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Going All In on Automation

Economic Growth, Labour Markets, and the Path Toward a Robust Transition

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Future Skills Centre | Centre des Compétences futures

The Future Skills Centre (FSC) is a forward-thinking centre for research and collaboration dedicated to driving innovation in skills development so that everyone in Canada can be prepared for the future of work. We partner with policymakers, researchers, practitioners, employers and labour, and post-secondary institutions to solve pressing labour market challenges and ensure that everyone can benefit from relevant lifelong learning opportunities. We are founded by a consortium whose members are Toronto Metropolitan University, Blueprint, and Signal49 Research, and are funded by the Government of Canada's Future Skills Program.

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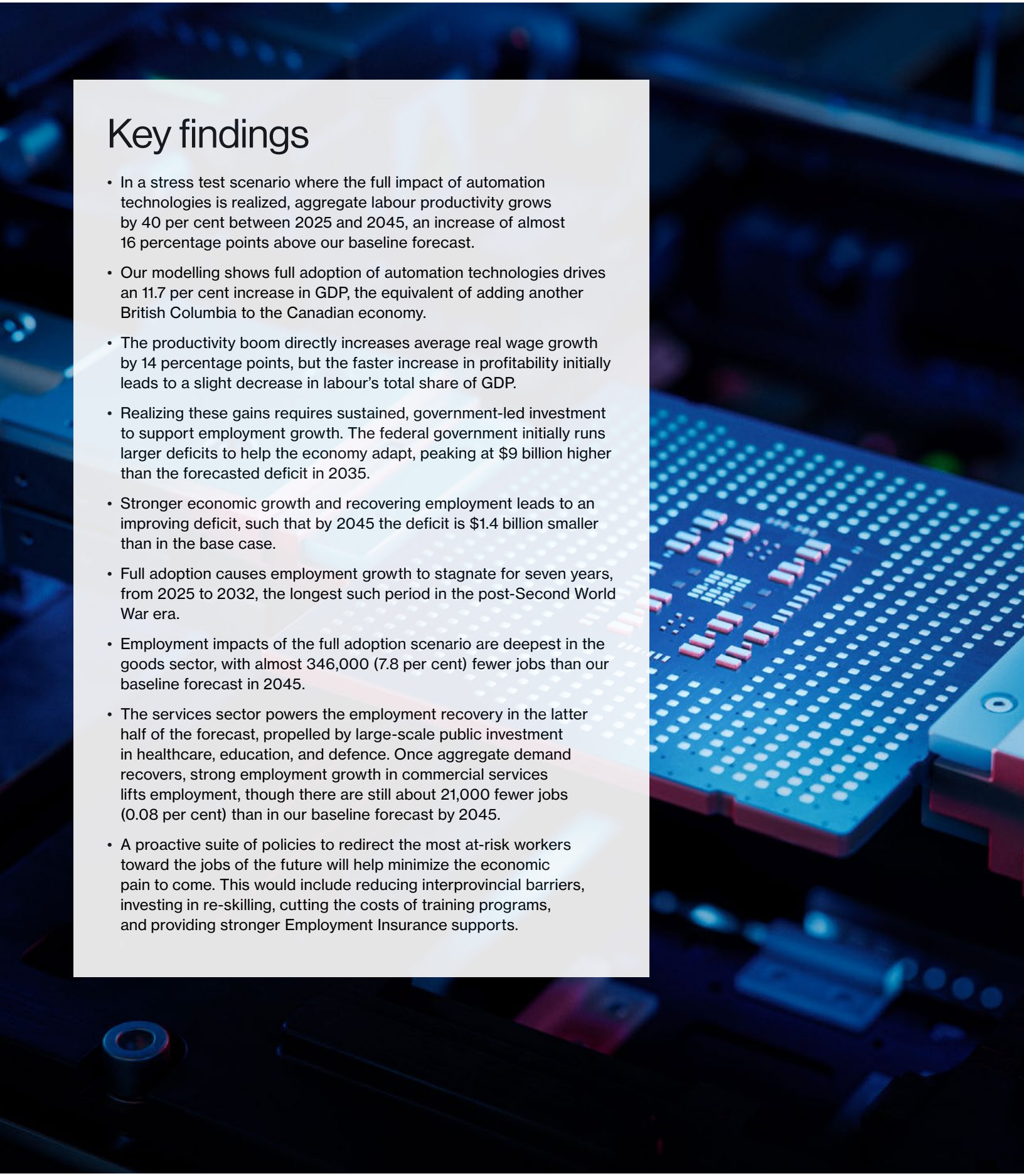
Contents



Key findings

- In a stress test scenario where the full impact of automation technologies is realized, aggregate labour productivity grows by 40 per cent between 2025 and 2045, an increase of almost 16 percentage points above our baseline forecast.
- Our modelling shows full adoption of automation technologies drives an 11.7 per cent increase in GDP, the equivalent of adding another British Columbia to the Canadian economy.
- The productivity boom directly increases average real wage growth by 14 percentage points, but the faster increase in profitability initially leads to a slight decrease in labour's total share of GDP.
- Realizing these gains requires sustained, government-led investment to support employment growth. The federal government initially runs larger deficits to help the economy adapt, peaking at $9 billion higher than the forecasted deficit in 2035.
- Stronger economic growth and recovering employment leads to an improving deficit, such that by 2045 the deficit is $1.4 billion smaller than in the base case.
- Full adoption causes employment growth to stagnate for seven years, from 2025 to 2032, the longest such period in the post-Second World War era.
- Employment impacts of the full adoption scenario are deepest in the goods sector, with almost 346,000 (7.8 per cent) fewer jobs than our baseline forecast in 2045.
- The services sector powers the employment recovery in the latter half of the forecast, propelled by large-scale public investment in healthcare, education, and defence. Once aggregate demand recovers, strong employment growth in commercial services lifts employment, though there are still about 21,000 fewer jobs (0.08 per cent) than in our baseline forecast by 2045.
- A proactive suite of policies to redirect the most at-risk workers toward the jobs of the future will help minimize the economic pain to come. This would include reducing interprovincial barriers, investing in re-skilling, cutting the costs of training programs, and providing stronger Employment Insurance supports.

Going all in to transform the Canadian economy

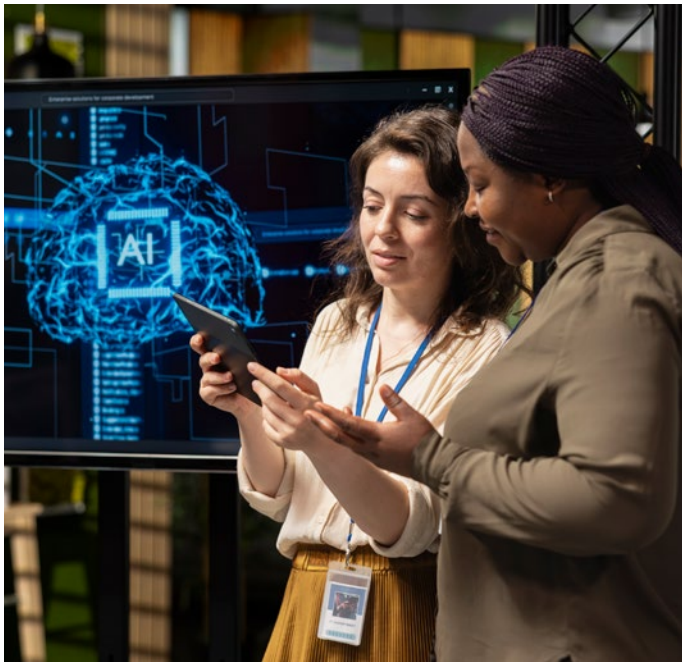
What if Canada went all in on artificial intelligence (AI), robotics, autonomous vehicles, connected devices and virtual reality? What would happen to productivity, jobs, and the economy? How could the country respond to these changes?

Increased productivity contributes directly to economic growth and higher wages. By boosting productivity, automation technologies like Generative AI have the potential to supercharge the economy and drive new job growth. Conversely, full adoption of these same automation technologies has the potential to severely disrupt labour markets, resulting in widespread job losses—firms may opt to decrease their workforce if these technologies sufficiently increase the remaining workers' output.

To understand the interplay of these opposing forces on Canadian jobs, we model what happens in a stress test where automation technologies are rapidly and fully adopted, without restriction, and used to their estimated full potential across industries. This exercise allows us to: 1) evaluate the trade-offs between improved growth and labour displacement, and 2) identify policy responses to support the employment recovery to help maximize the economic benefits. We deliberately ignore potential barriers to adoption besides timing and workflow integration, such as financing constraints, regulatory delays, or worker resistance, to present an all-in scenario of technology adoption. Also, we do not include the cost of investment in the model and instead focus on how investment priorities are reallocated to higher productivity inputs. In this sense, the modelled scenario represents the fastest plausible adoption path of these new automation technologies.

This allows us to address two key questions:

1. Which industries face the greatest employment disruption under full adoption of automation technology?
2. How do broad economic dynamics, particularly public investment and public finances, shape and sustain the recovery from the structural shift that our all-in scenario implies?



Foundations of the all-in technology adoption scenario

Our analysis considers adoption of automation technologies across five technology clusters, going beyond the standard focus on AI. (See Table 1.) In our view, the full impact of automation is driven by the interaction of each technology cluster to supercharge productivity.

Table 1
Five clusters of automation technologies included in the analysis

Technology cluster	Overview
AI	Includes technologies that enable computers to perform tasks such as learning, reasoning, problem-solving, and decision-making. Latest developments include Generative AI, Machine Learning (ML), and Natural Language Processing (NLP).
Robotics	Involves technologies that design, construct, and utilize robots for performing tasks with greater precision and efficiency than humans. Latest advances include collaborative robots (or "cobots") that work alongside humans.
Autonomous vehicles and drones	Includes automated technology that can navigate in various environments without much oversight. Latest innovations include driverless rides, autonomous taxis, self-driving trucks, and drone delivery.
Connected devices (aka Internet of Things)	These technologies use sensors and software to enhance network connectivity and critical data-sharing. Latest innovations involve integration with other technologies such as AI, augmented and virtual reality (AVR), and blockchain.
Virtual reality and augmented reality	Involves technologies that create immersive experiences by overlaying digital information on the real world or creating entirely digital environments that are fully immersive for the user. Latest developments include applications in prototyping, product visualizations, and architectural planning based on spatial computing.

Source: Signal49 Research.

Our recent work found that full adoption of these technologies could add a further 13.8 per cent to labour productivity over the next 15 years.[1] Our task-level exposure analysis on the types of work that can be automated shows that productivity gains vary widely across industries, with average annual increases ranging between 0.4 per cent per year (educational services) and 1.2 per cent per year (transportation).

From exposure to productivity

The potential productivity impact of automation technologies is built from the ground up. We aggregate task-level exposure to automation technologies to detailed occupational exposure and then derive industry-level exposure. The contribution of industry-level exposure to labour productivity growth is then estimated.[2]

What separates our approach from others is our inclusion of a broader range of automation technologies. Our analysis considers AI, robotics, autonomous vehicles, virtual and augmented reality, and connected devices.

Note that exposure is not a measure of potential job displacement. Just because a job can be automated does not mean it will be. The decision to automate depends on a host of factors, such as the associated financial costs, feasibility, and expected efficiency gains.

2 See Appendix A for methodological details on estimating exposure and productivity gains.

1 Our previous work on this topic covers our framework and our productivity estimates across industries. The Conference Board of Canada, "Automation Technologies and Canada's Labour Market"; and Signal49 Research (published as The Conference Board of Canada), "Automation Technology's Productivity Potential—September 2025."

Extending that work to a full-scale macroeconomic scenario finds that full adoption increases real GDP by 11.7 per cent over the next 20 years. This represents an increase relative to our baseline forecast, which represents our view of the path for the economy and includes a far more restrained view of productivity growth. The baseline forecast incorporates historical trends in technological adoption to provide a more realistic view of the actual path the economy will take. However, the full adoption scenario would be incredibly disruptive to labour markets. In our full adoption scenario, employment decreases by 142,000 jobs between 2025 and 2032. Following a surge in government spending, labour markets rebound between 2032 and 2045, driven by the 3.9 million jobs created in the services sector. Relative to our baseline forecast, our full adoption scenario sees the economy adding 1.1 million fewer jobs between 2025 and 2032 before returning to normal by 2045.

