ICT Skills Shortages: Framing the Issues

Ross Finnie
University of Ottawa
(rfinnie@uottawa.ca)

Ken Norrie
McMaster University
(norrie@mcmaster.ca)

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ABSTRACT
The objective of this paper is to provide a conceptual framework for thinking about skill shortages in the Information and Communications (ICT) sector. We start with the labour market context using a standard demand-supply perspective to describe the normal determination of employment rates and wages and what the existence of labour shortages normally implies. We then turn to the formation of these skills in the post-secondary education system, again using a supply-demand market analytical approach – an approach not often used to address these issues, including among economists, but one that seems useful to employ in this context. The paper is intended to set the stage for the other papers to be presented at the workshop and to otherwise frame guide the discussions planned for the day. This is a first, workshop draft. Comments are welcomed.

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1. Introduction

A recent survey of more than 100 Canadian Information-Communications-Technology (ICT) firms pointed to a critical labour shortage in their industry (Nordicity, 2012). The report noted that the unemployment rate in the sector was just 2.4% in 2011, meaning essentially full employment. Further, it indicated that ICT firms reported “alarming” difficulties recruiting suitable workers.

The survey pointed to factors on both demand and supply sides that are contributing to the identified shortages. First, the demand for ICT professionals in the ICT sector itself is growing rapidly as firms strive to succeed in the new global economy. This situation is exacerbated by the fact that the specialized ICT skills upon which this sector depends are also in great demand in banking, finance, manufacturing, transportation and virtually all other industrial sectors, including government and education. Indeed, estimates suggest that nearly half of all ICT professionals work outside the formal ICT sector.

Meanwhile, the supply of skills does not appear to be growing to match the increased demand, in large part due to the decline in undergraduate enrolments in ICT disciplines following the 2001 dot-com bust. Furthermore, the flow of immigrants with ICT skills from emerging economies is now only about one-quarter of what it was in 2001.

If this perception of a chronic labour shortage is accurate, it poses significant problems for Canada. The ICT sector is a key driver of any modern economy, and any limits on its growth will have significant adverse effects on the nation’s competitiveness. Furthermore, the ICT sector is generally thought of as creating “good” jobs, with high wages and other attractive attributes. The federal government recognized this central role of the ICT sector with the Digital Economy Strategy outlined in the 2011 budget, and SSHRCC subsequently announced that digital economy as a priority research area.¹

The Nordicity report and the attention it has garnered raise a number of issues. First, and most obviously, is this perception of a chronic shortage of ICT workers true? ² Secondly, if this shortage does in fact exist, how do we explain it? And finally, what is the appropriate policy response on the part of governments – or what actions may be required by employers, the post-secondary education system, and others who play a role in the relevant skills dynamics?

To address these questions, our starting point is to note that chronic labour shortages (or surpluses, although that is a different policy issue) do not exist in textbook scenarios. In these models, labour markets would signal conditions of excess demand for ICT workers in the form

¹ This workshop has been made possible due to funding received from SSHRC through their Connections program, which encourages gatherings of scholars with those from other backgrounds and sectors.

² Related to this issue is the question of whether any persistent shortage is unique to the ICT sector or if it reflects a more general failure of Canadian labour markets to adjust to changing times. Our focus here, however, remains on ICT skills/workers and the ICT sector.
of low unemployment rates, rising wages and other improvements in employment opportunities in the sector.

In response, some individuals would be attracted to the sector in the short run, and then – and our main focus here as in the workshop in general – result in responses on the part of students and the post-secondary education (PSE) system more generally to increase the number of individuals entering the labour market with ICT skills, thus cutting into the shortages.

More specifically, the standard model holds that students – who represent the demand side of the PSE system in our framework\(^3\) – would take note of the labour market signals just mentioned and alter their higher education program and course choices accordingly. Educational institutions – although usually not considered in any explicit way by labour market economists – would presumably note the changing application patterns, or perhaps even anticipate them, and adjust program and course offerings accordingly, thus boosting the supply of ICT training places available in the PSE system. After a predictable period roughly equal to the time required for students to move through and complete their programs, a stream of new ICT graduates would enter the labour market.

