomes can deviate from their contribution to value added.

owners.²⁰ Thankfully, the input-output data allows us to distinguish between value added by labour and by capital; that is, income received by labour and by capital.

In 2010, total production of goods and services in Canada was over \$2.93 *trillion*. Total purchases by all sectors on intermediate inputs were over \$1.36 trillion, leaving nearly \$1.57 trillion as income to workers and owners. This is also total GDP for Canada in 2010 (by definition). It is a large number. For each of the 34 million people in Canada in 2010, there was over \$46,000 in value added. For each job, value added is about \$90,000. These are impressive numbers — more than double Canada’s average value added per job in 1950, for example.²¹

Some of the value added goes to owners of capital while the rest (most) goes to workers. It is straightforward to estimate this split between labour and capital.²² Essentially, we track where the income goes, to workers or to capital owners, using the input-output data. In 2010, labour earned just over \$1 trillion while capital owners earned \$555 billion. I summarize these results in Figure 1(a). Overall, value added is just over half of total production, of which close to two-thirds is received by labour and one-third by capital.

To get income from value added, a number of adjustments are required. Thankfully, many of these adjustments are often trivially small. Taxes on and subsidies for products or business processes, for example, often complicate the discussion, so I will abstract from these issues and perform all the proper calculations in the background. So, it is entirely sufficient for most purposes to know the following:

$$\text{Value Added} - \text{Depreciation} = \text{Income}$$

Income is a concept we are all familiar with, but what is depreciation?

Think for a moment about how you might estimate the income of a family (without, of course, just asking or looking at pay stubs). You could look at the family’s bank records to measure total deposits over the course of a year. Is that income? Perhaps mostly, but some of those deposits may originate from asset sales. So, you track the family’s assets to measure how many stocks, bonds and so on, were sold over the same year. The proceeds from their investment sales, you would rightly conclude, are not income; so, you deduct those sales from total bank deposits. What’s left would be a reasonable estimate of the family’s income.

The analogy works well for firms or even an entire industry. As with our iTunes example, value added is the difference between the revenue and intermediate input costs of the goods being sold (in that case, 30 cents per song). But, not all of that is actually income — despite what I originally claimed. If in the process of facilitating the download, some of Apple’s hard drives wear out, this must be accounted for. Income is only what Apple has left after covering those lost assets. In general, some of what an industry receives as value added was effectively just “using up” capital that was previously accumulated, much like the sale of stocks and bonds for a household. If we measure how much its assets fell in value (which is called depreciation), we could adjust what it receives to account for this and derive a measure of income. In short, value added minus depreciation is income.

For the accountants out there, this is *not* the concept of depreciation you are familiar with. Businesses pay taxes on their profit through corporate income taxes. To determine profit in a given year, firms

²⁰ The exact split between labour and capital is not known — and would be extremely difficult to determine, even for Apple’s accountants — so I make this claim based on Apple’s overall capital income share. In its 2013 annual report, gross income was US\$63.63 billion and pre-tax income plus interest payments was US\$50.3 billion; together, this implies a capital income share of 79 per cent.

²¹ See the Penn World Table (version 8.0) at <http://dx.doi.org/10.15141/S5159X>.

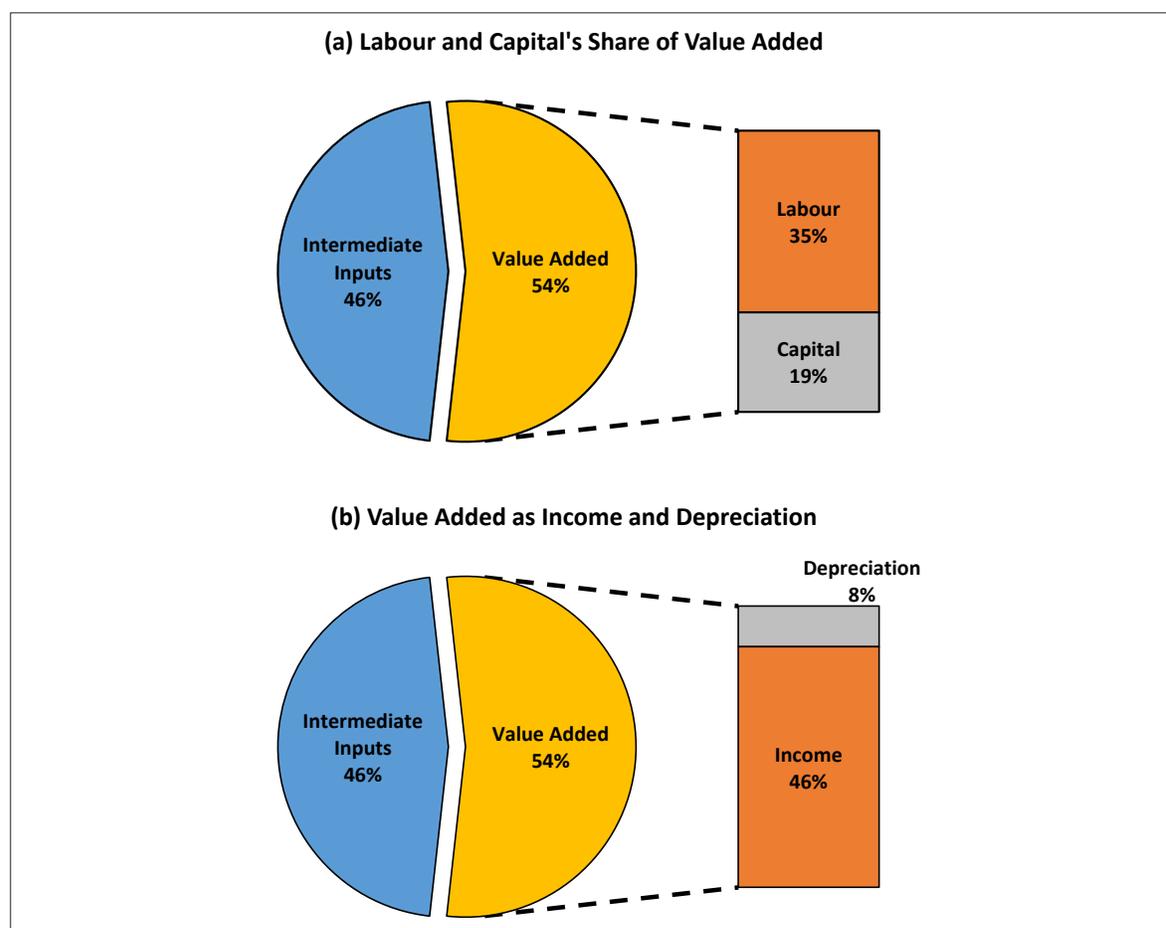
²² As is standard practice, I apportion mixed income and indirect taxes and subsidies to labour and capital according to the ratio of unambiguous labour compensation (wages, salaries and benefits) to unambiguous capital income (surplus of incorporated business).

subtract their costs from revenue. The precise value of costs in a given year is not a simple matter, as allowances must be made for buildings, machinery, computers, and other assets that wear out or break over time. Sometimes (perhaps often), depreciation expenses claimed for tax purposes are only loosely related to true economic depreciation. Instead, Statistics Canada produces a detailed set of estimates to quantify the actual economic depreciation by industry each year.²³ For our purposes, it is not important how these estimates are compiled (but if you're curious, they are based on detailed firm-level surveys and assumptions about the useful lifespan of different assets).²⁴

So how do the numbers shake out? Overall, for each dollar of output, as we saw, 54 cents of value added is created, 46 of those cents will be as income and only eight cents will go to cover capital depreciation. This result is illustrated in Figure 1(b). With depreciation comprising such a small overall share of value added, it is a good approximation for Canadians and policy-makers to think or say "income" instead of "value added."

When we take a closer look across different industries, things become more complex. The next section presents a detailed industry-by-industry examination of value added. Even with the added complexity and detail, the intuition that value added is (basically) income will still hold.

FIGURE 1 CANADA'S TOTAL PRODUCTION AND COMPONENTS OF VALUE ADDED



Source: Author's calculations from the National Symmetric Input-Output Tables, 2010, Statistics Canada Catalogue 15-208-XCB. Depreciation data from CANSIM Table 031-0002. Data for year 2010.

²³ Statistics Canada, "Fixed Capital Flows and Stocks," CANSIM Table 031-0002.

²⁴ For details, see Statistics Canada website, "Fixed Capital Flows and Stocks," <http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=2820&lang=en&db=imdb&adm=8&dis=2>.

