Postsecondary Student Choices and Skills Shortage in Canada’s ICT Sector

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Abstract: This paper aims to contribute to the policy debate regarding skills in Canada’s ICT sector by pointing out the importance of student choices in the postsecondary education system. While employers seek workers with different skill sets, individuals make career decisions according to a range of factors, including their personal preferences and abilities. We develop a simple conceptual framework that highlights the factors underlying ICT undergraduate enrolment at Canadian universities, and present data on how ICT enrolment has declined across entering cohorts in recent years. In a context where policy makers are trying to increase the number of ICT students. We summarize the issues and policy options for addressing the shortage of ICT students from the demand side of the post-secondary education system, with supply – which relates to the number and type of ICT places provided by individual PSE institutions, PSE systems more generally, and other related factors.

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1 Introduction

An important well known trend in both the Canadian and US labour markets is that the college wage premium for new labor market entrants has risen sharply since 1980. Boudarbat et al. (2010) use Canadian census data to show that most of this relative wage growth took place in the early 1980s and since 1995. A less well-known fact in the United States is that the wage gap across college majors is surprisingly large, given that there are in most cases no direct monetary costs associated with the choice of college/university major.

Faced with skill shortages in Canada’s ICT many private sector organizations are looking to governments to enact public policy. In the US, programs such as the National Science and Mathematics Access to Retain Talent Grant (SMART) and the Science, Technology, Engineering, and Mathematics Expansion Program (STEP) have been developed in an effort to increase the share of college students entering technical fields. Specifically, the SMART program is a need based federal grant that is awarded to undergraduate students in their third and fourth year of undergraduate studies in only specific majors and STEP provides additional opportunities for students only in these specific fields, thereby reducing incentives to switch majors. However, the success of any such policy depends crucially on whether we understand how college and university students not only choose their major to study but also the subsequent career.

Decisions on careers are influenced by choices made earlier in life. For example, when selecting a college major, an individual is also implicitly making investment in human capital specific to jobs associated with that particular field of study. These choices are often made with less than perfect information and have long-term consequences. For example, Kinsler and Pavan (2012) present evidence showing that on average, the labour market returns to college majors depends on occupational choices. That is, the expected return to majoring in a ICT-related field increases if an individual pursues a career related to their major.1 Thus, enriching our understanding of the factors that influence college major and subsequent career choice has substantial policy implications.

In this paper, we begin by describing trends in college major choice in Canada and the United States. We then point out that the simple economic model that underlies much of the higher education policy debates makes strong assumptions on student knowledge and does not account for many features of the contemporary labour market. To an extent these policy debates build off the Mincer (1958) model, where schooling is thought to only represent an investment in skills that are valued by all employers in the labour market, and what many economist term as general human

1 US data indicates that the within-major gaps in wages are nearly as large as the across major gaps
capital.\textsuperscript{2} That is, the wage impact of receiving a college degree is generally assumed to be the same in different occupations and industries. Returns to human capital investments that are specific to a subset of employers in the economy are generally restricted to operate though work experience. We present an outline of a richer economic model explaining how students choose which college major to study and point out the channels through which policymakers can influence student choice to reduce ICT skill shortages. Section 4 contains a review of the main findings from studies that have empirically investigated how individual, institutional and policy variables influence both college major and career choices. By synthesizing the findings from the empirical research we can point to features that should be accounted for in the design of policies that are more likely to be effective at increasing the number of students entering ICT disciplines. A concluding section summarizes what is known, what work needs to be done and discusses several policy implications in the current environment.

**Section 2: Stylized Facts and Trends in College Major Choice**

Aggregate statistics mask many interesting and well-known patterns. For example, while Canadian Universities have more than doubled their capacity in the last 30 years, there are large differences in student attendance across disciplines. Students appear to respond to labour market demand and not forecasts. Between 1992 and 1997 enrolment in computer science, biology and biomedical sciences as well as communication and journalism grew quite rapidly. Since 2002 computer science enrollment fell. Throughout this period, enrolment in physical sciences remained constant. There has been massive growth in enrolment in law and legal studies as well as business and management. Every year since 2007 there are more full time undergraduate students in business and management than in any other discipline. This is also striking given the large difference in tuition costs and no evidence that there are higher returns on average.

