DIGITALIZING EXTRACTIVE INDUSTRIES

STATE-OF-THE-ART TO THE ART-OF-THE-POSSIBLE: OPPORTUNITIES AND CHALLENGES FOR CANADA

For background information see …

https://munkschool.utoronto.ca/ipl/files/2017/11/IPL-White-Paper-2017-4.pdf

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Extractive Industries: Profile

- Definition:
  - Mining
  - Oil & Gas
- Economic Importance to Canada of Natural Resources (majority mining and oil and gas)
  - 11% of Employment: Direct & Indirect
  - 16% of GDP
  - 38% of Non-Residential Capital Investment
  - $25B in Government Revenues
  - $201B in Export Revenues
  - $582B in Publicly Traded Company Value

Extractive Industries: Common Issues

- Need to dig deeper or drill in **more challenging environments**
- Complexity of **underlying economics** (commodity price variability)
- Increased challenges from **perceived and real entitlements of various stakeholders** (need for win-win-win among communities, governments and industry, all with expectation for returns)
- Companies are **multinational in scope**, with global workforces, supply chains and consumers of their commodities
- Projects are **regionally important** (local employment and local supply and service sector)

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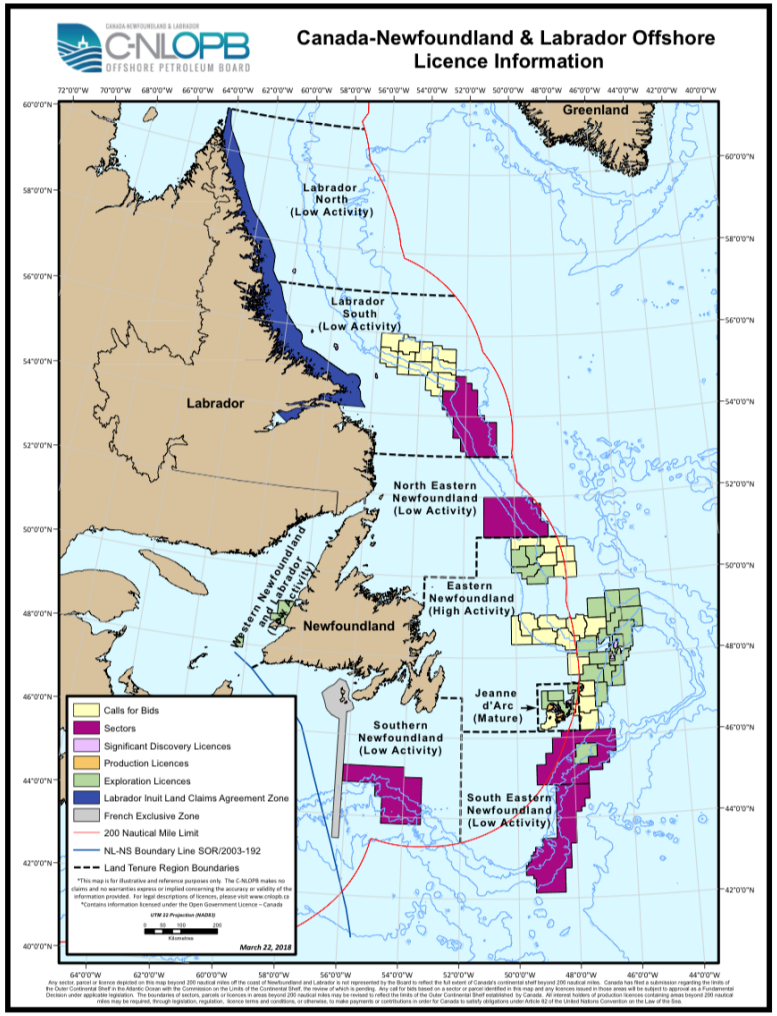
Offshore Oil & Gas: Drivers of Digitalization

New Frontiers: deep water, remote reservoirs, harsh environments (e.g. Iceberg Alley)

- Real-time monitoring of the operating environment,
- Better operational decision-making;
- Lower operational risk;
- Positive impacts on health, safety, and environment; and
- Enhanced productivity



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New Digital Technologies: Next 5 years and Beyond

- 3-5 Years
  - Big data/analytics, internet of things, and mobile devices
- 5-10 Years
  - Subsequent 5-year period is expected to see a focus on robotics/drones, artificial intelligence (AI), and wearable technology

From Accenture, The 2016 Oil and Gas Digital Trends Survey

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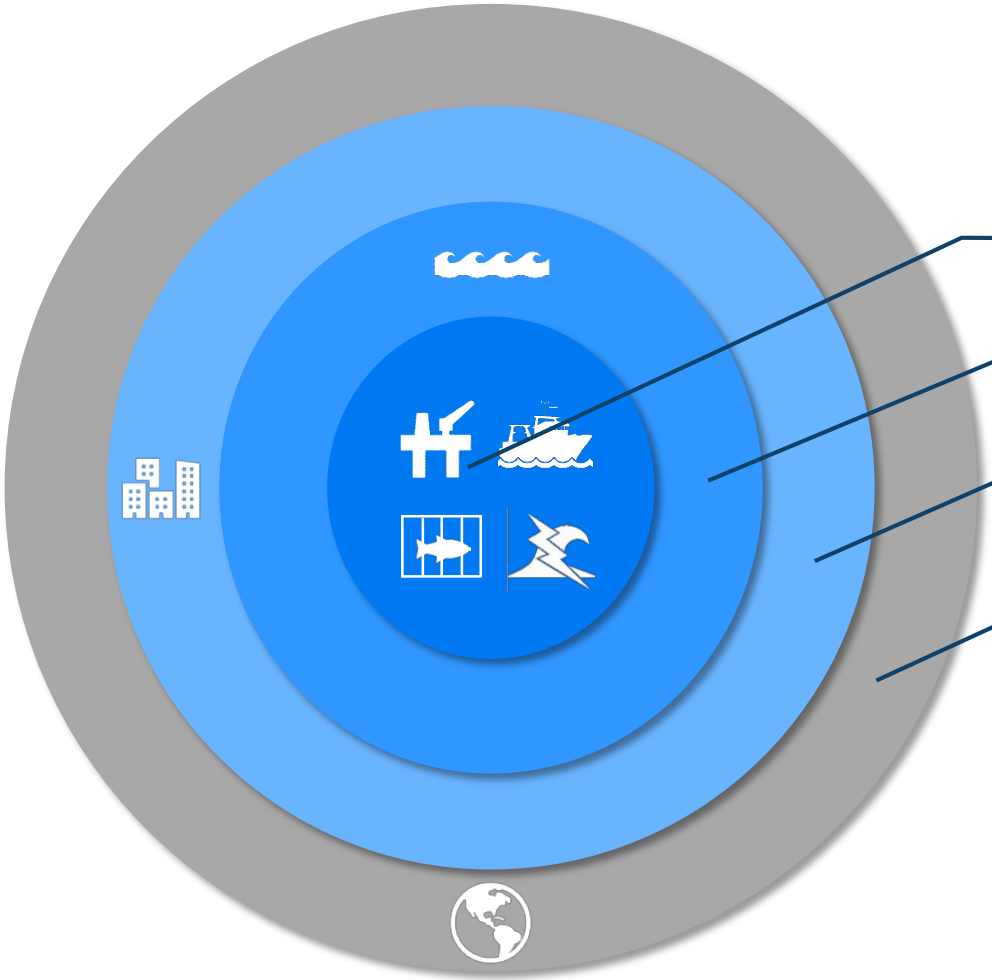
Offshore Scenario



DIGITALIZED ASSETS

DIGITAL OCEAN

DIGITAL ENTERPRISE

DIGITAL WORLD

CANADA'S OCEAN SUPERCLUSTER

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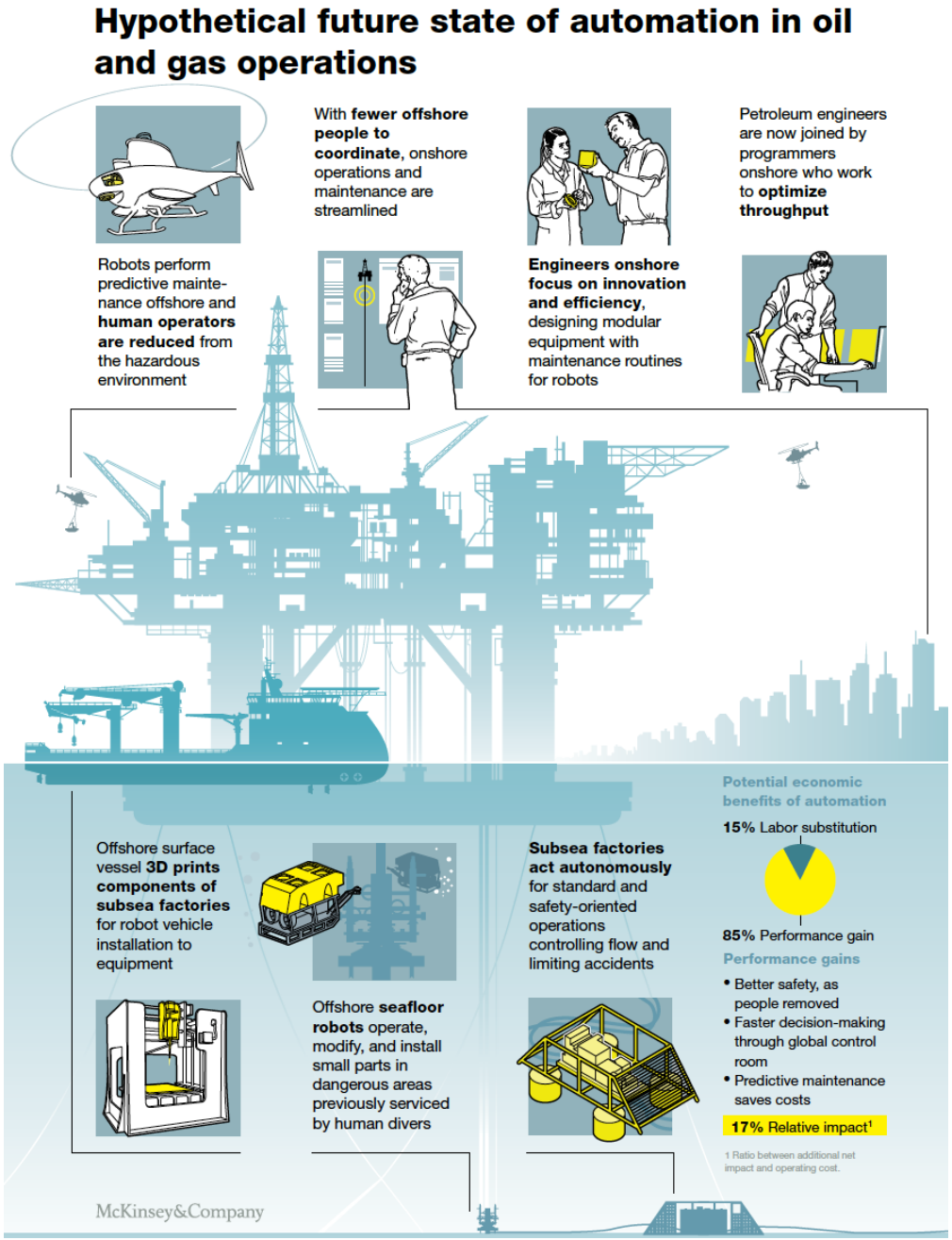
Offshore O&G Project of the Future