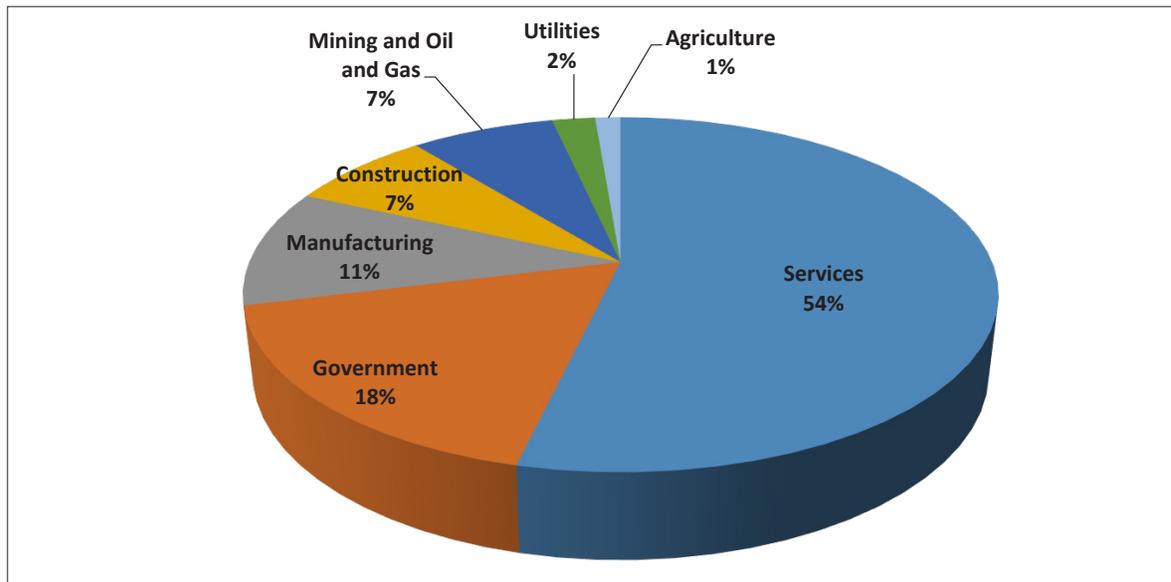
VALUE ADDED BY INDUSTRY

Examining value added by industry is often more relevant to policy discussion than is examining value added for the whole economy. Most of the earlier examples of public statements on value added claimed one sector added value while another did not (such as when lumber mills are compared to raw log exports). In the data, how does value added vary across industries? We will see that indeed some industries add more value than others.

Before proceeding to a detailed industry-by-industry analysis, consider a bird's-eye view of the Canadian economy. Figure 2 displays the share of Canada's total value added (GDP) by broad industry groupings. More precisely, it displays the share of total income across the entire economy created by each sector. Services — a broad category ranging from accounting to trucking — create just over half of all value added in Canada. Government is the second-largest contributor at nearly one-fifth — although distinguishing government from service activities is often tricky, since income created by education and health-care activities, for example, are categorized within services not government. For our purposes, this distinction matters little. More importantly, manufacturing creates just over 10 per cent of all value added in Canada. For a sector often touted as “the” source of value added, this low share may seem surprising. All other sectors create less than one-fifth.

While Figure 2 plots how broad sectors account for Canada's total value added, it is not a good measure of how effectively and productively each sector creates value. Manufacturing certainly accounts for more total value added than the oil and gas sector, but does that make it a “value-added sector”? After all, its large share may simply be due to its employing more people. The large share may also reflect the fact that capital-intensive sectors, such as oil and gas, purchase a large amount of inputs from the manufacturing sector (machinery, tools, and so on).

FIGURE 2 CANADA'S VALUE ADDED, BY SECTOR

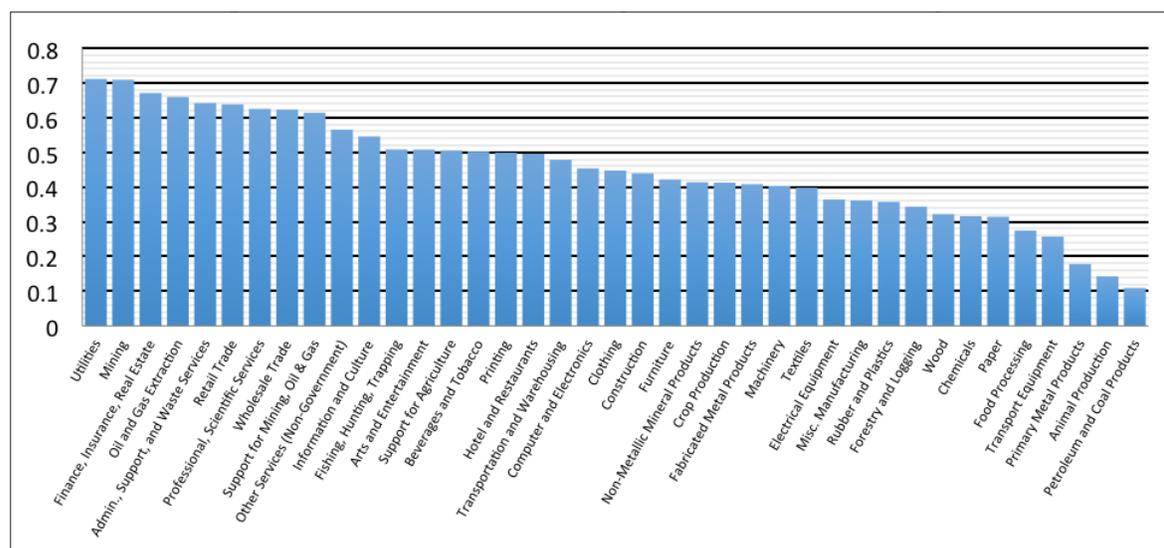


Source: Author's calculations from the National Symmetric Input-Output Tables, 2010. Statistics Canada Catalogue 15-208-XCB. Data for year 2010.

The simplest measure of how effective a sector is at adding value is how much value added it generates per dollar of total output. Figure 3 plots this measure for each of Canada's industries. At the high end we have utilities and mining, which both create roughly 70 cents of value added per dollar of output. Oil and gas extraction is a close third, at 66 cents of value added per dollar of output. At the low end are most of the processing sectors, such as food processing and petroleum and coal products (which includes

refining). Petroleum and coal products generate barely 11 cents of value added per dollar of output. The transport-equipment sector (which includes auto manufacturing) does better, but only generates 26 cents of value added per dollar. If these are the “value-added” sector most people think of, you wouldn’t know it by looking at these data.

FIGURE 3 VALUE-ADDED PER DOLLAR OF OUTPUT



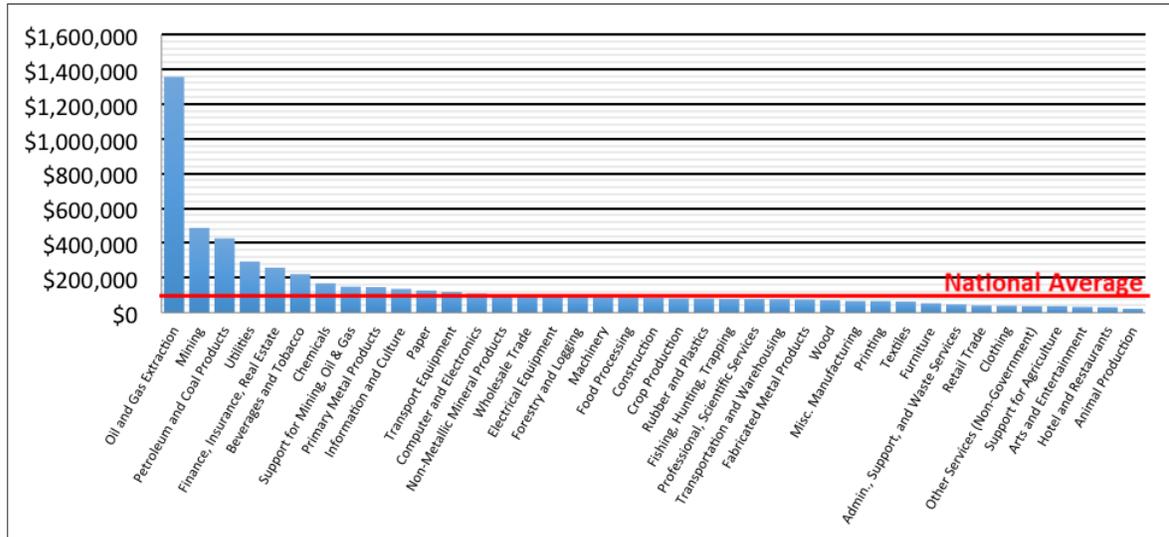
Source: Author’s calculations using “value added” from CANSIM Table 381-0022. Education and health care excluded. Data for year 2010.