It is worth noting that patterns in undergraduate enrollment differ sharply between the US and Canada. Akbari and Aydede (2012) document that the number of students enrolled in the discipline of economics rose sharply in many countries but not in Canada. They postulate that this may be a result of the continued perception of Canadian students of a lower economic reward to an economics degree. Canada’s mix of doctoral degree recipients is also quite different than that of the United States and more tilted towards the humanities and away from both health related fields and the physical sciences. Graphs documenting these differences will be provided.

A few less well-known facts are found from studies that use data from the US Baccalaureate and Beyond study. Students in the sciences tend to have higher incoming test scores and perform significantly better than their counterparts in science courses

\textsuperscript{2} Following Becker, the human capital literature often makes a distinction between “specific” and "general" human capital. Specific human capital refers to skills or knowledge that is useful only to a single employer or industry, whereas general human capital (such as literacy) is useful to all employers.
but majoring in other fields does not offer GPA advantages. Another trend observed in the United States related to persistence is that engineering and technology fields have the lowest rate of students switching from their intended major (articulated in high school) to a different field. Yet, once a major is declared by category, prior research has shown that these fields have lower rates of persistence, and this degree of persistence is lower, either the earlier a major is declared or the younger the student is. Last, Hsu and Schombert (2004) document large differences in grade distributions across 12 majors at the University of Oregon as well as the association between SAT scores and GPA that is highest in chemistry and lowest in sociology. This is an important issue that we will turn to later in that grade inflation in other fields may poach students from ICT related fields.

A final point is that Webb (2013) has examined the impact of graduate retention programs in Canada that seek to curb interprovincial/out migration of youth by offering tax credits to post-secondary education graduates who settle in province. This could be a cheaper strategy to poach high skilled labour but Webb (2013) currently finds no effects and argues that this may be due to limited knowledge. The punch line from this section and examining differences between Canada and the US in enrollment and graduation may be driven by the Canadian system making information on the benefits of fields less salient and discouraging differentiation both within and across institutions. We will expand on why these issues matters by reviewing the theoretical and empirical evidence on major choice in the next two sections and conclude by suggesting policy directions.

Section 3: Economic Model

The framework that underlies many higher education policy discussions and debates is based on a seminal paper written by Jacob Mincer in 1958. This paper develops a formal model to explain how individuals decide to make investments in their human capital. Like many other formal economics models, there are many strong

3 They also report that overachievers, with low SAT scores but very high GPAs are disproportionately female. Similarly, underachievers, with high SAT scores but very low GPAs are disproportionately male. Last, they find that certain majors, like math and physics, may exhibit a cognitive threshold – mastery of the material is unlikely below an ability threshold (as measured by SATM), no matter how hard the student works. The set of point in this paragraph is pointing to the importance of interventions at the secondary school level that we will return to in the following sections.

4 Specifically, Mincer (1958) explicitly models the relationship between earnings and both schooling and labour market experience in an effort to improve our understanding of the income distribution. This was to the best of our knowledge, the first paper that combined the concepts of human capital within a neoclassical competitive prior theory, and is the benchmark model in labour economics textbooks. This paper and his subsequent work on the topic had a profound and lasting influence on empirical work in the field of labour economics. See Heckman et al. (2005) for a discussion of the influence of this model and how it continues to underlie research and policy discussions centered on estimating the returns to schooling, returns to school quality and to measure the impact of work experience on male-female wage gaps.
assumptions being implicitly made, particularly that there is no uncertainty about future returns at the time schooling decisions are made. Thus, participation in postsecondary schooling, such as the choice of whether to study in an ICT field, is assumed to be largely determined by potential earning returns and there are no borrowing constraints.⁵

Recent work on college major choice surveyed in Altonji et al. (2012) has extended this model to accommodate many features of contemporary labour markets. First, labour markets in Canada are highly heterogeneous.⁶ This heterogeneity arises from both the demand and supply side of markets: while employers offer different kinds of jobs, each of which requires different skill sets, individuals select jobs according to their personal preferences, choosing from among the job offers that fit their specific training and experience. Second, schooling is not a homogeneous good and employers may have clear preferences for graduates of certain university and program combinations. The choice of field of education helps to condition occupational path⁷ since when individuals’ make decisions on what subject to study, they must also consider that some of the knowledge or human capital developed through this schooling choice is in part specific to particular types of jobs.