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A FUTURE THAT WORKS: AUTOMATION, EMPLOYMENT, AND PRODUCTIVITY

JANUARY 2017

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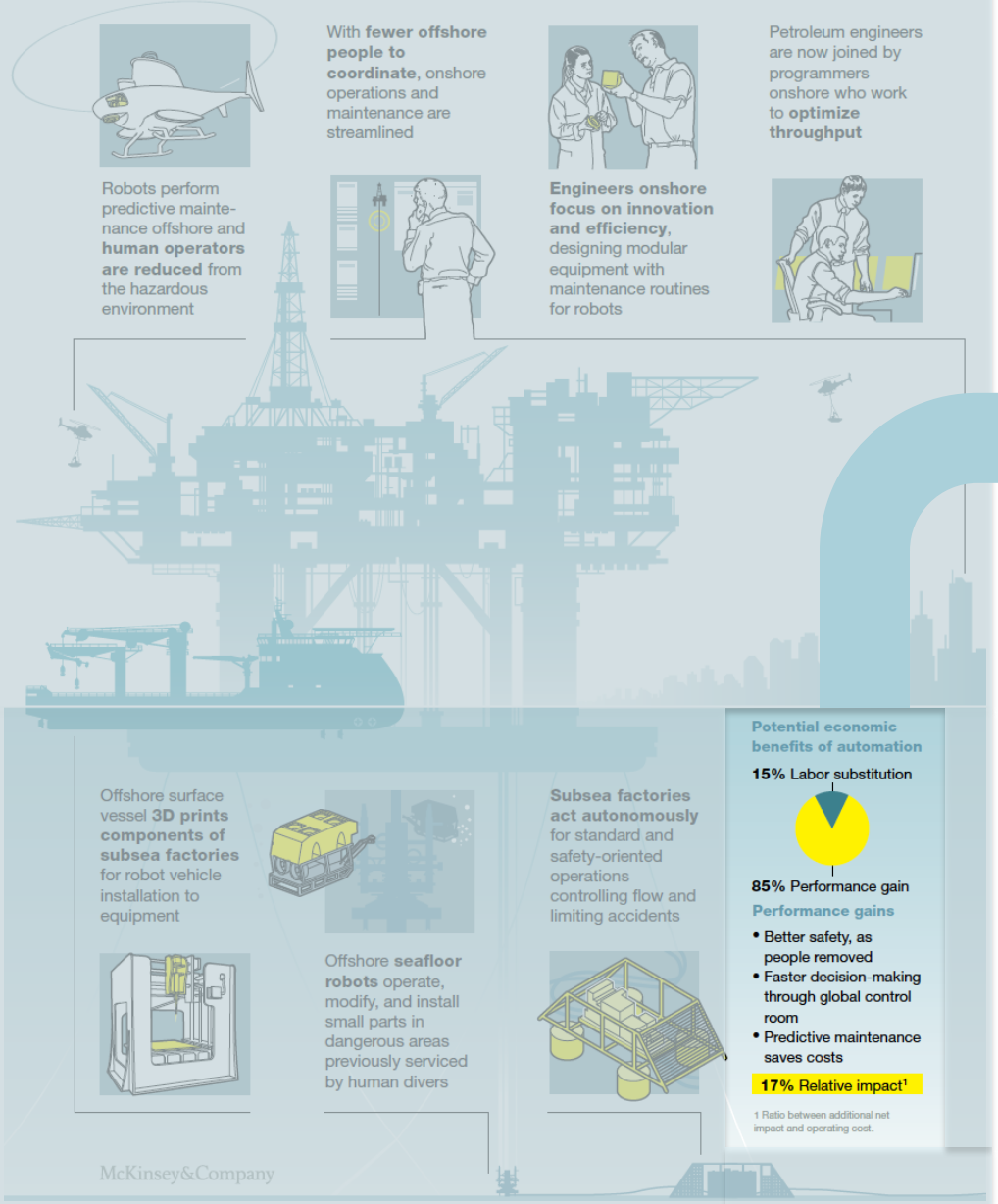
Hypothetical future state of automation in oil and gas operations



Digital is much more than an instrument for employment substitution …

Potential economic benefits of automation

15% Labor substitution

85% Performance gain

Performance gains

- Better safety, as people removed
- Faster decision-making through global control room
- Predictive maintenance saves costs

17% Relative impact[1]

1 Ratio between additional net impact and operating cost.

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Benefits Agreements: Meeting Public Expectations

Hibernia Management and Development Company Ltd.
Canada – Newfoundland and Labrador Benefits Report
January 1 – December 31, 2016

Table of Contents

Section 2.0 – Employment

As of December 31, 2016, a total of 2010 people were employed on Hibernia's operations, this includes the Hibernia Southern Extension (HSE) project, and 1094 were located offshore. This includes people employed with Hibernia and its contractors, of this 1718 or 85.5% were residents of Newfoundland and Labrador when hired, while another 192 or 9.5% were residents of other regions of Canada at the time of hire. All of these positions were located in Newfoundland and Labrador as of December 31, 2016. The number of females employed on Hibernia operations was 264 or approximately 13.1 % of the total workforce.

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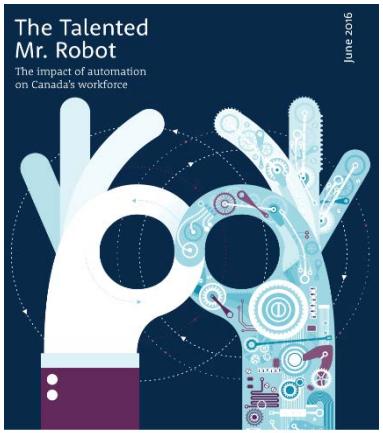
EMPLOYMENT

Automation nation: Which Canadian communities are most at risk?

RACHELLE YOUNGLAI ›
ECONOMICS REPORTER
PUBLISHED JUNE 8, 2017
UPDATED NOVEMBER 12, 2017

Nearly half of Canada's work activities could be automated, and the communities most susceptible tend to have smaller populations with an outsize share of manufacturing or natural resources jobs, according to a new report.

THE GLOBE AND MAIL



Thompson, Man.	**47.41%**	3,371	21% - Mining, Quarrying, and Oil and Gas Extraction	9,625
Lloydminster, Alta.	**47.65%**	8,514	17% - Mining, Quarrying, and Oil and Gas Extraction	23,450
Fort St. John, B.C.	**47.89%**	7,215	14% - Mining, Quarrying, and Oil and Gas Extraction	20,645
Estevan, Sask.	**48.34%**	3,580	21% - Mining, Quarrying, and Oil and Gas Extraction	10,135
Brooks, Alta.	**49.16%**	6,185	15% - Mining, Quarrying, and Oil and Gas Extraction	17,530

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CANADA February 1, 2018 2:29 pm Updated: February 1, 2018 7:13 pm

Union outcry as automation eats up 400 oilsands jobs – and it's just the beginning

By Jessica Vomiero
National Online Journalist Global News

Suncor Gears Up To Roll Out Autonomous Vehicles, Cut Jobs

Markham Hislop Monday, February 12, 2018 - 10:40am

Suncor is building a fleet of 150 driverless trucks that will cut 400 jobs over the next six years

The energy company is already preparing for the switch by hiring its truck drivers on a temporary basis

AS IT HAPPENS

This Suncor worker says new fleet of driverless trucks will be a 'big hit' on Fort McMurray

CBC Radio · February 1

BUSINESS 01/31/2018 13:27 EST | Updated 01/31/2018 13:32 EST

Oilsands Giant Suncor Deploys Driverless Trucks, Plans 500 Layoffs

The company plans to build a fleet of 150 driverless trucks over the next six years.

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Guardian sustainable business

Fourth industrial revolution

Automated mining will cost jobs and tax income: it's time for governments to act

Study shows all governments need to play a greater role in restructuring mining sector to compensate for automation effects

*"Automation's impact on the global mining sector is unlikely to be either smooth or homogenous. But one thing looks certain: if its claims to **shared value** are to remain valid into the future, it will have to ditch its 'colonial' model for a more **collaborative, confederate one** instead."*

*"Directing state revenues from mining to **economic diversification** is another possibility."*