In addition, if the Canadian labour market signals are compelling enough and the immigration system is accommodating, some of the excess demand for skilled labour would be met through increased immigration of individuals with ICT skills – a minor theme also treated in this paper, as in the workshop.

This textbook scenario is admittedly a simplified and idealized view (as are most economic models), but it has the virtue of allowing us to focus on conditions where chronic labour shortages might exist. In essence, to postulate the existence of chronic labour shortages is to postulate that one or more of these “markets” has somehow failed. In what follows, we examine each of the markets in more detail, first giving a fuller account of the textbook scenario, and then identifying the conditions under which such skilled labour shortages might arise and persist.

Our objective in this paper is to provide a framework for thinking about ICT skill shortages that will help set the stage for the other papers to be presented at the workshop and otherwise help frame the day’s discussions.

2. The Labour Market

The labour market is the sector in the scenario just described that most closely fits the traditional definition of a market. The demand for ICT professionals comes from private firms,

\(^3\) That is, they seek to study in ICT-related disciplines and to otherwise develop ICT skills at colleges and universities – which is not very different, conceptually, from any other market, where in this case those places in ICT-related programs and courses are the product or service in question.
The supply of ICT workers comes from Canadians and permanent residents possessing the requisite skills, as well as from ICT professionals in other countries who might be induced to immigrate to Canada. Demand and supply should interact in the usual manner to determine equilibrium wage and employment rates.

Suppose now that there is an increase in demand for ICT workers. This would result most immediately in there now being more jobs on offer at prevailing wage rates than there are workers seeking them. In a textbook labour market, these shortages move the market from equilibrium into disequilibrium, or a situation of labour shortage, where demand is greater than supply. This should soon become evident, showing up as decreases in relative unemployment rates for workers with the relevant skill sets and increases in posted job vacancies and other recruiting activities by employers.

Wages should soon being to rise as a given number of workers are competed for on the part of employers. We are also likely to see, in the real world, feature news stories and the release of reports by industry associations, government agencies, and others documenting the prevailing skill shortages, with accompanying predictions of how long they are expected to last, these representing further signals of improved career opportunities in the relevant sector.

In the short-run, there should be at least some response on the supply side of the market, as workers with ICT skills working in other sectors move towards the improved opportunities emerging in the ICT sector. Similarly, workers with border-line ICT skills or ICT skills not currently being used may brush off those skills, re-position themselves in the job market, and perhaps get a bit of re-training to further enlarge the pool of “ICT workers” available.

Meanwhile, as wages rise, demand will dampen: the infamous law of demand.

Thus even in the short-run, the standard model typically postulates, the market for ICT workers should move towards a new equilibrium with higher wages, and more workers. In short, there should be movements along the short-run demand curve and along the short-run supply curve to guide the market towards a new short-run equilibrium. Even if increases in demand continue to outstrip supply, keeping the market in a perpetual state of disequilibrium (and unemployment rates low – i.e., shortages), we should see these same kinds of increases in wages

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4 In economics, the demand for labour is – like other factors of production – a “derived” demand, meaning that in contrast to the demand for a final product (e.g., a car, a restaurant meal, etc.), it represents a demand based on what the factor is worth in terms of producing something else. In this jargon, the demand curve for labour (or any particular kind of worker) on the part of an employer is based on the “value of the marginal product” of the relevant workers, which is defined as what the workers contribute to production multiplied by what that product can then be sold for. For governments and others, similar principles apply.

5 It is worth noting that the whole exercise of predicting skill shortages can represent a bit of a mystery for academic labour economists, since shortages are assumed to be the result of the related labour demand and labour supply dynamics – i.e., demand being greater than supply at a given wage rate, while wage rates are in turn determined by those same underlying demand and supply dynamics and should typically equilibrate those – i.e., keeping demand equal to the available supply. One observer has commented that the whole purpose of predicting shortages, at least on the part of government, is to help ensure they don’t actually happen.
and the number of ICT workers, these tendencies continuing as long as the market remains in (short-run) disequilibrium.

