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Mushrooms and Yeast: The Implications of Technological Progress for Canada's Productivity

Technological change is a prerequisite for long-term economic growth, creating winners and losers in unpredictable ways. What are the implications for policymakers?

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The Study In Brief

Whether Canadians talk about income inequality, regional growth and technological change, it is clear that economic growth is not uniformly spread across the country. Canada is not unique in this regard: modern economic growth theory shows that economies grow like mushrooms, not yeast. Instead of expanding uniformly like bread in the oven, economic growth pops up sporadically like mushrooms in the forest bed.

Economic growth is a process of unpredictable "creative destruction" in which there will be winners and losers. The policy discussion around this kind of growth has often focused on the consequences for those left behind by change. It is often easier to identify those who lose from technological changes, while the winners are diffuse.

Policymakers should also think more about harnessing uneven economic growth. From international trade to education policy, this *Commentary* shows how governments should think about the mix of targeted and economy-wide policies they should introduce to grow the Canadian economy.

With increased international trade, Canadians as a whole will benefit not only from lower prices, but also from the more rapid productivity growth that will result from increased innovation by domestic firms as they seek to compete against foreign firms that can enter the Canadian market.

Exchange-rate movements have many conflicting and uncertain effects on both the level and growth rate of domestic productivity. Since monetary policy cannot affect the real exchange rate in the long run, the Bank of Canada should continue to focus not on the exchange rate, but on its inflation target.

Existing small business tax preferences are unlikely to promote productivity growth. Job creation is fostered not by small businesses per se, but by the young businesses that are the agents of creative destruction.

The Canadian telecommunications industry is ideally suited to benefit from enhanced innovation and productivity growth in the event of a serious threat of entry by foreign firms large enough to enjoy significant scale economies. To take advantage of that possibility, the federal government should eliminate foreign ownership restrictions in the industry.

Universities should also pursue independent research programs that foster basic science. Community colleges should focus on giving workers the skills they need to work with the most up-to-date technologies.

With growth comes change, and it is time that Canadian policymakers think about how that change occurs and how best to use it for the benefit of Canadians.

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Technological progress is never spread evenly across different regions and industries, so the growth rate of productivity, which ultimately depends on technological progress, always varies across sectors.

To use Harberger's (1998) metaphor, productivity grows like mushrooms, not yeast; instead of expanding uniformly like bread in the oven, it pops up sporadically in particular sectors, like mushrooms in the forest bed. Likewise, technological progress affects firms and people in different ways. New technologies create fortunes for some, while rendering obsolete the skills, products and processes on which others' livelihoods depend. Indeed, the history of technological change since the Industrial Revolution has been one of lives uprooted by new techniques and machines, and of sometimes violent conflict between proponents of new technologies and victims of obsolescence.

The reallocation and redistribution caused by technological change can make national policies difficult to evaluate. Many policies affect the pace, nature and direction of technological change. The resulting gains in some sectors must be balanced against losses in others. Given that technological change is a prerequisite for long-run economic growth, it is important for those who are proposing, implementing and evaluating policies in a healthy, growing economy not to focus exclusively on a particular group of winners or losers, but to keep the overall picture in mind. Reallocation and redistribution can also make economic events difficult to interpret. For example, a broad, non-targeted policy to subsidize innovation throughout the economy might result in productivity growth in one or two industries that were poised to take advantage of the subsidies. When this happens, it might seem as if the underlying cause of the burst of productivity was something specific to these industries, whereas in fact it resulted from a national policy affecting all industries.

This *Commentary* draws on the modern theory of innovation-based economic growth – see, for example, Aghion and Howitt (2008) – to explore the policy implications that follow from the unevenness of technological progress. It focuses in particular on

- the consequences for Canadian economic growth of the Comprehensive Economic and Trade Agreement with the European Union;
- how exchange-rate movements affect economic growth;
- how tax preferences for small businesses could be reformulated to promote economic growth;
- how Canada could gain from eliminating foreign ownership restrictions in the telecommunications industry; and
- the appropriate division of labour among universities, community colleges and businesses in developing the human capital appropriate for a growing economy.

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More broadly, these five examples show that, rather than focusing on supporting specific industries, as recent Ontario policies seem to be moving toward – see, for example, Ontario (2013) – governments should encourage economic growth through a process of creative destruction.

Theory and Evidence

Mushrooms and Yeast

Productivity in the overall economy is the size-weighted sum of productivities across different industries. Harberger (1998) showed that, over any five-year period, the growth of aggregate productivity in the United States is fully accounted for by the growth in a subset of industries representing less than half the economy. Moreover, those industries are rarely the same from one five-year period to the next.

The sectoral distribution of productivity growth is not only uneven; it is also unpredictable, because it depends on the distribution of technological change, which is notoriously difficult to predict. As Rosenberg (1982) has emphasized, the most fruitful use of newly discovered fundamental ideas is often far from what the inventor intended or predicted. For example, when US scientists first discovered how to produce a laser beam, the Bell Telephone Company, in whose labs the discovery was made, did not bother to patent the discovery because management could see no conceivable use for the tool in telecommunications. Thus, even if broad national policies have a predictable effect on the economy-wide rate of innovation, the resulting increase in productivity growth will be uneven and unpredictable across sectors. This unevenness creates losers as well as winners, because resources shift, either away from the sector where productivity is rising, as has happened over the years with the agricultural sector, or toward the sector where it is occurring, as has happened in the information technology (IT) sector, depending to a large extent on the nature of the change and on the income and price elasticities of the goods produced in the affected sector.