Altonji et al. (2012) state that the following five key features should be present in current economic models of college major choice.
“1) Preferences, innate ability, and the initial vector of skills and knowledge early in high school shape the feasibility and the desirability of particular education program.
2) Individuals only learn gradually about their preferences and ability and are also uncertain about wages.
3) The type of education program shapes what one learns during a schooling period.
4) Education programs and occupations have different skill and knowledge prerequisites that influence learning and job performance. Switching fields in the face of new information about ability, preferences, and returns is costly.
5) Knowledge accumulation is influenced by random shocks, which have differential effects across students of different productivity levels.⁸ These stochastic events ensure that students cannot simply decide that they are going to complete a program of study.”

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⁵ The standard empirical implementation of this model often makes a number of additional ad-hoc assumptions. For example, individual differences in market skills are captured in the intercept term of the wage equation.
⁶ That is different job professionals such as computer programmers and fashion designers work in completely different job markets.
⁷ For now we will ignore whether differences in university quality are actual or perceived.
⁸ Human capital for an individual is assumed to evolve via a production process that depends on the completed educational history of the individual as well as occupational experience. The inputs to the production process are not assumed to be substitutable so the level and type of education interacting with the same occupational experience would lead to a permanently different type of human capital.
As in most formal economic models, individuals in the models are assumed to maximize utility over their lifetime and are allowed to be risk-averse. Thus, when deciding on whether to work and study in an ICT field, both the expected wage and variation in the wages in that occupation will affect decisions. The impacts of risk aversion may be heightened when individuals are uncertain over their ability (or self-esteem). In essence there are three steps in the lifecycle where interconnected decisions are made. In high school, courses are selected which may influence the choice set of major an individual has upon entering college. In college, the major field of study is selected and following college and with entry to the labour market one decides which job or career to take. We will look at each of these decisions in reverse order.

Once an individual decides to enter college, the main decision is which major to select. Note the subset of all possible options may be influenced by educational history. After each period of college, students can update their beliefs about their own ability and preferences. If they continue to meet GPA requirements and remain qualified they can eventually graduate with a degree. However, some students may decide to switch majors.

In high school students make curriculum choices in high school based on all the information they possess from various sources about themselves and the subsequent labour market consequences. So students who prefer to study ICT fields will have higher ex ante and ex post returns to complete their studies and earn larger wages even though their preferences are directly rewarded in the labour market. At this stage, parents have the ability to influence their child and Altonji et al. (2012) note that financial transfers could be used to “distort” the child’s choice towards education. This is important since parenting preferences could affect the likelihood that an individual will ultimately choose to complete a program of study and suggests that parent training programs may also be considered as a policy option. That being said, due to cultural differences, there are likely large differences in these distortions across ethnic groups which may suggest policy targeting.

The most frequent policy in higher education appears to be monetary incentives to encourage participation. This assumes that borrowing constraints and not uncertainty is important. As the next section will indicate the latter factors play a large role in college major choice and offering further funds could just be viewed as further subsidizing bad decisions. In the next section, we summarize the empirical evidence related to the three steps of the model and discuss policies within universities that could drive more students to get degrees related to ICT careers.

Section 4: Stylized facts related to ICT choices at the postsecondary level from the empirical economics literature
An important emerging finding in the economics of higher education literature is first that students can easily be influenced to make sub-optimal decisions based on small amounts of money.\(^9\) It is well established that where you go to school matters.\(^{10}\) Research has found that students are willing to sacrifice institutional quality for relatively small amounts of money and Pallais (2009) summarizes evidence of students systematically under-predicting their suitability for selective schools, majors and careers. Students do not make decisions on which schools to apply to in an optimal manner and issues surrounding institutional quality need to be considered jointly with major choice.\(^{11}\)

The second unsurprising result shown by Finnie and Frenette (2003) among many others is that what you study affects your earnings. Generally, engineering consistently commands a high premium (around 0.40 relative to education), usually followed by business and science. This difference in returns to major remains even after controlling for pre-college test scores, math ability, hours worked in jobs and selection in to the labour force. Walker and Zhu (2010) use quantile regression methods to estimate effects beyond the mean and find that in social sciences outside of law economics and management as well as arts and humanities that the returns at the bottom of the distribution and in some cases even at the median are negative.