This scenario modelling aims to illustrate the economic response to the maximum possible automation-induced productivity growth and identify a plausible path forward assuming this all-in boost to productivity occurs. This is an exercise in ambition, enabling us to anticipate the impacts of a technological shift representing the highest potential economic benefit, so that we can determine areas in which supports will be most needed.[3] The scenario we present here offers a measure of how much we are leaving on the table on our current path, and the potential pitfalls of going all in without a coherent strategy to address the disruption.

A stress test for the economy

Using our national macroeconomic model, we apply the estimated maximum potential productivity gains across industries and consider the adjustments to government spending and tax policies that we feel are reasonable *given the scenario being explored*.

Our national model is a large-scale, quarterly econometric model of the Canadian economy based on the neoclassical synthesis. The model forecasts 1,800 variables, including nearly 600 freely estimated behavioural equations, and includes 14 major model blocks to forecast employment, wages, productivity, and industrial sector details. The model and database are updated each quarter. Economic activity is determined through the expenditure side of the model, with supply-side feedback channels that influence labour markets, prices, financial markets, trade, and as a result, industry output.

Though our analysis provides a rigorous assessment of the potential outcomes of such a massive productive transformation, there remain important questions about how this transition plays out. Our scenario purposely ignores any financial, social, and regulatory barriers and frictions to automation adoption. We also cannot account for the potential emergence of new occupations across industries that may also absorb some of the displaced workers.

This frictionless pathway still assumes an S-shaped growth path of productivity, representing a plausible, rapid path for adoption that allows for time to incorporate these technologies into workflow processes. The assumed path is one of many possible outcomes but is useful in that we do not assume an instantaneous transformation of the technological frontier, but a more rapid transformation than what we might otherwise expect.

3 We made no additional adjustments with respect to immigration policy, demographics, or trade. The underlying model mechanics answer how disruptive such a massive technological shock could be and what can be done to ensure the best economic response possible.

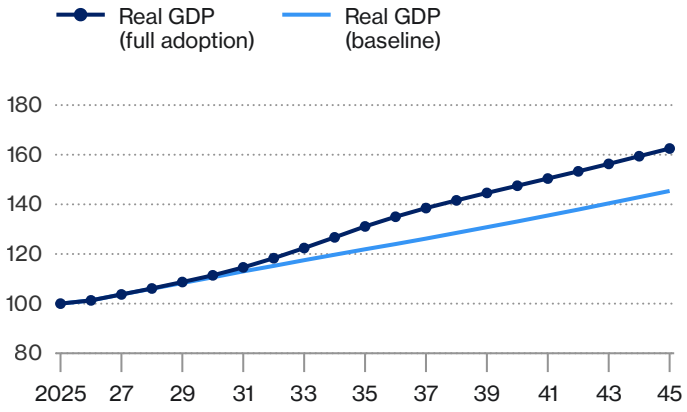
Full adoption boosts growth but leads to layoffs

Our main finding is that the productivity potential of full adoption of automation technologies yields strong economic growth, but is accompanied by a large, front-loaded decline in employment followed by a long reallocation process as the economy recovers.[4]

The impact of our full adoption scenario is an immediate boost to economic activity, resulting in real GDP being nearly 12 per cent higher than baseline by 2045, roughly the equivalent of adding another British Columbia to the Canadian economy. (See Chart 1.) Between 2026 and 2032, real GDP grows by 16.7 per cent. As adoption accelerates, GDP grows by 37.4 per cent between 2032 and 2045.

The result is an annualized growth rate of 2.5 per cent. This would represent the fastest and most sustained expansion of the economy since the 1990s. Compared with our baseline scenario, real GDP growth is lifted by 0.5 percentage points per year between 2025 and 2045. As a result, real GDP grows to be $417 billion above baseline in 2045. In per capita terms, this is the equivalent of a gain of $8,661 per person.

Chart 1
Full adoption increases GDP by nearly 12 per cent
(GDP, full adoption scenario and baseline forecast, indexed to 2025 = 100)



Source: Signal49 Research.

4 Several reports, focused on AI, have expressed similar outcomes. Goldman Sachs estimates that AI will directly displace 7 per cent of the U.S. labour force during a transitionary period. Goldman Sachs, “How Will AI Affect the Global Workforce?”

The effect of our full adoption scenario on employment is stark. (See Chart 2.) Total employment falls by 142,000 jobs by 2032 from today's level—about one-seventh of the employment decline during the COVID-19 pandemic.[5] This represents a marked divergence from our baseline forecast, delivering almost a decade of no employment growth, the longest period of labour market stagnation in the post-Second World War era.[6] At the lowest point of the trough in 2032, total employment is 1.2 million below baseline (5.3 per cent). We expect that this weakness in job creation would require active policy intervention. Government spending and investment deliver a boost to aggregate demand, allowing for a period of recovery over the final 12 years of our scenario. As production becomes more efficient and expands, there is downward pressure on prices. Workers also become more effective, average wages grow, and those who remain employed see their disposable incomes increase.

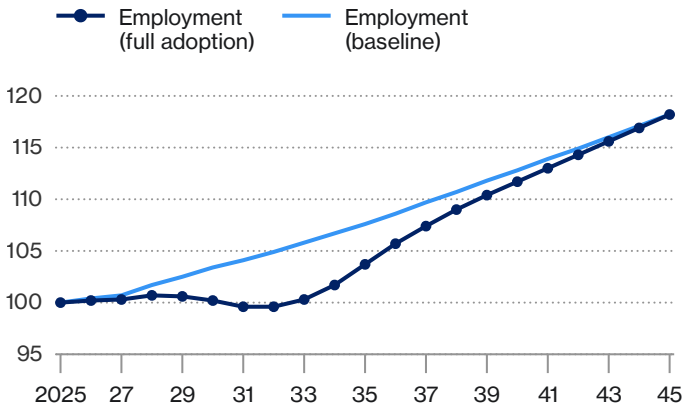
This scenario presents a grim impact on unemployment. (See Chart 3.) The unemployment rate peaks in 2033 at 10.3 per cent (compared with 5.8 per cent in our baseline forecast). This is slightly higher than the average unemployment rate of 9.7 per cent in 2020 during the COVID-19 pandemic, and the highest annual unemployment rate since 1993 when it reached 11.4 per cent.

While automation displacement is one of the contributing factors to the increase in unemployment, our assumption that immigration policy remains unchanged from our baseline forecast drives the magnitude. In response to a shock of the size that we are imposing on the Canadian economy, a robust review of immigration policy and targets would be an important lever to ease the strain on the labour market during a period of prolonged stagnation in employment growth.

Chart 2

Full adoption reduces and stalls employment for almost a decade

(employment full adoption scenario and baseline forecast, indexed to 2025 = 100)

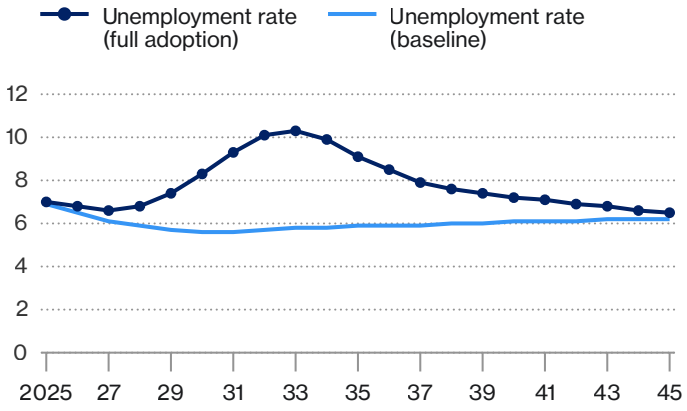


Source: Signal49 Research.

Chart 3

Employment stagnation accompanied by dramatic peak in unemployment

(unemployment rate, full adoption scenario and baseline)



Source: Signal49 Research.

5 In Appendix B, we present results relative to the Signal49 baseline forecast. This allows us to isolate the direct impacts of our full technological adoption scenario on growth, employment, investment, wages, and public finances, representing a maximum-impact scenario.

6 One would have to go back to the Great Depression to find a similar extended period of weak employment growth.

Policy interventions to support the transition

On their own, the automatic stabilizers within our model, such as Employment Insurance, income-tested transfers, and the cyclical response of tax revenues, are not enough to absorb a shock of the magnitude we impose on the model. We assume plausible spending changes from federal, provincial, and local levels of government to address the labour market impacts. These increases are supported by increased revenues and by lower financing costs due to the decline in bond yields.

In our full adoption scenario, government revenues rise while job growth stagnates. In our view, it is plausible that governments would employ fiscal policy to stimulate labour markets. We increase federal health and social transfers to provinces, as well as higher federal direct spending on defence and public infrastructure. We also assume that provincial governments would increase spending on healthcare, education, and infrastructure relative to baseline, and local government infrastructure spending is increased as well. In addition, we assume a 1 percentage point reduction in the federal goods and services tax beginning in 2035.

We note that these spending measures are not explicit forecasts. Governments could potentially also introduce additional direct support to households. However, a policy focus on retraining and re-skilling displaced workers appears more plausible, alongside continued emphasis on healthcare, defence, and infrastructure as persistent policy priorities.

We assume no changes to immigration and population growth relative to our baseline forecast. Labour-market adjustment occurs through changes in employment, unemployment, and participation rather than through population dynamics. These dynamics reflect cyclical withdrawal from the labour force rather than changes in underlying population or migration trends, which remain exogenous to the simulation.

The goods sector, particularly the manufacturing, agriculture, and primary extraction industries, reduce their labour force requirements due to automation while still meeting growing demand. (See Table 2.) These are industries that have already been directly impacted by robotics and autonomous vehicles. Paired with AI to assist in efficient, rapid decision-making, these industries could experience the greatest reduction in required labour, with our scenario seeing 345,678 fewer jobs versus the baseline in 2045 (7.8 per cent).

In the long run, aggregate demand grows enough to reabsorb the full shock to employment. Firms expand operations and hiring resumes. From 2032 to 2045, the economy adds close to 3.9 million jobs. But the labour market has undergone a structural shift, with goods production shrinking, the services sector expanding, and all sectors now paying higher wages on average. Productivity gains raise output per worker, even in sectors with net job losses. The remaining roles often become more complex and better paid.

As incomes grow during the recovery period, discretionary spending grows. (See Table 3.) Spending on non-durable goods (comprising staples such as fuel, groceries, and utilities) grows less than spending on discretionary semi-durable goods (such as clothing, small appliances, and other personal effects) and services (such as financial services and dining out).

The rise of automation technologies is not unique to Canada. As a result, some of this spending growth will “leak out” of the domestic economy. For example, the exceptional growth in spending on durables is less likely to drive growth in domestic manufacturing as this sector is particularly vulnerable to international competition. Manufacturing has long been an industry with a declining share of overall employment as incomes grow, and the impact of our full adoption scenario is to accelerate such existing trends rather than reverse them.

Table 2
Goods industries employment declines in full adoption scenario

Industry	Employment growth, full adoption per cent, 2025–45	Employment relative to baseline, per cent, 2045
Goods	**–1.9**	**–7.8**
Agriculture	–22.1	–11.8
Mining, oil and gas	–12.5	–13.3
Manufacturing	–13.4	–8.6
Construction	16.4	–5.7
Utilities	–7.2	–9.2
Commercial services	**20.7**	**–0.3**
Wholesale and retail trade	7.2	–1.4
Transportation and warehousing	16.0	–11.0
Financial services	25.1	3.7
Professional services	46.0	1.1
Administrative services	18.8	0.2
Information services	5.2	4.3
Accommodation and food services	29.5	0.9
Other services	9.9	0.8
Non-commercial services	**32.3**	**3.3**
Educational services	10.5	3.0
Heatlhcare	44.5	3.4
Public administration	**13.1**	**14.6**

Source: Signal49 Research.