For example, a product innovation that introduces a new good will shift resources away from producing the goods that are being replaced, and towards the new good. On the other hand, a process innovation that reduces the cost of producing already-available goods might shift resources away from the industry if the fall in price and the resulting increase in peoples' real incomes do not increase industry demand by much. In this case, the improved technology will allow producers to satisfy a slightly higher demand with the use of fewer resources, which are then freed up for use in the rest of the economy. In either case, the incomes of those working in, or owning capital specific to, the expanding sectors will rise, while the incomes of those linked to shrinking sectors will fall.

Resource reallocation induced by technological change is a necessary part of the growth process. Without it, society would not enjoy much of the benefit that technological change makes possible. Indeed, without resource reallocation, more than half the population would still be working in agriculture, and all the labour and capital needed to produce modern consumer goods, capital equipment and so on would have to come from population growth and new savings.

Creative Destruction

Economic growth also entails what Schumpeter (1942) called "creative destruction," meaning that the new technologies that improve living standards typically render older technologies obsolete. When a firm gains a competitive advantage over its rivals as a result of some process or product innovation, resources will be reallocated between the firms in that sector. This implies that turnover of firms is one of the positive correlates of economic growth. A dynamic economy in which technological progress is occurring at a fast rate is one in which new firms are continually entering with new ideas, hoping to use their innovations to steal business from

incumbents. They either succeed, in which case they might drive out incumbents, or they fail, in which case they too are likely to drop out.

Reallocation at the firm level, or even the plant level, is also a vital part of the growth process. Baldwin and Gu (2006) conclude, for example, that turnover – with some plants entering or growing while others shrink or exit – is the main source of aggregate labour productivity growth in Canadian manufacturing. Likewise, Foster, Haltiwanger, and Krizan (2001, 2006) estimate that plant-level reallocation accounts for around 50 percent of US manufacturing productivity growth and 90 percent of retail productivity growth; they also find that entry and exit account for about half of the turnover in the manufacturing sector and almost all of it in the retail sector. Syverson (2011) concludes that a substantial portion of the productivity gaps among different countries can be attributed to impediments to resource reallocation among firms.

At the same time, since new businesses are a major source of job creation and exiting firms a major source of job destruction, a rapidly growing economy also has a high rate of job creation and destruction; because of the relentless force of obsolescence, the same is true of occupational groups and industries. In a rapidly growing economy, new technologies constantly raise demand for new skills and new occupations (such as computer scientists and electrical engineers), but also reduce demand for old ones (such as typists, travel agents and booksellers).

Thus, that a particular class of firm is experiencing a high failure rate is not necessarily a sign that this type of firm is in distress and in need of government assistance. Instead, it might be just a normal manifestation of the high turnover characteristic of a growing economy. Efforts to protect incumbents from failure raise barriers to the outsiders who would otherwise introduce new technologies and create new jobs.

The Nature of Modern Technological Change

Another reason technology leads to a diversity of outcomes lies in the nature of the computer-related technological change that has been ongoing since the mid-1970s, which is an example of what Bresnahan and Trajtenberg (1995) first called a "general purpose technology" (GPT). A GPT is a radically new technology that facilitates some basic tasks that can be used in almost every sector of the economy and that reaches its full potential only after many years, possibly decades, during which complementary technologies are discovered and implemented. In this respect, IT is affecting the world economy in much the same way as the steam engine and electrification did during the first and second Industrial Revolutions.

When a GPT is first introduced, people tend to use it to replace some earlier method of performing certain tasks, without any reorganization of the tasks themselves. This phase of development can last many years, and can continue even after the GPT has diffused throughout the economy. But the full force of a GPT is realized only after people discover how to use it to restructure the way work is done. So, for example, manufacturers first used electrification to replace the central power source in factories without redesigning the factories. Only when work was reorganized with assembly-line production were dramatic productivity gains realized, a reorganization that electrification enabled because the power from water or steam could not be distributed easily along a lengthy assembly line the way electric power could be.

At all stages, GPT enhances the value of some skills and decreases the value of others. As the technology develops and production is reorganized, the losses can become even larger, as the demise of Kodak, once an employer of more than 145,000 people in the United States, and its replacement by Instagram, which employs fewer than 5,000, attests (see Upbin 2013). Brynjolfsson and McAfee

(2014) point out that IT appears now to be advancing much faster than other GPTs did at the same state of maturity, with correspondingly more power to enhance aggregate productivity, but also more power to destroy jobs. They attribute this rapid development to three forces: the exponential nature of hardware improvement, as embodied in "Moore's Law," the digitization of nearly everything and the enormous gains attainable by combining exponential growth with digitization.

Computers have a great advantage over humans in performing routine tasks, both cognitive and physical. Given a well-specified set of instructions, they can perform long chains of calculations, free of error, in a few seconds, that would take teams of humans without computers years to accomplish with no guarantee of accuracy. Computerized machines or robots can also be designed to perform specified repetitive tasks on an assembly line without suffering from the fatigue, boredom and inattention that cause humans to make mistakes. Humans, on the other hand, have a comparative advantage in performing tasks that require imagination and pattern recognition; as a species, we evolved when survival depended not on a person's ability to perform long chains of reasoning, but to rapidly recognize opportunities to eat or threats to be eaten. This is why attempts to program computers to replace humans in such tasks as interpreting speech or recognizing facial expressions have faced great difficulties.