In a recent paper, Akbari and Aydade (2012) compare earnings and unemployment rate across 50 disciplines in Canada. They show that wage gaps between disciplines increase sharply as an individual ages. For example, upon graduation economics and physical science majors earn similar amounts and have large wage

\(^9\) Anecdotal evidence suggests this issue is heavily influenced by competition across universities for students and may increase the variance of peer ability in the classroom. If peers affect student achievement in a non-linear and convex manner this will lead to large inefficiencies in the economy as students are not optimally allocated across schools. Understanding whether this problem can be remedied by either increasing information about college quality, students being present-biased or standardizing aid offers across institutions or imposing aid ceilings across institutions to encourage peer sorting based on ability requires further work.

\(^{10}\) Black and Smith (2006) among others show that students at lower-quality schools earn less over their lifetimes than their counterparts at higher-quality school.

\(^{11}\) That is, it would seem we do not simply want to encourage more ICT degree recipients and also must ensure that we consider quality and quantity jointly. To a large extent differences across institutions are less salient in Canada than the United States. Universities in Canada are much less likely to specialize than those in the United States. As a result, quality differentiation is less obvious and this may indicate that there is much duplication. This may reflect provincial funding competitions encouraging all universities to follow similar strategies. Expansions in many areas are irreversible but funding bonuses tend to be short lived. Forecasts for the coming years are not pleasant given demographics. We are currently seeing a large number of high schools being closed. With dwindling public support and fewer heads, there may be a need for specialization
advantages over political science majors Black, Sanders and Taylor (2003) show in the US that an undergraduate degree in economics indicate a better preparation for graduate work in many related disciplines.

An emerging finding is that the returns to math ability has increased sharply over the last two decades (e.g. Paglin and Rufolo (1990) and Grogger and Eide (1995). Last, as mentioned in the introduction Robst (2007) and Kinsler and Pavan (2012) document wage penalties for students whose jobs are in fields unrelated to their field of study. The size of the penalty increases in fields such as engineering which develop more specific skills relative to social sciences that promote more general skills. This is important and a point we will return to later since it stresses that promoting ICT majors in isolation is insufficient and we need there to be a good match also for career.

The third unsurprising pattern in the data are that large gender differences in choice of major continue to persist especially with less aggregated data. For example, Turner and Bowen (1999) show that while the gender gap in science enrollment declined, this was driven by a surge of women in biology and there has been no change in the gender gap in mathematical sciences.

Fourth, there is sorting into academic majors based on academic preparation. Arcidiacono et al. (2012) document that in California science majors at each campus having on average stronger credentials than their non-science counterparts. A few studies have shown that course selection in high school influences college major decisions and wages later in life. Not surprisingly, Altonji (1995) and Levine and Zimmerman (1995) find that taking additional math and science courses increase the probability of choosing a technical college major. Rose and Betts (2004) look at the type of math taught in high school and find that returns to taking these classes are larger for advanced math courses, particularly algebra and geometry.

Taken together, the above findings have motivated researchers to understand what factors drive college major choice and college major switching. Many factors ranging from expected earnings (e.g. Montmarquette et al. 2002 among many others), risk (e.g. Chen (2004) and Heckman et al. (2003)) to the role of ability proxies, performance and preferences has been investigated. Nonmarket factors also play a role in college major choice. DeGiorgi et al (2007) present evidence from Italian universities that peers’ behavior influences the choice of college major. Having peers in the same major could lead some to shift away from topics where they seem to have a relative ability advantage. Nonmarket channels and studying ICT fields also has learning effects.

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12 Related work by Bonnard et al. (2012) on understanding expectations of ex ante earnings which underlie major choices show that parental involvement helps students make better forecasts. Forecast errors also decline the closer is the connection between the discipline and the father’s occupation.
Brunello et al. (2010) find that being randomly assigned a roommate enrolled in the hard sciences leads to larger gains in performance.