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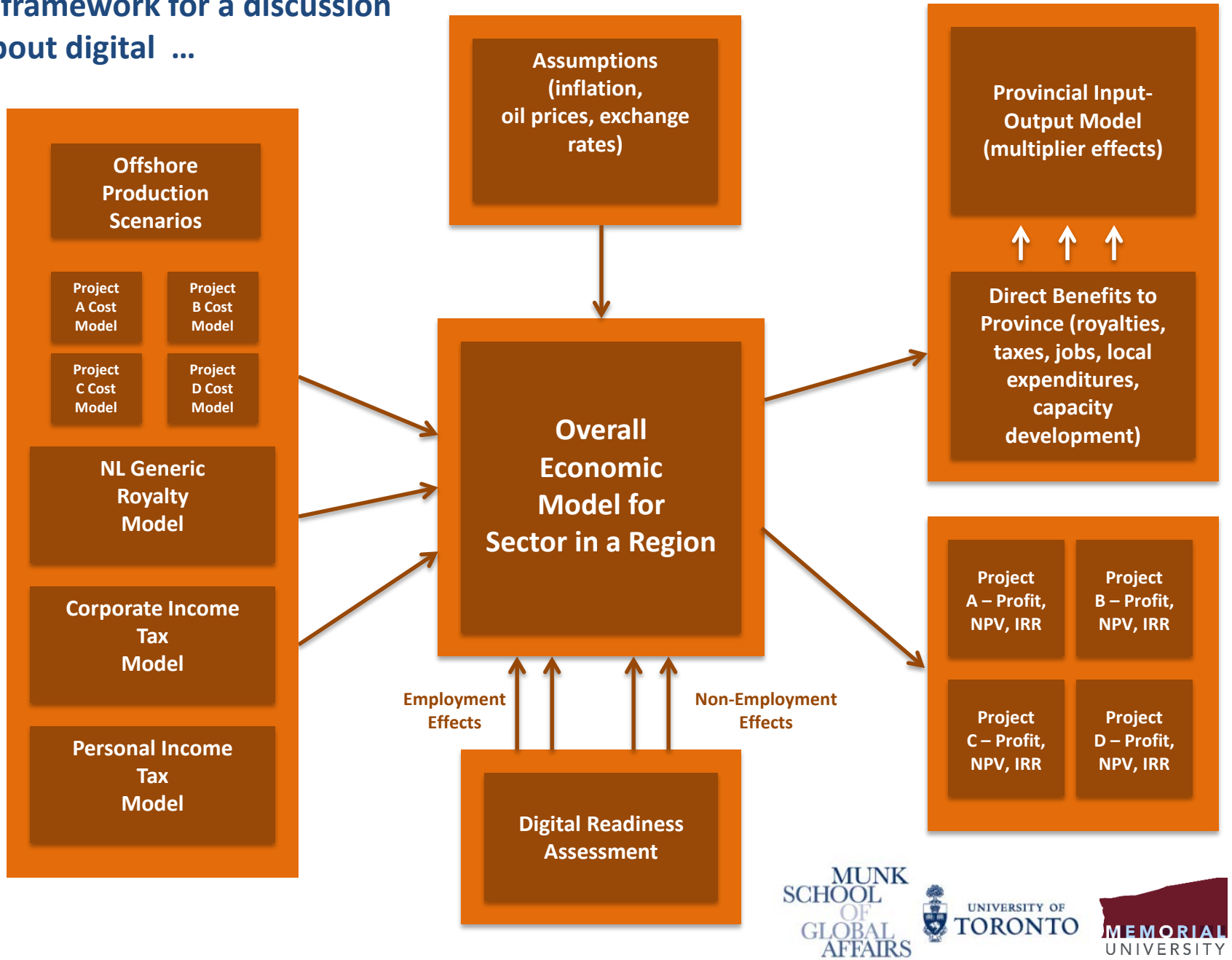
A framework for a discussion about digital …



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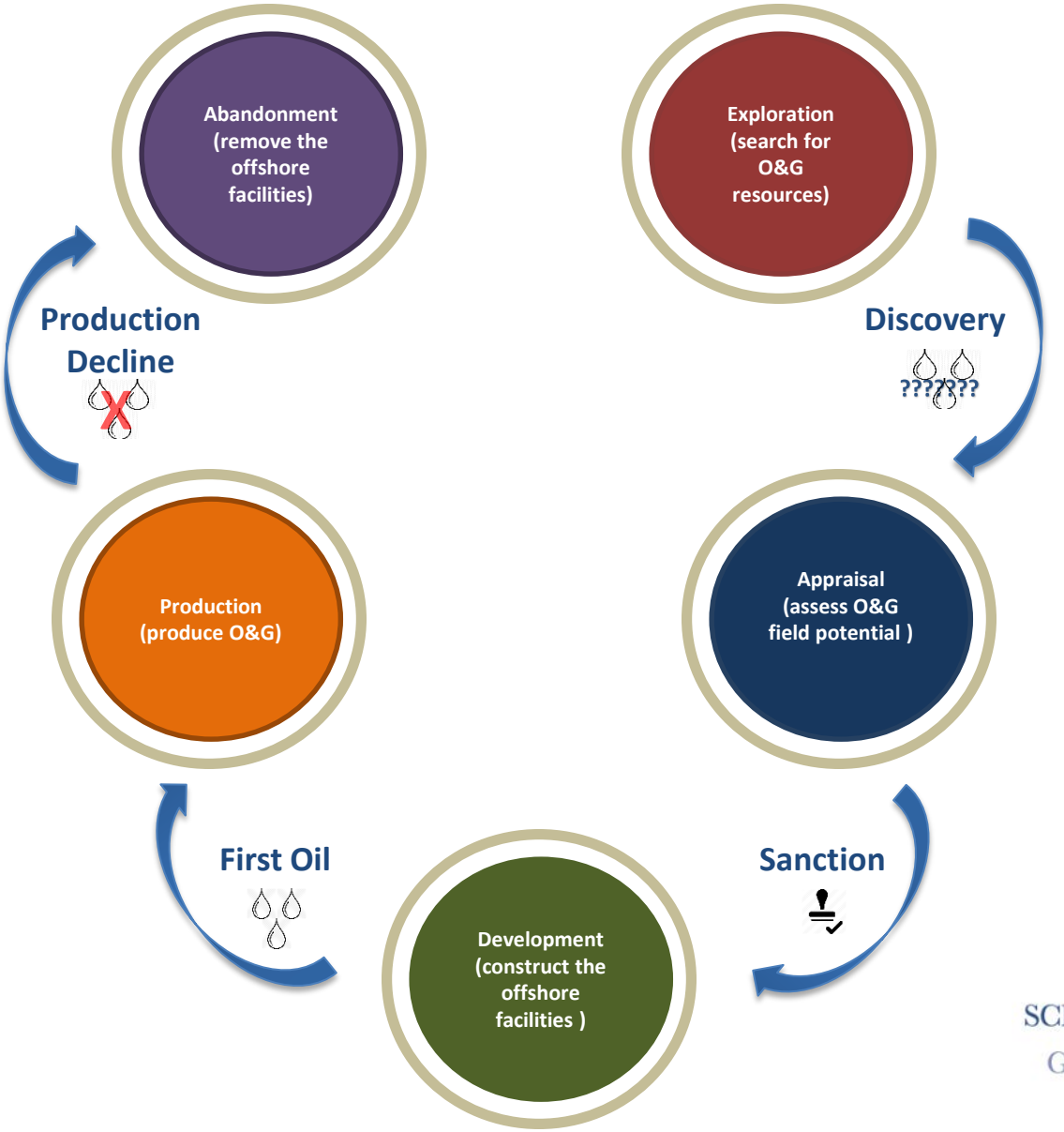
Process Analysis



Process

How it has been done?

How could it be done ?

Technology

What are the key techniques/technologies involved?

What technologies will be involved ?

People

Who does what?

Who will do what ?

Who decides ?

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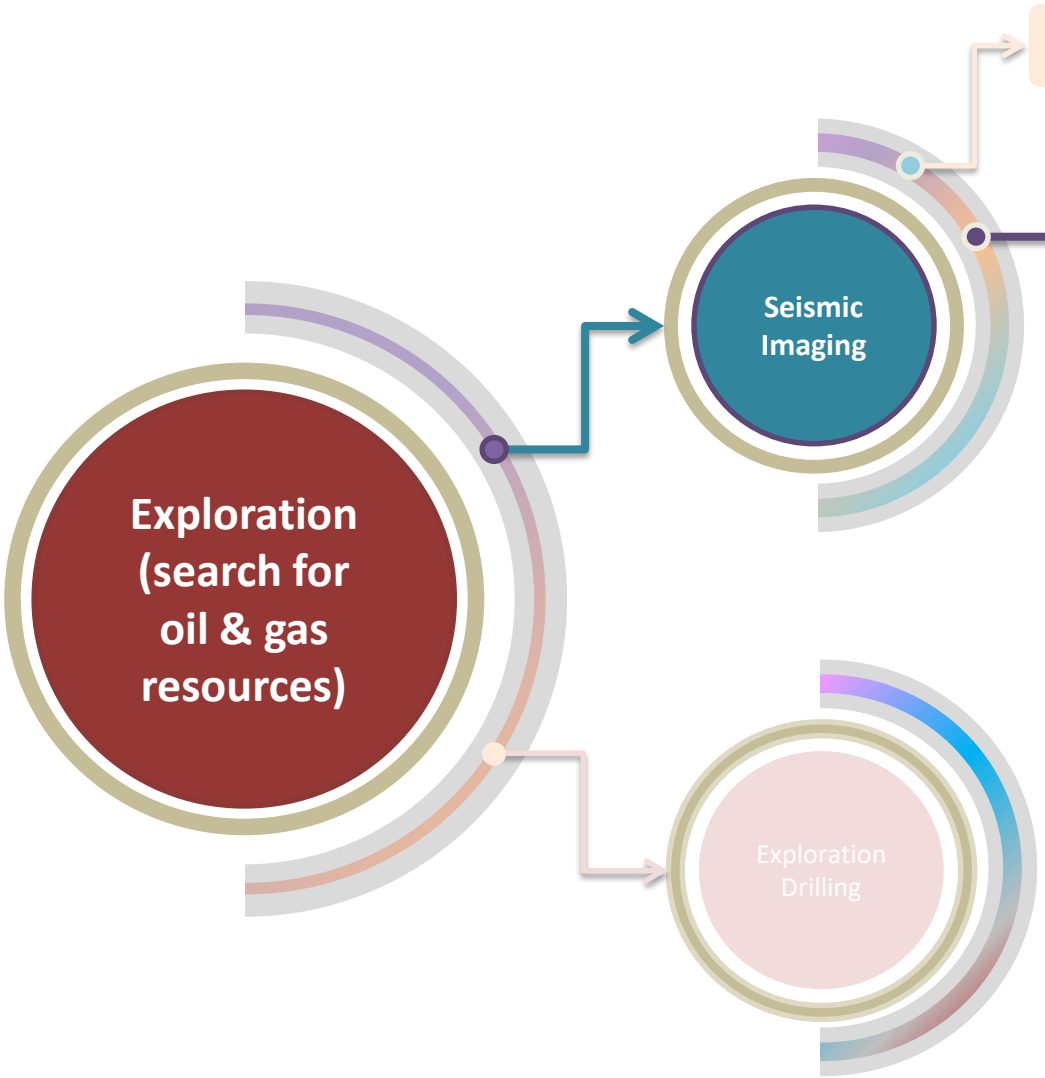

Data Acquisition

Process

Main Activities:

- Acquire seismic data
- Data acquisition methods
  - 1D, 2D seismic survey
  - 3D seismic survey
  - Ocean bottom sensing (OBS)

Technology

Digital Technologies:

- Big data
- Data analytics
- Computational technologies
  - Advanced data processing
  - Advanced data visualization
- Cloud enabled technologies
- Data storage

People

Key Occupations:

- Geologists
- Geophysicists
- Data analysts
- Business analysts
- Reservoir engineers