Thus, as Acemoglu and Autor (2011), among others, have documented, computerization has a polarizing effect on the labour market. It devalues or destroys the jobs of those performing relatively routine tasks, while leaving untouched, and even enhancing the value of, jobs that involve imagination and pattern recognition. Those jobs that remain tend to be either low paid, non-repetitive or non-routine (sales clerk, nanny, restaurant server, janitor) or high paid requiring extensive training, skills and judgment; the jobs most vulnerable to computerization tend to be those in the middle of the earnings distribution. Once again, the same economy-wide force – in this case, the diffusion of a GPT – will have diverse effects on people with different skill levels and in different occupations and industries.

Incentives to Create Technological Change

Just as different people are affected differently by innovations, likewise different people are likely to have different incentives to produce innovations. Thus, a given event or policy might generate an increase in research and development (R&D) and productivity growth in some sectors, while decreasing them in others. Consider, for example, an increase in the level of product-market competition engineered by the tighter enforcement of competition law.[1] One important characteristic that determines how firms in an industry react to such a change is the degree to which they are on an even technological footing, producing similar products and facing similar costs of production. For each firm, the incentive to innovate depends upon the expected incremental profit from the innovation – that is, the profit the firm would expect in the event of a successful innovation minus the profit it would otherwise expect. The effect of stronger competition on incremental profit depends critically on how close firms are technologically, since competition has little effect on the profits of a firm that has a large technological lead over its rivals. The leader does not need to fix prices or create artificial barriers to earn a substantial profit; instead, it can maintain a high margin over cost because it has products and cost structures that its rivals cannot match.

1 The following discussion draws on Aghion et al. (2001).

Thus, in an industry with an established technology leader, an increase in the intensity of competition will not have much effect on the leader's incentive to innovate. At the same time, intensified competition will reduce the incremental profit of the laggards by reducing the profit they can expect from making a catch-up innovation. Thus, increased competition will reduce the industry-wide rate of innovation by reducing the prospective profits of successful innovators. But when firms are neck-and-neck technologically, the effect on expected incremental profit is likely to be reversed. In this case, the main effect of increased competition is to reduce the profit a firm will earn if it does not innovate, whereas by innovating the firm is able to get ahead of the competition.

To assess the impact of increased competition on the overall level of R&D in the economy, we need to know how many firms are in unlevel industries, where the incentive to innovate is reduced, and how many are in level industries, where the incentive is increased. Moreover, the share of unlevel industries will rise over time as a result of increased competition, for two reasons. First, the pace of innovation in level sectors will increase, and [illegible]y innovation will make the sector more unlevel. Sec[illegible]d, since the pace of innovation in unlevel sectors will decline, it will take longer on average for an unlevel sector to become level.

The prediction that comes out of this is that there should be an inverted-U-shaped relationship between competition and growth. That is, when there is not much competition to begin with, a large fraction of industries is likely to be in the level state, where more intense competition raises the incentive to innovate, and the overall effect on the economy-wide rate of innovation is therefore likely to be positive. On the other hand, if there is a lot of competition to begin with, then most industries are likely to be in the unlevel state, where the reduced incentive of followers to innovate makes it unlikely that the industry will soon be levelled. Thus, beyond a certain point, the overall result of increasing competition even further will be to reduce the overall level of innovation.

Policy: Some General Considerations

One obvious implication of the preceding analysis is that one cannot judge a national policy by the number of firms that will go out of business, or industries that will shrink, or savers whose wealth will be reduced or people who will lose their jobs. What matters for society as a whole is the overall distribution of gains and losses. Predicting this distribution is often difficult, but the task must be undertaken.

The Perilous Job of Comparing Gains and Losses

One complication arises from the fact that it is often easier to identify one side, either the winners or the losers, than the other. When factories close because of intensified foreign competition, the plight of laid-off workers makes headlines, but when demand picks up for firms that can compete more effectively in foreign markets, there is less fanfare. Moreover, the winners' success is often attributed to their wisdom, vision and hard work, rather than to distant macroeconomic forces, especially when the winners themselves make the attribution. This difference in visibility biases public opinion, the political consequences of which can easily distort the policy process.

More seri[illegible]ly, when a conflict between winners and losers arises from the process of creative destruction, there is generally a bias in favour of the status quo – of established producers using the technologies under threat, who have had the time and resources to influence public opinion, and the political process more generally. Regulatory agencies, which often act as barriers to the entry of firms with new technologies, are notoriously subject to capture by the incumbent producers they regulate

and on whom they often rely for expert opinion and information. And even if regulators are immune to such influences, their political masters frequently are not. A prime example is the way several Canadian cities have sought to protect incumbent taxi companies against Uber. In a dynamic economy, there is always a conflict between protecting people's jobs and investments and promoting technological change and economic growth. Policies that promote the former tend to favour incumbents over upstart rivals, thus discouraging innovation by outsiders. But rapid technological change requires that a large number of independent entrepreneurs be allowed to contest markets with their new ideas.

As many European and Latin American countries have learned, relying on a single national champion to promote technological change in an industry is a recipe for stagnation and declining international competitiveness.[2] Thus, the wise policymaker should always keep the status quo bias against outside innovators firmly in mind when deciding how much weight to give to the objective of protecting jobs and investments. Instead of keeping an incumbent firm alive even after it has been rendered obsolete, it might be better to allow it to fail while offering compensation to those most directly harmed, on the grounds that this would allow the benefits of the new technology to be shared more equitably.