More recent work has tried to gain more accurate information of student preferences and ability by trying to elicit them in survey. Using data from Berea College Stinebrickner and Stinebrickner (2011) combine administrative data following students over time with survey data were repeatedly asked to assign probabilities that they would finish different majors. While many students initially assigned a high probability to finishing a science major, poor grades led many to finish a different degree. If students feel that grades measure their abilities, evidence in Ost (2011) showing that science majors get higher grades in non-science courses than in science courses seems troubling. Further, given that the degree of grade inflation is higher in non-science fields relative to science fields, many students may be quite tempted to leave majors that could lead to careers in ICT fields. This is an avenue for policy intervention, where students are not only given a grade but also their relative rank. The evidence also highlights interventions can be targeted at earlier ages, where policymakers have more control on the student environment.

Student perceptions of majors play a large role in their decision making. For example, Arcidiacono, Hotz and Kang (2012) find students seem to justify their own major choice by holding higher expectations of earnings in the major in which they are currently enrolled than in other majors where there expectations are less accurate. Zafar (2009) finds that in making major choices at Northwestern university, students do not only care about expected future earnings, but students (and female more so than men) care about enjoying coursework, parental approval, and the social status of future occupations. Further, Zafar’s (2009) decomposes the source for the gender gap choice majors and reaches the conclusion that gender differences in preference are much more important that differences in abilities. Given the importance of learning about preferences and ability in school and major choice, it may be a benefit to delay student choice of major. Malamud (2011), however, shows that the Scottish system which allows later specialization than the British system decreases field-switching upon labor market entry. This is an important point for ICT fields that we will return to later.

Designing effective policies to increase student enrollment at high quality schools should be approached with caution. For example, reducing gender gaps in ICT enrollment is often discussed. Yet, Arcidiacono et al (2012) show that in California in an effort to increase the proportion of certain underprivileged groups at top schools simply crowds out and does not reduce gaps despite the good intentions. This policy changed the composition of minority and non-minority students across campuses in California, shifting many minority students to higher ranked campuses. Since students with relatively weaker academic preparation are significantly more likely to leave the

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13 Arcidiacono (2004) also documents a positive association between performance and persistence within a specific major.
sciences and take longer to graduate at each campus, it is likely the case that the vast majority of minority students would be more likely to graduate with a science degree and graduate in less time had they attended a lower ranked university.

This result that introducing students who on average, have lower ability than their peers, subsequently transferring to other majors, reinforces that students learn gradually about their preferences and ability as suggested by Altonji et al. (2012) as a feature that needs to be accounted for in an economic model. Simply providing information that ICT fields earn high wages may also not be a great policy. After all, suppose that the only the wage premium to ICT graduates increases, this model would suggest that by raising the ex-ante return to starting college induces more students to study in this area. However, since enrollment in these fields are capped, and if some college entrants who start in an ICT field conclude that they either prefer a humanities major and the occupations it leads to, or feel they are more likely to graduate with a humanities degree they would transfer to the humanities following the start of their postsecondary studies. Thus, it may not be surprising that even though many students start college with no intention of pursuing a humanities degree, they complete one. It appears in many universities quite difficult to switch into an ICT field at a later stage. Thus, it may also be optimal to raise the size of entering classes in ICT fields relative to other disciplines, given the ready transfer of students as well as now more students could be ranked a being above the median. Since this is primarily first and second year classes that would be larger in size, the budget implications are likely small since this only involves extra graders and teaching assistants.

A growing body of research demonstrates that there are benefits from providing students in secondary school with more information about their ability levels. A number of studies including Jacob and Wilder (2010), Stinebrickner and Stinebrickner, (2012); Zafar (2011) and; Stange, (2012) all show that this new information about academic ability leads them to recalibrate their expectations and change their future educational plans. More troubling is research by Oreopoulos and Dunn (2012) show that many Canadian adolescents do not seem to even understand the benefits of higher education. Given that characteristics other than expected earnings matter, information based interventions should be designed focusing on a specific subset of these other factors which align more closely with student preferences.

On this note, there is a move in the Canadian postsecondary system is to allow course credits to transfer freely across institutions. Having lower quality prerequisites (i.e. perhaps from online classes offered by for profit schools) may not help students who will immediately struggle. A broad liberal arts or liberal science base has desirable features to be mandated since it not only ensures that our citizens have general skills but gives students time to figure out their specialization and may lead to better student-ICT program matches. Universities also need to make it easier to move in directions other than just ending up in humanities.
More generally, a substantial number of graduate programs require no prerequisites in Canada. In some areas, advanced level research or course work does not require an undergraduate degree in the same discipline as a foundation for admission. As a result, many students who complete an ICT major have few barriers to be “retrained” in a professionally oriented program that has few links to their skills since they may perceive a better match. This reinforces that institutional barriers make it difficult and costly for students to remediate a poor decision and transfer to an ICT field.