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PROJECT PARAMETERS

PROJECT A PARAMETERS

Production Volume (MMBBLS)	800	
Well Productivity (MMBBLS)	30	baseline was 30
Drilling Cost per Well (US$)	$70	baseline was $70M
Injector/Producer Ratio	0.5	baseline was 0.5
Enhanced Oil Recovery Factor	0%	baseline was 0%
Transport (US$)	$1.50	baseline was $1.50
Start PreCommercial (Year)	0	baseline was 0
Start Exploration (Year)	1	baseline was 1
Start Facilities (Year)	9	baseline was 9
Start Drilling (Year)	15	baseline was 15
Start Production (Year)	16	baseline was 16
Pre-Commercial Cost Adjust	0%	baseline was 0%
Exploration Cost Adjust	0%	baseline was 0%
Facilities Cost Adjust	0%	baseline was 0%
Operations Cost Adjust	0%	baseline was 0%
NL Wage/Salary Adjust	0%	baseline was 0%
Abandonment Cost Adjust	0%	baseline was 0%

CPI	2.0%	baseline was 2%
Oil Price Inflation	2.0%	baseline was 2%
Starting Oil Price ($US/BBL)	$65	baseline was $65

PROJECT B PARAMETERS

Production Volume (MMBBLS)	800	
Well Productivity (MMBBLS)	30	baseline was 30
Drilling Cost per Well (US$)	$70	baseline was $70M
Injector/Producer Ratio	0.5	baseline was 0.5
Enhanced Oil Recovery Factor	0%	baseline was 0%
Transport (US$)	$1.50	baseline was $1.50
Start PreCommercial (Year)	0	baseline was 0
Start Exploration (Year)	1	baseline was 1
Start Facilities (Year)	14	baseline was 14
Start Drilling (Year)	19	baseline was 19
Start Production (Year)	20	baseline was 20
Pre-Commercial Cost Adjust	0%	baseline was 0%
Exploration Cost Adjust	0%	baseline was 0%
Facilities Cost Adjust	0%	baseline was 0%
Operations Cost Adjust	0%	baseline was 0%
NL Wage/Salary Adjust	0%	baseline was 0%
Abandonment Cost Adjust	0%	baseline was 0%

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How might digitalization impact the project parameters ?

PROJECT PARAMETERS

PROJECT A PARAMETERS		
Production Volume (MMBBLS)	800	
Well Productivity (MMBBLS)	30	baseline was 30
Drilling Cost per Well (CA$)	$70	baseline was $75M
Injector/Producer Ratio	0.5	baseline was 0.5
Enhanced Oil Recovery Factor	3%	baseline was 0%
Transport (US$)	$1.35	baseline was $1.50
Start PreCommercial (Year)	0	baseline was 0
Start Exploration (Year)	1	baseline was 1
Start Facilities (Year)	8	baseline was 9
Start Drilling (Year)	14	baseline was 15
Start Production (Year)	15	baseline was 16
Pre-Commercial Cost Adjust	0%	baseline was 0%
Exploration Cost Adjust	-10%	baseline was 0%
Facilities Cost Adjust	-5%	baseline was 0%
NL Wage/Salary Adjust	0%	baseline was 0%
Operations Cost Adjust	-3%	baseline was 0%
NL Wage/Salary Adjust	-15%	baseline was 0%
Abandonment Cost Adjust	0%	baseline was 0%

PROJECT B PARAMETERS		
Production Volume (MMBBLS)	800	
Well Productivity (MMBBLS)	30	baseline was 30
Drilling Cost per Well (CA$)	$70	baseline was $75M
Injector/Producer Ratio	0.5	baseline was 0.5
Enhanced Oil Recovery Factor	3%	baseline was 0%
Transport (US$)	$1.35	baseline was $1.50
Start PreCommercial (Year)	0	baseline was 0
Start Exploration (Year)	1	baseline was 1
Start Facilities (Year)	13	baseline was 14
Start Drilling (Year)	18	baseline was 19
Start Production (Year)	19	baseline was 20
Pre-Commercial Cost Adjust	0%	baseline was 0%
Exploration Cost Adjust	-10%	baseline was 0%
Facilities Cost Adjust	-5%	baseline was 0%
NL Wage/Salary Adjust	0%	baseline was 0%
Operations Cost Adjust	-3%	baseline was 0%
NL Wage/Salary Adjust	-25%	baseline was 0%
Abandonment Cost Adjust	0%	baseline was 0%

CPI	2.0%	baseline was 2%
Oil Price Inflation	2.0%	baseline was 2%
Starting Oil Price ($US/BBL)	$65	baseline was $65

Reduce drilling cost by 10%

Enhance oil recovery by 3%

Reduce time to production by 1 year

Reduce operating wages/salaries cost by 15%

Reduce operating cost by 3%

Reduce capital cost by 5%

Reduce exploration cost by 10%

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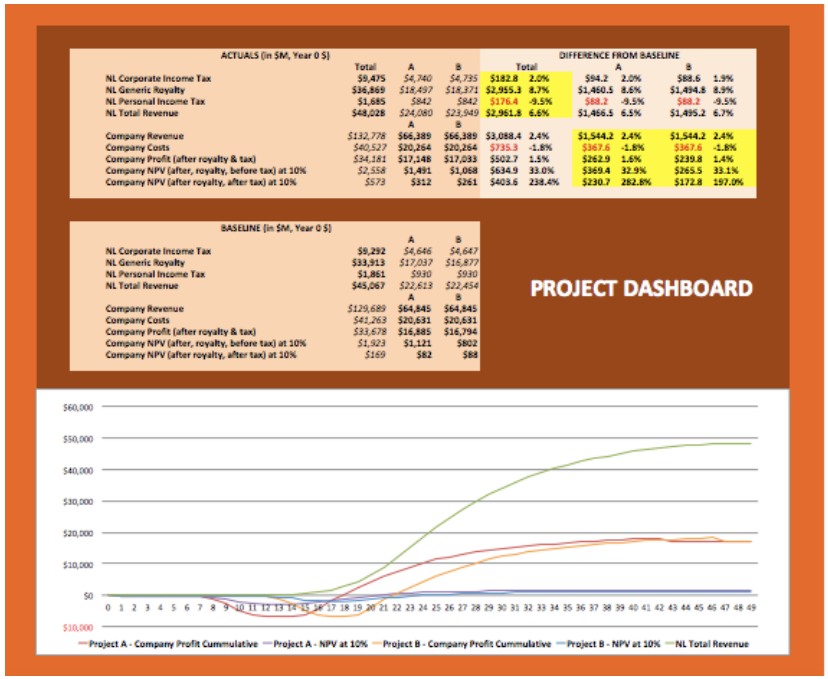
How might benefits of the digital effect be shared ?



Industry revenues increase by ~$3B

Industry costs reduce by ~$750M

Industry NPV increases by ~$650M

NL Royalty increases by ~$3B

NL Corporate Income Tax increases by ~$180M

NL Personal Income Tax decreases by ~$175M

Overall NL Revenue increases by ~$2.9B

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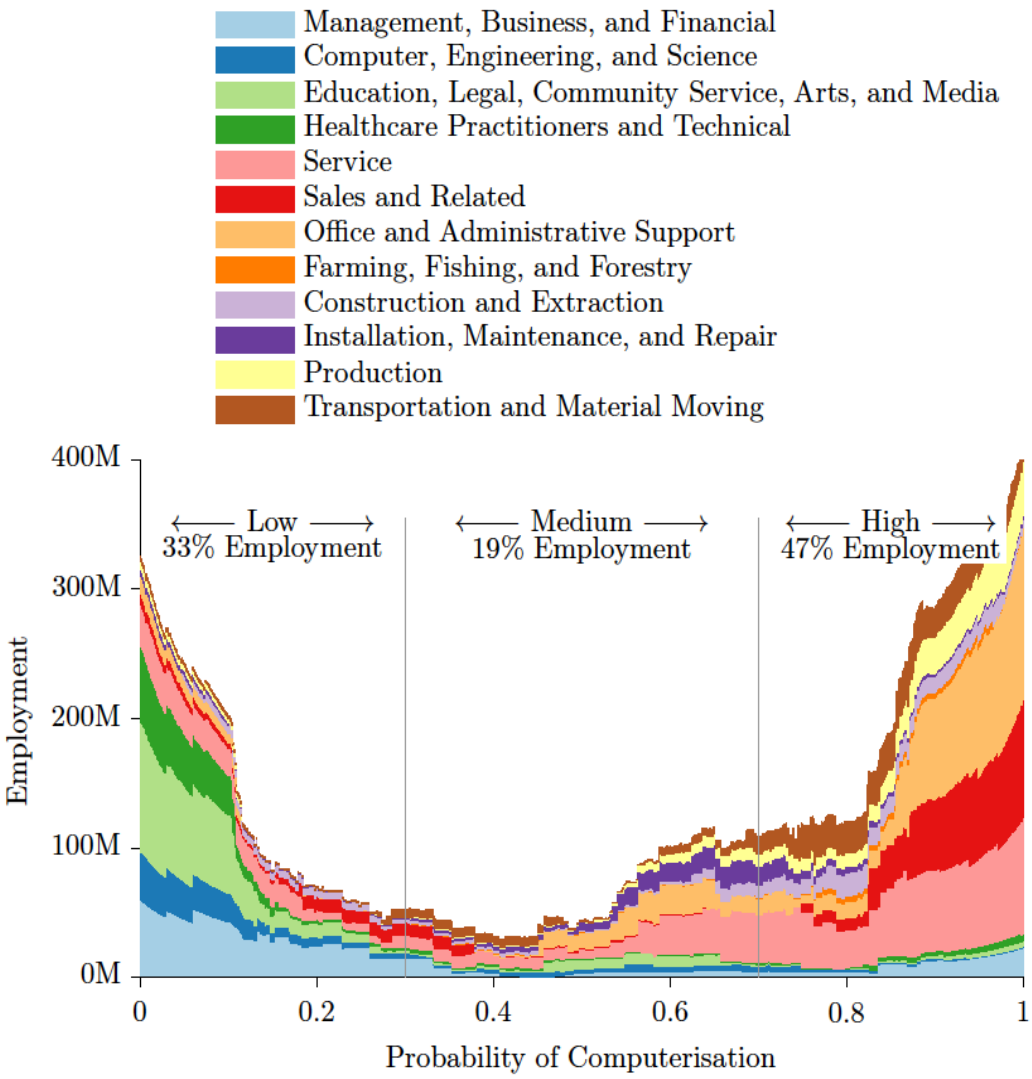

*"According to our estimate, **47 percent** of total US employment is in the **high risk** category, meaning that associated occupations are **potentially automatable** over some unspecified number of years, **perhaps a decade or two**."*