A general policy of compensating losers can also be carried too far. Although it can reduce anxiety among people whose livelihoods are under threat from new technologies, it can also dull the innovative spirit. Indeed, Phelps (2013) argues that the post-1960 industrialized world has lost much of its dynamism because of an overemphasis on income security. For Phelps, keeping the innovative spirit alive is the key to enjoying the benefits of modernism, which, he argues, lie not so much in the proliferation of material goods as in the opportunities for intellectual challenge, self-expression, job satisfaction and personal growth. Whether or not one agrees with Phelps on this last point, there is clearly a trade-off between making people content with what they have and encouraging them to engage in the uncertain and often stressful activity of seeking betterment through innovation.

The New Machine Age?

On the other hand, the experience of modern computer technology suggests that a more proactive policy toward the uneven effects of technological change might be needed. Computers can now perform better than humans in many tasks that a decade ago were thought to be beyond their scope. One example is Google's relative success in showcasing the possibility of driverless cars (see Brynjolfsson and McAfee 2014; Urmson 2015). Even if completely autonomous cars are still years away from being commonplace, computers in many cars are already programmed to perform critical functions, such as emergency braking and lane keeping, without relying on the human driver. Computers now are arguably as good as, or better than, humans at writing various classes of newspaper articles, diagnosing serious illnesses, solving symbolic equations, interpreting body language and facial expressions and many other

2 Maloney (2002) argues that inward-looking industrialization, in which firms are sustained by monopoly rents from protectionist policies, rather than by the quasi-rents attainable from innovation or adoption, accounted for much of the failure of Latin American resource-based economies in the 20th century to keep up technologically with those, such as Canada, Australia and the Scandinavian countries, that were more open to foreign competition.

activities that involve complex pattern recognition.[3] Samuelson's (1988) imagined scenario, in which androids are capable of doing everything a human worker can do, but at a user cost less than the subsistence wage, still lies in the realm of science fiction. But the skill level of those whose jobs are threatened by advances in computer technology is rising steadily, as is the attendant polarization of the labour market.

Moreover, we might now be entering a world in which technological change increases the aggregate unemployment rate. For many decades, technology advanced without a tendency for unemployment to rise along with it, because the new jobs opened up by advancing technologies more than made up for the loss of jobs that were destroyed through creative destruction, reallocation and automation. However, we have now gone through two "jobless recoveries" in the past two decades, which suggests that new technologies might be providing too few new jobs, especially those requiring middle skills, to compensate for the jobs destroyed (see Jaimovich and Siu 2012). Of course, the employment effects of technological change are notoriously difficult to predict. Income growth generated by technical progress increases the demand for many goods and services, some or much of which are actually labour intensive – such as personalized services, nursing care, entertainment and so on – but a technologically driven rise in the aggregate demand for labour would constitute a reversal of recent trends.

Thus, if present trends continue, it would be wise to devise proactive policies to counteract the negative effects of technological change on employment. One way might be to try steering technological changes in directions that involve less job destruction – in particular, toward new products that do not compete directly against old products. For example, tougher environmental regulations that require or encourage abatement at the factory level would encourage research into greener capital equipment and/or more effective emissions-control systems. To the extent that tighter requirements required an increase in particular kinds of capital, such innovations might create more new job opportunities than they destroy (Porter and van der Linde 1995). Moreover, as Zivin and Neidell (2012) show, for example, one benefit of a cleaner environment is to make the entire economy more productive.

Another proactive policy that might reduce the unemployment cost of technical progress is to offer firms subsidies to train existing workers to adapt to new equipment and technologies, which would tend to raise the market value of equipment that existing, but retrained, workers could operate relative to the cost of the equipment that might replace them. More broadly, helping people cope with and adapt to the vicissitudes of technological change through education, retraining and employment insurance are particular policy avenues that come to mind.

Neutral versus Targeted Policies

Neutral policies are not necessarily preferable to specific targeted policies. If policies that apply uniformly across all sectors produce uneven results – with some sectors flourishing and others not, and with some sectors innovating more rapidly than others – then perhaps policies should be considered that apply differently in different sectors. For example, competition law could be strengthened, but only in sectors where the technological playing field has been even for some period; in principle, such a policy could increase the rate of innovation in all sectors.

3 Thus, computers are coming to have an absolute advantage over humans even in those areas where humans have a comparative advantage.

Of course, this might not be possible, for a number of reasons. How can "evenness" be measured in the real world, as opposed to in a simple mathematical model? Should it depend on measured total factor productivity? How many firms should the measure take into account? Should it be a standard deviation of the log of productivity or an average absolute deviation of followers' market shares from that of the leader? What is the appropriate level of aggregation across sub-industries? Even within a sub-industry, how should firms that produce many different product lines be treated? Moreover, policies that apply differently to different classes of firms are notorious for introducing distortionary incentives into the economy. For example, small firms that receive preferential tax treatment have an incentive not to grow beyond the point where they no longer qualify for the preferential treatment.

The formulation of targeted policies is perhaps even more subject to status quo bias than is the formulation of neutral policies because they give more scope for successful incumbents to influence public opinion and lobby for policies that favour their cause. Thus, industrial policies are naturally biased toward sectors dominated by well-established and politically connected firms.