Oreopoulos and Salvanes (2011) also make a point echoing Zafar (2009) that increasing income and wealth may not be the key motivator for educational choice.\textsuperscript{14} By reducing uncertainty about ability and preferences can boost non-cognitive skills that help reduce errors in decision making. The conventional policy response of throwing money at the issue had had little success and will be even tougher to justify in an era of increasing austerity. However, since the popular press loves to report about record levels of college loan debt, there will remain temptation for policy to continue to follow that track. Concerns that skills acquired in college are underutilized since graduates are in low-paying jobs will drive the press, and we believe it is probably a better target to improve career match by helping students make better choices.

One of the most popular explanations for wage dispersion among college graduates is overeducation and skill mismatch. This is viewed as evidence for market inefficiency reducing aggregate productivity because of less than perfect worker to position skill matching. Leuven and Oosterbeek (2011) summarize evidence showing that in most developed nations that college graduates are more likely to be overeducated, with an overeducation rate ranging from 39\% to 51\%. This is only important for policy if the rate is permanent. On the positive side, Clark et al. (2012) present evidence from longitudinal data that the prevalence of overeducation declines over the lifecycle suggesting that labour market frictions play a role, but there remains a persistent gap. Future work is needed to decompose the overeducation gaps by college major.

Section 5: Conclusion

OECD economies are increasingly based on knowledge which is shifting the demand for labour towards university graduates. The skills needed for jobs in the knowledge based economy will vary substantially across positions, which have

\textsuperscript{14} That being said a case could be made if students are risk averse and make poor choices and there may be a role for public policy to subsidizing schooling since it diversifies individual risks of education investment. However, this may not lead to the correct skill mix and we may need to disentangle riskiness of investment into ICT fields from riskiness of getting a college education.
important implications for higher education. In Canada, we have observed large gains in the number of business majors whereas the proportion with degrees in the sciences has remained constant. In addition, there are growing differences between Canada and the United States in the proportion of PhDs in the humanities relative to the physical sciences as well as those majoring in economics relative to business. To a large extent, the trends seem to suggest that salient program titles appear more attractive in Canada and this is striking given the cost differences.

While financial factors have been shown to influence student choices, the general trends suggest that Canadian students are attracted to practical fields (i.e. business and computer science in the early 1990s) based on perceptions of higher earnings rather than the empirical evidence. Within institutions, despite their calls for increased funds, it may be better to consider adopting policies that would provide students broader exposure to subject matter prior to specialization as well as reducing barriers regarding transfers across majors. It will also be worth considering developing policies that can give students a greater understanding of their relative ability which may involve introducing policies that curb disciplines from heading down a grade inflation death spiral. Last, if peer effects are important, policies that cap aid offers to improve sorting should be considered.

We suggest the role for public policy in higher education must better reflect the diversity of skills required and the manner by which these are developed. This requires considering the dynamics of individuals education and career choice together. Simply put, the current system has significant hurdles for students who often find it very difficult to remedy a mistake early in the lifecycle (i.e. not to take a math class). The economics literature summarized above presents a large body of work showing that many of the mistakes students make are due to their limited knowledge of either their ability or their tastes for different disciplines. We need to devise a means to provide opportunities for most students to experience a broader set of majors to understand where they may best fit. Students have many misperceptions about different majors and lack information about their standing and the quality of their degree.

In summary, there does not seem to be any advantage to subsequent employers, aggregate productivity or even individuals themselves later in life, by telling kids early on that there is little difference across institutions and majors by not providing them with relevant information. Decisions have consequences and sadly undoing errors make when choosing postsecondary investments is quite costly and students also need to have a better understanding of the career opportunities prior to making their choices. Designing policies at the secondary and postsecondary level that reduce uncertainty will likely allow Canada to produce its own graduates to reduce skill shortages in the ICT sector.
References