*"It shall be noted that the **probability axis can be seen as a rough timeline**, where high probability occupations are likely to be substituted by computer capital relatively soon."*

From Frey & Osborne, 2013

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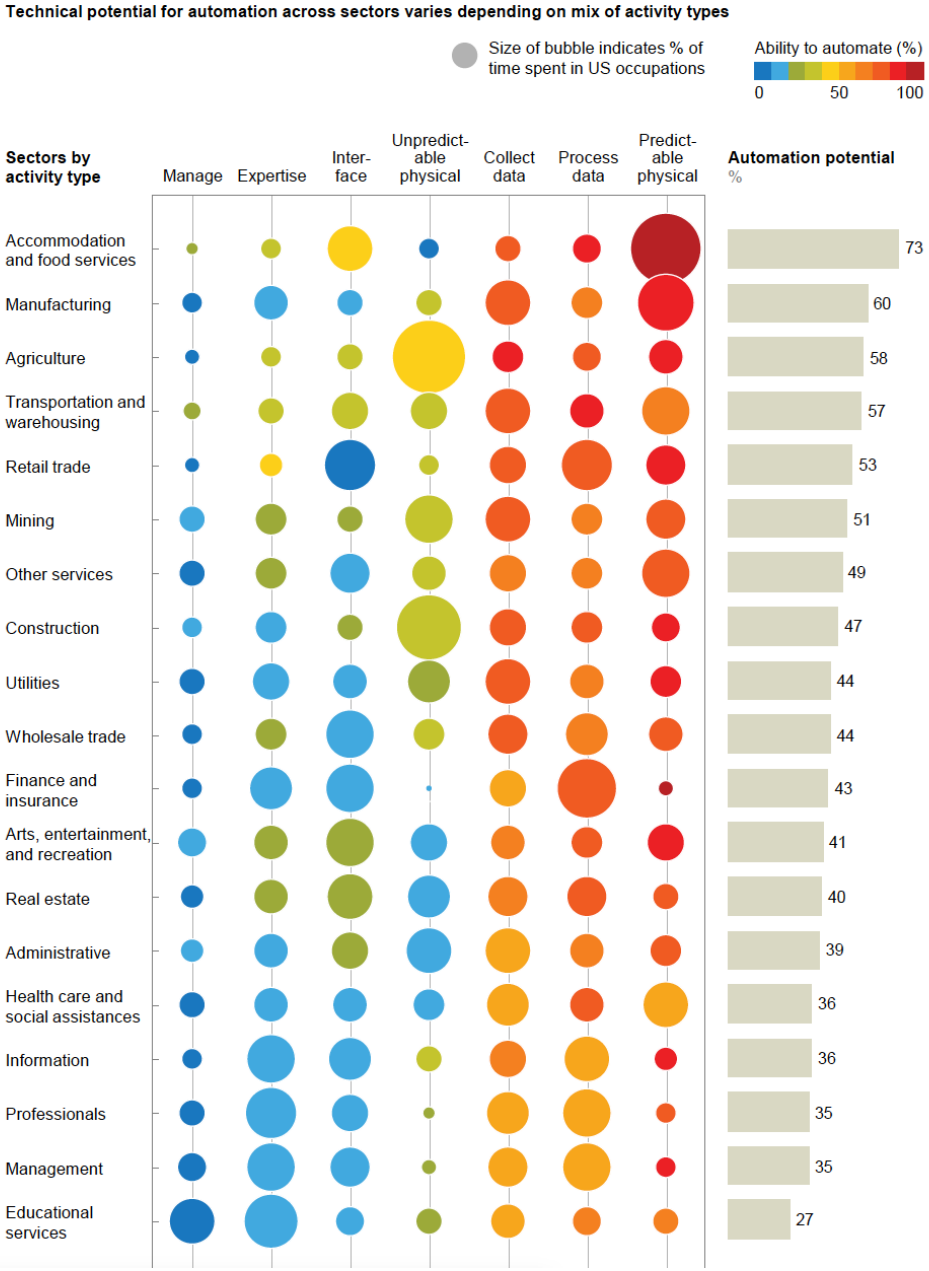

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JANUARY 2017

*"About **half the activities** people are paid almost $15 trillion in wages to do in the global economy have the potential to be **automated by adapting currently demonstrated technology**, according to our analysis of more than 2,000 work activities across 800 occupations."*

*"The cost of technology, competition with labor including skills and supply and demand dynamics, performance benefits including and beyond labor cost savings, and social and regulatory acceptance **will affect the pace and scope of automation**."*

From MGI, 2017

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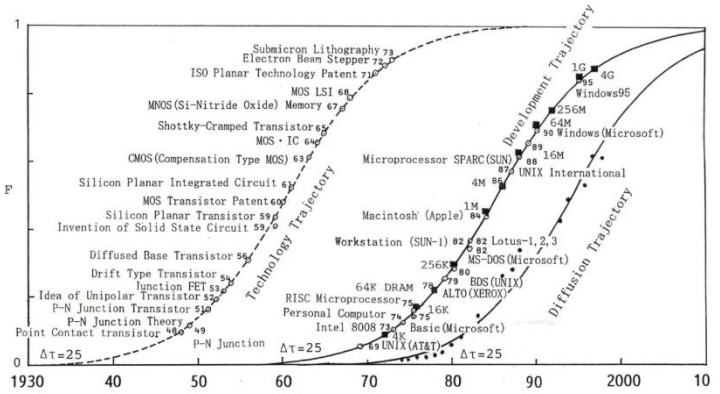
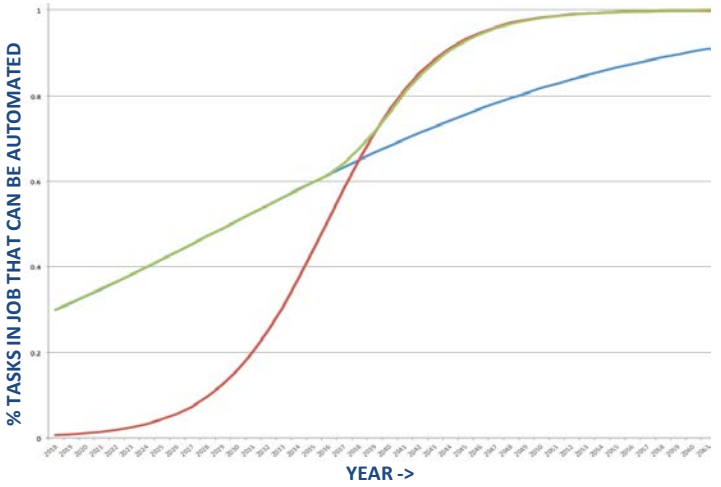
Offshore Occupations

Offshore Job Descriptions	NOC	TECHNICAL LIMITS McKinsey	Oxford	M+O	Full Automation
Offshore installation manager	811	30%	15%	41%	2105
Drilling Supervisor	811	30%	36%	55%	2066
Toolpusher	8222	38%	17%	49%	2097
Driller	8232	68%	77%	93%	2051
Assistant Driller	8232	68%	77%	93%	2051
Derrickman	8412	68%	77%	93%	2051
Roughneck	8615	27%	37%	54%	2065
Roustabout	8615	27%	37%	54%	2065
Maintenance supervisor	7301	63%	68%	88%	2053
Senior mechanic	7311	60%	63%	85%	2054
Rig mechanic	7311	60%	63%	85%	2054
Electrical technician	2241	23%	84%	88%	2050
Assistant engineering/clerk	1452	78%	87%	97%	2049
Motorman	7612	35%	88%	92%	2049
Materials manager	113	36%	3%	38%	2371
Crane operator	7371	85%	90%	99%	2049
Radio operator	1525	40%	96%	98%	2048
Medic	3112	31%	1%	31%	4038
QHSE specialist	112	14%	1%	15%	3705
Logistics technician	1215	22%	1%	23%	2752
Geologist	2113	65%	63%	87%	2054
Drilling engineer	2145	19%	16%	32%	2101
Completions engineer	2145	19%	16%	32%	2101
Completions equipment supervisor	8222	38%	17%	49%	2097
Completions equipment technician	2232	23%	38%	52%	2064
Cement pump operator	7611	35%	88%	92%	2049
Well intervention supervisor	8222	38%	17%	49%	2097
Datalogger	2145	19%	16%	32%	2101
Mudlogger	8232	68%	77%	93%	2051
Chef	6321	54%	10%	59%	2138
Steward	6522	75%	35%	84%	2067
Well test supervisor	8222	38%	17%	49%	2097
Well test surface technician	8232	68%	77%	93%	2051
Well tester	8232	68%	77%	93%	2051
Electric line logging engineer	8232	68%	77%	93%	2051
Electric line winch operator	8232	68%	77%	93%	2051
Operations assistant/clerk	1411	61%	96%	98%	2048
Production supervisor	8222	38%	17%	49%	2097
Production operator	8412	68%	77%	93%	2051
Instrumentation technician	2243	41%	67%	81%	2053

Occupations as per White Rose Extension Benefits Plan Amendment, Husky Energy (2014)