Instead of looking at value added per dollar of output, let’s look directly at how much value added is created per job. This gets directly at the “value-added jobs” people are so fond of referring to. To do this, I take the total value added created by each sector and divide by the number of jobs in that sector.²⁵ I plot the results of this in Figure 4. Overall, the national average value added per job in 2010 was roughly \$90,000. Some sectors add substantially more value than others. At the high end, oil and gas extraction — not a sector that typically gets credit for adding value — adds much. By this measure, oil and gas extraction creates \$1.36 million in value added per job per year. This is 15 times higher than the national average. The petroleum and coal products sector — which includes refining — also creates a great deal of value per job (over \$400,000 per job). Impressive, to be sure, but only one-third the value created per job in oil and gas extraction.

Let’s look at other “value-added” industries and compare them to their raw-extraction counterparts. Furniture manufacturing, for example, creates \$54,000 per job, which is below the national average. Compare this to its raw-commodity counterpart — forestry — at \$94,000. Of course, not all industries typically viewed as adding value have value added less than their raw commodity counterparts. Crop and animal production and the fishing, hunting, and trapping sectors all have value added per job below the food processing industry. The agricultural sector as a whole, with total value added of just over \$20 billion and with 363,500 jobs, has value added per job at just below \$56,000. By comparison, the food-processing industry has nearly \$88,000 — just shy of the national average.

²⁵ Jobs in these data captures all employee and self-employed jobs, both full- and part-time.

FIGURE 4 ANNUAL VALUE ADDED PER JOB



Source: Author's calculations using value added from CANSIM Table 381-0022 and number of jobs from CANSIM Table 383-0031. Education and health care excluded. Data for year 2010. "Jobs" covers all employee and self-employed jobs, both full- and part-time.

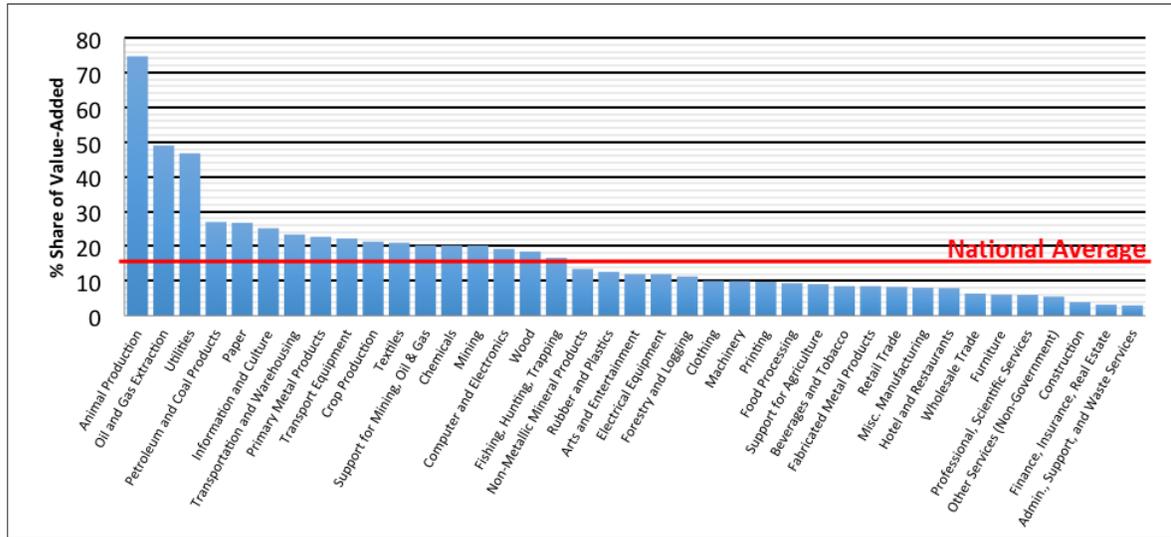
FROM VALUE ADDED TO INCOME, BY INDUSTRY

The difference between value added and income is depreciation, as we saw. For many industries, depreciation can be significant. In Figure 5, I plot each industry's depreciation costs as a share of value added. Notice how wildly different depreciation can be between industries. For animal production, where cattle is counted as an investment good, the depreciation costs are high. In oil and gas extraction, where staggeringly expensive machinery is subjected to harsh conditions in often remote areas, depreciation accounts for nearly half of all value added.²⁶ At the other extreme are mainly service-sector activities, such as hotel and restaurants or finance, insurance, and real estate. Overall, as we saw earlier, the national average depreciation cost is roughly eight per cent of total value added.

So, after subtracting depreciation from each industry, how much income is generated in each sector? Figure 6 plots the results of this subtraction, revealing a largely similar pattern to the earlier results on value added per job. Oil and gas extraction — typically viewed as adding little value — generates not only huge value per job (as we saw) but also substantial levels of income per job. In fact, each job in this sector is associated with nearly three-quarters of a million dollars per year in income. The petroleum and coal products sector is no slouch, generating roughly \$300,000 per job, which, while substantial, is less than half that generated in oil and gas extraction. Finance, insurance, and real estate — typically seen, especially recently, as creating very high-income jobs — is associated with a quarter of a million dollars per year. Nationally, approximately \$77,000 in income is generated per job.

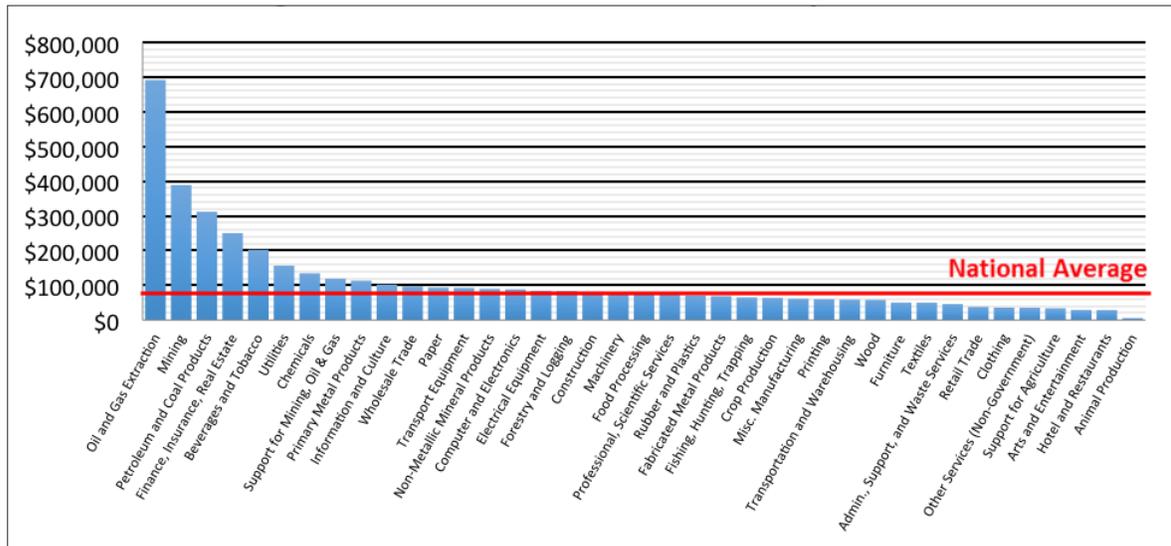
²⁶ Depreciation for this sector does not account for depletion of resource reserves.

FIGURE 5 DEPRECIATION COSTS BY INDUSTRY



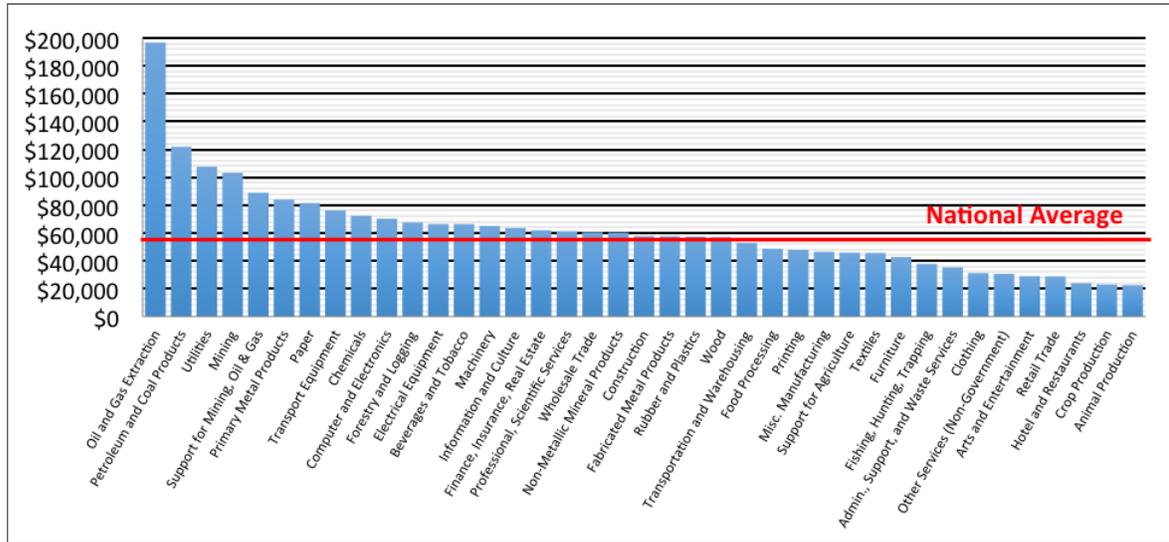
Source: Total output, by industry, is from CANSIM Table 381-0022 and depreciation is from CANSIM Table 031-0002. Education and health care excluded. Data for year 2010.