Even if one could solve these difficulties, overly complicated policies and regulations raise the cost of doing business. The productivity gains of even a sophisticated policy that is sensitive to cross-industry differences and carefully designed to avoid perverse incentives can be dissipated through increased accounting and legal costs incurred to deal with, and possibly to attempt to evade, the policy's complex contingencies. So the big challenge is to design policies that are simple, transparent and incentive compatible, and yet appropriate to diverse sectors.

Specific Policy Issues

International Trade Policy

The Comprehensive Economic and Trade Agreement that Canada recently signed with the EU raises the important issue of how international competition affects this country. One often-ignored aspect of trade liberalization is its effect on innovation and productivity growth. Trade liberalization affects innovation much like competition policy, by forcing firms to deal with competition from foreign firms that previously could not compete on an equal footing. Freer trade differs from competition policy, however, in two main respects. First, it offers a bigger market that should allow firms that can compete successfully in a more open international environment to expand – a market-size effect that has no direct counterpart in competition policy. Second, it often exposes domestic firms to competition from firms that are technologically more advanced, unlike the outsiders that are better able to compete (or forced more into competition in the case of neck-and-neck competitors) when domestic competition is intensified.

Trefler (2004), for example, shows that, following the introduction of free trade between Canada and the United States in 1989, Canadian firms with higher productivity than their US counterparts in the same industry expanded rapidly, while firms with lower productivity than their US counterparts shrank or even disappeared (see also De Loecker 2011), thus vindicating those who had warned that free trade would result in large-scale plant closures. But, once again, focusing on the losers tells only part of the story. The main effect of free trade was to reallocate resources from firms and sectors where productivity was relatively low to those where productivity was relatively high. Moreover,

all Canadians benefited from the lower prices and improved product quality in sectors where the relatively inefficient Canadian firms were displaced by competition.

Modern growth theory goes beyond the static gains that free trade creates, and suggests that a positive growth effect can arise. Part of this effect comes from the increased market size relatively productive firms enjoy. That is, the incentive to perform R&D is an increasing function of market size, because it costs the same to create a new product or process regardless of market size, while the prospective reward from such an innovation rises with the size of the market. So, not only does productivity rise in sectors where Canadian firms are displaced by more efficient foreign competitors; it also rises, and continues to rise more rapidly than it would have, in sectors where Canadian firms expand to take advantage of their high relative productivity. In effect, their past success in promoting productivity growth breeds more success in producing a broad market that justifies intensified R&D efforts. Indeed, to the extent that freer access to the Canadian market increases the market size of the firms that replace Canadian firms, they too have a stronger incentive than before to perform R&D, which raises Canadians' standard of living faster because the prices of imported goods and services decline faster.[4]

Moreover, the very threat of increased international competition is likely to have a stimulating effect on R&D by those domestic firms that are at least close enough to the international technology frontier to have some chance of surviving the intensified competition. Just as firms in a closed economy have an incentive to get ahead of the competition by innovating, so too, domestic firms that face the prospect of foreign firms entering their markets can try to reduce the potential competition from those entrants by intensifying their efforts to increase productivity. Once again, however, the same results cannot be expected from all firms. Those whose productivity is much lower than that of potential foreign competitors might reduce their R&D efforts because they know that they are unlikely to catch up and compete no matter how much they improve their productivity.

Exchange Rate Policy

One area where it is clear that macro forces have divergent micro effects is monetary policy, especially as it affects the value of the Canadian dollar. The main objective of Canadian monetary policy is to maintain a steady rate of inflation near 2 percent per annum. At times that means a high value for the dollar and at other times a low value, mostly depending on what is happening to global markets, especially commodity markets. Until about two years ago, this policy was consistent with a high value for the dollar, and exporters complained that this made it hard for them to compete in global markets. More recently, with commodity markets slumping and the threat of a Chinese banking crisis looming, the dollar has dropped below US$0.80, which has quieted exporters but raised complaints from other Canadians about the loss of purchasing power of the currency.

There is no objective way to judge whether the Bank of Canada is getting the exchange rate right; some always like it higher and some lower. In reality, there is not much the Bank can do about the exchange rate in the medium to long term,

4 Even trade liberalization that does not directly involve Canada benefits Canadians to some extent through this channel, by inducing some firms that produce Canadian imports to innovate more rapidly; the freer is Canada's trade with those engaged in such liberalization, the more Canadians benefit from this channel.

the period over which the real exchange rate is determined on global markets by a variety of forces that are beyond the Bank's control. Once again, however, it is important to keep an eye on the big picture, which in this case is the inflation rate, the long-run trend of which the Bank can control.

In addition, exchange rate movements can have subtle effects on productivity that are different from what one might think. When the dollar appreciates, for example, making it more difficult for Canadian firms to compete, the least productive firms are likely to exit, thus making Canadian firms as a whole more productive. And when it depreciates, even the least productive firms might be able to compete, since their costs fall in terms of foreign currency. Tomlin (2014) estimates that a 20 percent permanent real depreciation would cause the overall level of labour productivity in Canadian manufacturing to fall by 4.5 percent – in contrast, average annual growth from between 1961 and 2008 was only 2 percent (Statistics Canada 2009). So, depreciation that allows a firm to compete more easily in the short run actually causes firms as a group to become less productive, and hence less competitive.

