The determinants of literacy and numeracy, and the effect of literacy and numeracy on labour market outcomes

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Abstract In this study we examine the determinants of literacy and numeracy among native-born Canadians. The role of literacy and numeracy as determinants of labour market outcomes is assessed, and both are found to contribute to the explanation of labour market status, weeks worked, and income. Significant differences in the male and female estimates are noted. Estimates of the return to years of schooling are shown to be sensitive to the exclusion of measures of literacy and numeracy. Further, the inclusion of these variables decreases the estimated return to years of schooling for males and increases the estimated return for females. JEL Classification J31, J24.

Les facteurs déterminants de 1'alphabétisation et des capacités de calcul, er les effets de ces habiletés sur la performance dans le marché du travail. Ce mémoire examine les facteurs déterminants de l'alphabétisation et des capacités de calcul pour les canadiens de souche. On évalue l'impact de ces habiletés sur la performance dans le marché du travail. Il appert que ces deux habiletés expliquent en partie le statut dans le monde du travail, le nombre de semaines de travail, et le niveau du revenu. On note des différences significatives entre les résultats pour les hommes et les femmes. Les mesures du taux de rendement sur les investissernents en années de scolarité sont affectées par l'exclusion de ces variables. L'inclusion de ces variables tend à réduire le taux de rendement mesuré pour les hommes et à l'accroître pour les femmes.

1. Introduction

There has been considerable public discussion of issues involving literacy, numeracy, and education (cf. Ontario 1994). At least part, and perhaps a significant part, of the concern over the level of literacy and numeracy centres on the labour market implications of illiteracy and lack of arithmetic skills. This public discussion is premised on literacy and numeracy skills being basic components of human capital.

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Empirical analysis of literacy acquisition and the effect of literacy on labour market outcomes has generally been limited to the study of immigrant populations (cf. Kossoudji 1988; Rivera-Batiz 1990, 1996; Chiswick and Miller 1992, 1995; Charette and Meng 1994). These authors have focused on the ability of immigrants to acquire the dominant language(s) of their host country and the effect of dominant language acquisition on earnings. A related literature examines language .and earnings among Hispanics in the United States (cf. Bloom and Grenier 1994; Grenier 1984; McManus 1990). Although most of the latter studies are concerned with the labour market performance of native-born. Spanish-speaking Americans, several also considered Spanish-speaking immigrants. There are a number of Canadian studies that examine the role of 'mother tongue,' 'home language,' or ethnic group (British or French) in the explanation of earnings differentials (cf. Carliner 1981; Chiswick and Miller 1988; Robinson 1988; Shapiro and Stelener 1987). The authors of these studies generally examine the earnings differences across language groups, but not the role of degree of literacy in the given languages.

While motivated by the literature on immigrants, in the present study we make a number of advances over previous work on literacy. First, and most important, the data set used makes available an objective measure of reading ability. Previous studies have generally relied on self-assessed literacy scores, similar to those reported in the American or Canadian census. Generally, these self-assessed measures are limited to speaking ability.[1] Charette and Meng (1994) have shown that there are potentially serious measurement errors in self-reported literacy variables. Second, the data set used in this study also includes a numeracy test score. Little research has been conducted on the determinants of numeracy or its role as a component of human capital. Third, the model specification includes a number of socio-economic background variables not found in other studies. In particular, we are able to control for factors such as parental education and immigration status, and childhood learning disabilities. Fourth, we consider a sample of native-born Canadians. Finally, except for the work of Rivera-Batiz, previous studies of literacy have tended to focus on males. Men and women might acquire language and numeracy skills differently, while literacy and numeracy might affect the labour market activity of men and women differently.

Anticipating the empirical results reported below, we find a differing role for the formal education system in the literacy and numeracy acquisition of males and females. Both literacy and numeracy play a significant role in expressions explaining labour market outcomes. even after years of schooling are accounted for. Male and female experiences also differ with respect to the impact of literacy and numeracy on labour market outcomes. Our results indicate the potential for serious omitted variable and measurement error bias in parameter estimates on years of schooling terms in specifications that do not control for a wider set of human capital characteristics and the quality of years of schooling.