FIGURE 6 TOTAL ANNUAL INCOME PER JOB



Source: Author's calculations using total output from CANSIM Table 381-0022, depreciation from CANSIM Table 031-0002, and number of jobs from CANSIM Table 383-0031. Education and health care excluded. Data for year 2010.

FIGURE 7 LABOUR COMPENSATION PER JOB



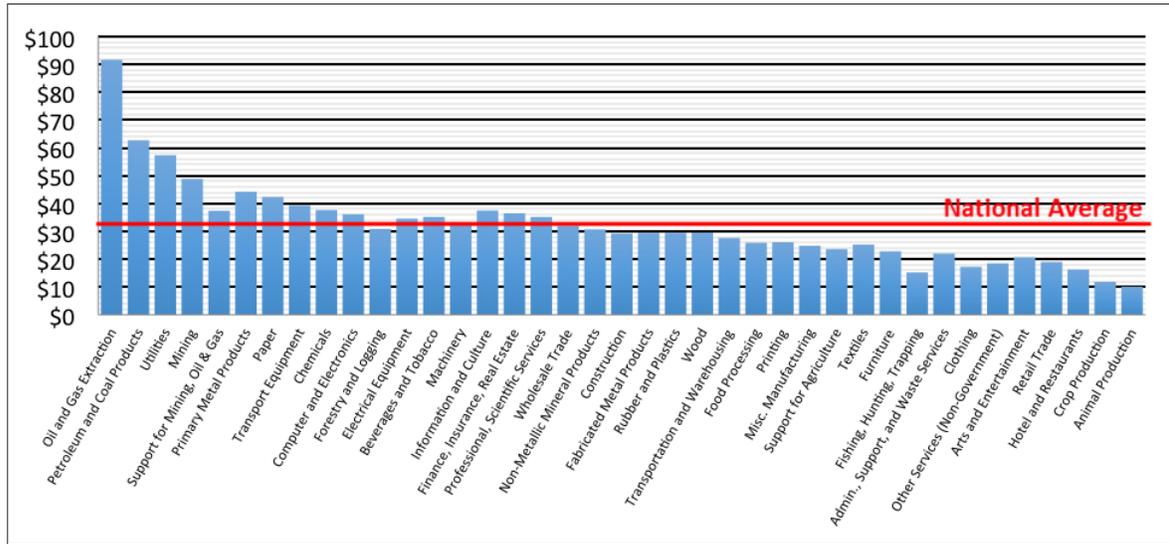
Source: Total compensation per job from CANSIM 383-0031. Data for year 2010.

Income is split between labour and capital, just as value added is created by both factors. To see how much of the income is received by workers, Figure 7 displays employee compensation per job in 2010 (which includes both employees and the self-employed, either full- or part-time). The national average was just over \$51,000 but, as before, there is substantial variation around this average. At the top, oil and gas jobs typically earn close to \$200,000 per year, compared to \$120,000 in petroleum and coal products. Transport-equipment manufacturing — which includes auto plants — typically generates just under \$80,000 per job. At the low end, jobs in the retail trade and hotel and restaurants earn among the least. The low income levels for crop and animal production are likely because much of the income is generated by owners and recorded as profit (capital income) rather than as wages.

Some of this high income per job may be due to workers putting in long hours. To get at income per hour worked, I plot in Figure 8 the hourly compensation from the same Statistics Canada database with industries ordered in the same order as annual total compensation. Clearly, the ranking is quite similar. Industries with high annual earnings are industries with high hourly wages. Oil and gas extraction leads the pack by far, at just over \$90 per hour — compared to the national average compensation of \$30. How much of the between-industry differences in annual earnings are due to differences in hours worked? It turns out, about 40 per cent.²⁷ The remaining 60 per cent of labour-compensation differences are due to differences in compensation *per hour*. Put another way, some industries are just more effective at creating value — and therefore income — than others.

²⁷ This is based on a simple comparison of the variance of log values. Specifically, the share of variation due to differences in hourly compensation is the variance in log per-hour compensation relative to the variance in log annual compensation.

FIGURE 8 LABOUR COMPENSATION PER HOUR



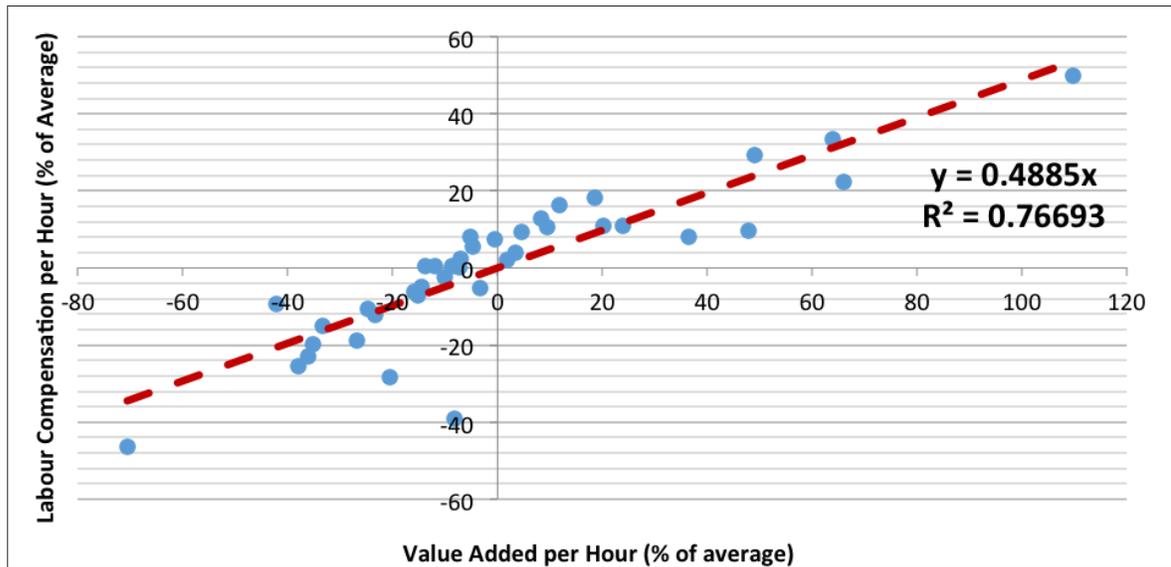
Source: Total compensation per job from CANSIM 383-0031. Data for year 2010.

Value added per hour is strongly related to how much workers earn per hour. The previous bar graphs make it difficult to clearly see this. Instead, I plot each industry’s labour compensation per hour against its value added per hour in Figure 9. Both are expressed relative to the national average. There is clearly a strong positive relationship between the two: industries with high value added pay more than industries with low value added. This relationship can be effectively summarized by a simple trend line, illustrated as a dotted line, which shows that each \$10 per hour in value added is associated with \$4.89 in additional labour earnings.²⁸ This doesn’t even count earnings to self-employed individuals within each industry. In short, value added matters. It often generates substantial incomes and workers are large recipients. What is not true, although it is widely believed, is that oil and gas extraction is not a value-added industry. The evidence suggests the opposite: it creates the *most* value of any sector along a number of dimensions (per dollar of revenue, per job, per hour, and so on).

Let’s move on from the focus on labour income to investigate more closely income earned by capital owners. From the previous graphs, it is clear that in most sectors, labour’s share of value added and income is large — typically two-thirds of value added goes to labour. In oil and gas extraction, however, the share is substantially lower at 14 per cent. Depreciation explains a huge fraction of capital’s share, but what of the rest? It is difficult to fully account for where the income accruing to each sector goes, but in Figure 10, I gather data from a variety of sources to estimate where the oil and gas value added goes. Income to capital owners is represented by the coloured slices of the pie, while depreciation is in grey. After accounting for new investments, depreciation expenses, and royalty payments to governments, only six per cent of oil and gas extraction value added is received as income by firms. Note that this is *not* profits, as one must still subtract other operating costs (land or equipment-rental costs, for example) and eventually even corporate income taxes. Moreover, any self-employed individuals have all of their income attributed to “firms” in this graph — when it should really be counted as returns to their labour (time). So, labour actually receives a fairly large share of what isn’t easily explained by the oil and gas sector’s extremely high level of capital intensity.