The new growth theory also implies that depreciation will affect not just the level, but also the rate of growth, of productivity, because it offers theoretical support for what was once called the "lazy manufacturer hypothesis." This hypothesis – first put forth by Courchene and Harris (1999) in arguing for a currency union with the United States – maintains that, when a low exchange rate helps to shield Canadian manufacturers from foreign competition, they relax their efforts to improve technology and raise productivity. Whether or not one agrees with the idea of a currency union, there is a kernel of truth in the hypothesis: a lower exchange rate does have much the same effect on Canadian manufacturers as a reduction in the level of foreign competition, which, as we have seen, does indeed reduce the incentive of many, perhaps even most, firms to innovate and raise productivity.

None of these productivity effects of exchange-rate movements can be counted on to act with certainty. For example, as we have seen above, the reduced competition engendered by a depreciation will actually increase some firms' incentive to innovate. Likewise, as Tomlin (2014) points out, much of the selection effect by which depreciation reduces productivity is dissipated in the long run because the increased entry that the depreciation initially induces ultimately makes the domestic market more competitive by raising the number of active firms, and this in turn reduces the ability of low-productivity firms to enter and remain in business. Moreover, Tomlin's dramatic results apply only to a permanent change in the real exchange rate, whereas the most that the Bank of Canada can hope to accomplish is a temporary change, whose effects Tomlin shows to be quite limited quantitatively.[5]

Thus, although a low exchange rate makes Canadian exports more competitive in the short run, it also might make exports less competitive in the long run. Given all the conflicting and uncertain effects of exchange rates on productivity, and given that monetary policy does not have a long-run effect on the real exchange rate, this is all the more reason for the Bank of Canada to focus on controlling the long-run trend rate of inflation and to leave the exchange rate to be determined by market forces.

5 Tomlin's analysis leaves open the issue of how exchange-rate variability might affect the level of productivity.

Small Business Policy

One area in which Canadian economic policy has been tailored to recognize diversity across firms relates to federal and provincial tax laws that favour small business (see Canada 2014, 2015). The two tax provisions that involve the largest expenditure of tax revenue are the Small Business Deduction (SBD) and the enhanced Scientific Research and the Experimental Development (SR&ED) investment tax credit. The federal SBD reduces the tax rate of a small Canadian Controlled Private Corporation (CCPC) by four percentage points on its first $500,000 of taxable income. To qualify for the full SBD, the company must have taxable capital of less than $10 million, after which the SBD is phased out. All the provinces have a similar SBD. The average effect, across all provinces, of the combined federal-provincial SBD is to reduce the combined tax rate of a qualifying CCPC by almost 11 percentage points. The enhanced SR&ED tax credit allows a small CCPC to claim a refundable R&D credit that is 20 percentage points higher than normal. The credit is phased out when the company's income or capital grows beyond certain thresholds ($500,000 in income, $10 million in capital). In 2014, the federal government's tax expenditure on the SBD was $3.2 billion, and on the enhanced SR&ED credit it was $1.4 billion.

These preferences are intended to promote growth by offsetting some of the disadvantages small businesses face, on the grounds that they are important job creators. In particular, small businesses are thought to have higher tax-compliance costs and less favourable access to external finance than large businesses. There is reason to doubt, however, that such preferences do indeed promote growth, largely because they give small firms an incentive to remain small, which can reduce productivity through several effects (see Chen and Mintz 2011). For example, a small business can break up into smaller and less efficient units instead of growing to a more efficient size; likewise, an entrepreneur can create several small businesses instead of growing existing ones. Probably the most important effect is that a firm can simply avoid growing any further by cutting back on investment when it reaches the threshold where its tax preference starts to be phased out. As a firm crosses this threshold, its marginal tax rate can rise dramatically. Chen and Mintz show that a firm's effective tax rate can double when its assets grow from $1 million to $11 million.

The effects of this barrier would be mitigated if it were indeed true that small firms are exceptionally important job creators. Hendricks, Amit, and Whistler (1997) show, however, that small Canadian firms tend to remain small: only 12 percent of businesses with fewer than five employees in 1985 increased their employees to between five and 20 by 1992, and only 1 percent increased to more than 20.[6] On the other hand, Dachis and Lester (2015) suggest that the aggregate effect on growth of the reluctance of small businesses to cross these thresholds is not likely to be large, given the relatively small number of firms involved – although, as they point out, the substantial tax expenditures of the SBD and SR&ED would be better directed toward measures that actually promote growth.

Innovation-based growth theory suggests a particular set of such measures. Specifically, the theory suggests that the focus of tax preferences should be on young firms, rather than on small firms. New jobs and new technologies tend to be

6 Their results might have been influenced somewhat by the fact that 1992, the end year of their analysis, was a recession year, but the unemployment rate that year was only one percentage point higher than in the start year, 1985.

brought into being by young firms, which also tend to be small, so preferences given to small firms also accrue to most young firms. As Hendricks, Amit, and Whistler (1997) show, however, many small firms are no longer young, which leads them to conclude that most of the benefits of small business preferences go to mature firms, rather than to young ones.

The case for giving preferences to young firms is strengthened by the status quo bias, whereby incumbent firms tend to be favoured by economic policy because of their greater visibility and stronger political connections. Giving tax preferences to young firms would be a way to counteract this bias and offset the drag on economic growth it creates. Moreover, favouring young firms, rather than small firms per se, would eliminate the threshold effect that discourages investment, since it would not be size but the age of the firm that would determine whether it could continue to receive preferences.[7] Indeed, the prospect of growing past the age threshold should give young businesses an incentive to invest even faster than otherwise, to take advantage of a limited window of opportunity in which to grow to the point where they can escape the small business handicaps of high tax-compliance costs and limited access to external finance.