One possible explanation for persistent skilled labour shortages then is that “real-world” ICT labour markets do not respond in this way – i.e., initial shortages due to shifts on the demand side resulting in lower unemployment rates, then rising wages and the movement of workers into the sector. It may be, for example, that relative wage and unemployment rates for ICT professionals adjust only relatively slowly even in the face of persistent excess demand. And even when unemployment and wage rates do adjust as appropriately, these data are typically released with a relatively long time lag and can be difficult to access and to interpret, thus potentially slowing the movement of workers into the sector even as employers remain desperate to fill vacancies. Other such rigidities may also characterise the market.

Alternatively, the signals coming from the labour market, especially those regarding the long-run prognosis of the sector and its related employment opportunities, may not be judged as credible, thus slowing the adjustment mechanisms, especially on the supply side. There is, in this respect, possibly a widespread lack of confidence in the ability of governments, in particular, to predict economic trends or otherwise “pick the winners” in terms of future career opportunities – perhaps especially when it pertains to the ICT sector. We only need remember the experience starting in the mid-1990s when significant efforts were made to increase enrolments in technology-related disciplines in colleges and universities (as well as to increase the number of ICT-trained immigrants entering the country), only to have these new labour market entrants graduate just as the dot-com bubble burst.

One important research issue, therefore, is to understand better how effectively labour markets signal conditions of excess demand (or excess supply for that matter) for ICT professionals, and how the market responds to those signals. Where we look could perhaps gain some guidance from the simple model sketched out above.

That is, have unemployment rates indeed been high, as some measures indicate, perhaps persistently so, thus pointing to the existence of the alleged chronic shortages? Has there been a change in the efforts made – and investments undertaken – by employers to recruit ICT talent?6 What other measures of labour market tightness in the ICT sector might already exist, or could be developed?

More directly regarding workers, have the wages of ICT professionals been rising in the manner predicted by the model? What has the record been in the ICT sector generally, among ICT professionals as a group across all sectors, and among ICT professionals working in the ICT sector in particular? What has been the experience of those just entering these areas, including recent graduates and immigrants, who might better reflect current market conditions, than the “average” worker, for whom wages are likely to be much stickier? Have workers been moving

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6 The OECD has of late been developing measures of precisely this type to these same purposes.
into the ICT sector from other sectors, and what has happened to their earnings for those who have done so?

And has the result of these demand and supply forces in fact been the increase in workers in the sector as predicted by the model?

Various data sources could be used to these purposes, some already in existence, others needing to be developed. These sources could include standard datasets such as those currently used to measure unemployment rates by sector. Special surveys of employer hiring practices could also be useful. Other data, especially of a timely nature, measuring the various kinds of wage changes, including tax data, which possess at least much of the information required on an annual basis, represent another source.

Thus we welcome the contribution to this workshop by Mike Veall on “Looking for evidence of skills shortages in labour market data”, and Mikal Skuterud’s perspective of these dynamics in terms of recent immigrants and temporary foreign workers.

We also welcome discussions regarding the potential linking of PSE administrative data held by institutions (i.e., individual colleges and universities) to tax data, which would provide a view of post-schooling outcomes on an annual basis for different cohorts of PSE graduates. This could be done for those studying in traditional ICT-related areas (as compared to others), as well as those leaving more innovative programs which providing training in non-traditional combinations of ICT-relevant skills, such as business programs with an accompanying “technical” component, more traditional ICT programs offering courses in entrepreneurship or other business elements, or still other, even more innovative, combinations of courses and training. How have such students/graduates been doing in general, and what has been happening in terms of the numbers, and outcomes (especially wages), of such students over time? Further linkages to other datasets, such as firm-level data, would open up even more interesting opportunities to track ICT professionals and workers in the ICT sector.

One obvious direct policy consideration coming from such work could include improving the quality, timeliness, credibility, and availability of all these kinds of labour market information, as well as a commitment to the analysis of the relevant labour market dynamics.

Deeper issues regarding any identified lack of adjustment in ICT labour markets in the manner predicted by the model would present a further set of questions, and quite possibly a more perplexing, and complex, set of policy challenges.
3. The PSE “Market”

The second sector we consider is the PSE system. We believe it is useful to think of this sector as a market as well, complete with demand and supply curves, even though it does not fit the usual definition.\(^7\)

*The demand for ICT education and skills training* comes from students contemplating their first PSE application, from students already in the higher education system who might be induced to switch programs, and from older adults contemplating returning for further education and training. It also comes from students in other countries who are considering pursuing their further education in Canada.