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[1] Rivera-Batiz (1990, 1992) uses a test score similar to the score used in this study for a sample limited to individuals 21 to 25 years of age. Ishikawa (1993) makes use of a similar test score in processing the impact of literacy on the labour market activity of young, unemployed workers in United States.

In section 2 the determinants of literacy and numeracy are considered. A discussion of the data base and variables used in the empirical work is presented. In section 3 the impact of literacy and numeracy on the probability of an individual's being in the labour force, employed, employed on a full-time basis, or unemployed is considered. The role of literacy and numeracy as determinants of the number of weeks worked is also considered. Finally, we examine the relationship between literacy and numeracy, and income. In section 4 we present some conclusions and qualifications.

2. The determinants of literacy and literacy

2.1. Data

Statistics Canada's Survey of Literacy Skills Used in Daily Activities (LSUDA) provides the data set used in this study (see Statistics Canada 1991b). LSUDA is a weighted survey of 9,445 adult Canadians, aged 16 to 69 years. The survey consisted of face-to-face interviews, during which respondents were asked to complete thirty-seven tasks designed to measure specific reading, writing, and numeracy skills. The interviews were conducted in one of the two official languages, as chosen by the respondent. Although LSUDA included two writing exercises, the results of these exercises did not allow for the development of a measure of writing ability comparable to that reported for reading and arithmetic sells (see Statistics Canada 1991a, 21). In what follows, the term 'literacy' refers to reading ability.

The LSUDA measures of literacy and numeracy are based on item response theory or latent trait scoring, designed to provide a joint estimate of question difficulty and the respondent's ability. The resulting measures are continuous variables ranging from zero to 500. For the sample used in this study, the mean values of the latent trait scoring measure of literacy, denoted LIT, were 256.7 for men and 259.5 for women. Statistics Canada analysts (Statistics Canada 1991a, 17-18) characterize individuals with LIT scores less than 150 as 'having difficulty dealing with printed material.' Individuals with LIT scores of between 150 and 204 are characterized as having the ability to 'use printed materials for limited purposes only, such as finding a familiar word in a simple text.' Individuals with LIT scores of between 205 and 244 are characterized as being able to 'use reading materials in a variety of situations, provided the material is simple, clearly laid out, and the tasks involved are not too complicated.' Individuals with LIT scores of 245 or greater are characterized as being capable of 'meeting most everyday reading demands.'

A subset of LSUDA literacy questions was used to assess numeracy. These questions were designed to simulate daily arithmetic operations, such as paying bills or adding receipts, and required both literacy and numeracy skills. Given that the numeracy questions were 'embedded' in a subset of the reading tasks, the resulting measure of numeracy is not completely independent of the individual's level of literacy.[2]

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[2] Of the 9,455 survey respondents 104 could not attempt the literacy portion of the survey, owing to their inability to communicate in one of the two official languages. The numeracy level of an additional 321 respondents was not evaluated, owing to their failure to complete an elementary set of literacy questions. In addition, we might expect that individuals with LIT scores of less 205 would suffer a more or loss serious 'literacy' disadvantage in the LSUDA numeracy evaluation process, irrespective of their true numeracy skills.

Our sample mean values for the latent trait scoring measure of numeracy, denoted NUM, are 256.9 for men and 256.6 for women. Statistics Canada analysts characterize individuals with NUM scores of less than 200 as 'having very limited numeracy abilities which enable them to, at most, locate and recognize numbers in isolation or in a short text.' Individuals with NUM scores of between 200 and 249 are characterized as having ability to 'deal with material requiring them to perform simple numerical operations such as addition and subtraction.' Individuals with NUM scores of 250 or greater are characterized as being capable of 'dealing with material requiring them to perform simple sequences of numerical operations which enable them to meet most everyday demands.'

In what follows we treat literacy and numeracy as distinct skills. Given the LSUDA questionnaire design, however, measured numeracy is expected to be influenced by the respondent's level of literacy. Independent of measurement considerations, we would expect a positive correlation between literacy and actual numeracy skills. If the true correlation between literacy and actual numeracy is a perfect one, or if the LSUDA questionnaire fails to distinguish numeracy skills from literacy skills, then NUM should not contribute to the explanatory power of a specification that includes LIT.