Of course, converting small business preferences into young business preferences would cause much hardship, and probably increase failure rates, among mature small businesses, but the overall productivity of the economy would be increased if there was a smaller proportion of such firms. Mature small firms that lost the tax breaks would be more prone to failure, and the failure rate among small businesses in general probably would increase permanently, because a greater proportion of small businesses would be young businesses, which tend to have a much higher failure rate than do more mature businesses. A high failure rate, however, is characteristic of a healthy capitalist system, since risky entrepreneurial activity is a major source of technological progress. If more entrepreneurs are given a chance to succeed, more of them will also fail. Again, we need to look at the big picture: from the entrepreneur's point of view, failure is a big risk, but for society as a whole, business failure is just a side effect of the creative destruction that drives economic growth.

Telecommunications Policy

The Harper government has tried to increase the level of competition in the Canadian telecommunications industry. This is an admirable objective, not only because of the static gains in efficiency and lower prices that competition brings, but also because the main competitors in the industry are on a roughly level technological footing, so, according to the new growth theory, more competition should result in more innovation and productivity gains. The attempt to increase competition by giving preferred access to smaller competitors in spectrum auctions has not worked, however, since all of them have struggled to survive, and neither has a slight relaxation of some of the restrictions against foreign telecom ownership. The telecommunications industry thus remains an oligopoly of three main firms that have not been seriously threatened by competition. This not only leaves Canadian households facing high

7 To avoid wasteful tax expenditures, the rules would have to exclude firms that close and then reopen under a new name but carry on the same business with the same assets.

communications costs;[8] it also leaves Canada without the productivity gains that might come from more innovation.

So far, the government's efforts to make the industry more competitive have been unsuccessful. What is now called for is a change, not in strategy, but in tactics, by removing all existing restrictions on foreign ownership, as contemplated in the Trade in Services Agreement between Canada, the EU and 23 other countries[9] and recommended by the C.D. Howe Institute's Competition Policy Council (C.D. Howe Institute 2011).

Removing foreign ownership restrictions would improve performance in the telecommunications industry in two ways. First, since the federal government's failure to encourage innovation by incumbents probably reflects the large economies of scale that small domestic competitors find difficult to achieve, a foreign firm already serving a large market could spread its fixed costs more widely and compete more effectively in the Canadian market. Relaxing foreign ownership restrictions would give full scope to these economies of scale, and the increased competition would induce more innovation. Second, for a foreign competitor to succeed in driving out a Canadian incumbent, it would have to offer a better combination of product quality and cost than the Canadian rival, which would not only reflect technological progress within the industry, but would also benefit Canadian consumers.

Of course, there is a very real possibility that the industry would come to be dominated by foreign firms, that Canadians who had invested in shares of the Canadian telecoms would suffer capital losses and that those employed by a losing Canadian incumbent might lose their jobs.

Again, however, it is important to look at the big picture. In today's world of integrated capital markets, there is no reason Canadians should not also be heavily invested – through retirement funds and defined-contribution plans – in the foreign telecoms entering the Canadian market, whose shares likely would appreciate. In this sense, the situation would be no different than in any industry in which incumbents are threatened by competition and where there are winners and losers. In either case, investors who diversify their portfolio will not gain or lose inordinately. Similarly, although some of those employed by a losing incumbent firm might lose their jobs, the successful new foreign entrant into the Canadian market undoubtedly would create many new jobs. And even if there were fewer new jobs than those lost, again the situation would be no different than in any industry where technological progress induces a reallocation of labour away from that sector. Thus, to realize the full benefits of technological progress, Canada should allow the resulting reallocation of resources to take place. Although this might create hardships for some Canadians whose jobs are destroyed, which could be alleviated with compensatory policies, the alternative is technological stagnation and higher costs for all Canadians, who would be deprived of the benefits of access to the world's best telecommunications technology.

8 The Organisation for Economic Co-operation and Development ranks Canada among the 10 most expensive countries (out of 34 ranked) in almost every category of telephone usage (Geist 2013). Church and Wilkins (2013) challenge this conclusion, arguing that there is no evidence the industry suffers from insufficient competition. But even if they are correct – see Church and Wilkins (2014) for their reply to critics – there are still no grounds for excluding foreign telecoms from the Canadian market.

9 Confidential documents published by WikiLeaks show that the Canadian negotiators opposed the removal of such restrictions; see Freeman (2015).

As for the argument that removing foreign ownership restrictions would threaten Canadian cultural values by exposing them to foreign, especially US, media, there is no reason this should occur as long as existing Canadian-content regulations remain in place (see Hunter, Iacobucci, and Trebilcock 2010). Those regulations would apply just as much to a US-owned cable company operating in Canada as they do to existing Canadian telecoms, and it is hard to see how the nationality of the providers of telephone or Internet services would make a difference to Canadian culture.

To summarize, the Canadian telecommunications industry is an oligopoly in which firms facing little effective competition provide relatively high-priced services and have little incentive to innovate. Removing foreign ownership restrictions would constitute the most effective way to provide competition, reduce prices for all Canadians and allow the industry to benefit from access to world-class technology. There is no reason to think that such a move would increase the threat to Canadian cultural values or create greater losses among some people than would result from any other major technological improvement, especially if Canadian companies were to rise to the challenge and fend off foreign competitors.