Table 3
Household spending growth strongest in discretionary spending

Expenditure	Spending growth, full adoption, per cent, 2025–45	Spending relative to baseline, per cent, 2045
Household final consumption expenditures	**68.6**	**13.5**
Non-durable goods	38.2	7.0
Durable goods	85.3	24.5
Semi-durable goods	76.1	7.3
Services	76.7	14.1

Source: Signal49 Research.

Wages grow, but not as much as profits

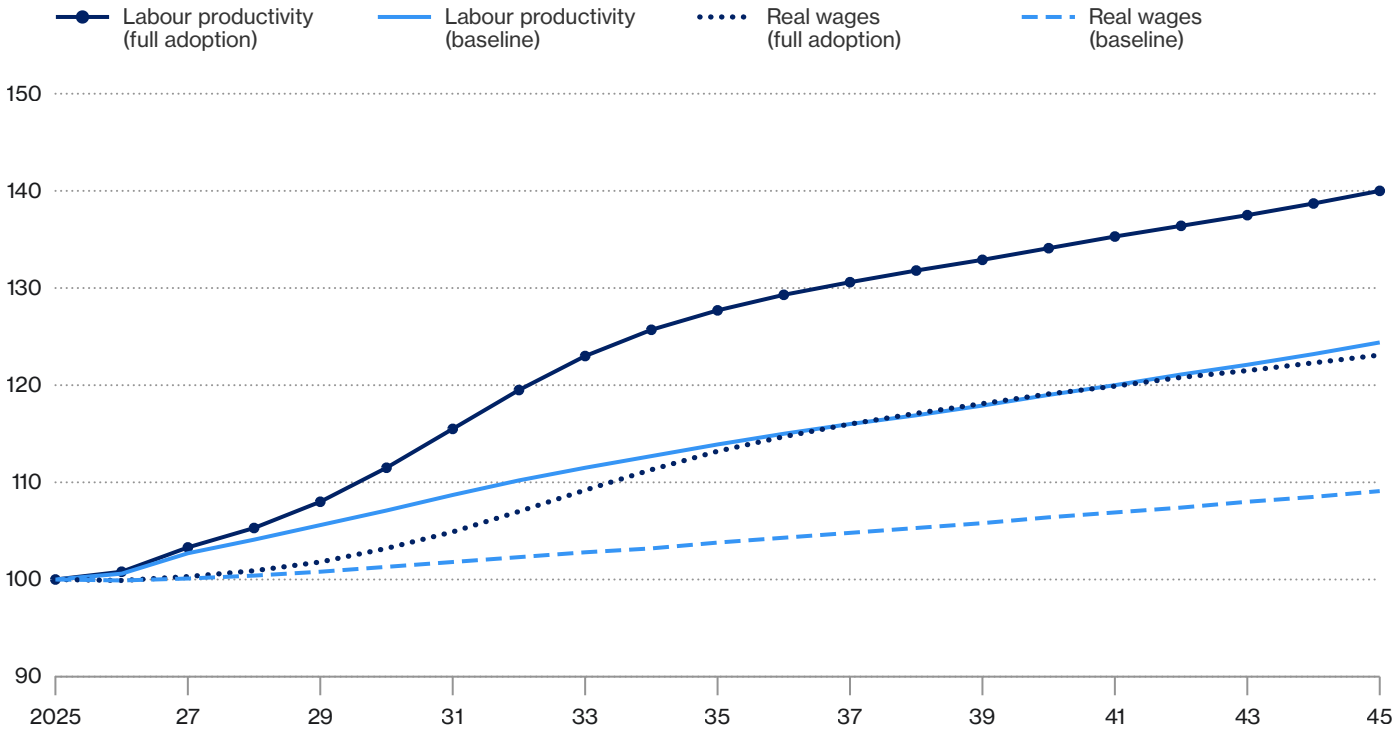
Automation, to varying degrees, is already a reality in most workplaces, but the impact on overall productivity is not always apparent. The full impact of adoption takes time before it is realized.[7] Eventually, confidence in adoption takes off and industries reorganize their production around a new mix of capital and labour inputs. Employing more software, robotics, and data-rich workflows, combined with more productive workers, produces greater output. We assume that productivity across industries follows an S-shaped curve, with a slower initial impact being followed by rapid growth that then stabilizes in later years at a new, permanently higher level. (See Chart 4.).

The tight link between productivity and wages is also apparent. Real hourly wages grow by 23.1 per cent over this period, an increase of 14 percentage points over baseline. Rising productivity means each worker can produce more output in the same amount of time, increasing the employee's value to the firm. As well, because firms can now produce more efficiently, profitability is improved.

Chart 4

Under full adoption, aggregate labour productivity grows by 40.0 per cent

(aggregate labour productivity and real wages, full adoption scenario and baseline forecast, indexed to 2025 = 100)



Source: Signal49 Research.

7 This phenomenon is well-known in the economics literature, referred to as the "productivity paradox" or the "Solow paradox". During the IT boom of the 1980s, measured labour productivity growth in the U.S. slowed despite the massive increases in computing capacity and large-scale investments in IT adoption. By the 1990s the paradox appeared to resolve, giving rise to a theory of "productivity lag". This situation has recurred more recently in the age of AI adoption. Brynjolfsson and others, "Understanding and Addressing the Modern Productivity Paradox."

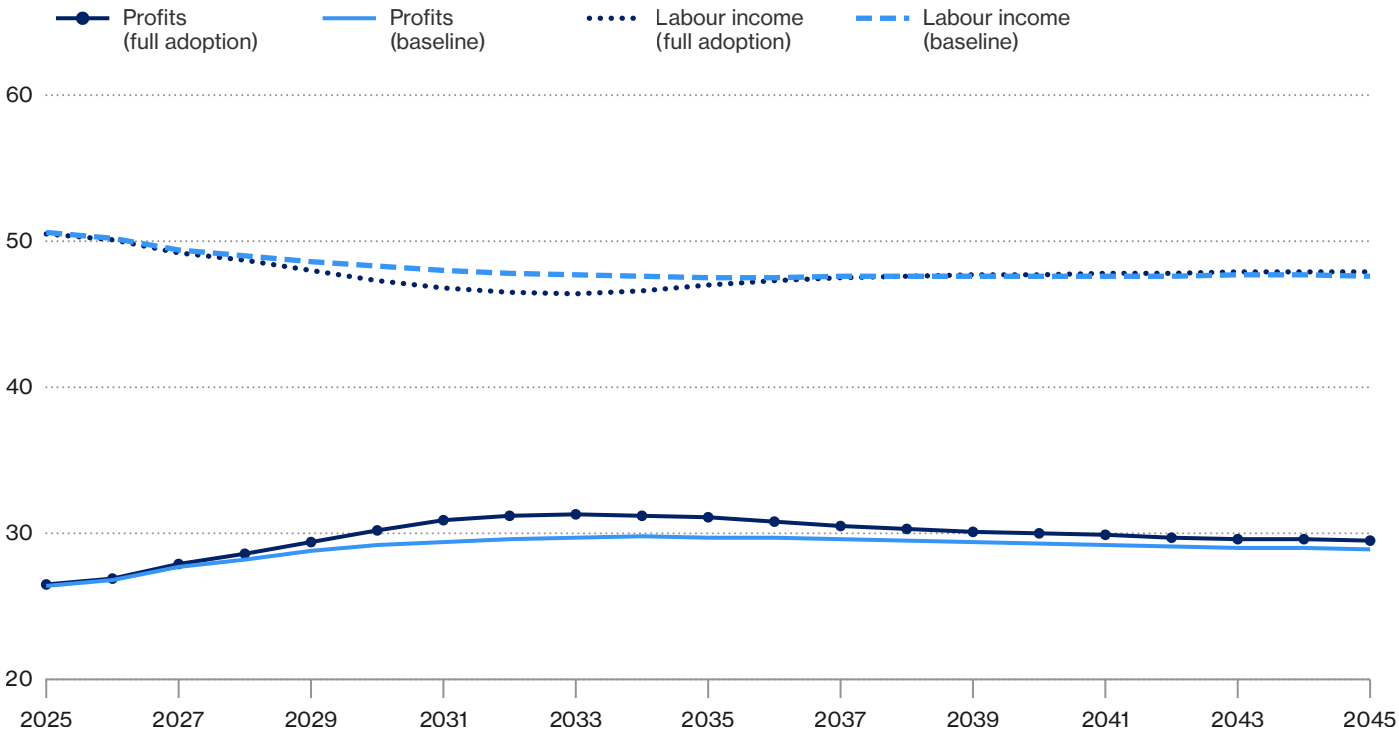
The impact of our full adoption scenario on the distribution of income varies over time. In the early years, profits rise faster than incomes, due in part to the reduction in total employment. (See Chart 5.). Once the labour market starts to recover, real wage growth strengthens and the labour share of the distribution of income generated recovers. At the end of the forecast period, the labour and profit shares of income are similar to the baseline.

It is also worth noting that the employment recovery in the full adoption scenario is skewed toward high-value service jobs, which raises the risk of lower-income households being left behind. If displaced workers cannot find employment in the industries with both strong employment growth and strong wage growth, the risk of worsening income inequality could result in a continued rise in social resentment.[8]

Chart 5

Profits account for larger initial gains in income split before labour market rebounds

(share of GDP, per cent, accruing to capital and labour, per cent, under full adoption scenario and baseline forecast)



Source: Signal49 Research.

8 There is some concern that AI may worsen global inequality, as rich countries are best positioned to capture the benefits. Schellekens and Skilling, "Three Reasons Why AI May Widen Global Inequality." The degree of complementarity between workers and AI also affects the predicted inequality outcomes with the potential for wealth inequality to worsen. Rockall and others, *Ai Adoption and Inequality.*

Government investment to support labour recovery

The recovery from the structural shock of full adoption relies on meaningful actions taken by federal and provincial governments. A proactive government would address the considerable initial employment declines by increasing spending and transfers. We assume that government policy priorities will include an HST/GST tax cut in 2035 and increased investments in education, healthcare, infrastructure, and defence. This insulates and stimulates the economy during the transitional period, creating employment opportunities and demand when private sector hiring is weak.

The expansion of government supports for workers is made possible by the improving government revenue generation driven by the rapid growth in GDP. This provides the fiscal space for governments to effectively respond to the shock. Proactive policies stimulate the labour market recovery and even improve the broader fiscal situation by 2045. As the labour market recovers, incomes grow and consumer spending and business investment accelerate.

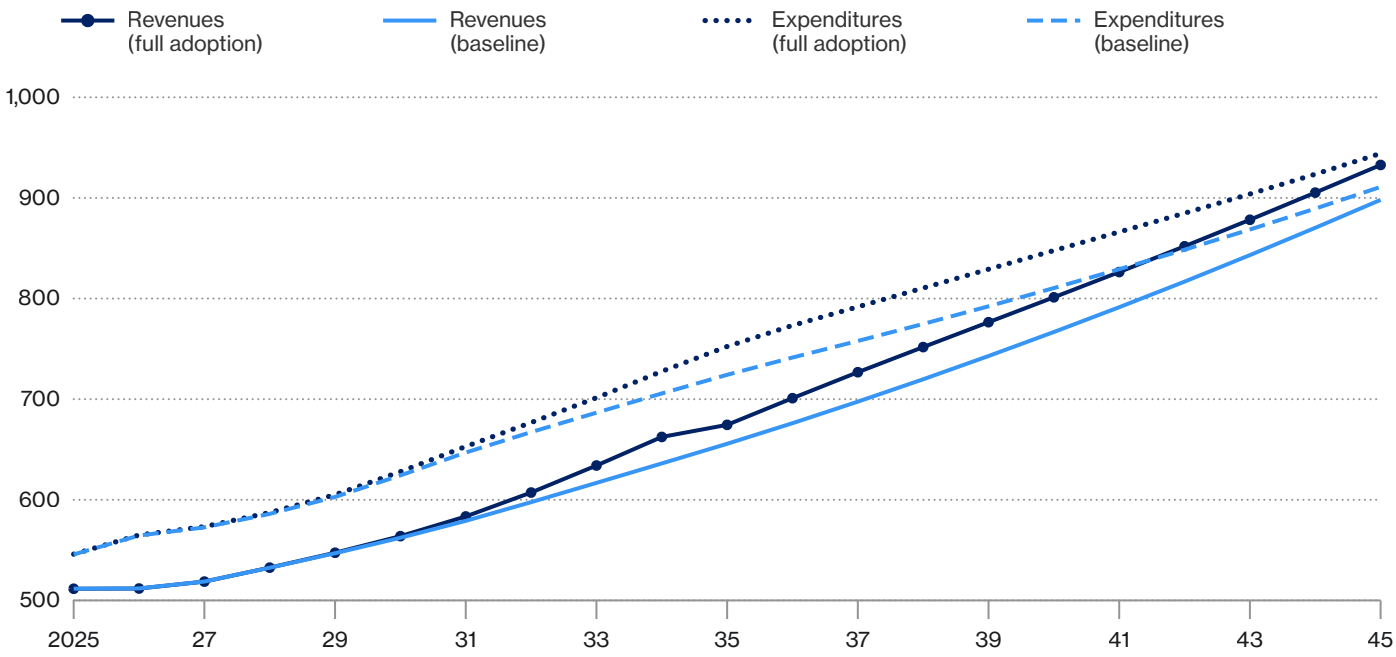
This boosts demand across industries such as construction, financial services, accommodation and food services, and culture and recreation, among others.