The sample used in this study consists of native-born Canadians aged 25 to 69 years. In order to avoid inclusion of individuals whose schooling is not yet complete, observations on individuals 16 to 24 years of age are dropped, yielding a sample of 7,147 (see Rivera-Batiz 1992). In addition, individuals who did not answer questions used to define variables included in our specifications and the approximately 11 per cent of LSUDA respondents who were foreign born were deleted from the sample. Our base sample contains 6,084 observations, including 2,724 men and 3,360 women. When the NUM variable is included in a specification, the sample is further reduced to 2,616 males and 3,256 females. The disproportionate number of unweighted female observations in our sample reflects the relatively large number of unweighted female observations in the LSUDA data set itself (56 per cent), not our particular subsetting of the raw data. Table 1 provides brief variable descriptions and sample means. The correlation coefficient between LIT and NUM for all 5,872 observations in the numeracy restricted sample is 0.75.

2.2. Model of literacy and numeracy determination

There are three issues that must be considered in specifying the expression for the determinants of literacy and numeracy: whether or not the formal education system is the only resource for the acquisition of literacy/numeracy skills; whether or not the formal education system acts as an effective screening device for literacy/numeracy skills, however they are acquired, whether or not the quality of the education experience varies across individuals with respect to either its role the acquisition of, or the screening for, literacy/numeracy skills. Consider, first, the case in which the quality of education does not vary. If formal education 15 the only resource for the acquisition of literacy/numeracy skills, or if the formal education system represents a strict literacy/numeracy screening mechanism, a model explaining literacy or numeracy would include either the years of schooling or the usual socio-demographic variables that explain an individual's level of education (mother's education, father's education, social status, etc.) but not both. Alternatively, if the socio-demographic determinants of an individual's level of education also influence literacy and numeracy skill acquisition outside the context of the formal education system, and if the educational system does not act as an effective screening mechanism, then the socio-demographic variables that explain an individual's level of education might also have a direct influence on the individual degree of literacy and numeracy.

Table 1
Variable descriptions and means

Variable name Description Men Women

TABLE 1
Variable descriptions and means

Variable name	Description	Men	Women
LIT	Literacy test score	265.65	259.47
NUM	Numeracy test score	256.87*	256.62*
LF	Was employed or unemployed at some time during the previous 12 months	0.89*	0.71*
EMP	Worked during previous 12 months	0.87*	0.68*
FTIME	Worked mostly full time during previous 12 months	0.83*	0.49*
UNEMP	Experienced at least one unemployment spell during previous 12 months	0.10*	0.13*
WKSEMP Ln(WKSEMP)	Number of weeks worked during previous 12 months	42.0*	30.1*
INCOME Ln(INCOME)	Total income from all sources	$29.953*	$15.608*
EDUC	Years of education	11.41	11.50
LDIFF	Experienced learning difficulties as a child	0.11	0.09
LEARN+5	Learned English/French after the age of 5	0.07	0.07
MOED	Mother's years of education	9.12	9.23
FAED	Father's years of education	8.93	8.87
MOIMM	Immigrant mother	0.16	0.17
FAIMM	Immigrant father	0.17	0.19
MARR	Married, (spouse present)	0.74	0.70
CHILD	At least one child present	0.52	0.53
ENG	First language is English	0.69	0.69
DISABLED	Currently disabled	0.09*	0.08*
Age			
Age 25	23–34 years old (reference group)	0.35	0.35
Age 35	35–44 years old	0.27	0.26
Age 45	45–54 years old	0.18	0.17
Age 55	55–69 years old	0.20	0.22
Urban area			
CITY	pop. ≥ 100,000	0.54	0.54
TOWN	30,000 ≤ pop. ≤ 99,999 (reference group)	0.27	0.26
RURAL AREA	pop. < 30,000	0.19	0.20
Region			
ATL	Atlantic region	0.09	0.10
PQ	Quebec	0.30	0.29
ONT	Ontario (reference group)	0.35	0.33
PRA	Prairie Provinces	0.17	0.17
BC	British Columbia	0.09	0.11
Minority language			
ATLMIN	Atlantic non-anglophones	0.01	0.01
PQMIN	Quebec non-francophones	0.03	0.03
ONTMIN	Ontario non-anglophones	0.02	0.02
PRAMIN	Prairie non-anglophones	0.005	0.006
BCMIN	BC non-anglophones	0.001	0.002
N (*denotes NUM restricted sample)		2718	3360