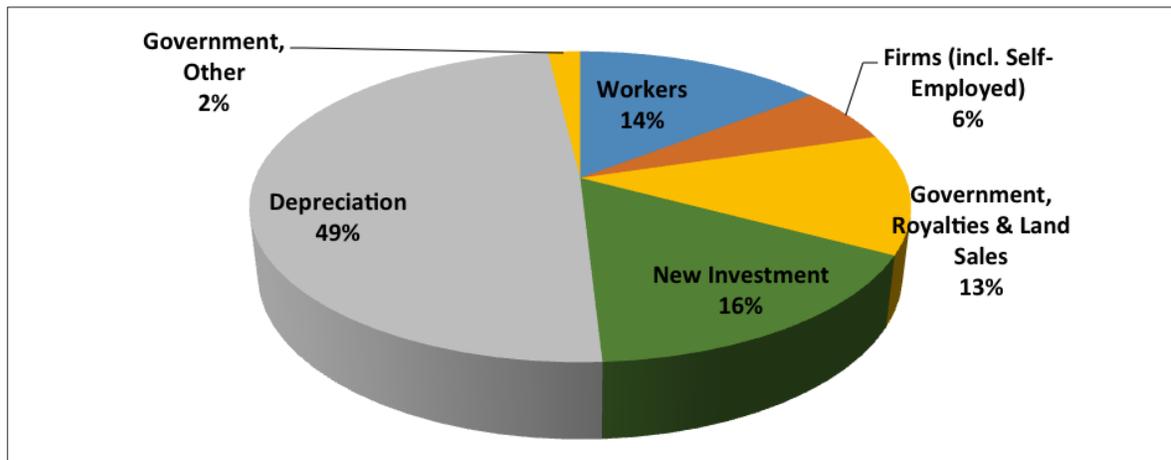
²⁸ This differs from the share of value added going to labour since CANSIM 383-0031 does not include any mixed income within its measure of labour compensation. Mixed income includes, for example, self-employment income.

FIGURE 9 LABOUR COMPENSATION VS. VALUE ADDED



Source: Labour compensation per job from CANSIM 383-0031 and value added from CANSIM 383-0022. Data for year 2010.

FIGURE 10 HOW IS VALUE ADDED BY THE OIL AND GAS INDUSTRY ALLOCATED



Source: Author's calculation. New investment and depreciation data from CANSIM Table 031-0002. "Government, other" represents indirect net taxes on products and production from the input-output table. Government royalties and land sales data from the CAPP Statistical Handbook's Cash Expenditures Tables. Data for year 2010.

VALUE ADDED AND INTER-SECTORAL LINKAGES

We have (extensively) documented the direct creators of value added in Canada; connections between industries can further enrich the picture. As we saw, producing most goods and services requires many intermediate inputs supplied by other firms. The output of one sector will therefore not only create value added directly through its own operations, but its purchases of inputs will further create value added in the supplying sectors. For example, each dollar of production by primary metal manufacturers requires 17 cents in metal ore inputs. Some of that 17 cents will be received as income by workers and owners of metal ore mining operations (about 12 cents, to be more precise). As another example, consider that

over 10 per cent of a new car's value is from the auto-parts sector. For each dollar received by auto-parts manufacturers, 32 cents is received as income by its workers and owners.

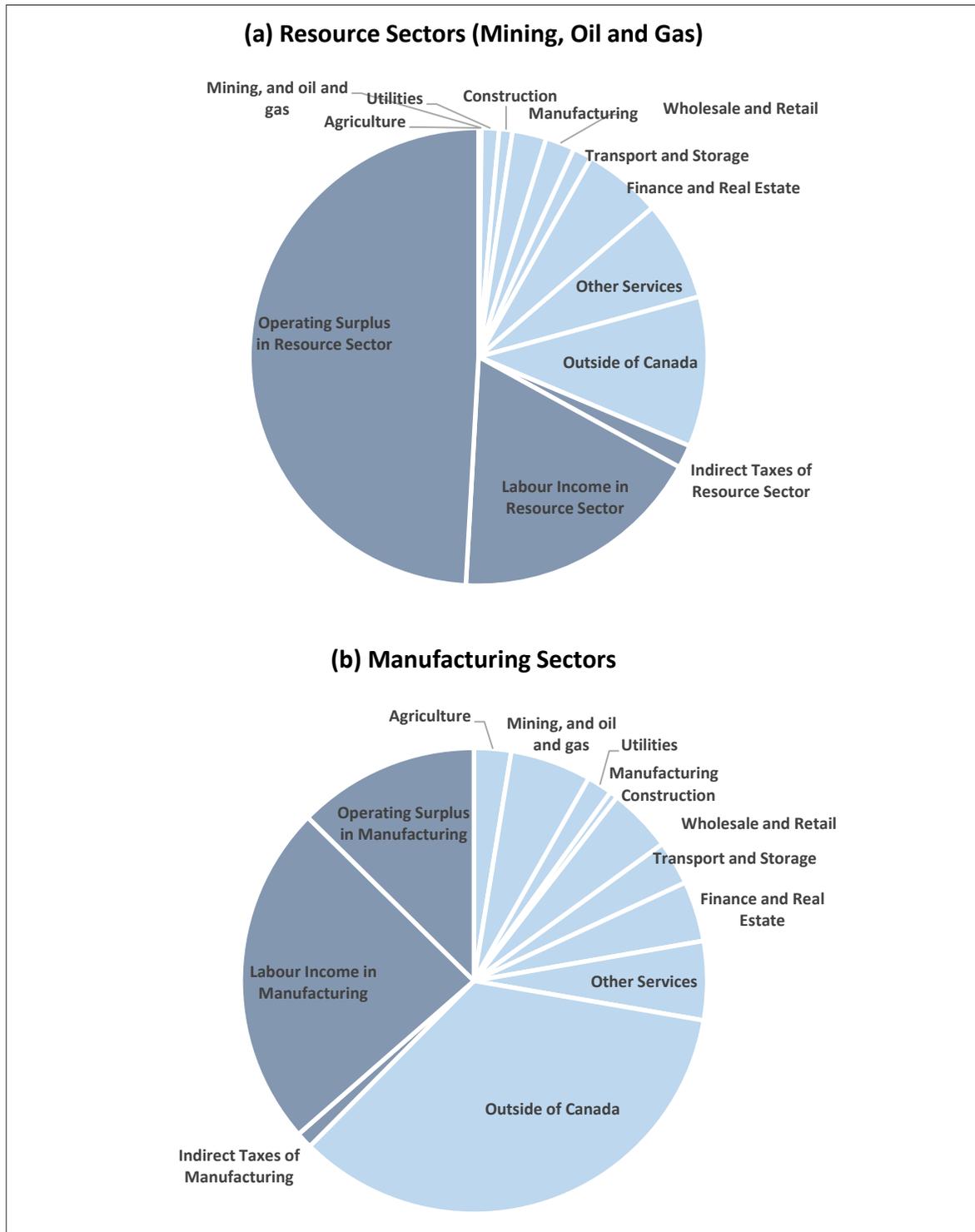
Tracing all of this indirect value added and income will help shed light on whether it makes sense to label any particular sector a creator of “value-added jobs.” If more value added is indirectly accounted for by sectors that supply refineries, for instance, how can we claim that the refinery jobs are the “value-added” jobs rather than the jobs in the supplying industries? Thankfully, our data from the input-output tables allows us to systematically explore the entire path of production and value added throughout the Canadian economy.

What does this data reveal? Figure 11 displays the ultimate source of value added for two broadly defined sectors: resources (mining and oil and gas extraction) and manufacturing. The dark-shaded regions represent value added from within the sector and the light-shaded regions represent value added from other sectors. For the resource sectors, slightly over two-thirds of all value added created is from the resource sector itself. For manufacturing, it is closer to one-third. That is, two-thirds of all value added created from manufacturing output is created *outside of Canada's manufacturing sector*.²⁹ When commentators claim that some sector or another creates “value-added jobs,” they miss the important fact that *the economy is a complex network — not a collection of separated sectors that can easily be thought of in isolation from each other*.

At the risk of being repetitive, let's go through the numbers for a specific narrow sector: refining. For each dollar of refinery output, about 12 cents is direct value added (income) in the refining sector. The remaining 88 cents is used to purchase inputs from other industries, which create value added and income in *those industries*. Those industries also buy inputs, so the process feeds back on itself continuously. Overall, for each dollar of refinery output, nearly 43 cents of value added and income is created in other countries, 28 cents is created by the Canadian oil and gas extraction sector, two cents is created by pipelines, and the remaining 16 cents by all other sectors in Canada (mainly support activities, wholesale trade, banks, and legal and accountancy services).

²⁹ The large share of imported intermediate inputs for manufacturing is also interesting. Though we must be careful not to conclude imported inputs are “bad” and Canada's prosperity would be enhanced by “Buy Canadian” policies — quite the opposite — although a full analysis of the gains from trade is beyond the scope of this report.