In our full adoption scenario, the deficit surpasses $77 billion in 2035 at the federal level, coinciding with the introduction of the HST tax cut. This marks an increase in the federal deficit of $9 billion relative to our baseline scenario in 2035. (See Chart 6.) As the economy adjusts, employment recovers, real incomes continue to climb, revenues strengthen, and spending pressures ease. This allows government revenues to rapidly increase, improving the fiscal situation.[9]

Chart 6

Large deficits in the early years of the transition are recovered in later years as the economy takes off

(federal government revenues and expenditures, C$ millions, nominal, under full adoption scenario and baseline forecast)



Source: Signal49 Research.

9 This results in the federal deficit improving by $1.4 billion relative to our baseline in 2045.

The size of provincial government deficits in the initial years is similar in both scenarios, but their financial position improves in the full adoption scenario after 2030, in part due to the increased transfers from the federal government. (See Chart 7.) Rapid revenue growth ensures that by 2037 provincial governments are running a surplus of $1.3 billion in our full adoption scenario, even as expenditures on healthcare, education, and infrastructure grow. This results in an improvement in the provincial deficit of more than $10 billion relative to our baseline.[10]

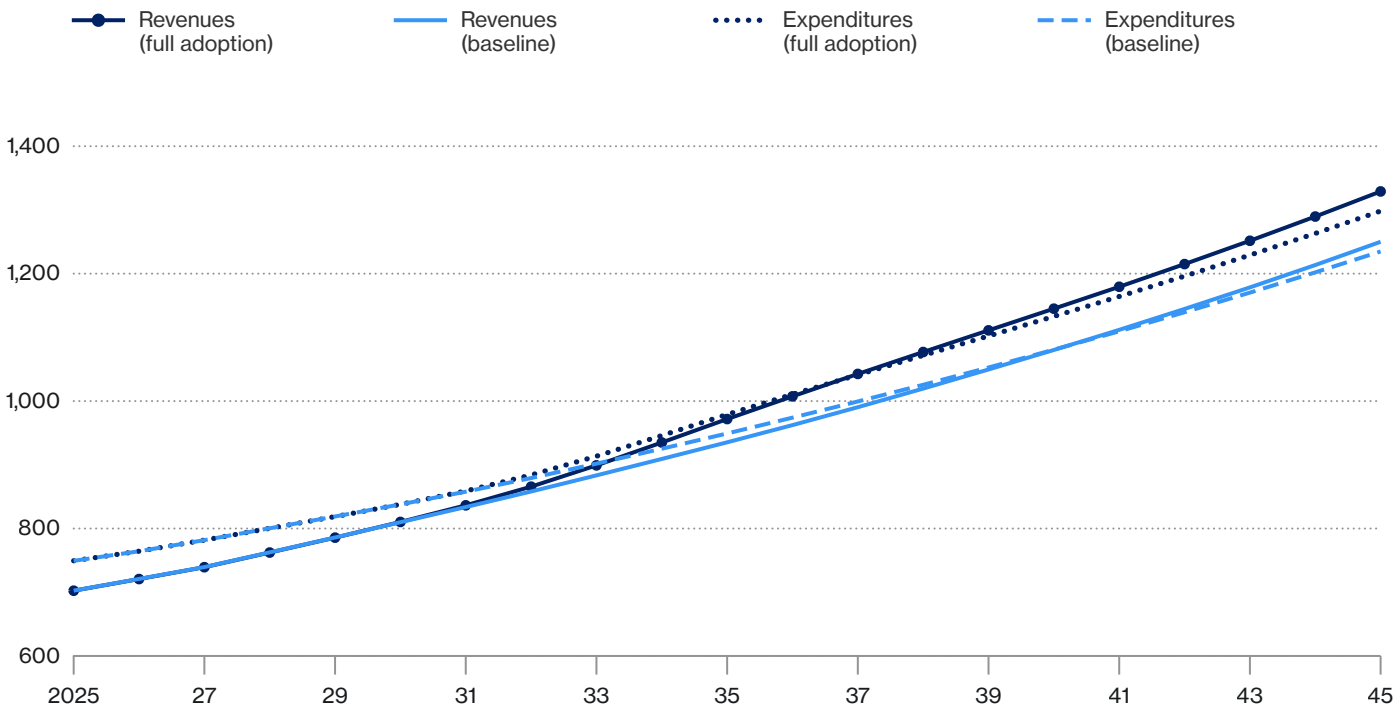
The recovery relies on both public and private investment. Governments invest an average of about $121 billion per year (an increase of $8 billion per year relative to our baseline forecast).

Private business investment averages $549 billion per year ($41 billion per year more than our baseline forecast). It is important to note that in our full adoption scenario, we do not include the associated costs and necessary investments with adopting and installing these technologies. Private investment instead responds to the productivity shift and is directed toward higher productivity inputs, such as robots (machinery and equipment) and AI tools (software and intellectual property products). As a result, private investment in our full adoption scenario should not be interpreted as the cost associated with realizing these productivity gains, but rather as how much more investment could result from the improving growth. The true level of investment that incorporates the actual costs of adoption to achieve this scenario would be much larger.

Chart 7

Federal transfers and improved tax base push provincial government finances into surplus territory

(provincial government revenues and expenditures, C$ millions, nominal, under full adoption scenario and baseline forecast)



Source: Signal49 Research.

10 In our baseline forecast, provincial governments are running deficits of nearly $9 billion in 2037, reaching budget surpluses in 2041. By 2045, provincial government surpluses in our full adoption scenario are $15.5 billion higher than they are in the baseline forecast.

We do not see any crowding out of private investment, which accounts for between 80 and 83 per cent of total investment in both scenarios. Much of this investment is targeted toward intellectual property products and machinery and equipment. (See Table 4.) These are essential investments to deploy the productive capacity of these new technologies, and the government has an active role to encourage this in our full adoption exercise.

As the productive capacity of an industry expands and demand grows beyond the cost savings that automation technologies provide, firms hire more workers. Some industries are limited by potential demand growth (such as agriculture), while others will see opportunities to expand as prices fall and incomes rise (such as professional and technical services).

Table 4
Large investments in intellectual property products and machinery and equipment support the economic transformation

Investment type	Investment growth, full adoption, per cent, 2025–45	Investment relative to baseline, per cent, 2045
Gross fixed capital formation	**59.9**	**14.7**
Business	**63.9**	**15.2**
Residential structures	44.1	8.5
Non-residential structures	61.6	11.6
Machinery and equipment	86.0	22.3
Intellectual property products	92.2	29.1
Government	**42.6**	**12.5**
Residential structures	12.1	0.0
Non-residential structures	36.9	13.4
Machinery and equipment	54.8	13.7
Intellectual property products	40.4	13.9

Source: Signal49 Research.

Employment impacts vary widely across industries

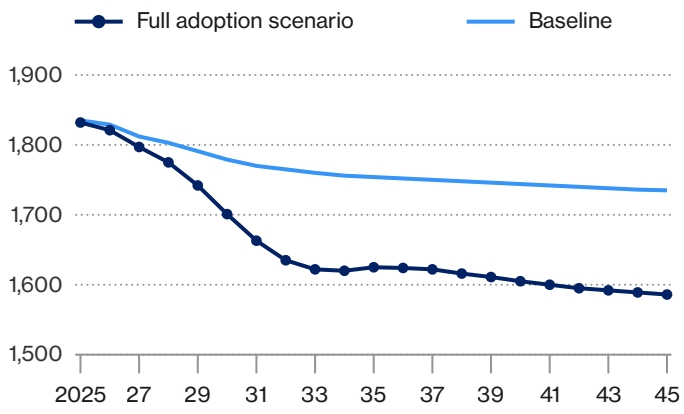
Automation impacts jobs in two key areas: tasks performed and productivity gained. First, automation takes over or supplements tasks. This increases productivity per worker, putting upward pressure on the person's wages. Second, this productivity growth drives prices down, increasing consumer purchasing power and bolstering real incomes. In industries where demand grows beyond the pure productivity gains, such as in financial services, employment also grows. Workers gain the most by leveraging the growth in demand in services where human judgment, interaction, and creativity are central.

Differences in employment impacts between goods and service industries reflect both the level of exposure to automation technologies and the continuation of long-running structural forces. As incomes grow, domestic production and employment is displaced away from agriculture and manufacturing toward the growing and more productive services sector. Some of this transition reflects the kinds of automation technologies each sector is most exposed to. Robots are designed to reduce the need for labour-intensive assembly lines and streamline production in goods-producing industries that have more repetitive, manual tasks and fewer human-centred skills. Conversely, service industries rely more on interpersonal skills and human communication, things not easily replaced with automation technologies. However, the key driver of this services sector ascendancy is the robust growth in consumer spending on services.

Manufacturing employment decline accelerates

In manufacturing, we see a decline of 245,000 jobs between 2025 and 2045, nearly equivalent to the number of jobs lost in the industry during the 2007–10 recession. (See Chart 8.) However, unlike in the years following that recession, or the COVID-19 pandemic, there is no recovery of any of the jobs lost. Most manufacturing jobs (196,000, or 80 per cent of the decline) are lost between 2025 and 2032. Under our full adoption scenario, this marks an acceleration of the existing trend of reduced manufacturing employment apparent in our baseline forecast, which suggest a decrease of 71,000 jobs over the same period. Even as the economy recovers, the employment declines persist with roughly 49,000 more jobs lost by 2045 (compared with 30,000 in the baseline).

Chart 8
Automation accelerates trend of job losses in manufacturing
(manufacturing employment, thousands of jobs, under full adoption scenario and baseline forecast)



Source: Signal49 Research.

This consistent decline in manufacturing employment, despite strong growth in consumer spending on durable and semi-durable goods, can be explained by a combination of factors. First, the productivity gains in the industry are so strong that even exceptional domestic demand growth is not enough to drive net job growth in this industry. Second, manufacturing is an industry that is particularly exposed to international competition from emerging economies. In isolation, productivity growth tends to make production costs fall and profits rise. However, the automation technologies analyzed are not unique to Canada and thus the same structural forces that have shifted employment away from manufacturing in rich countries will accelerate as our competitors adopt these technologies.

Occupations such as motor vehicle assemblers are particularly vulnerable to assembly processes being automated by robotics. As AI further improves the efficiency of these processes, these workers are likely to face the brunt of the job losses. Even as output per worker rises, total manufacturing employment declines as fewer workers are needed to directly work the assembly lines. Office and administrative staff, particularly those in the industry's sales and managerial roles, are less exposed but also make up a much smaller fraction of the total employment in the industry.