If the quality of the educational experience differs across individuals, and this variance in quality is related to the socio-demographic variables normally used to explain level of schooling, then a model explaining literacy/numeracy again would include both years of schooling and variables such as mother's education father's education, social status, and so on. We begin by assuming that literacy numeracy skills can be acquired independent of the formal education process and,, that the education system is a less than perfect screening mechanism or there quality differences in the education experience across individuals. Thus, the model used to explain the degree of literacy and numeracy contains both the individual's years of schooling (EDUC) and a number of socio-demographic variables that are commonly used to explain the level of education.[3]

The numeracy expression includes the level of literacy as an explanatory variable. This term accounts for the relationship between literacy and measured numeracy implicit in the design of the LSUDA questionnaire. It might also be that there exists a casual relationship between literacy skills and the acquisition of numeracy skills. In addition to years of schooling, two education-related measures are considered: learning difficulties experienced as a child (LDIFF) and whether or not the individual first learned English or French after five years of age (LEARN + 5). Individuals are classified as having suffered as learning disability if they reported having suffered from a physical disability or a non-physical disability with age of onset prior to 16 years, or from any health or disability problem that affected learning. In addition, if individuals reported having been in a special class for learning disabled, they were included in the LDIFF grouping. To the extent the education system effectively screens for literacy and numeracy skills, LDIFF and LEARN + 5 should not exert an independent influence on LIT and NUM.

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[3] LSUDA reports 'highest level of schooling' attained. EDUC, as well as the variables measuring mother's education and father's education, represent standard transformations of the 'highest level hoofing' into continuous 'years of schooling' variables.

The second set of explanatory variables represents socio-demographic characteristics including: mother's years of schooling (MOED); father's years of schooling (FAED); whether or not the mother immigrated to Canada (MOIMM); whether or not the father immigrated to Canada (FAIMM). Given that educated parents might tend to invest more resources in their children's training or more effectively expend ,a given level of resources than do less educated parents, there should be a positive relation between parental education and an individual's literacy and numeracy. In the case of immigrant parents the expected effect is less clear. Chiswick (1977) has demonstrated that the sons of immigrants are significantly more successful than the sons of native-born Americans. If immigrant parents are non-English or non-French speaking, however, they might be less effective in providing language acquisition resources.

Younger adults might or might not have greater language or numeracy skills than do older adults. The average length of time spent in school has increased significantly over the past three or four decades. There has been much recent discussion, however, concerning the possibility of declining standards of education in Canada. If the quality of education has declined over time, or if the school system has become a less effective literacy and numeracy screening mechanism, then younger cohorts should be less literate and less numerate than are older cohorts for a given level of formal education. It might also be the case that younger Canadians have been exposed to a broader range of language-based media, resulting in greater potential for language acquisition outside the formal education system. To the extent that popular media, such as television, are broad-based media, such forms of language acquisition will be independent of socio-demographic factors. The role of the popular media in the development of numerical skills is less clear. The age literacy/numeracy relation is further clouded by the possibility of changes in taste with respect to literacy and numeracy or changes in technology such as calculators, which might lead to increasing or decreasing demand for these skills. Our literacy 1 and numeracy specifications allow for four distinct age cohorts, denoted AGE 25, AGE 35, AGE 45, and AGE 55. The youngest cohort, the 25- to 34-year-old reference group, would have completed high school between 1973 and 1982, while the oldest cohort would have completed high school prior to 1952.