FIGURE 11 ULTIMATE SOURCES OF VALUE ADDED



Source: Author's calculation from input-output tables ("Symmetric Industries for 2010," Statistics Canada catalogue 15-208-XCB). The resource sector is industry code BS210 and manufacturing is code BS3A0 — both from Statistics Canada's summary aggregation.

We can repeat this exercise across any number of sectors to estimate what fraction of all the value added generated by a sector's output is actually from producers within that sector. Whether we are looking at oil, coal, agriculture, forestry, or fishing, the share of the total contribution to value added created by each sector's output is higher for resource sectors than it is for manufactured goods. Simply put,

manufacturing and processing activities typically generate more value added in *other sectors* than they generate themselves.

One can use the input-output tables to go even further and ask: What fraction of each sector's output is accounted for by value added *in total across the Canadian economy* regardless of the sector creating the value added. For refining, each dollar of output is associated with only 57 cents of domestic value added. For motor vehicles, the corresponding value is even lower: just 37 cents. At the other extreme, oil and gas extraction creates over 90 cents of value added for each dollar of output and universities generate nearly 94 cents on the dollar. Of course, this *does not* imply that motor-vehicle manufacturing is *worse* for the economy than resource extraction or higher education. It merely highlights that typical views of where value added is created are far off the mark.

THE DANGERS OF FAVOURING SPECIFIC SECTORS: AN ILLUSTRATIVE POLICY EXERCISE

We have repeatedly seen that the meaning and nature of value added in Canada's economy is very different from what public commentators typically suggest. Correcting these misunderstandings is a key objective of this report. But, do these misunderstandings have economic consequences? Do policies motivated by a desire to support value-added jobs help or hurt Canada's economy? This last section of the report examines these questions.

We will see that policies supporting supposedly high-value-added sectors at the expense of others are counterproductive. They can actually lower the total value added (and therefore income) produced in Canada — exactly the opposite of what their proponents intend. The intuition is straightforward. What matters is whether moving resources (workers and capital) to a given favoured project will create more value than an alternative use for those resources would. The value created by a prospective project (a new lumber mill, for example) may actually be *less* than what *would have been* created had the workers and capital investments gone into something else (say, a new copper mine or a chain of hair salons). For the most part, resources are allocated between competing uses by prices, wages, and rates of return on capital — all of which are constantly changing as economic conditions change. When a new lumber mill (to follow the same example) creates less income than a new copper mine or chain of hair salons, its owners will find it difficult to offer high enough wages for workers or a high enough rate of return to capital to operate. It will eventually shut its doors.³⁰ By interfering, government subsidies — which presumably are given only to marginal projects that would fail without them — actually *destroy* value and lower total income in Canada. Of course, there may be perfectly valid reasons to provide subsidies, but supporting “value-added” projects is *not* one of them.

Policy-makers are right to desire high value added, but the surest way to maximize value added in Canada's economy is by minimizing distortions to it. Favourable tax treatment or other supports to particular firms or industries often do more harm than good. I demonstrate this with the aid of a simple theoretical model — essentially, a toy economy — and also through more rigorous quantitative simulations. In all that follows, take nothing in the model as a statement of fact. The model's purpose is to communicate ideas *precisely* and to ground our intuition. That being said, the general conclusions are extremely robust across a wide range of models.³¹

³⁰ Firms with high productivity and therefore high value added will not gobble up all other firms; as a firm grows larger, each additional input tends to become less effective and its output tends to become less valuable to consumers. These sources of “diminishing returns” ensure many firms will operate simultaneously, though they will be different in size.

³¹ Indeed, the aggregate consequences of firm-specific distortions is the subject of a recent and growing literature in macroeconomics, starting with Diego Restuccia and Richard Rogerson, “Policy Distortions and Aggregate Productivity with Heterogeneous Plants,” *Review of Economic Dynamics* 11, 4 (2008): 707-720. Another highly influential paper is Chang-Tai Hsieh and Peter Klenow, “Misallocation and Manufacturing TFP in China and India,” *The Quarterly Journal of Economics* 124, 4 (2009): 1403-1448.

The simplest possible case is where there are *no input-output linkages* between sectors. Without intermediate inputs, all production is consumed as final goods by households and all sales translate directly into income. Let the share of household spending allocated to goods from sector i be represented by β_i . For example, a little under one per cent of final-goods spending in Canada is allocated to goods from the crop and animal production sector; so, $\beta_{crops} = 0.01$. If we make a further assumption that production requires *only* labour (this is useful for illustrative purposes, and is not a statement of reality) then value added created by sector i (denoted Y_i) is just the value added per worker *times* the number of workers. If we denote value added per worker with A_i and the number of workers with L_i then

$$Y_i = A_i L_i$$

In the model, total GDP in the whole economy (denoted Y) is an average (a geometric average, to be precise) of value added created by all sectors. Mathematically,

$$Y = \prod_{i=1}^N Y_i^{\beta_i},$$

where β_i is just the share of total spending allocated to goods from sector i . This way of aggregating across sectors ensures households' spending shares do not change (they are always β_i). It greatly simplifies the analysis to come.

To maximize total GDP Y , how many workers L_i should each sector have? Should sectors with high value added per worker A_i receive more? Or should sectors to which households allocate more of their spending β_i receive more? It turns out the optimal share of total national employment in each sector is β_i and has nothing to do with A_i . Specifically,

$$\left(\frac{L_i}{L}\right)^* = \beta_i,$$

where total national employment L is and the star denotes "optimal" (that is, "GDP maximizing" or the employment in each sector that maximizes total value added in the whole economy).

What happens if we were to subsidize one sector? We must account for two things. The money to provide the subsidy must have come from somewhere. Let's make the generous assumption that taxes can be raised without themselves distorting the economy (this is through what economists call a "lump-sum tax"). If we provide a subsidy to a sector of \$1, then \$1 in taxes are levied on the households and their total spending must fall by \$1. The second thing to consider is the subsidy expanding the size of the sector lucky enough to receive the subsidy. The overall effect will be to shift employment towards the subsidized sector and away from the unsubsidized ones.

Can subsidizing high-value-added sectors increase GDP? Consider an extreme case: a subsidy to the sector with the *highest* value added per worker. Let's call this "sector 1," $A_1 > A_i$ where for any $i \neq 1$). For each dollar in sector 1 sales, subsidize producers such that they receive $s > 1$ dollars. For example, a 10 per cent subsidy implies $s = 1.1$. How do workers respond to this subsidy? I leave details to the appendix, but the new share of total national employment in each sector is

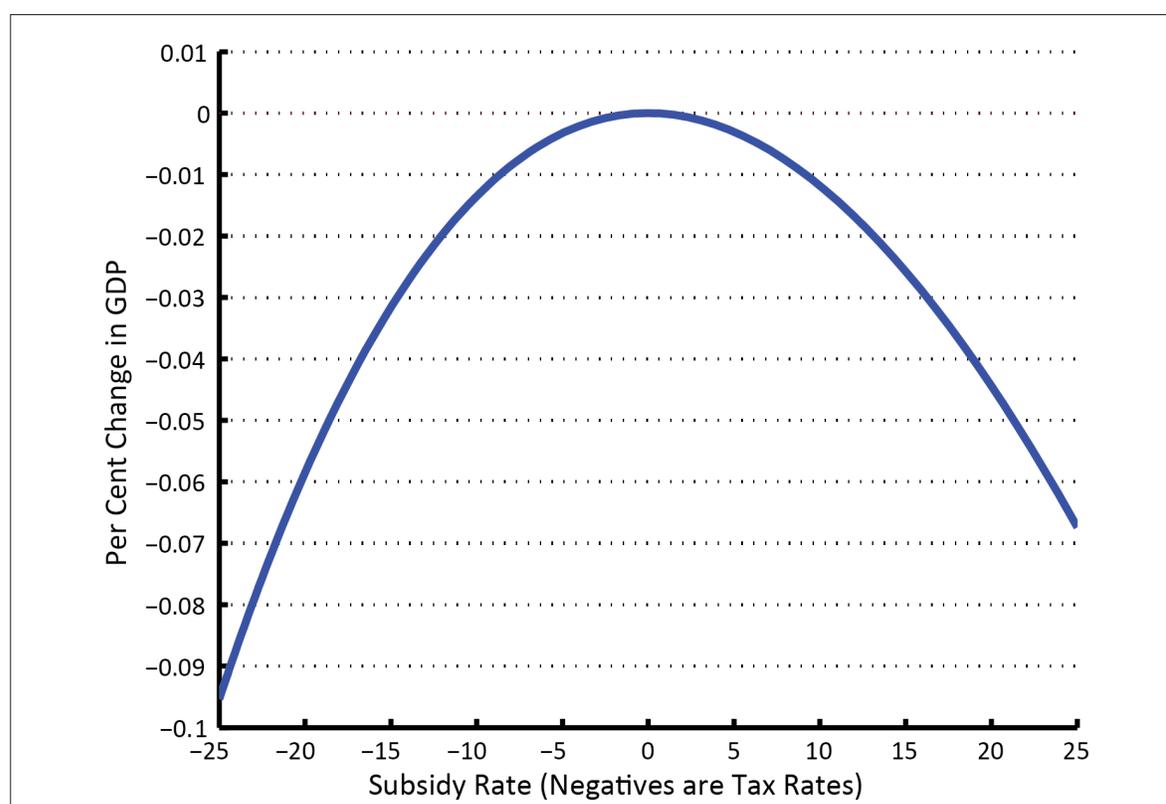
$$\text{Subsidized Sector 1: } \frac{L_1}{L} = \beta_1 \frac{1+s}{1+\beta_1 s} > \beta_1 = \left(\frac{L_1}{L}\right)^*$$

$$\text{All Other Sectors } i \neq 1: \frac{L_i}{L} = \beta_i \frac{1}{1+\beta_1 s} < \beta_i = \left(\frac{L_i}{L}\right)^*$$