*The supply of ICT education and training* is provided by universities, public colleges, and private career colleges. These programs range from a few months for upgrade certificates to graduate degrees extending over many years.

The allocation of students to programs – ICT and others – typically proceeds in the following manner. Students apply to their top-choice programs, submitting evidence of their suitability in the form of grades, reference letters, portfolios, work and volunteer experience, and so on. PSE institutions screen applications and extend offers of admission to a target number of applicants, with targets set by the availability of the faculty, facilities and equipment needed to mount the program – among other less tangible considerations such as institutions’ overall short and longer run goals.

Students receiving offers of admission choose among their options, institutions make a second round of offers, and the process repeats. The end result is that some PSE programs will meet their target enrolments while others will fall short of theirs. Some students will end up in their first-choice programs, others in their second- or third-choice ones, and some will defer or maybe even abandon their higher education plans.

With the exception of a few advanced professional programs such as the executive MBA, prices do not figure significantly in this process – or in this market more generally. Tuition fees are highly regulated in Canada, and differ only marginally among programs – including most of those relating to ICT – and among institutions. The key rationing device which “clears the market” (or otherwise matches demand and supply in cases where the former exceeds the latter)

\(^7\) Economists’ general avoid treating the PSE system in any detail – using a market approach or otherwise. The main reason for this is likely that it does not easily lend itself to the neoclassical economist’s standard tool kit, which is heavily dependent on identifying economic agents who have well defined objective functions and who are assumed to pursue well-defined goals over equally nicely defined choice parameters. The PSE system is obviously much messier than this on the supply side. It is also highly questionable as to how much students engage in the typically assumed “lifetime utility maximisation behaviour” typically assumed by economists (these challenges gaining increasing traction from the growing literature in behavioural economics – see Finnie, 2012, for example). Finnie (2005) presents the PSE system using such a market approach in a simple intuitive way, and this approach is borrowed from in this section.
is perceived academic ability, generally proxied by grade point average. Thus entering averages differ significantly among faculties and specific programs, and across institutions, being highest in those with the greatest excess demand and declining as application rates relative to program capacities fall.

Another interesting characteristic of this system is that the number of students – overall, and in any given program at any particular institution – will typically be “supply constrained” in cases where demand exceeds supply. This simply means that if there are more students wanting to get into a program than there are places available, there can only be as many students as there are places. This implies that increasing the demand for PSE places (e.g., encouraging more students to enter the relevant disciplines or institutions) in such situations will not necessarily change the number of actual students enrolled, since that is already limited by the number of spots available. Entry criteria (e.g., high school grades) will, however, likely rise, as more students chase those fixed numbers of places.

We should, though, see an increase in student numbers where the supply of places is increased, while the change in entry criteria (and the characteristics of entering students) will depend on whether there is a simultaneous shift in demand, and to what degree.

Conversely, where there is an excess supply of places (i.e., more places available than there are qualified students seeking those places), we consider the system to be “demand-constrained”. In such cases, increasing supply further will not change the number of students, but shifting the demand curve will do so. Entry criteria will again depend on the relative changes in the underlying supply and demand curves.

Thus, observing the number of students in the system, entry criteria, and application data can give us good clues as to what is happening to the underlying supply and demand dynamics in the PSE system, including in any particular area of study, such as ICT disciplines and programs.

Assume now, more concretely, that students (or at least their parents and advisors to the degree student choices are determined by these third parties) conclude from various labour market signals that career prospects in the ICT sector have improved significantly in recent years. In the textbook scenario, some proportion of PSE applicants will take these signals into account when making education and training choices. They can be high school graduates entering PSE for the first time and opting for computer science or software engineering instead of biological sciences or arts; they can be students already in PSE who switch their majors; or they can be students who stay in non-traditional ICT programs but add more ICT-type courses to their curriculum, such as “humanities computing”.