Previous studies indicate that literacy and numeracy skills improve as one moves from cast to west in Canada (e.g., Crocker 1990). Tests scores of high-school graduates are highest in British Columbia and Alberta, while the poorest test scores are found in Atlantic Canada. Although LSUDA does not allow us to determine the region in which an individual was educated, we can control for region of current residence. The standard definition of Canadian regions is used in our specifications and denoted ATL, PQ, ONT, PRA, and BC.

LSUDA allowed individuals to complete the literacy survey in either official language, irrespective of place of residence. Of the geographic divisions considered in this study, all but Quebec can be classified as primarily English-speaking regions. To a greater or lesser degree, educational opportunities in both official languages are available in all regions. Nonetheless, it is generally the case that minority educational opportunities are restricted, as would be the broader set of language acquisition resources available to individuals who do not speak the dominant language in a given region. In order to capture this 'minority language' effect, we consider the following set of regional/language variables: ATLMIN, PQMIN, ONTMIN, PRAMIN, BCMIN. PQMIN indicates that the individual is a non-French-speaking resident of Quebec. The remaining four variables indicate that the individual non-English-speaking resident of the respective region.[4]

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[4] In specifying the determinants of host country literacy among immigrants, Chiswick and Miller (1992, 1995) include variables indicating whether or not the individual was married, had children or lived in a rural/urban setting. As indicated by one of the referees, the direction of causality is much less certain in the case of the native-born population considered in this study. Adult immigrants tend to acquire host country language skills once marriage and child-rearing prospects have been mostly determined. Native-born individuals acquire language skills at a relatively young age, however, which might improve their marriage and child-rearing prospects and influence their choice of rural/urban residency.

2.3. Estimates

Table 2 contains the estimation results for expressions explaining the levels of literacy and numeracy.[5] A Chow test for structural differences between the parameter, estimates, for men and women, was carried out by comparing the sum of squared errors from separate regressions for men and women with the sum of squared errors from a regression on the pooled sample. The resulting F-values of the literacy expression and 6.12 for the numeracy expression allow us to reject the null-hypothesis of common male and female coefficients in both cases. Separate male and female estimates are reported.

The above model of the determinants of literacy and numeracy was initially estimated by OLS. It might be the case that literacy and numeracy skills, perhaps acquired outside the formal education system, influence an individual's level of education. In addition, as discussed above, the LSUDA measure of numeracy is not independent of the respondent's literacy skills. Given the relationship between measured numeracy and literacy and the possible relationship between literacy/numeracy and educational attainment, the consistency of our OLS estimates brought into question. The artificial regression version of the Durbin-Wu-Hausman (DWH) test for the consistency of OLS estimates, as detailed in Davidson and MacKinnon (1993), was carried out, with LIT, NUM, and EDUC considered as potentially endogenous. The set of exogenous variables used in obtaining estimates, and the associated error terms, for LIT and EDUC included LEARN+5, MOED, FAED, MOIMM, FAIMM, MOIMM x MOED, FAIMM x FAED, and the age, regional, and regional/language terms as specified in the literacy and numeracy expressions. In addition, variables indicating English as the individual's language, whether or not the individual suffered physical disabilities, whether or not the individual suffered learning disabilities, three cross-product terms relating MOED to the age of the respondent, and three cross-product terms relating FAED to, age of the respondent were included. The results of the DWH tests are reported in table 2 and denoted F_{DWH}. Except in the case of the male numeracy expression, the null-hypothesis of consistent OLS parameter estimates can be rejected at conventional significance levels. Both the OLS and the 2SLS estimates are reported. The 2SLS estimates are based on the same set of exogenous variables used in carrying out the DWH test. In discussing the parameter estimates, we focus on the 2SLS results while noting the possible inefficiency of these estimates and also noting the indirect influence of a number of the exogenous variables through their role as determinants of years of schooling.

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[5] All estimation was carried out using LIMDEP version 7.0.

As expected, EDUC has a positive and statistically significant effect on literacy. There is some evidence that the impact of years of schooling on literacy is smaller for women than for men. Having suffered from a learning disability as a child has a statistically significant adverse effect on adult literacy. There is only mild evidence that having learned English or French as a second language decreases adult male literacy.