So, employment in unsubsidized sectors declines below optimal levels while employment in the subsidized sector grows above its optimal level. Importantly, *the employment response has nothing to do with value added*. What matters is only the subsidy rate s and spending shares β_i .

What happens to total GDP? Since the employment across sectors is no longer equal to their optimal levels, GDP will surely fall. To illustrate this, I solve the simple model for various subsidy levels to motor-vehicle manufacturing and display the results in Figure 12. Along the horizontal axis are subsidy rates — where negative subsidy rates are taxes. Along the vertical axis is the percentage change in Canada’s GDP. Notice that *both taxes and subsidies to a single sector lower GDP*. It does not matter what kind of distortion creates a deviation of employment from the optimal level, total GDP will fall.

FIGURE 12 EFFECT OF TAXES/SUBSIDIES TO A MOTOR-VEHICLE MANUFACTURING ON NATIONAL GDP (IN THE SIMPLE MODEL)



Source: Author’s calculation from the simple model; see text for details.

The same result will hold regardless of which sector receives the subsidy (or the tax). Total GDP will fall. We can subsidize high-value-added per worker sectors and tax low-value-added per worker sectors all we like, the only result will be to *lower* total GDP.

Of course, this is a simple model and one can surely imagine a model where subsidies to particular sectors are beneficial — this exercise does not deny that. Subsidizing R&D, for example, may create positive spillovers from technological innovation. Taxing polluting sectors may be beneficial if it causes environmental damages to fall. The simple model features none of these considerations, but does feature value-added-per-worker differences across sectors. The above exercise demonstrates that value-added differences are *not sufficient* to justify supporting one industry or another.

There is another general lesson here. Advocates of government support of “value-added sectors” often say how much GDP and how many jobs will be created by expanding that sector’s output. On their face, these calculations can be entirely accurate. What the headline numbers miss is where these jobs come

from. As one sector expands, workers, equipment, land, and so on, must be employed. These don't fall from the sky. If there is no pool of unemployed (and suitable) workers or machines ready to go, then they must be hired away from other sectors — which shrinks output in those sectors. In the same way, government subsidies do not fall from the sky. The spending allocated to the favoured industry must ultimately be paid for elsewhere in the economy.

Can we get a handle on how big these negative effects on other industries might be? To answer this question, we can expand the above model to provide more precise quantitative predictions. The details are in the appendix, though the model is standard in the literature,³² and some simple intuitive results are available. Notably, the change in Canada's total value added is just an average of changes in final goods production across all of its sectors. Specifically, a *weighted* average

$$\% \text{ Change in GDP} = \sum_{i=1}^N \beta_i (\% \text{ Change in Sector } i \text{'s Production of Final Goods}),$$

where the weights β_i are the spending shares — as in the simple model. The additional complication in the full model comes through simulating what the effect of a given tax or subsidy policy will have on each sector's production of final goods. I will only discuss the results here.

As before, subsidizing one sector will come at the expense of others. Also as before, the losses in other sectors will exceed the gains in the sector receiving the subsidy. Going through the numbers for a particular example industry — motor-vehicle manufacturing — is instructive. If auto manufacturing were to experience a 10 per cent increase in productivity (consider this as a subsidy funded by “*manna from heaven*”) then total Canadian GDP would increase by 0.263 per cent. But, subsidies are not productivity increases; they induce factors of production, such as workers or capital, to reallocate in inefficient ways across industries — as we saw in the simple model. If the auto sector receives a 10 per cent subsidy (funded through taxes on households) then its total production of final goods will increase, *but this will come at the expense of other sectors*. Simulating the model, I find the motor-vehicle sector's final-goods production increases 9.3 per cent while most other sectors (auto parts being a notable exception) see production decreases averaging 0.3 per cent. Inserted into the above expression, overall GDP declines by 0.012 per cent. While this may not seem like much, it works out to a decrease of 4.6 cents in total value added in the overall economy per dollar of subsidy to motor-vehicle manufacturers. Policies meant to increase value added, by subsidizing a supposedly high-value-added sector, actually do the reverse.

The order of magnitude found by the above exercise is fairly consistent across industries. Subsidizing each sector — individually, one sector at a time — by 10 per cent reveals by how much national GDP will decline. That is, I perform a separate simulation for each subsidy to each sector, recording the change in total GDP. I display the results for a selected group of sectors in Figure 13. Each bar in the graph represents a separate experiment, with a 10 per cent subsidy to that sector's output. Subsidizing any sector will lower GDP, and the average reduction is roughly five cents in total GDP losses per dollar of subsidy.³³ Some industries are worse to subsidize than others. Aerospace manufacturing, for example, is among the worst sectors to subsidize, where overall GDP declines by close to 10 cents per dollar of subsidy if we subsidize that sector's output by 10 per cent.

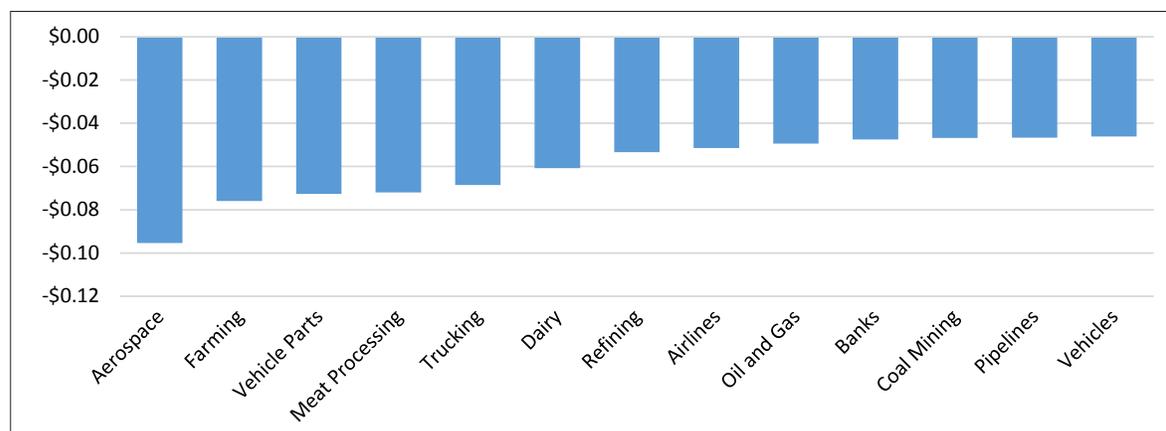
While these exercises are simplified, the general insight they provide is sound. One cannot increase output in any sector — putting aside technological change or efficiency improvements — without

³² Specifically, I follow Charles Jones, “Misallocation, Economic Growth, and Input-Output Economics,” in *Advances in Economics and Econometrics* Volume 2 (Cambridge, U.K.: Cambridge University Press, 2013).

³³ The results depend on the size of the subsidy. For 100 per cent subsidies, the average reduction in total GDP is over 35 cents per dollar in subsidy.

inefficiently drawing away resources, such as workers, buildings, machines, and land, from other sectors. If there are idle workers, buildings, or machines available, then perhaps the reallocation will be minor — though there is likely to always be *some* loss to other sectors, especially if taxes to pay for the subsidy lowers household spending. So, in general, policies that artificially increase output in one sector *must* decrease output in some (and likely most) other sectors. The precise numbers reported here are only illustrative, to provide a sense of the magnitudes at work.

FIGURE 13 LOSS IN NATIONAL GDP PER DOLLAR OF SUBSIDY FOLLOWING A 10 PER CENT SUBSIDY TO EACH SECTOR'S OUTPUT (ONE SECTOR AT A TIME)



Source: Author's calculation from input-output tables ("Symmetric Industries for 2010," Statistics Canada catalogue 15-208-XCB). Each bar displays the change in national GDP per dollar of subsidy following a 10 per cent subsidy to that sector's output. They are separate experiments.