From Hirooka (2006), Innovation Dynamism and Economic Growth



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Technology Impact Heatmap

Offshore Job Descriptions	NOC	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Offshore installation manager	811	0.00000	0.01809	0.06220	0.15739	0.25558	0.30556	0.32478	0.33373	0.33989	0.34536	0.35067	0.35597	0.36130	0.36665	0.37204
Drilling Supervisor	811	0.00000	0.01817	0.06377	0.16467	0.27273	0.33235	0.35990	0.37657	0.39030	0.40336	0.41634	0.42938	0.44250	0.45571	0.46897
Toolpusher	8222	0.00000	0.02286	0.07834	0.19767	0.32011	0.38162	0.40450	0.41449	0.42096	0.42654	0.43190	0.43722	0.44254	0.44786	0.45320
Driller	8232	0.00000	0.04161	0.14443	0.36854	0.60264	0.72449	0.77337	0.79710	0.81335	0.82709	0.83964	0.85133	0.86229	0.87256	0.88216
Assistant Driller	8232	0.00000	0.04161	0.14443	0.36854	0.60264	0.72449	0.77337	0.79710	0.81335	0.82709	0.83964	0.85133	0.86229	0.87256	0.88216
Derrickman	8412	0.00000	0.04161	0.14443	0.36854	0.60264	0.72449	0.77337	0.79710	0.81335	0.82709	0.83964	0.85133	0.86229	0.87256	0.88216
Roughneck	8615	0.00000	0.01671	0.05890	0.15274	0.25406	0.31091	0.33808	0.35516	0.36957	0.38341	0.39722	0.41115	0.42521	0.43939	0.45367
Roustabout	8615	0.00000	0.01671	0.05890	0.15274	0.25406	0.31091	0.33808	0.35516	0.36957	0.38341	0.39722	0.41115	0.42521	0.43939	0.45367
Maintenance supervisor	7301	0.00000	0.03839	0.13318	0.33974	0.55562	0.66828	0.71393	0.73663	0.75263	0.76652	0.77947	0.79181	0.80361	0.81489	0.82566
Senior mechanic	7311	0.00000	0.03656	0.12684	0.32365	0.52950	0.63716	0.68109	0.70323	0.71907	0.73297	0.74605	0.75861	0.77072	0.78239	0.79362
Rig mechanic	7311	0.00000	0.03656	0.12684	0.32365	0.52950	0.63716	0.68109	0.70323	0.71907	0.73297	0.74605	0.75861	0.77072	0.78239	0.79362
Electrical technician	2241	0.00000	0.01539	0.05839	0.16230	0.28795	0.37397	0.42928	0.47350	0.51448	0.55428	0.59313	0.63078	0.66689	0.70113	0.73326
Assistant engineering/clerk	1452	0.00000	0.04741	0.16389	0.41633	0.67761	0.81068	0.86110	0.88309	0.89658	0.90719	0.91643	0.92472	0.93223	0.93903	0.94519
Motorman	7612	0.00000	0.02290	0.08494	0.23058	0.39937	0.50628	0.56731	0.61107	0.64878	0.68356	0.71610	0.74645	0.77456	0.80039	0.82393
Materials manager	113	0.00000	0.02142	0.07266	0.18143	0.29077	0.34311	0.36001	0.36522	0.36726	0.36850	0.36953	0.37050	0.37147	0.37243	0.37340
Crane operator	7371	0.00000	0.05134	0.17640	0.44555	0.72126	0.85853	0.90760	0.92666	0.93695	0.94441	0.95066	0.95613	0.96100	0.96535	0.96922
Radio operator	1525	0.00000	0.02672	0.10066	0.27630	0.48170	0.61211	0.68503	0.73464	0.77460	0.80894	0.83883	0.86476	0.88706	0.90607	0.92217
Medic	3112	0.00000	0.01841	0.06230	0.15526	0.24831	0.29241	0.30618	0.30997	0.31107	0.31147	0.31170	0.31189	0.31207	0.31224	0.31241
QHSE specialist	112	0.00000	0.00832	0.02821	0.07038	0.11271	0.13289	0.13932	0.14123	0.14190	0.14227	0.14255	0.14282	0.14308	0.14334	0.14360
Logistics technician	1215	0.00000	0.01309	0.04438	0.11081	0.17755	0.20948	0.21975	0.22289	0.22410	0.22481	0.22540	0.22596	0.22651	0.22706	0.22760
Geologist	2113	0.00000	0.03944	0.13625	0.34627	0.56431	0.67654	0.72061	0.74150	0.75574	0.76796	0.77936	0.79025	0.80072	0.81079	0.82046
Drilling engineer	2145	0.00000	0.01160	0.04034	0.10327	0.16968	0.20521	0.22064	0.22932	0.23621	0.24271	0.24920	0.25576	0.26243	0.26921	0.27609
Completions engineer	2145	0.00000	0.01160	0.04034	0.10327	0.16968	0.20521	0.22064	0.22932	0.23621	0.24271	0.24920	0.25576	0.26243	0.26921	0.27609
Completions equipment supervisor	8222	0.00000	0.02286	0.07834	0.19767	0.32011	0.38162	0.40450	0.41449	0.42096	0.42654	0.43190	0.43722	0.44254	0.44786	0.45320
Completions equipment technician	2232	0.00000	0.01435	0.05095	0.13315	0.22313	0.27507	0.30127	0.31874	0.33397	0.34882	0.36377	0.37895	0.39435	0.40996	0.42576
Cement pump operator	7611	0.00000	0.02290	0.08494	0.23058	0.39937	0.50628	0.56731	0.61107	0.64878	0.68356	0.71610	0.74645	0.77456	0.80039	0.82393
Well intervention supervisor	8222	0.00000	0.02286	0.07834	0.19767	0.32011	0.38162	0.40450	0.41449	0.42096	0.42654	0.43190	0.43722	0.44254	0.44786	0.45320
Datalogger	2145	0.00000	0.01160	0.04034	0.10327	0.16968	0.20521	0.22064	0.22932	0.23621	0.24271	0.24920	0.25576	0.26243	0.26921	0.27609
Mudlogger	8232	0.00000	0.04161	0.14443	0.36854	0.60264	0.72449	0.77337	0.79710	0.81335	0.82709	0.83964	0.85133	0.86229	0.87256	0.88216
Chef	6321	0.00000	0.03219	0.10934	0.27348	0.43901	0.51886	0.54527	0.55401	0.55797	0.56069	0.56310	0.56543	0.56773	0.57003	0.57232
Steward	6522	0.00000	0.04481	0.15258	0.38245	0.61521	0.72853	0.76703	0.78070	0.78757	0.79264	0.79720	0.80157	0.80585	0.81005	0.81418
Well test supervisor	8222	0.00000	0.02286	0.07834	0.19767	0.32011	0.38162	0.40450	0.41449	0.42096	0.42654	0.43190	0.43722	0.44254	0.44786	0.45320
Well test surface technician	8232	0.00000	0.04161	0.14443	0.36854	0.60264	0.72449	0.77337	0.79710	0.81335	0.82709	0.83964	0.85133	0.86229	0.87256	0.88216
Well tester	8232	0.00000	0.04161	0.14443	0.36854	0.60264	0.72449	0.77337	0.79710	0.81335	0.82709	0.83964	0.85133	0.86229	0.87256	0.88216
Electric line logging engineer	8232	0.00000	0.04161	0.14443	0.36854	0.60264	0.72449	0.77337	0.79710	0.81335	0.82709	0.83964	0.85133	0.86229	0.87256	0.88216
Electric line winch operator	8232	0.00000	0.04161	0.14443	0.36854	0.60264	0.72449	0.77337	0.79710	0.81335	0.82709	0.83964	0.85133	0.86229	0.87256	0.88216
Operations assistant/clerk	1411	0.00000	0.03876	0.13925	0.36572	0.61235	0.75031	0.81297	0.84749	0.87197	0.89176	0.90849	0.92278	0.93497	0.94535	0.95415
Production supervisor	8222	0.00000	0.02286	0.07834	0.19767	0.32011	0.38162	0.40450	0.41449	0.42096	0.42654	0.43190	0.43722	0.44254	0.44786	0.45320
Production operator	8412	0.00000	0.04161	0.14443	0.36854	0.60264	0.72449	0.77337	0.79710	0.81335	0.82709	0.83964	0.85133	0.86229	0.87256	0.88216
Instrumentation technician	2243	0.00000	0.02562	0.09109	0.23796	0.39818	0.48959	0.53422	0.56248	0.58592	0.60780	0.62895	0.64954	0.66957	0.68900	0.70778
Average time liberated		0%	3%	10%	26%	42%	51%	55%	56%	58%	59%	60%	61%	62%	63%	64%
Potential productivity (compared to 2018)		100%	103%	111%	134%	173%	203%	220%	230%	237%	245%	252%	259%	266%	274%	281%

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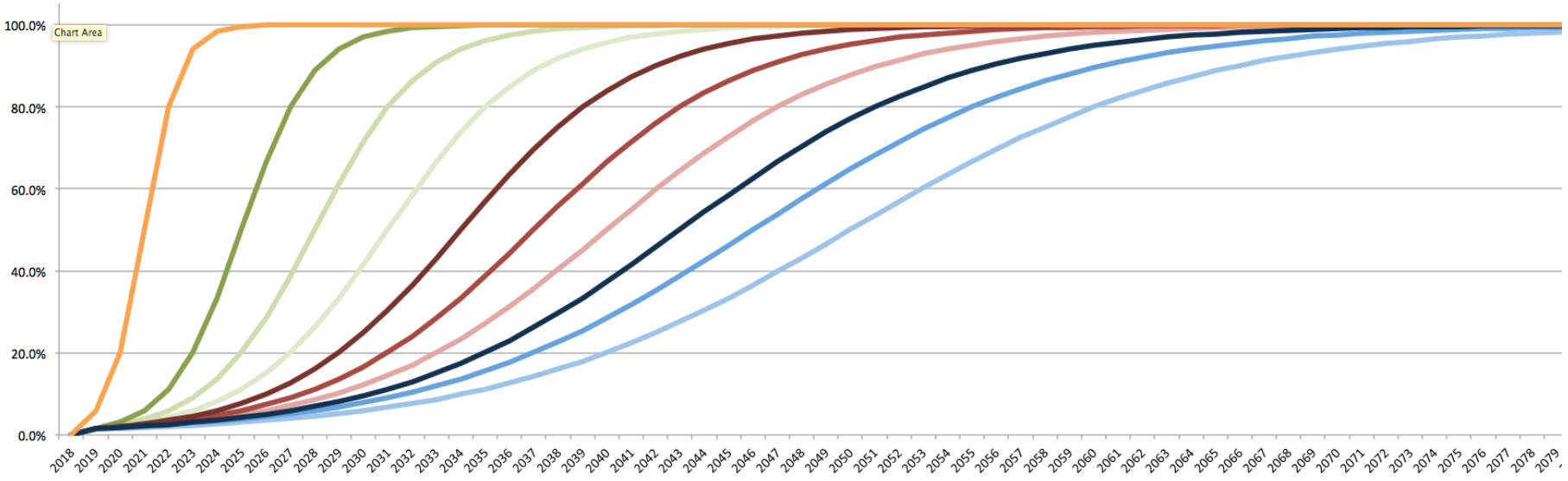
Digital Readiness Level - integration of non-technology factors

(regulatory, labour, education and training, corporate culture, supply chain, society, …)