Mother's years of schooling exerts a significant positive influence on female literacy, but not on male literacy. The sons of immigrant mothers have, on average, a higher level of literacy than do the sons of native-born Canadian women. Parental immigration status does not appear to influence the literacy level of women. The LSUDA data base, however, does not allow for a distinction between parents who immigrated from non-English or non-French speaking countries and those who immigrated from English- or French-speaking countries. Further, there is the possibility of multi-collinearity between the parental immigration variables and LEARN+5. The oldest male cohort is less literate than the youngest cohort. Older women are significantly less literate than are women under 44 years of age, while women in the 35 to 44 year age cohort are significantly more literate than is the youngest cohort.[6]

The average level of literacy is lower in Atlantic Canada and Quebec than in Ontario. There is some indication that male literacy is higher in the Prairies and British Columbia than it is in Ontario. Non-French-speaking males in Quebec and non-English-speaking males in the Prairies have a significantly higher level of literacy than do their dominant-language counterparts. Minority-language males in Ontario are less literate than English-speaking males. There is somewhat weaker evidence that non-English-speaking women in Ontario have a lower level of literacy than do English-speaking female residents of Ontario. The proportion of our sample represented by the minority language group in Atlantic Canada, the Prairies, and British Columbia is very small. Nonetheless, minority language results are generally consistent with the notion that minority educational opportunities are more restricted for non-English-language groups outside Quebec than for non-French-language groups in Quebec.

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[6] Our findings are roughly consistent with those of Boothby (1993). He concludes that younger cohorts, those born since the Second World War, are more literate than are older Canadians, and that this increased literacy holds for any given level of schooling.

Despite the possible efficiency loss associated with the 2SLS procedure, a comparison of the OLS and 2SLS estimates for the male literacy expression indicates that they are consistent with the notion that variables such as LEARN+5, parental schooling and immigration status, cohort age, and to a lesser extent PQMIN and ONTMIN, affect literacy primarily through their role as determinants of EDUC. Most of the OLS parameter estimates on these variables are significant, while the 2SLS estimates are smaller in absolute size and generally are not significant, The 2SLS point estimate on EDUC is almost twice as large as the OLS estimate. The broader hypothesis, that the formal education system acts as the primary source of literacy acquisition and/or as a literacy screening device, appears to hold for Canadian males age 25 or older in 1989. The notable exceptions are the learning disabled, who might not appear to be subject to the same screening standards, and the sons of immigrant mothers. Region of residence and minority language status appear to influence literacy, independent of years of schooling. These variables might be accounting for quality differences in regional education systems; otherwise there is no strong evidence that the educational experience differs significantly across males within a given region.

TABLE 2
The determinants of literacy and numeracy (*t*-statistics in parentheses)