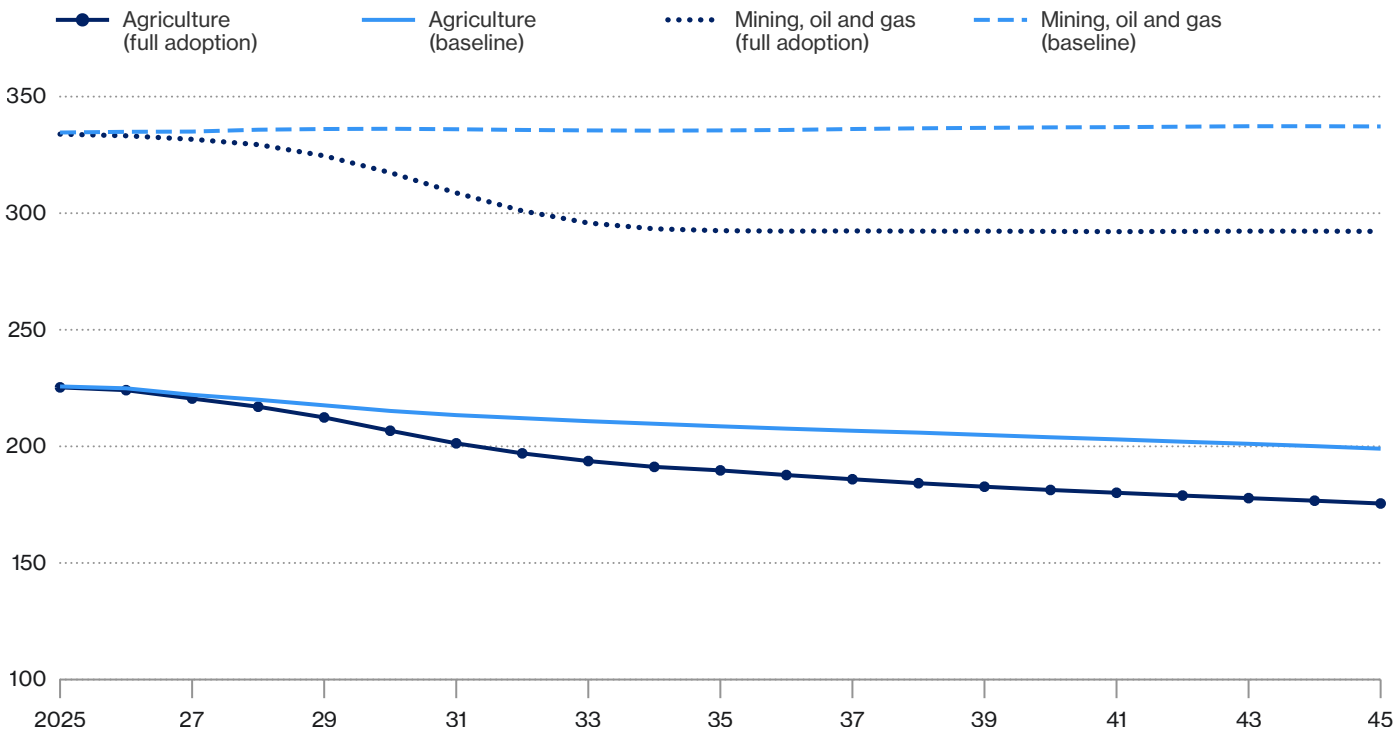
Job losses accelerate in extractive industries

Manufacturing is not alone in seeing existing employment declines amplified. Full adoption of new technologies reduces employment in agriculture, and mining, oil and gas over the next 20 years. (See Chart 9.) Mining workers are hit particularly hard, as the impact of automation reduces employment in 2045 by about 45,000 jobs (12.2 per cent) below the stable path in our baseline forecast.

Chart 9

Robotics and automated processes further erode employment in agriculture, and mining, oil and gas

(employment in agriculture, mining, and oil and gas, thousands of jobs, under full adoption scenario and baseline forecast)



Source: Signal49 Research.

These industries already use autonomous vehicles and drones.[11] In agriculture, the use of robotic weeders, drones for precision spraying, and self-driving tractors are already reducing the need for workers.[12] Automated rigs, remote monitoring systems, and autonomous haulage systems also reduce the need for consistent on-site workers in resource extraction. As the need for heavy equipment operators, process operators, and production and development staff is shifted onto automation technologies, the overall employment in these industries falls by 69,000 jobs below baseline in 2045 (12.8 per cent).

Agriculture and mining have the weakest demand growth in our full adoption scenario, as growth in consumer spending on non-durables is about half that of semi-durables and services. Weaker demand growth is due to the natural constraint that households have on how much more they will spend on non-discretionary items like groceries, and energy. As incomes grow and households can satisfy a certain level of consumption on necessities, the extra income is more likely to be spent on discretionary items (e.g., like dining out). Like manufacturing, automation technologies are not expected to make Canada uniquely more competitive globally, and so international demand for Canadian agriculture and primary materials is unlikely to grow to a point that these capital-intensive industries start increasing their labour force, provided climate change does not negatively impact major breadbasket regions.

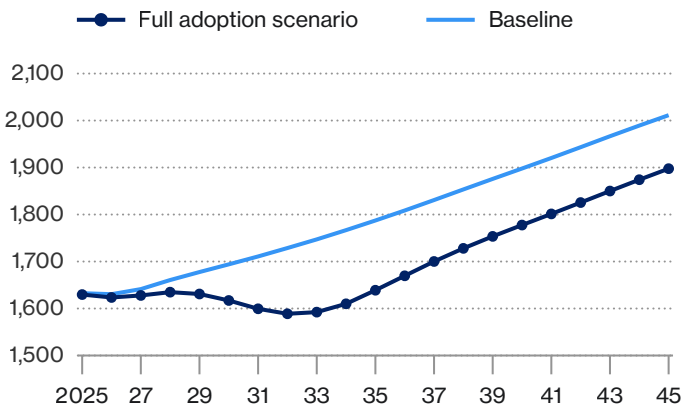
Demand recovery limits negative hit to construction employment

In the construction industry we see an initial decline of about 41,000 jobs. (See Chart 10.) By contrast, our baseline scenario forecast employment growth of 96,000 jobs over this period. As tools like autonomous vehicles, robotic bricklaying, 3D-printed structures, and automated project management improve in efficiency and are adopted, it gradually reduces the overall need for workers due to the reduced labour intensity. However, construction is an industry that benefits tremendously from the demand generated by the large-scale government investments needed to assist the transition. As the economy recovers, this industry sees the strongest recovery among goods producers, adding some 309,000 jobs between 2032 and 2045. However, even with this strong growth, construction employment in the full adoption scenario lags the baseline by approximately 114,000 jobs in 2045 (5.7 per cent).

Chart 10

Construction employment recovers thanks to investments and demand recovery

(construction employment, thousands of jobs, under full adoption scenario and baseline forecast)



Source: Signal49 Research.

11 The B.C. On-Farm Technology Adoption Program has provided important investments in the industry within British Columbia to assist with the purchase and installation of automation equipment. Agriculture and Agri-Food Canada, "Automation, robotics helping farmers strengthen food security."

12 Up to a third of jobs in agriculture could be automated within the next 10 years. The Conference Board of Canada, *The Next Frontier in Canada's Agri-Food Sector.*

Automation reduces need for transportation workers, even after the rebounds

The transportation industry illustrates most clearly the tension between automation potential and pacing. With full adoption, robotics and autonomous vehicles equipped with AI can deliver outsized efficiency gains and eliminate the need for drivers and warehousing staff entirely.[13] The growth of Waymo, for instance, points to a future where the need for workers in taxi services could be impacted.[14] Autonomous rail rapid transit and shuttles (which are being piloted in some Canadian cities) will reduce demand for bus drivers and subway operators.

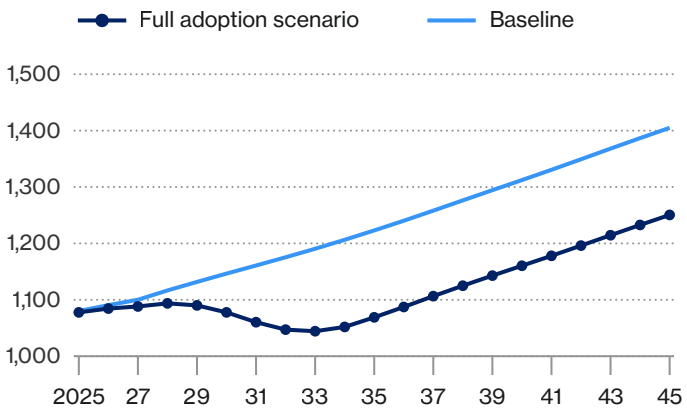
There are relevant questions about the costs of replacing an entire fleet of vehicles, or the infrastructure requirements to fully automate transit, all of which would limit the actual realized productivity gains. Our full adoption scenario suggests a little over 30,000 jobs lost between 2025 and 2032, followed by a rebound of more than 200,000 jobs gained in the recovery phase. (See Chart 11.)

However, the initial decline opens a permanent gap of about 150,000 jobs below our baseline forecast, indicating that the demand is insufficient to absorb the full impact of the spike in productivity. As individual worker productivity soars, there is a reduced need for drivers and operators. These new technologies may require specialized mechanics and maintenance staff, providing potential opportunities to absorb a fraction of the total employment hit.

Chart 11

Initial declines in transportation employment recover thanks to robust demand growth

(employment in transportation and warehousing, thousands of jobs, under full adoption and baseline forecast)



Source: Signal49 Research.

13 For example, Amazon has already begun employing robots within warehouses to “improve efficiency and reduce employee injuries.” Hadero, “As Amazon expands use of warehouse robots, what will it mean for workers?”

14 The technology is not limited to passenger transport. Gatik AI Inc. recently announced it has secured contracts and is actively operating completely autonomous freight trucks that run 24 hours a day. Reuters, “Self-driving truck firm Gatik secures $600 million in contracted revenue.”

Government investments result in an expansion in the public service

Public administration and defence employment expands as governments invest heavily in services and national security. (See Chart 12.) In the initial period, during the largest declines in employment, this still results in a reduction of about 66,000 workers. This is consistent with the current trends toward reducing the size of the public sector, even slightly accelerating with 21,000 fewer public servants in 2032. Once the government spending and investment start to take hold in 2033, the sector adds roughly 230,000 jobs.[15] This increase is in line with the total change in public administration employment between 2000 and 2020.[16]

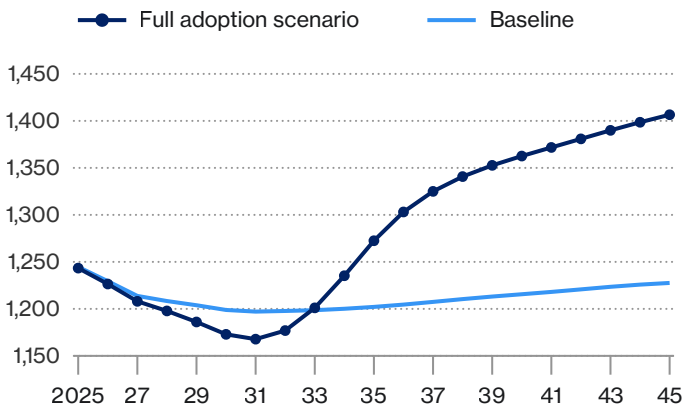
Routine tasks like processing applications and tax filings can be unloaded to automated processes, and enhanced cybersecurity monitoring can be deployed for detecting threats and improving operational efficiency, but the public service still requires humans to interact with citizens day to day.

While some of this employment growth will likely be allocated to growing the federal workforce to provide essential services during the transition, the large investments in defence spending will result in much greater numbers of operations members and officers in the armed forces.

Chart 12

Employment in public administration grows as government adjusts investment priorities

(employment in public administration and defence under full adoption scenario and baseline forecast, thousands)



Source: Signal49 Research.

15 In comparison, our baseline forecast suggests the government will add only about 30,000 jobs over this same period.

16 More recently, employment in public administration grew by approximately 251,000 jobs between 2020 and 2025.

Government spending supports growth in healthcare and education employment

Healthcare employment is supported by the government investments. (See Chart 13.) The industry adds almost 1.3 million jobs between 2025 and 2045. The government investments act as a growth accelerant. Between 2025 and 2032, the sector adds about 132,000 fewer jobs than our baseline forecast. As government action speeds up, the sector adds almost 1.1 million more jobs between 2032 and 2045, increasing employment in 2045 by 136,000 relative to baseline.