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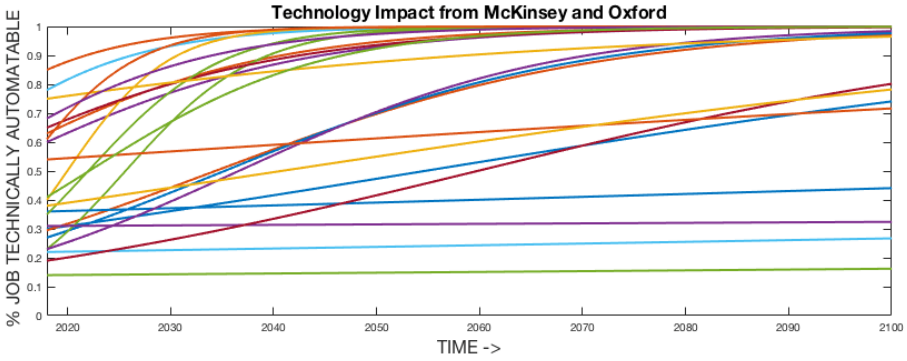
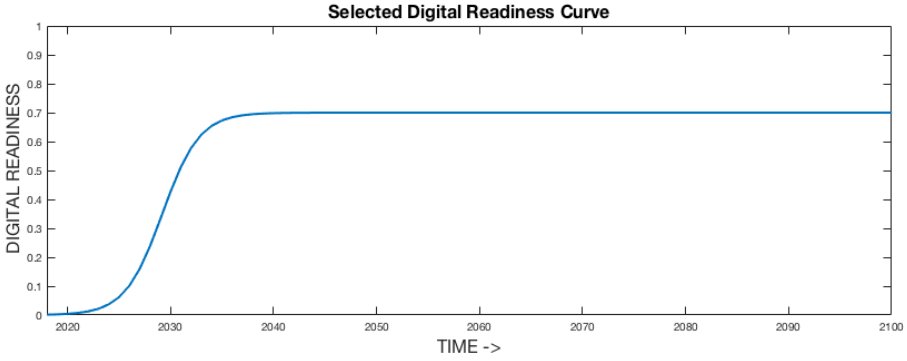
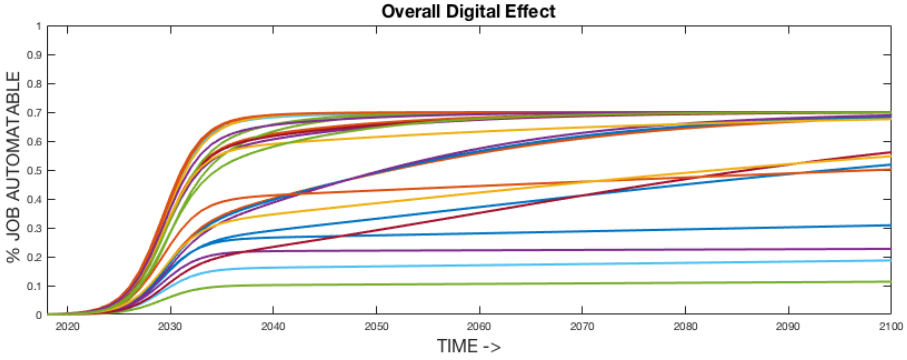
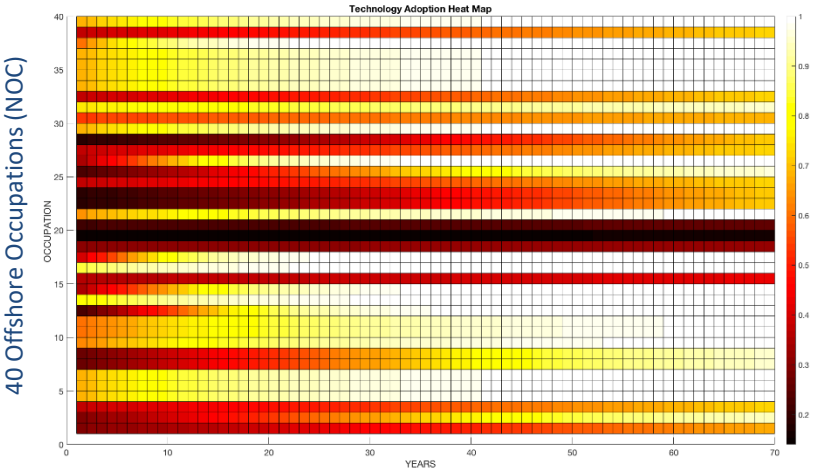




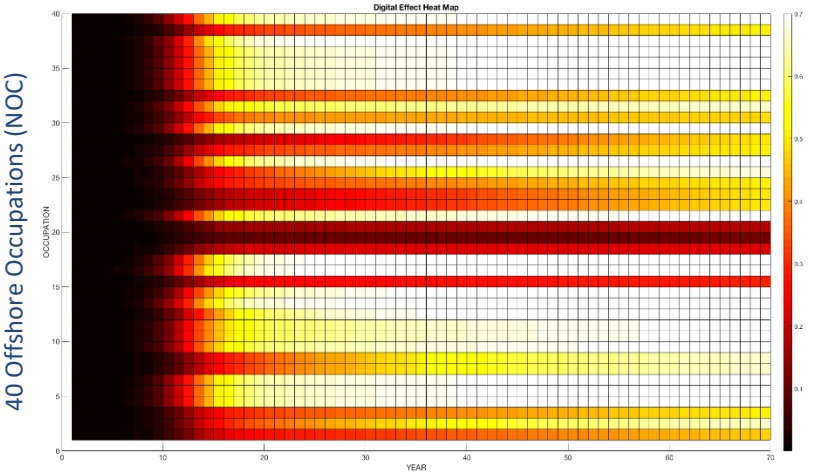


Impacts as per Oxford & McKinsey



Year ->

Overall Digital Effect (Modulated)



Year ->

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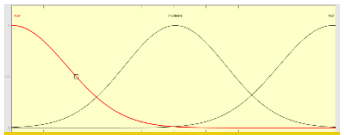
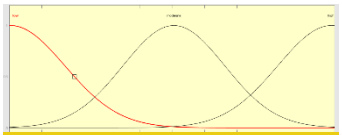
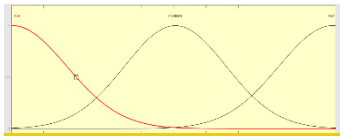


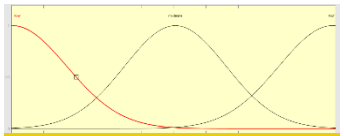
Society Readiness



Regulatory Readiness



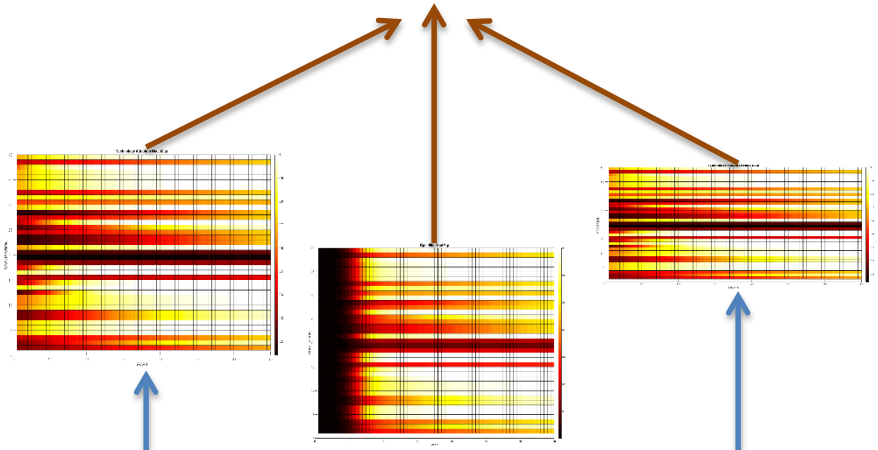
Management Readiness



Labour Readiness

Overall Economic Model for Sector in a Region

Inference Engine (Fuzzy Rule Base)