Independent variables	Literacy				Numeracy			
	Men OLS	Men 2SLS	Women OLS	Women 2SLS	Men OLS	Men 2SLS	Women OLS	Women 2SLS
LIT					0.7005	0.6343	0.6839	0.1846
					(44.62)	(6.67)	(49.65)	(0.98)
EDUC	3.8911	6.9778	3.9329	5.5795	1.0772	1.6302	0.5967	4.5990
	(23.37)	(5.39)	(26.33)	(7.51)	(7.36)	(1.64)	(4.69)	(3.89)
LDIFF	−8.2438	−5.6246	−8.6534	−7.6500	−0.3926	−0.1238	−3.0561	−4.5614
	(3.74)	(1.89)	(4.37)	(3.23)	(0.22)	(0.06)	(1.97)	(1.91)
LEARN+5	−5.3112	−4.6826	−2.3977	−2.4466	4.9315	4.6497	0.3617	−1.4624
	(1.87)	(1.56)	(0.98)	(0.98)	(2.25)	(2.04)	(0.19)	(0.63)
MOED	0.8603	0.0543	1.5608	1.2195	−0.0582	−0.0763	−0.1264	0.1904
	(3.68)	(0.13)	(7.74)	(4.85)	(0.31)	(0.27)	(0.81)	(0.59)
FAED	0.8727	0.0023	0.8009	0.3730	−0.3223	−0.3476	0.1868	−0.003
	(3.94)	(0.01)	(4.31)	(1.39)	(1.82)	(1.22)	(1.30)	(0.01)
MOIMM	7.7096	5.5947	1.3596	0.5513	−0.3701	−0.0531	1.6491	1.1198
	(3.55)	(2.85)	(0.71)	(0.28)	(0.22)	(0.03)	(1.19)	(0.61)
FAIMM	4.0522	1.5218	−1.3894	−2.2725	−0.6528	−0.6204	0.5354	−1.3553
	(1.88)	(0.61)	(0.76)	(1.18)	(0.38)	(0.33)	(0.38)	(0.74)
AGE35	−0.4160	−0.4045	3.3853	4.4375	4.1263	4.1406	2.8730	5.6894
	(0.23)	(0.22)	(2.22)	(2.74)	(2.91)	(2.91)	(2.45)	(3.42)
AGE45	−4.2741	0.2170	−10.574	−7.0133	7.7173	7.8788	4.0121	3.4451
	(2.07)	(0.07)	(5.96)	(2.92)	(4.69)	(3.84)	(2.92)	(1.32)
AGE55	−20.444	−9.3711	−23.689	−17.092	10.224	10.083	3.6612	0.2949
	(9.58)	(1.81)	(13.33)	(4.96)	(5.87)	(2.91)	(2.59)	(0.07)
ATL	−17.456	−15.473	−16.607	−16.564	−3.3719	−4.1945	−6.3392	−14.114
	(6.51)	(5.23)	(7.40)	(7.27)	(1.63)	(1.69)	(3.79)	(3.97)
PQ	−12.024	−10.175	−9.9275	−7.4325	−0.4800	−0.9502	−1.3077	−3.4214
	(6.48)	(4.78)	(5.97)	(3.64)	(0.34)	(0.57)	(1.07)	(1.50)
PRA	2.8029	3.2088	0.3168	0.1062	6.0303	6.3460	0.9924	1.0236
	(1.35)	(1.45)	(0.18)	(0.06)	(3.68)	(3.73)	(0.74)	(0.61)
BC	3.6611	4.2771	0.3822	−0.3656	1.0912	1.3806	0.8883	−0.079
	(1.43)	(1.57)	(0.19)	(0.17)	(0.54)	(0.67)	(0.57)	(0.04)
ATLMIN	−4.9354	−2.7549	−3.8049	−1.8811				
	(0.74)	(0.39)	(0.63)	(0.30)				
PQMIN	12.143	9.8125	−0.9661	−2.6036				
	(2.78)	(2.07)	(0.26)	(0.69)				
ONTMIN	−22.866	−18.582	−9.3054	−7.5771				
	(4.04)	(2.97)	(1.90)	(1.50)				
PRAMIN	10.031	25.101	−4.3066	−3.484				
	(0.99)	(2.02)	(0.54)	(0.43)				
BCMIN	3.0027	−14.630	−14.766	−13.486				
	(0.16)	(0.69)	(1.03)	(0.93)				
Constant	205.48	181.83	204.85	190.06	61.356	72.550	68.733	153.77
	(64.15)	(17.26)	(70.73)	(26.12)	(14.83)	(3.77)	(18.84)	(4.11)
$\bar{R}^2$	0.39	0.32	0.45	0.43	0.57	0.57	0.59	0.39
F	94.54	67.79	142.79	131.55	232.72	229.11	316.76	135.75
IMR – from a PROBIT on LITMIN					−27.442		−36.876	
					(2.48)		(3.96)	
F_{DWH}	8.9180		7.1829		0.2997		8.7145	
(d.f.)	(1.2697)		(1.3339)		(2.2598)		(2.3238)	
N	2718	2718	3360	3360	2616	2616	3256	3256

This general pattern is not entirely repeated in the case of female literacy, As it is in the case of males, LDIFF is again significant, but mother's years of schooling and all of the cohort age terms are also statistically significant after the endogeneity of EDUC is accounted for. Of note is the difference in the impact of the age cohort terms between males and females. It might be that the quality of the female educational experience has improved more over time than has that of males.