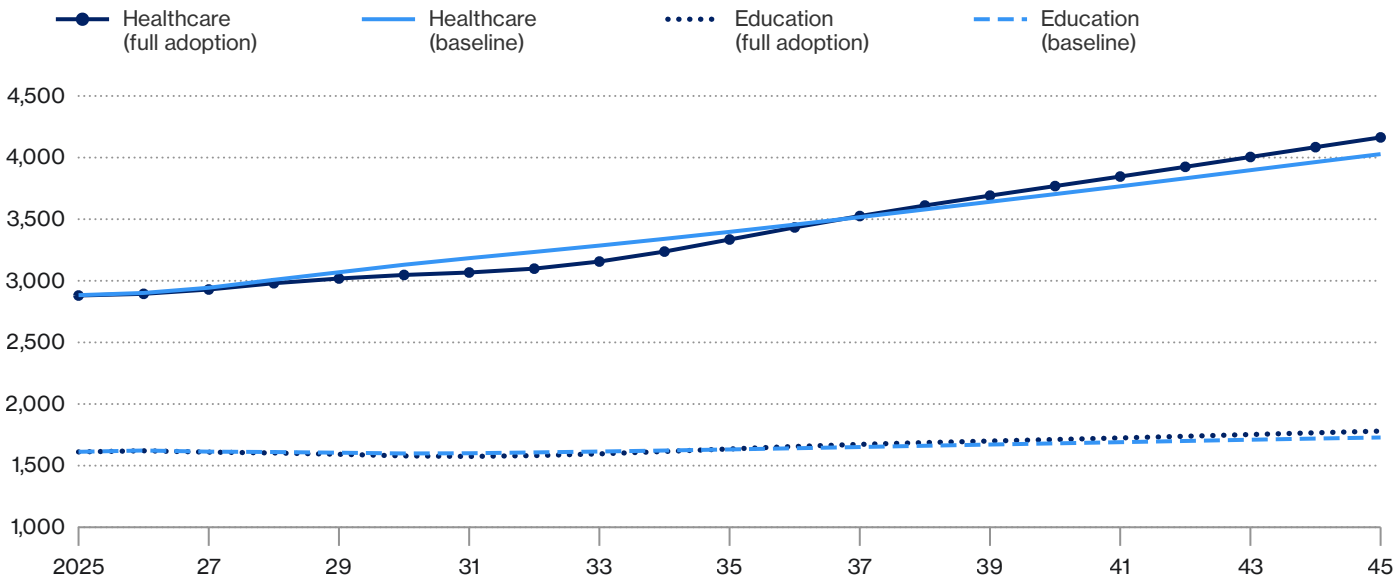
Education also sees some growth, though not to the degree of healthcare. After an initial loss of 30,000 jobs between 2025 and 2032, employment rebounds and adds almost 200,000 jobs by 2045.[17] While AI tools may prove to be ubiquitous in the classroom in the decades to come, the need for teachers, support staff, and administrators will grow in this new landscape. Some of the demand for educational services will be driven by a need for retraining programs to help retrain displaced workers, and for redeveloping post-secondary curricula to equip young Canadians entering the workforce with the skills and knowledge needed to be impactful with these new technologies.

To be clear, automation in the healthcare sector is still very present—taking over repetitive tasks and assisting with speeding up decision-making—reducing worker burnout. Automated scheduling, processing patient in-take forms, and AI tools for reading medical scans will likely mean the workforce can deliver services more efficiently, reducing existing backlogs and wait times. But patients may want to continue interacting with human doctors, nurses, and support staff, and demand for these services grows sharply as the population ages. Investments in healthcare are expected to be treated as a policy priority by government over the recovery period.[18]

Chart 13

Additional spending in healthcare and education delivers employment gains

(employment in healthcare and education, thousands of jobs, under full adoption scenario and baseline forecast)



Source: Signal49 Research.

17 Relative to baseline, there are 78,000 more jobs added over this period.

18 Other research has attempted to quantify occupational exposure to AI while controlling for physical and social factors. The importance of face-to-face interactions in occupations such as physicians or trial lawyers limits the overall exposure. Pizzinelli and others, *Labor Market Exposure to AI*. Cross-country analysis of attitudes toward AI also indicates that Canadians demonstrate lower levels of trust and acceptance toward AI. Gillespie and others, *Trust, attitudes and use of artificial intelligence*.

Commercial services drive the future of employment as demand recovers

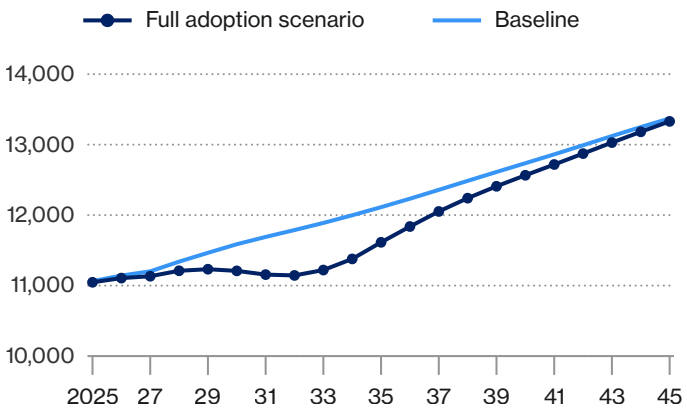
Commercial services benefit during the recovery as demand for services grows. (See Chart 14.) Financial, professional, and information services all see employment gains as disposable incomes grow with the recovery. In these sectors, automation and AI help accelerate analysis, drafting reports, customer service, and back-office processing, while leaving core tasks that rely on judgment, ethics, and relationship-building to people. Robust demand growth for these services will result in an expanded workforce in these industries, offsetting the automation job losses due to productivity growth. The commercial services sector absorbs all impacts of automation and returns to the baseline scenario for employment but with greater demand for and productivity from each of those workers.

As disposable incomes grow, demand for these services grows beyond the productivity gains, necessitating a hiring boom. For instance, household spending on financial services grows by 108.1 per cent between 2025 and 2045. (See Table 5.) Growth in household spending on transport services and recreation also contributes to much of the growth in employment across the services sector.

Chart 14

As disposable incomes grow, employment across commercial services accelerates

(employment in commercial services, thousands of jobs, under full adoption scenario and baseline forecast)



Source: Signal49 Research.

Table 5

Household spending on services drives employment growth in financial services

Type of service	Household spending growth, full adoption, 2025–45 (per cent)	Household spending relative to baseline, 2045 (per cent)
Transport services	81.1	8.0
Recreation and culture services	70.1	19.7
Food and beverage services	46.2	5.8
Insurance, financial, and legal services	108.1	15.4
Education, healthcare and personal services	65.7	11.7

Source: Signal49 Research.

This growth in demand is also the key driver for the employment growth in financial services. Between 2025 and 2045, the industry adds about 373,000 jobs.[19] (See Table 6.) At the end of our series, employment in the industry is almost 67,000 jobs higher than baseline (3.7 per cent). Financial analysts, real estate agents, and insurance agents use AI as a tool to accelerate the speed and volume of work they can perform. However, actual workers are still needed to interpret the results and communicate with clients. As households increase their spending on insurance and financial services, the need for workers to meet this demand grows.

Employment growth in professional services is in part driven by the increased government spending on defence, education, and healthcare. The industry adds about 924,000 jobs over the next 20 years, about 34,000 jobs higher than what our baseline forecast suggests. By 2045, employment is 31,000 higher than baseline (1.1 per cent). Paired with the real wage gains over the same period (about 24 per cent), this points to the potential role for policies aimed at re-skilling workers and facilitating matching high-skilled candidates to fill these jobs.

Cultural services and accommodation and food services also see employment growth, increasing by a combined 390,000 jobs.[20] As households increase their discretionary spending (e.g., dining out more often and attending concerts), employment in these industries grows considerably, with employment in 2045 being almost 50,000 higher than our baseline (an increase of 2.1 per cent). These are also areas that are less exposed to automation technology overall, and beyond AI have little exposure to the other technology clusters we analyzed.

Table 6
Growing demand drives employment growth in commercial services, particularly in financial services and professional services

Type of service	Net change in employment, full adoption, 2025–45	Net change in employment, baseline, 2025–45
Wholesale and retail trade	216,678	257,054
Financial services	372,917	304,248
Professional services	924,756	890,699
Building and other support services	129,576	126,565
Information, culture, and recreation	43,830	5,998
Accommodation and food services	346,201	331,684
Other services	76,223	67,898

Source: Signal49 Research.

19 By comparison, our baseline scenario forecasts employment in financial services will be about 306,000 jobs over this period.

20 Our baseline forecast sees these industries adding a little over 337,000 jobs combined between 2025 and 2045.

Actionable insights

Technology-driven changes are already a reality of the modern workplace.[21] The question is how to best prepare our economy and society for that change. Broadly speaking, this extreme scenario highlights two competing priorities—harnessing faster growth and minimizing the negative impact on employment. If the costs and barriers to adopting these technologies can be minimized while proactively equipping and preparing workers for the transition toward a more technologically advanced, knowledge-based service economy, the pain of the deepest automation-induced employment trough can be minimized.

Full automation adoption could create a richer, more productive economy and raise incomes, but it would also be a difficult and painful transition for many. The recovery will take time. Pragmatic policy will have a crucial role to play as a stabilizing force, helping firms execute structural change while guiding workers toward expanding sectors. Handled well, the gains from automation will arrive sooner and be shared more broadly. Steps we can take to achieve this outcome include the following:

Increased federal spending on healthcare, education, and defence is key to mitigating the negative impacts of rapid technology adoption.
The federal government plays a vital role in our scenario, responding to the cooling labour market proactively. Our full adoption scenario requires sizable spending and investments by governments. These should be seen as mandatory to ensuring that the Canadian economy can absorb the magnitude of this productivity shock. Investments, focused on healthcare, education, and defence, can absorb some of the displaced labour and generate spillover effects across industries that would help jumpstart aggregate demand.

Immigration policy coordination could reduce unemployment.
Our scenario also makes no adjustment to existing immigration levels. Considering the potential disruptions to labour markets that our full adoption scenario presents, it would be prudent to proactively adjust immigration policy to ease the pressure on labour markets. Reducing immigration levels during the initial downturn will help to ease labour market pressures.

A federal automation strategy could accelerate adoption, as well as anticipate and mitigate negative effects.
A robust national automation strategy could enact safeguards before the transition is fully under way. Countries developing strategies focused on the impacts of AI are exploring vocational programs that target the most at-risk workers.[22] A coordinated strategy aimed at supporting automation technologies, particularly in sectors where Canada can gain a competitive advantage, while also putting in supports to protect and assist vulnerable workers, will allow us to put our resources where they're needed as technologies change.

For example, our scenario shows that there is important growth potential in financial services and professional and technical services. Canada has one of the G7's most educated and credentialed populations. Canada could become a major player as a financial service and research and development powerhouse if workers can be moved into these high-skilled, high-value service jobs efficiently. Expanding the Canada Retraining and Opportunities Initiative to train and upskill workers with a focus on the industries that will be most in need of workers in the coming years is one step toward seizing the opportunity.

21 Responses to the Canadian Survey on Business Conditions in 2025 suggest that 18 per cent of businesses had plans to adopt software using AI in the next year. Also, 10 per cent of responses had plans to automate specific tasks in the next year. Statistics Canada, "Table 33-10-1000-01."

22 Examples of proactive policies, including training programs and tax credits, are already being considered or enacted in Lithuania, Spain, Finland, Italy, and Germany. These policies are largely aimed at training the workforce with AI literacy and skills. In Norway, the government is working with employers to develop a system of industry-specific programs. OECD, "OECD Employment Outlook 2023."

Monetary policy could accommodate productivity-driven wage inflation.
It is also important that the Bank of Canada allow for some wage inflation. Rising wages are an important feature of adjustment in this scenario, supporting the demand recovery following the initial policy response. Monetary and fiscal policy should be coordinated to avoid over-tightening while the economy is still absorbing displaced workers.

Suppressing wage growth could blunt the demand response and prolong unemployment. A key insight from our scenario is the strong economic growth brought on by the gains from automation translates into higher incomes.