Still in this textbook world, institutions would be assumed (to the degree institutional behaviour is considered at all – see the note above) to observe this shift in application patterns, or have even anticipated it, and adjust enrolment targets accordingly. More spaces are opened up in high-demand ICT programs and more ICT-type courses are offered in other faculties, as the institution shifts resources from declining to growing enrolment areas. Ideally – from the
perspective of all (except perhaps those with a stake in the declining areas of study – see further below) – the adjustment in program admissions targets takes place as rapidly as possible, given the constraints imposed on the institution by existing obligations to current faculty, staff and students. There is then an unavoidable lag between increased admissions and when graduates enter the labour market, depending on usual program lengths.

This textbook account of the PSE process thus points to a number of factors that could contribute to chronic labour market shortages. The explanation may lie at least in part on the demand side. That is, more students may not be choosing to enter ICT-related programs of study even in the presence of skill shortages there. This may be for a number of reasons.

One demand side factor could related to the kinds of information problems discussed earlier regarding labour market adjustments: the signals coming out of the labour market – low unemployment rates, higher earnings, etc. – may not be received by students, or they are not be regarded as credible indicators of long-run career possibilities. Indeed, if the latter were true, and short-run labour market improvements were in fact only that, we would not necessarily want students’ schooling choices to change in the face of short-run labour market fluctuations. Current labour market signals should, therefore, presumably be not only measured on a timely basis and widely disseminated, but also be bolstered by credible information pointing to longer-run improvement in career opportunities for those entering ICT areas of study.

A second PSE demand side hindrance may be a belief that ICT careers – even if booming now and likely to do so into the foreseeable future – too often consist of graduates being taken in, worked hard, and then turned out to pasture out by the sector as a new crop of ICT graduates possessing even more recent skills is recruited. Again, improved labour market information regarding ICT careers would help address any such misconceptions.

Thirdly, students may receive these labour market signals, but not be fully aware of what schooling pathways lead to ICT careers. Industry Canada has, for example, identified six occupations as representing ICT professionals: Information Systems Analysts, Software Engineers, Programmers and Media Developers, Database Analysts and Administrators, Computer Engineers, and Electrical and Electronics Engineers. Some of these occupations correspond to departments in colleges and universities, but some do not, and it may be the case that students do not generally understand the education and skill requirements relating to ICT careers.

There is, in fact, other evidence to suggest that there are no clear links between specific higher education programs and ICT employment. Census data indicate that those reported as working in ICT industries come from a wide variety of educational backgrounds, many of them not obviously ICT related, while also indicating that many workers with formal ICT training are employed in non-ICT industries and non-ICT occupations/jobs. Thus it may not be obvious to students what they need to study to become an ICT professional, and it is not obvious that those with specific ICT training will end up in this sector of the economy.
Fourthly, and still on the PSE demand side, it may be the case that not enough students take labour market considerations into account when choosing their programs of study, and instead subscribe to the view that university education, in particular, is not about job training. This is, however, probably a less likely reason, since the vast majority of PSE students – those in university programs almost as much as those at colleges – do appear to place future career opportunities among the most important factors underlying their schooling choices, and this attitude is likely to prevail even more so for those students who may be at the margin of entering ICT careers (say, those with reasonable technical skills looking for a place to use them).

A fifth demand-side issue may be that students are put off by other, non-wage, aspects of ICT careers or the schooling programs that will lead them there – whether these considerations are real or only perceived. Perhaps the jobs, and schooling leading to them, are considered too hard. That said, labour market shortages should shift the balance in favour of ICT training for at least some students, and it is only some students that need to move. Image issues may also be part of this: “ICT is for geeks” may encapsulate these issues in a casual way.

For women, who now comprise 60 percent of all university entrants and approximately half of those entering colleges out of high school, non-wage factors and “image issues” may be particularly important. Whether their concerns reflect reality or only misconceptions, making ICT careers more “female friendly” is probably a fundamental element of addressing issues pertaining to any true shortage of students wanting to enter ICT areas of study.

Alternatively, explanations for the lack of expansion of ICT students in times of labour shortages in ICT careers may lie primarily on the supply side of the PSE system. It may be the case that PSE institutions are unable or unwilling to adjust acceptance and registration targets (as well as curricula) in the face of growing (or shifting) program demand for ICT professionals.