CONCLUDING THOUGHTS AND POLICY RECOMMENDATIONS

Economic policy is too important to be guided by vague notions of value added, yet there are countless examples of policy motivated and justified by just that. In this report, we explored not only the common misunderstanding of value added but also an alternative, and much more effective, definition of value added for policy discussions. Value added is no abstract concept; value added is (essentially) income.

It is also easily measured. With readily available data from Statistics Canada, it is clear that raw resource extraction creates a huge amount of value added. This is true regardless of how one measures it: in total, per worker, per hour, and so on. Sectors most people don't think of as generating much value added do the opposite. Not surprisingly, since value added is income, we find that sectors with high value added are also sectors with high labour earnings. The data are clear:

Resource sectors (including raw extraction for export) tend to create more value added per worker than do manufacturing or processing industries.

Precisely the opposite of what most people believe.

This mistaken belief has consequences. Policy that transfers resources between sectors — from supposedly low-value-added sectors to high-value-added ones — are typically motivated by a desire to increase total value added in the economy; in fact, these policies can often be counterproductive. We should dismiss those who advocate subsidies to "value-added" projects not because "value-added" projects do harm — they do generate income, which is good — but because they substitute for other activities that could create more value added and income, which is better. When governments subsidize or otherwise distort the market's operation, value added is often lost, not created. This should be lesson

number one for all policy-makers.

With the results of this report in mind, there are a few concrete recommendations that all producers and consumers of public policy should follow. Chief among these:

Never use the words “value added” in public policy discussions.

Simple. Effective. Very little else would achieve as much to improve the quality of economic policy discussions as this. While extreme, this would immediately avoid any improper use of an important concept. There is no statement that includes “value added” that wouldn’t be improved through the use of more precise and generally understood words.

If one *must* use “value added,” then use it properly. Luckily, there is a simple and memorable rule of thumb to test whether a claim about value added is true or false:

If replacing “value added” with “income” does not make sense, then the claim is likely false.

This is also useful advice for consumers of policy discussions (namely, voters and journalists). If any claim involving the words “value added” does not make equally good sense when the word “income” is used, then the claim is most likely false. Pages of discussion and detailed data throughout this report firmly establish this. The only difference between the two concepts — depreciation — is often minor; high-value-added sectors are also high-income sectors.

Turning to policy, when discussing the consequences of policy, it is important to never forget the indirect effects on other industries. Appropriating a lunch from your neighbour does not make it free. Subsidizing one sector will likely come at the expense of other sectors, if only because workers, land, equipment, and other inputs, will move to the subsidized sector and constrain the rest. There are, of course, subtleties and exceptions to this, but the onus is on the advocate of each policy to clearly explain his motivations and objectives. Appeals to a project’s or a sector’s value added are insufficient. Policies that subsidize supposedly high-value-added sectors can do the reverse: lowering total value added, and therefore income in the economy as a whole. The final recommendation is therefore a warning to policy-makers:

Do not discriminate: absent strong and specific reasons, treat all sectors equally.

This is especially true when policy discriminates between sectors *solely* because of a view that one sector generates higher value added than another. Subsidies to particular sectors or for particular projects will tend to move workers and capital towards those sectors or projects — enlarging their size above what is appropriate. One must not forget those resources have *alternative uses*. For an economy to generate the greatest amount of value added and income it can, there must be as few distortions as possible. Taxes should be broadly based, trade and investment across borders should be free, regulations should bind on all firms and households equally, and subsidies should never be motivated by notions of a sector’s value added. Any special treatment to one sector, whether a tax or a subsidy, must be clearly justified *without* appeals to value added (such as positive spillovers from research and development activities, which might justify a subsidy, or negative spillovers from environmental damage, which might justify a tax). Absent those special considerations: do not discriminate.

Well-meaning policy can all too often achieve precisely the opposite results as one might intend. Vaguely defined notions of value added, while politically catchy, are economically dangerous.

MATHEMATICAL APPENDIX

The model is from Charles Jones's 2013 paper entitled "Misallocation, Economic Growth, and Input-Output Economics," published in volume 2 of *Advances in Economics and Econometrics* through Cambridge University Press. A more accessible version from 2011 is available as an NBER Working Paper (specifically, number 16742). I reproduce here only the equations necessary to replicate Figure 13.

Let there be $i = 1, \dots, N$ sectors that use labour L_i and intermediate inputs to produce output X_i with

$$X_i = A_i L_i^{\alpha_i} \left(\sum_{j=1}^N X_{ij}^{\sigma_{ij}} \right),$$

where X_{ij} denotes intermediate inputs used by sector i that were produced by sector j , the sector's total factory productivity is A_i , α_i is the value-added share of output, and σ_{ij} is the fraction of sector i 's total purchases of all inputs (including labour) allocated to intermediate inputs from sector j . Assume constant returns to scale, so $\alpha_i + \sum_{j=1}^N \sigma_{ij} = 1$. Labour inputs L_i can be broadly understood as all primary factors of production (labour and capital), as the aggregate supply L is not relevant for any of the quantitative exercises that follow.

Total output of each sector is used as intermediate inputs by other sectors, as we saw, and also consumed directly as final goods to produce aggregate GDP according to

$$Y = \prod_{i=1}^N y_i^{\beta_i}.$$

Turning to individual sectors optimal decisions, denote distortions to firm output as proportional subsidies s_i . Total revenue of sector i is then $P_i X_i (1 + s_i)$. If competition is sufficiently strong that profits are zero, then total revenue equals total purchases. It is straightforward to solve the sector's optimization problem and find the spending on inputs from j is

$$P_j X_{ij} = \sigma_{ij} P_i X_i (1 + s_i),$$

and the spending on labour is

$$w L_i = \alpha_i P_i X_i (1 + s_i).$$

Finally, markets must clear, so $X_i = y_i + \sum_{j=1}^N X_{ji}$ and $L = \sum_{i=1}^N L_i$, where L is the total number of workers (or primary factors) in the entire economy.

We can now proceed to characterize the equilibrium of the model. The optimal allocation of purchases of final goods — due to the Cobb-Douglas functional form — yields a simple relationship between spending on final goods $P_i y_i$ and total spending PY . Normalizing total nominal spending to one, we have

$$P_i y_i = \beta_i.$$

Combine this with market clearing, yields with some manipulation an expression for the equilibrium sales $P_i X_i$ of each sector — hereafter denoted γ_i , where

$$\gamma_i = \beta_i + \sum_{j=1}^N \sigma_{ji} (1 + s_j) \gamma_j.$$

The equilibrium sales for each sector is therefore a function only of exogenous parameters.

Next, sum firm labour-demand across all sectors and use the labour-market clearing condition, to find

$$\frac{L_i}{L} = \frac{\alpha_i(1 + s_i)\gamma_i}{\sum_{j=1}^N \alpha_j(1 + s_j)\gamma_j}.$$

Finally, using the optimal firm intermediate input demands, along with goods market clearing, to find

$$X_{ij} = \sigma_{ij}(1 + s_i) \frac{\gamma_i}{\gamma_j} X_j,$$

where it is helpful to use $\frac{P_i}{P_j} = \frac{\beta_i \gamma_j}{\beta_j \gamma_i}$. Inserting the above two equations into the sector's production function for X_i yields

$$X_i = A_i \left(\frac{\alpha_i(1 + s_i)\gamma_i}{\sum_{j=1}^N \alpha_j(1 + s_j)\gamma_j} \right)^{\alpha_i} \prod_{j=1}^N \left(\sigma_{ij}(1 + s_i) \frac{\gamma_i}{\gamma_j} X_j \right)^{\sigma_{ij}}.$$

This solves the equilibrium output of each sector as a function of exogenous parameters.

To get at aggregate GDP, note that $y_i = \beta_i X_i / \gamma_i$ and therefore

$$Y = \prod_{i=1}^N \left(\frac{\beta_i X_i}{\gamma_i} \right)^{\beta_i}.$$

This completes the model. One can simulate counterfactual changes in Y from arbitrary subsidy rates s_i across sectors given values for $(\beta_i, \alpha_i, \sigma_{ij})$. Each of these are readily available from input-output tables. Note that TFP A_i are irrelevant; counterfactual *percentage* changes in Y are independent of their values.

About the Author

Trevor Tombe (PhD) is an Assistant Professor of Economics at the University of Calgary. Prior to joining the University of Calgary in 2012, he was an Assistant Professor of Economics at Wilfrid Laurier University in Waterloo, Ontario. He received his PhD and MA from the University of Toronto. His research focuses on the intersection of international trade and macroeconomics, with a particular focus on the factors influencing productivity within and between countries. He has published in leading economics journals, such as the *Journal of Monetary Economics* and the *Review of Economic Dynamics*.

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