Provincial governments can work to improve labour mobility.
While a coordinated national strategy is important, provincial governments are better positioned to directly address potential impediments to economic and employment growth. Policies to accelerate labour reallocation will be most effective if they focus on training, re-skilling, and addressing labour mobility barriers. Interprovincial barriers, particularly with respect to credential recognition, have already been identified as an impediment to growth in Canada.[23] If workers are going to transition quickly into high-value services sector jobs, removing unnecessary red tape and impediments to enable them to quickly find employment in the industries and regions where they are most needed will help reduce the economic pain.

Provincial governments would play a critical role in re-skilling displaced workers for emerging roles.
Equipping displaced workers with the knowledge and skills they need to adapt quickly is essential, and provincial governments can play a vital role in assisting the transition by making the investments in training programs and identifying pathways to help workers transition. Working with post-secondary institutions to ensure that graduates have the requisite training and experience to work effectively in conjunction with these technologies upon entering the labour market will maximize their impact.

Unions can help their members through the transition by contributing to and promoting re-skilling programs.
Working with unions to provide coaching and retraining for workers displaced by automation to equip them with in-demand skills in industries like manufacturing will also serve to ease the transition.[24] Active participation from unions in promoting and developing training programs to ensure that workers have both the financial supports they need to stay afloat and lowering barriers to re-skilling are potential pathways to minimize the long-term economic impacts from prolonged unemployment.

Improved labour market information systems will help displaced workers identify new opportunities.
Beyond skills gaps, barriers that prevent the right workers from finding the right roles will also slow recovery. Real-time labour market information systems can help to identify potential gaps and opportunities. This can help inform how to best develop re-skilling programs to help workers adapt to new roles, as well as to facilitate the identification of new and emerging occupations with the greatest potential for growth.

23 The Macdonald-Laurier Institute estimates that eliminating internal trade costs, such as by adopting mutual regulatory requirements across provinces, could increase interprovincial migration by as much as 1.7 per cent, and add as much as $200 billion a year to the Canadian economy. Manucha and Tombe, *Liberalizing internal trade through mutual recognition.*

24 Job security councils have been a feature of the Swedish economy since the 1970s. Their purpose is to assist with smoothing job transitions and ensuring employment security. Trade Union Advisory Committee to the OECD, "The Swedish Job Security Councils."

A shift in business investment would be required for technology adoption to accelerate.

Our scenario does not try to estimate the additional investment required to realize the increase in adoption. In reality, increased business investment would be needed to generate the productivity growth that we describe. Lacklustre private investment has long been a weakness for the Canadian economy.[25] The potential gains to Canada can be realized only if the investment puzzle is solved.

Policies aimed at eliminating uncertainty and that promote Canada as a stable and reliable investment environment would help to unlock the productivity potential we have identified. Regulatory burden in Canada has been found to dampen both employment growth and GDP growth.[26] Removing unnecessary regulation, and streamlining regulations where feasible, will contribute to making Canada a more attractive destination for investment.

Similarly, tax reform aimed at improving competitiveness is another channel to promote business investment, hindering the growth of start-ups and SMEs.[27] A review of how capital gains are taxed could help incentivize greater investment. Working with start-ups and SMEs to manage the costs and uncertainty of adoption, possibly through grants, tax credits, and favourable capital gains tax rates, will also help drive growth.

Finally, improving competition and business dynamism will contribute to developing a more innovative ecosystem, and further encourage investment. Businesses that face more competition tend to be more innovative.[28] The lack of innovative activity in Canada is another contributing factor to weak investment, ranking below the OECD average in R&D intensity.[29] Eliminating competitive barriers and fostering a dynamic, innovative business environment is a promising path toward improving private investment.

25 Business investment per worker has declined in recent years. As of 2025, Canadian investment per worker is about 55 per cent of that in the United States. Bafale and Robson, “Canada’s Investment Crisis.”

26 A Statistics Canada study has found that the growth in regulations in Canada between 2006 and 2021 is associated with GDP growth being 1.7 percentage points lower, and with employment growth being 1.3 percentage points lower. Gu, “Regulatory accumulation, business dynamism and economic growth in Canada.”

27 In a survey of 250 business leaders in Canada, KPMG found that 72 per cent stated that Canadian tax policies do not provide sufficient incentive to invest, while 88 per cent responded that changes to the capital gains tax rate would promote investment in Canadian start-ups and SMEs. Also, 91 per cent stated that governments should pursue tax policies aimed at promoting investment and accelerating the adoption of innovative technologies like AI. KPMG, “Canadian businesses want tax system to drive investment, economic resilience.”

28 Statistics Canada found that roughly 8 per cent of businesses with at least 11 competitors in their main market reported introducing innovations between 2020 and 2022, while approximately 69 per cent of businesses with between one and three competitors reported innovative activity. Statistics Canada, “Survey of Innovation and Business Strategy 2022.”

29 Canada ranks below the OECD average with respect to R&D intensity, measured as R&D expenditure as a fraction of GDP. OECD, *OECD Main Science and Technology Indicators*.

Appendix A

Methodology

Exposure scores

Our exposure scores are computed using Natural Language Processing to compare occupation descriptions in OaSIS with U.S. Patent and Trademark Office patents from 2005Q1 through 2025Q1 to determine the percentage of tasks of a given occupation that can be performed by automation technologies. Specifically, we combine two OaSIS datasets to define tasks: 1) the main duties dataset that records the tasks that are specific to a given occupation; and 2) the work activities dataset that ranks all occupations according to their importance. Since the main duties are occupation-specific, we give them a weight similar to the highest importance score a task can receive (i.e., 5 out of 5).

Each task in the OaSIS database is compared with descriptive U.S. patent titles to determine the similarity between the task and the technology. A cosine similarity score, bounded between -1 and 1, is used to determine how similar the task is to the technology.

Undertaking this measure produces nearly 390 million task-by-patent similarity scores. To make the results tractable, we classify the technology patents into five mutually exclusive technology clusters. When the same patent falls into more than one technology cluster, it is uniquely joined to the group it is closest to. For a task to be deemed exposed, we retained a threshold of 0.4 or above. This threshold was decided by testing different values and examining patents just above and below the threshold. The 0.4 threshold appeared as the threshold least likely to exclude true positives and most likely to exclude false positives.

Task-level exposure is aggregated for each occupation at the 5-digit (NOC) level using a formula that combines two key elements: a) the intensity of innovation, and b) the extensiveness of the tasks exposed weighted by the importance of the task to the overall occupation. The intensity of innovation is expressed as the ratio of the total number of patents matching a specific task over the largest total number of matches across all tasks and technology clusters weighted by their importance. Thus, the higher the number of matches and the closer to the maximum across occupations, the higher the intensity component of exposure for this task. These intensity metrics are aggregated to the 7-digit OaSIS occupation level by taking their weighted average using the importance of the task for the occupation.

The extensiveness component of exposure is measured as the importance-weighted share of tasks in each 7-digit OaSIS occupation that is exposed to at least one patent. Exposure is then calculated as the product of these two elements. Finally, the resulting exposure scores are aggregated to the 5-digit NOC level for further analysis.

The resulting occupational exposure score is a number between 0 and 1 and can be interpreted as a percentage of the share of tasks at risk of being automated, where values closer to 1 indicate a larger number of tasks being more intensively exposed to innovation.[1]

For example, suppose Occupation A has three tasks. Tasks a, b, and c have a weighted importance score of 0.5, 0.3, and 0.2, respectively.[2] The extensiveness of exposed tasks is defined as the number of tasks exposed to at least one patent. Weighting these exposures by importance yields the following extensive exposure:

$$e_{A,extensive} = \underbrace{[0.5 \times 1(Exposed = true)]}_{\text{Task a}} + \underbrace{[0.3 \times 1(Exposed = true)]}_{\text{Task b}} + \underbrace{[0.2 \times 1(Exposed = false)]}_{\text{Task c}}$$

$$e_{A,extensive} = \underbrace{[0.5 \times 1]}_{\text{Task a}} + \underbrace{[0.3 \times 1]}_{\text{Task b}} + \underbrace{[0.2 \times 0]}_{\text{Task c}} = 0.8$$

Eighty per cent of the work activities and duties of Occupation A are thus exposed to at least one patent. To compute the intensity of exposure, we take the average number of patents matching each task weighted by their importance and normalize this number by the highest weighted average across all occupations. Say that Occupation A is exposed to 100 patents for task a, and 30 patents for task b.[3] Then the weighted average of the number of matched patents is:

$$AverageCount_A = 100 \times 0.5 + 30 \times 0.3 = 59.$$

1 Note that, given our definition, for an occupation to receive an exposure score of 1, it would first need to have all its tasks exposed to at least one patent, and the number of patents matching these tasks would have to be the highest among all other occupations.

2 Weights are normalized so they add to 1. In this example, the importance scores are, respectively, 5, 3, and 2. Conversely, if the three tasks had a score of 2, then their corresponding weight would be of one-third each. This normalization pre- or post-calculation is required to have extensive values bounded between 0 and 1.

3 Recall that task c is not exposed to any patent.

To get the intensity we normalize this number by the value that is the highest among all occupations. Say that this value is 295 for some other occupation in our dataset. Then the exposure intensity is given by:

$$e_{A,intensive} = \frac{59}{295} = 0.2$$

The exposure score of Occupation A is then the product of these two components:

$$exposure_A = \underbrace{0.2}_{e_{A,intensive}} \times \underbrace{0.8}_{e_{A,extensive}} = 16\%$$

meaning that 16 per cent of tasks for Occupation A are exposed on average when accounting for the share of tasks being exposed, their importance, and degree of patent intensity.

At the industry level, we aggregate occupation-level exposures across all occupations within an industry (and within a province) at the NAICS 3- or 4-digit level, weighted by each occupations share of employment within an industry. For a given industry i within province p, the exposure score is computed as

$$c_{i,p} = \sum_{a \in NOC} e_A \times \frac{Employment_{a,i,p}}{\sum_{j \in NOC} Employment_{j,i,p}}$$

Thus, if Industry X in Ontario is composed of one worker from Occupation A with an exposure score of 0.2, and two workers from Occupation B with an exposure score of 0.6, the resulting exposure score is

$$c_{X,ON} = \left(0.2 \times \frac{1}{3}\right) + \left(0.6 \times \frac{2}{3}\right) = 0.47$$

We aggregate by industry and province for two reasons. First, to allow us to control for province-specific factors that affect the estimation of productivity growth. Second, to allow for differences in the occupational composition of industries across provinces. So, while we do not assume that there is a difference of the level of exposure between "data scientists" in any industry or province, we do allow for the possibility that data scientists may account for a greater proportion of employment within a given industry in Ontario than in Alberta, which affects the relative exposure scores computed.

Productivity gains

To estimate productivity gains, we employ a standard production function used in the economics literature to estimate the relationship between real value-added growth within an industry (3- or 4-digit NAICS) and province between 2005 and 2020 and exposure scores, controlling for changes in hours worked, province, and sector (2-digit NAICS). We use Statistics Canada tables 36-10-0402-01 and 36-10-0489-01.[4]

This structure assumes that by controlling for changes in inputs (hours worked) and long-run changes in the economic environment (by controlling for province and industry), the impact of exposure scores is interpreted as the contribution to productivity growth. By using real value added, we avoid confounding changes in prices with changes in productivity.

For the estimation on historical data, we restrict our sample of patents to those between 2005 and 2020 to avoid adding unnecessary statistical errors due to patents from outside the sample years.

We employ a weighted least squares regression using the functional specification

$$\log \Delta GDP_{i,p} = \beta_0 + \beta_1 c_{i,p} + \beta_2 \log \Delta Hours_{i,p} + \delta_s + \delta_p + \epsilon_{i,p}$$

where $\log \Delta GDP_{i,p}$ is the log change of GDP (value added) of industry i in province p between 2005 and 2020, $c_{i,p}$ is the exposure score of industry i in province p, $\log \Delta Hours_{i,p}$ is the log change of hours worked in industry i in province p between 2005 and 2020, and δ_s and δ_p are controls for 2-digit industry codes for sector s and for province p. Observations are weighted by industry and province employment shares.