There are several possibilities as to why the supply may be the constraining factor. ICT programs tend to be relatively expensive to mount and operate and the necessary incremental funding may not be available. Such problems are, furthermore; likely to only worsen as we move into a period of greater fiscal constraint, the PSE sector included. And as noted above, tuition rates are generally regulated, so using higher fees to fund expansion is likely to be very limited.

Or, and related, it may be that university administrators are slow to adjust program enrolment targets because of the need to meet obligations to existing faculty and staff. You can’t, say, get an English Literature Professor to start teaching advanced C++ programming, nor easily lay them off in order to hire someone who can. In times of retrenchment, rather than expansion, these issues will, again, become all the more acute.

Another possible supply side issue pertains to one of the demand side factors mentioned above regarding education-career matches, in this case taking the form that individual PSE institutions, and PSE systems more generally, may not fully understand the links between PSE courses, program, and detailed curricula and ICT careers – especially in those ways that are newest and most path-breaking which represent the leading edge of ICT skill shortages. In short,
perhaps institutions lack understanding of exactly where, or how, to expand to meet the growing needs of an ICT sector.

Or, related, education and skill requirements for ICT professionals may be reasonably well understood, but PSE providers may not aim to design programs with these requirements in mind. This would be especially true to the degree university faculty and administrators hold to the view that universities are not about job training, although this attitude is likely less prevalent among faculty and administrators in professional faculties that are most likely to feed the ICT sector.

Even if the intent and ability to offer programs to meet ICT employment needs are there, the act of specifying intended learning outcomes, designing curricula accordingly, and measuring value added is a relatively new focus for Canadian universities. Assessment of Higher Education Learning Outcomes (AHELO), the Tuning process, and the Collegiate Learning Assessment measures are still in the early stages of trial and experimentation in this kind of thing. Thus it may be the case that universities are at least moving towards graduating sufficient numbers of ICT students, but without the requisite skill mix to meet industry requirements. The co-existence of ICT firms seeking workers and ICT workers seeking positions would be evidence of such a misalignment.

Finally, a third general reason for the lack of current flows of ICT students into the labour market may in part be an issue of lags. It takes time for labour market signals to be measured and widely understood. Student choices may take time to adapt to these new realities. PSE institutions will likely also need time to shift their resources. Then students have to make their way through their programs of study. From beginning to end, this will take a considerable amount of time.

Indeed, to the degree some of these processes, such as the formation of student choices and the preparation for ICT study at the PSE level start in high school, these lags will be even longer – and point to a need to start at an even earlier point in the education system, and in students’ lives, to make sure the right number of ICT graduates, with the right kind of ICT skills, make it into the labour market.

All these aspects of the PSE system are worthy of further study, again using a variety of existing and currently undeveloped data sources. We see, in this respect, particular hope for much greater exploitation of the kind of PSE administrative data mentioned above. Policy implications will flow from what these data, and this research, uncovers.

On the demand side, one specific candidate for further work is whether and how labour market signals factor into students’ higher education program choices. Thus we welcome the two papers on this topic at this workshop: “Student choices of what to study – a theoretical/conceptual framework” by Steve Lehrer and “Women’s schooling choices and ICT disciplines” by Richard Mueller.
For the supply side, we welcome the presentations to be made by Kent MacDonald, President of Algonquin College, and Bonnie Patterson, President of the Council of Ontario Universities. We need, in particular, a better understanding of how institutions set and adjust enrolment targets, the specific course and program offerings, and the actual course curricula over time.

We also welcome the comparative perspective, “The ICT skills issue in Australia and New Zealand”, provided by Kostas Mavromaras and Roger Smyth.

4. Conclusion

The Nordicity report and companion documents and media stories alleging a chronic shortage of ICT professionals have identified an important issue for this nation. We need, first of all, to know if the allegation is accurate. If the evidence is that it is an accurate description, we need to know how a skills shortage of this type has arisen, and especially how it has persisted. Is it unique to the ICT sector, or does it reflect a more general failure in Canadian labour markets? What are the appropriate policy responses?

We hope this framework proves useful in pointing to areas for further research and policy discussion. We welcome the opportunity this workshop provides to bring together knowledgeable representatives from industry, educational institutions and governments.

REFERENCES