Offshore Jobs

Onshore Jobs

Non-Employment Effects

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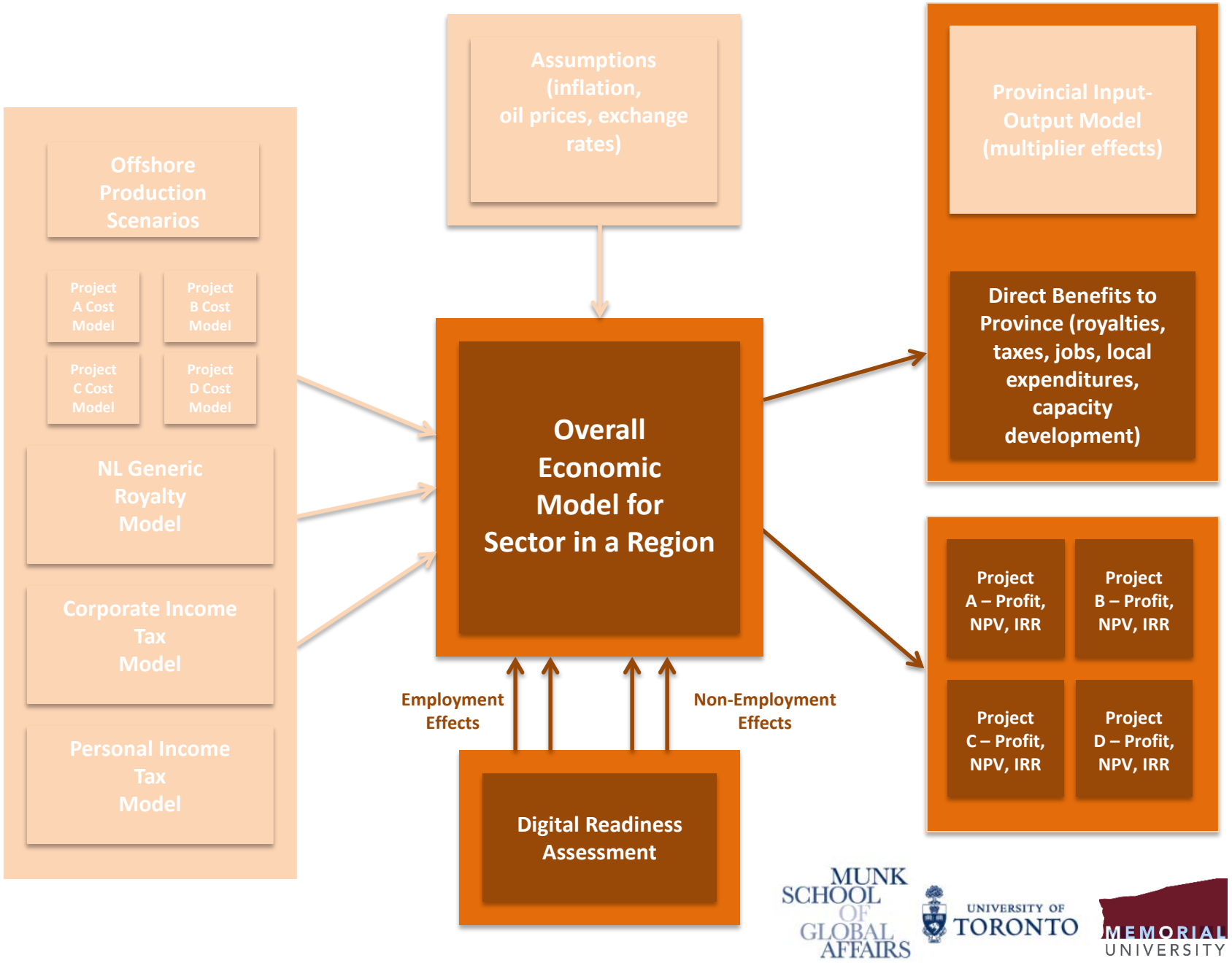
Assumptions (inflation, oil prices, exchange rates)
Provincial Input-Output Model (multiplier effects)
Offshore Production Scenarios
Project A Cost Model
Project B Cost Model
Project C Cost Model
Project D Cost Model
NL Generic Royalty Model
Corporate Income Tax Model
Personal Income Tax Model
Overall Economic Model for Sector in a Region
Direct Benefits to Province (royalties, taxes, jobs, local expenditures, capacity development)
Project A – Profit, NPV, IRR
Project B – Profit, NPV, IRR
Project C – Profit, NPV, IRR
Project D – Profit, NPV, IRR
Employment Effects
Non-Employment Effects
Digital Readiness Assessment
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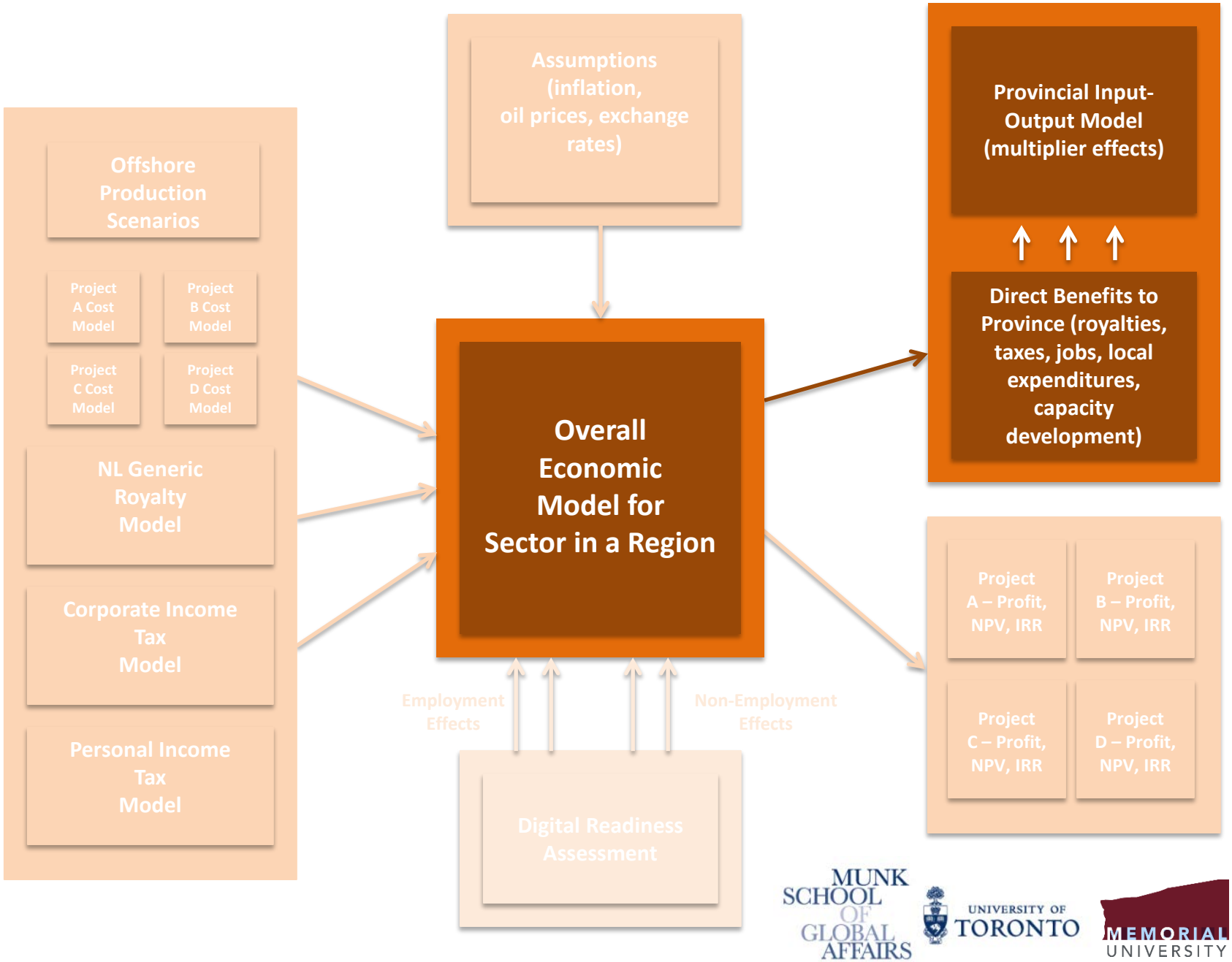
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Non-Employment Effects
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Broader Economic Benefits: How will these be impacted by digitalization ?

Table 3.1 Direct Impacts of Offshore Petroleum Industry, Newfoundland and Labrador, 2006-2014

	2006	2007	2008	2009	2010	2011	2012	2013	2014
Capital Costs ($ Millions)									
Exploration	241.4	122.3	92.1	384.3	333.9	385.5	165.1	712.7	300.4
Development	2.3	54.4	252.9	449.9	177.1	568.0	1046.2	3,027.4	3,416.0
Production (Sustaining)	815.8	587.4	627.8	606.4	497.2	607.8	932.9	772.2	847.6
Total	**1,059.5**	**764.1**	972.8	1,440.6	1,008.2	1,561.3	2,144.2	4,512.3	4,564.0
Employment (person years)									
Development	15	100	326	328	352	467	1,069	4,414	6,565
Production	2,839	2,516	2,641	2,813	2,839	3,092	3,796	3,345	3,608
Total	2,854	2,616	2,967	3,141	3,191	3,559	4,865	7,759	10,173
Oil Production (millions of bbl)	110.8	134.5	125.2	97.7	100.7	97.3	72.2	83.6	78.9
Operating costs ($ Millions)	621.0	602.7	701.4	707.1	686.9	694.0	730.1	758.0	844.8
Wages/Salaries & Employee Benefits ($ Millions)									
Development	1.1	7.7	27.8	29.7	31.2	48.1	126.9	544.8	834.6
Production	317.3	270.9	289.1	324.8	336.9	368.7	485.0	456.5	528.1
Total	318.4	278.6	316.8	354.4	368.1	416.8	611.9	1,001.3	1,362.9

Table 3.2 Total Economic Impacts Related to the Offshore Petroleum Industry in Newfoundland and Labrador

	2006	2007	2008	2009	2010	2011	2012	2013	2014	Average
GDP ($ Millions)	8,179	10,295	12,932	6,829	8,598	11,266	10,414	12,452	11,777	10,305
Share of Total (%)	36.4	36.9	43.6	29.5	31.8	35.8	34.4	37.0	36.1	35.7
Real GDP Chained ($2007 Millions)	8,962	10,295	9,813	7,782	7,837	7,917	6,202	7,855	7,734	8,266
Share of Total (%)	35.1	36.8	35.3	31.2	29.8	29.2	23.8	28.2	28.6	30.9
Household Income ($ Millions)	1,018	888	987	1,050	1,011	1,160	1,635	2,640	3,338	1,525
Share of Total (%)	6.2	5.4	6.0	6.0	5.6	5.9	7.9	12.0	14.5	7.7
Labour Income ($ Millions)	763	666	740	788	759	870	1,226	1,980	2,503	1,144
Share of Total (%)	7.0	6.3	7.0	7.1	6.5	6.9	9.0	13.5	16.3	8.8
Other Income ($ Millions)	254	222	247	263	253	290	409	660	834	381
Share of Total (%)	4.7	3.8	4.1	4.1	3.9	4.2	5.7	8.9	10.7	5.6
Disposable Income ($ Millions)	788	677	741	799	770	877	1,238	2,000	2,528	1,158
Share of Total (%)	6.2	5.4	6.0	6.0	5.6	5.9	7.9	12.0	14.5	7.7
Retail Sales ($ Millions)	442	379	415	448	431	491	693	1,120	1,416	648
Share of Total (%)	7.3	5.8	5.9	6.3	5.8	6.3	8.5	13.0	15.9	8.3
Housing Starts	144	122	130	140	131	145	200	317	394	191
Share of Total (%)	6.4	4.6	4.0	4.6	3.6	4.1	5.1	11.1	18.6	6.9
Employment (000s)	14.0	11.9	12.7	11.9	11.0	12.4	16.0	24.7	29.6	16.0
Share of Total (%)	6.5	5.5	5.7	5.5	5.0	5.3	6.6	10.2	12.4	7.0
Labour Force (000s)	11.0	9.3	9.8	9.8	9.3	10.4	13.3	18.1	21.5	12.5
Share of Total (%)	4.4	3.7	3.8	3.9	3.6	3.9	4.8	6.6	8.0	4.7
Unemployment Rate (%)	-1.9	-1.7	-1.8	-1.5	-1.2	-1.3	-1.6	-3.4	-4.3	-2.1
Population (000s)	18.3	15.4	16.3	16.4	15.6	17.3	22.2	30.1	35.9	20.8
Share of Total (%)	3.6	3.0	3.2	3.2	3.0	3.3	4.2	5.7	6.8	4.0

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Concluding Remarks

- Opportunities include potential benefits of **increased safety** of workers, improved **environmental performance**, improved **productivity and efficiency** of operations, shortening **time to production**, and reducing **capital/operating costs** and increasing **royalties and taxes**.

- The challenges include impacts on **employment and nature of work**, securing talent with **required education and skills**, navigating more **complex relationships** among industry, governments and communities, innovating in a **highly regulated industry**, and integrating new technologies with **legacy operations** and processes.

- There is a need for a framework that lets all stakeholders consider the opportunities and challenges of digital technology for extractive industries.

    - Poor outcomes are likely in the absence of a ‘big picture’.

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Dr. George Mann, Professor of Engineering , Memorial University
Dr. Oscar de Silva, Assistant Professor of Engineering, Memorial University
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Dr. Wade Locke, Professor of Economics, Memorial University
Dr. Thumeera Wanasinghe, Post-doctoral Fellow (Industrial Automation), Memorial University
Dr. Bui Petersen, Post-doctoral Fellow (Employment and Social Impacts), Memorial University

For background information see …

https://munkschool.utoronto.ca/ipl/files/2017/11/IPL-White-Paper-2017-4.pdf

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