The resulting estimates $\widehat{\beta_1}$ are then adjusted with the estimated standard errors. Larger standard errors, which reflect less precise estimates, lead us to lower the expected impact proportionally to their size so as not to overstate the true effect.

To give us our forecast of 15-year productivity growth, we compute $\widehat{\beta_1}\ \tilde{c}_{i,p}$, where $\tilde{c}_{i,p}$ is exposure score derived using patent data from 2005 to 2025 to incorporate the most recent technological innovations in our estimates. We apply our productivity estimates $\widehat{\beta_1}$ to the most aggregated industry-level exposure scores.

4 Statistics Canada, "Table 36-10-0402-01"; and Statistics Canada, "Table 36-10-0489-01".

Appendix B

Capturing the technology impacts with MTFM

We relied on our large-scale macroeconomic model of the Canadian economy—the national Medium-Term Forecasting Model (MTFM)—to assess the impact of the full technology adoption assumptions. The MTFM simulation is produced over the 2025–45 period, a 20-year horizon that helps us better understand how the economy may respond to a generational shift in the path of productivity growth.

Initial research on the implications of technology adoption across a wide range of detailed occupations was used to inform industry-level labour productivity shocks aligned with MTFM's employment categories. Labour productivity was increased by varying but substantial amounts across industries. At the lower end, industries such as education (+7.5 per cent), accommodation and food services (+9.5 per cent), and healthcare (+10.9 per cent) experience more modest gains, while at the higher end, manufacturing (+19.3 per cent), other primary industries (+20.3 per cent), and transportation, storage, and communication (+21.6 per cent) see much larger increases. (See Table 1.)

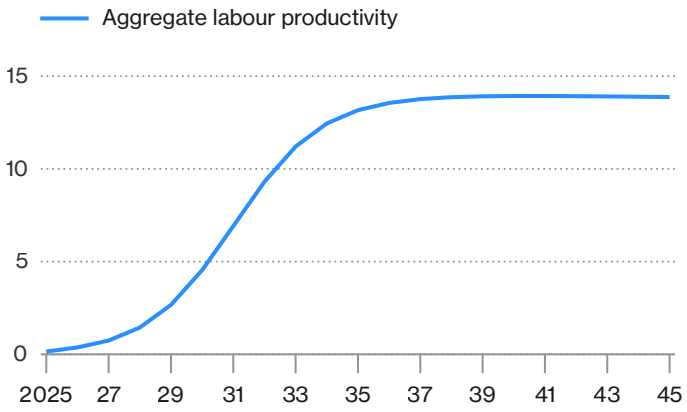
Table 1
Total labour productivity, percentage increase from baseline

Industry	Labour productivity increase (per cent)
Economy wide	**13.8**
Agriculture	15.8
Other primary	20.3
Manufacturing	19.3
Construction	16.9
Utilities	16.3
Wholesale and retail trade	12.5
Transportation and storage	21.6
Finance, insurance, and real estate	9.1
Professional, scientific, and technical	11.3
Building and other support services	13.8
Information, culture, and recreation	11.3
Accommodation and food services	9.5
Other services	13.7
Education	7.5
Healthcare	10.9
Public administration and defence	11.6

Source: Signal49 Research.

The potential for artificial intelligence and other technologies to lift productivity is large; however, the speed of adoption remains uncertain. The productivity increases applied in MTFM were assumed to occur over time, following an S-shaped adoption path. The adoption curve is held constant across industries, with most of the acceleration in productivity gains occurring between 2028 and 2035. (See Chart 1.)

Chart 1
Economy-wide pace of adoption accelerates from 2030 to 2035
(aggregate productivity increase in percentage change, 2025–45)



Source: Signal49 Research.

The increase to industry-level labour productivity immediately boosts Canada's productive capacity. For businesses, unit labour costs decline in step with the pace of technology adoption, which boosts profits and investment, and quickly lifts real GDP. Initially, demand for goods and services fails to keep pace with the gains in productive capacity, creating a transitional imbalance that results in job losses in comparison to the baseline. Employment declines and so does total labour income in the first years of the simulation. Over the medium term, real wages re-align with productivity gains, in line with historical links. This helps total labour income recover and, by 2034, surpass levels in the baseline, even if employment levels are still down by over a million jobs in that year.

The unemployment rate impact peaks in 2033, rising by about 4.5 percentage points relative to baseline, while the labour force participation rate declines during the period of labour-market disruption. It is important to note that immigration assumptions and population growth are not altered in this scenario. As a result, labour-market adjustment occurs through changes in employment, unemployment, and participation rather than through population dynamics. These dynamics reflect cyclical withdrawal from the labour force rather than changes in underlying population or migration trends, which remain exogenous to the simulation.

The lift to productive capacity results in a widening of the output gap—a situation where actual output falls below potential. The excess capacity leads to a reduction in inflation. MTFM incorporates a Taylor[5] rule that mimics central bank policy changes. As economic activity slows and inflation eases, the rule implies policy-easing, with the Bank Rate lowered and rates moving down across the yield curve. This automatic mechanism is one of the ways in which MTFM helps to boost economic activity to close the output gap.

With respect to fiscal policy, most spending measures in MTFM are exogenous—that is, determined outside the model and generally aligned with policy announcements incorporated in federal and provincial budgets. There are automatic stabilizers, such as Employment Insurance, income-tested transfers, and the cyclical response of tax revenues, which adjust in line with changes in employment and income.

However, on their own, automatic stabilizers within MTFM are not sufficient to address a situation in which labour is so radically disrupted. As such, we include an exogenous lift to spending from federal, provincial, and local levels of government. These increases are assumed (policy-motivated rather than mechanical) and are facilitated by increased revenues, as nominal GDP is bolstered, and by lower financing costs due to the decline in bond yields.

It is reasonable to assume that, in a scenario where government revenues are rising sharply while employment is considerably disrupted, fiscal policy would become highly stimulative. In line with job losses, we increase federal health and social transfers to provinces, alongside higher federal direct spending on defence and public infrastructure. Provincial government spending on healthcare, education, and infrastructure is also raised relative to the baseline, and local government infrastructure spending is increased as well. In addition, we assume a 1 percentage point reduction in the federal goods and services tax beginning in 2035.

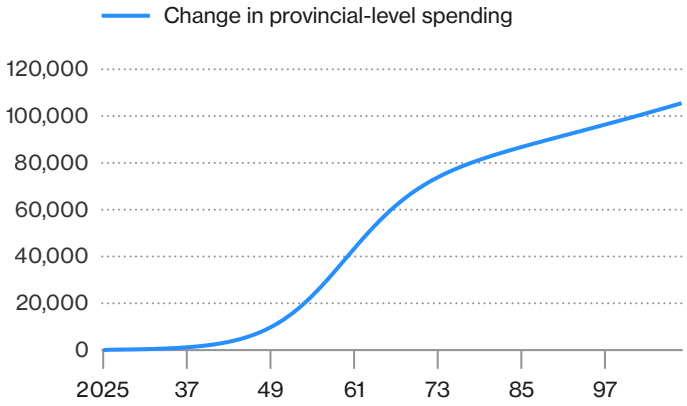
These spending measures are modelling assumptions rather than explicit policy forecasts. It is certainly possible that governments would also introduce additional direct support to households. However, given the nature of the shock, a policy focus on retraining and re-skilling displaced workers appears more plausible, alongside continued emphasis on healthcare, defence, and infrastructure as persistent policy priorities.

The lift to government spending is substantial. Supported by an increase in federal transfers, total provincial-level program spending rises steadily, in line with gains to nominal GDP—an increase of roughly 13 per cent relative to the baseline. (See Chart 2.)

Chart 2

Federal transfers boost total provincial spending

(increase in provincial-level spending on healthcare, education, and social services, $ millions)



Source: Signal49 Research.

5 The Taylor rule is a monetary policy guideline that links the policy interest rate to deviations of inflation from its target and economic activity from its potential. While the Bank of Canada does not follow a mechanical policy rule, Taylor-type rules are widely used to emulate central bank policy. Fung and others, *Taylor Rules in the Quarterly Projection Model.*

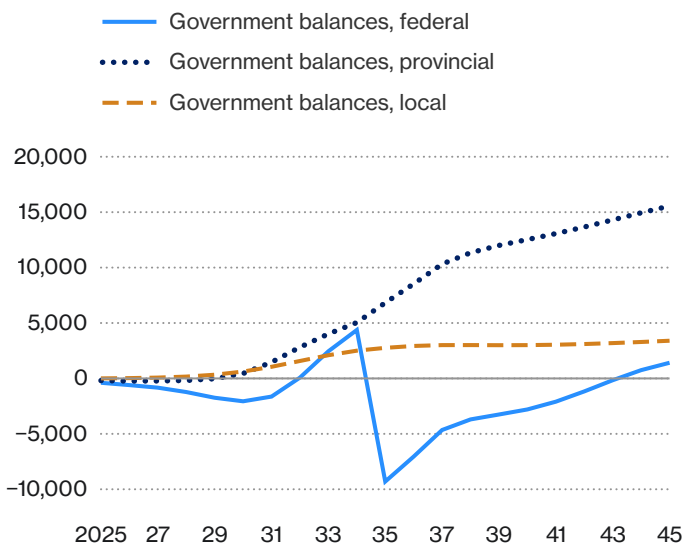
Two forces help contain fiscal strain despite the substantial support: lower financing costs and higher nominal GDP as productivity lifts output and incomes. In combination, these effects keep the medium-term fiscal position from deteriorating markedly. As such, the impact on the fiscal situation for the various levels of government does not deteriorate meaningfully over the medium term and, in fact, improves over the long term. (See Chart 3.) Including the lift to nominal GDP, total public sector debt as a share of GDP is down by 3 percentage points relative to the baseline.

The adoption shock raises labour productivity, lowering unit costs and lifting margins. Corporate profits respond quickly, with pre-tax profits surging and peaking at roughly $79 billion above baseline around 2035 before easing somewhat thereafter. Increased profits coupled with lowered financing rates helps bolster business investment.

Chart 3

Full automation scenario dramatically improves fiscal situation over the long term

(government balances, C$ millions)



Source: Signal49 Research.

Real GDP rises relative to the non-adoption baseline early on and remains higher through the horizon. In level terms, the economy is about 5.8 per cent above baseline by 2034 and 11.7 per cent higher by 2045—a very large cumulative gain by historical standards. The path is not costless, however—employment falls to a trough in 2033 of roughly 1.2 million jobs below baseline (about 5.3 per cent) before gradually recovering thereafter. As real wages re-align with productivity, total labour income moves back above baseline by 2034 and widens further over the long term.

Monetary policy settings move in the direction implied by the model's policy rule as excess capacity opens up and inflation pressures ebb. The Bank Rate declines materially—by about 2.6 percentage points at the widest point in 2036, and still roughly 2.1 percentage points lower than baseline by 2045—with associated easing across the curve. Headline inflation runs below baseline as the output gap widens and then narrows, leaving the Consumer Price Index inflation rate lower by about 0.4 percentage points by 2045. These dynamics provide additional support to demand during the transition and help the economy absorb the technology shock.

Domestic demand does the heavy lifting over the simulation horizon. By 2045, final domestic demand is roughly $508 billion (2017$) above baseline, led by household consumption (about $283 billion) and business investment (about $89 billion), with government consumption also higher (about $118 billion). In contrast, net exports subtract from growth as the expansion draws in imports—the real trade balance is down by $17 billion by 2035 and widens to around -$96 billion by 2045. These patterns are consistent with the stronger import gains due to the investment and consumption-led expansion.

The employment trough occurs in 2033, when the largest declines versus baseline are concentrated in more trade-exposed or goods-producing segments: wholesale and retail trade (about -185,000), construction (about -155,000), transportation and storage (about -146,000), and manufacturing (about -137,000). Through the recovery and into the 2040s, domestic demand lifts services activity enough to offset productivity gains in many parts of the economy—by 2045, employment levels are well above baseline in public administration (about 178,000), healthcare (about 135,000), finance, insurance, and real estate (about 67,000), education (about 52,000), and information, culture, and recreation (about 37,000), with professional, scientific, and technical services also higher (about 32,000).

Appendix C

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