Human Capital Policy

Human capital – in the form of health, on-the-job experience, practical training and education, among other sources – is a key input into the R&D that generates productivity growth. Within each category, however, there are important distinctions. For example, education can be at the primary, secondary or postsecondary level, it can be directed toward specific narrowly defined subjects or broader in scope and it can focus on the acquisition of cognitive or non-cognitive skills.

One difficulty in designing human capital policy appropriate for a growing economy is the tension that exists between providing people with the specific skills needed to work most effectively with the technologies currently in place, and providing people with the general skills that allow them to adapt to whatever technologies displace those now in use. Education thus plays a role in the growth process, not just by giving people particular marketable skills, but also – if creativity is emphasized at the expense of more routine learning – by making them psychologically better able to cope with and contribute to an ever-changing world.

As computers take over more and more tasks, the ability to perform routine tasks, no matter how complicated, is likely to be poorly rewarded. Innovation, however, is likely to remain in the domain of humans, and those who will reap most of the productivity gains of the new technology are not the workers who assemble hardware or the programmers who code software, but those who generate the new ideas that drive the R&D that results in new hardware and software. Indeed, innovation is getting better rewarded all the time. For example, by 2014, Facebook, with 4,600 employees, had created seven billionaires, each with at least 10 times the wealth George Eastman ever had with his 145,000 employees at Kodak (Brynjolfsson and McAfee 2014); moreover, the Facebook billionaires were not those who did routine coding, but those whose creativity led the enterprise to become the success it is.[10]

It is thus distinctly possible that, within the lifetime of today's students, innovation might

10 This is not to say that all coding is routine; on the contrary, as Chandra (2014) argues, coding at its best is an art form that requires creativity and embodies aesthetic values, in much the same way literature does at its best.

become the only valuable task humans still perform, and education policy should take this possibility into account. Primary and secondary education should be geared toward teaching students to learn and adapt to the uncertainties of life in a dynamic economy. And postsecondary education should emphasize creativity, the ability to think critically and the basic general skills likely to be most useful in any given technological environment. One concrete step in this direction would be to engage undergraduate university students more actively in the research process, even in fairly menial tasks at first, as is already taking place to some extent in many universities. This would be an excellent way to familiarize students at an early stage of their careers with the challenge, excitement and uncertainties of life on the frontier of knowledge, where the competitive environment is constantly changing in unpredictable ways, just as it is likely to change in the world in which they are going to live.

This is not to say that the acquisition of specific skills should be replaced entirely with teaching general coping skills and encouraging creativity. The future remains unknowable, and not everyone is cut out for a life of innovation and entrepreneurship. Meanwhile, many specific skills are still much in demand in the market place. Accordingly, community colleges have a vital role to play in equipping people with those skills that are still needed. They can also help the retraining that will be required when the demand for specific skills undergoes a radical transformation.

Moreover, human capital is created not just in educational institutions, but also in businesses, which play a critical role in retraining workers displaced by technological change. The main difficulty in designing retraining policy, however, is to know in what direction the retraining should take place. Thus, retraining efforts should be based on the best, most up-to-date information about what kinds of skills are most in need, and the best source of that information is the businesses that will provide the employment opportunities. For this reason, the federal government's recent decision to involve employers more directly in the renewed Canada Job Grant program is welcome. Under the renewed program, the $500 million allocated to retraining will be directed by employers themselves, and will take the form of matching grants to the employers. In this way, the assistance will go in directions on which employers themselves are willing to bet. By helping people develop the kind of human capital appropriate to a changing technological environment, this kind of policy is an excellent example of how to help spread the gains from technological change without dampening the incentive to innovate.

Conclusion: A Vision of the Growth Process

Rather than a rising tide that lifts all boats, economic growth is a process of creative destruction in which there will be winners and losers. Policymakers at all levels should take this into account both in formulating policy and in predicting the reactions to policy changes. Accordingly, this *Commentary* has argued, first, that, although some domestic firms and workers will be harmed by enhanced import competition from trade liberalization others will benefit from expanded export opportunities. Moreover, Canadians as a whole will benefit not only from lower prices, but also from the more rapid productivity growth that will result from increased innovation by domestic firms as they seek to compete against foreign firms that can enter the Canadian market.

Second, since exchange-rate movements have many conflicting and uncertain effects on both the level and growth rate of domestic productivity, and since monetary policy cannot affect the real exchange rate in the long run, the Bank of Canada should continue to focus not on the exchange rate, but on its inflation target.

Third, existing small business tax preferences are unlikely to promote productivity growth. Job creation is fostered not by small businesses per se, but by the young businesses that are the agents

of creative destruction. Therefore, the federal and provincial governments should transform their small business preferences into young business preferences.

Fourth, the Canadian telecommunications industry is ideally suited to benefit from enhanced innovation and productivity growth in the event of a serious threat of entry by foreign firms large enough to enjoy significant scale economies. To take advantage of that possibility, the federal government should eliminate foreign ownership restrictions in the industry.

Finally, human capital policy should leave universities to pursue independent research programs that foster basic science, encourage community colleges to give workers the skills to work with the most up-to-date technologies and induce businesses to guide the direction of retraining policies.

Whether it pertains to free trade, exchange rates, small business supports, removing foreign ownership restrictions or training policies, modern economic growth theory points the way toward renewed economic growth through policies that recognize, and help shape, the diversity of outcomes technological change produces.

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