The last four columns of table 2 report the estimation results for the numeracy expressions. As a result of their lack of the basic literacy skills required to complete the relevant portion of the survey, 102 male observations and 104 female observations in our base sample were not assigned numeracy scores, resulting in 2,616 male and 3,256 female observations in the respective numeracy samples. This exclusion of the least literate implies an incidental truncation of the sample, which could result in the failure of OLS parameter estimates to achieve consistency, The sample truncation problem can be addressed by considering a selection model in which the probability of a respondent's achieving the minimum literacy level is first estimated, yielding estimates of the inverse Mill's ratio (IMR). The numeracy expression can then be estimated, with the IMR included as an additional explanatory variable (cf. Greene 1990, 740-6). From such a regression, the coefficient estimate on IMR is reported in table 2. This coefficient is statistically significant, and negatively signed, in both the male and the female expressions.[7]

LIT has a significant impact on numeracy in the male expression. This is not the case for females, after the possible endogeneity of LIT and EDUC is accounted for. Years of schooling is a significant determinant of female numeracy but of only marginal significance in determining male numeracy. The parameter estimate on EDUC for females is approximately three times that for males. Having suffered a learning disability lessens adult female numeracy but not male numeracy. Males who learned English or French as a second language are, on average, more numerate than are males whose first language was English or French. Parental education and immigration status do not influence numeracy. Older males are more numerate than are younger males, and the higher level of numeracy is more pronounced the older is the age group. Women in the 35 to 44 year age cohort are more numerate than are females in the youngest cohort. These age cohort effects on numeracy are quite different from those for literacy and, to the extent that they reflect on the quality of education, might imply a relative decline in the quality of numeracy education.[8] Although Prairie males are significantly more numerate than are their Ontario counterparts, the general pattern of increased literacy as we move from east to west is less pronounced in the case of numeracy.

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[7] The sample selection parameter estimates are similar to the OLS estimates. These estimates are available from the authors.

[8] Boothby (1993) discusses the age-literacy relationship but not the age-numeracy relationship. The positive conclusions he draws concerning the performance of the Canadian educational system during the post-Second-World-War period, do not appear to hold with respect to numeracy skills.

As in the case of literacy, the broader hypothesis that the formal education system acts as the primary source of numeracy acquisition and/or as a numeracy screening device appears to hold, The formal education system appears to play a greater role in numeracy acquisition for females than for males. This was not the case for literacy acquisition.

3. The impact of literacy and numeracy on labour market outcomes

LSUDA provides information on the respondent's labour market activity during the previous twelve months. We consider binary variables that have a value of unity if, during the previous twelve months, the individual was in the labour force at some time (LF); was employed at some time (EMP); suffered at least one spell of unemployment (UNEMP); worked mostly full time (FTIME). The labour market status of a given individual might have changed during the twelve-month period, so that a given individual might have been employed for a part of the period, suffered a spell of unemployment, and/or been out of the labour force entirely. As an indication of the average labour market status of the individual during the period, we consider the number of weeks worked during the previous twelve months (WKSEMP). LSUDA also provides information on the annual income of the respondent. This variable, which is denoted INCOME, includes income from all sources.

The specification of the labour market outcome expressions includes LIT, NUM, EDUC, and DISABLED as measures of human capital. If literacy and numeracy are forms of human capital distinct from education and if years of schooling accurately measures level of education, then we would expect a positive relationship between both the level of literacy and the level of numeracy and positive labour market outcomes, such as labour market participation, being employed, being employed full time, weeks worked, and earnings. We would expect a negative relationship between both the level of literacy and the level of numeracy and negative labour market outcomes, such as unemployment spells. Alternatively, it could be that literacy and numeracy are not forms of human capital distinct from education, but years of schooling do not accurately measure level of education. If this is the case, and literacy and numeracy are measuring quality of education, we would again expect a positive relationship between both literacy and numeracy and positive labour market outcomes, and a negative relationship between both literacy and numeracy and negative labour market outcomes. Finally, if literacy and numeracy are not distinct forms of human capital and if years of schooling accurately measures level of education, then we would expect zero coefficients on the literacy and numeracy terms. The remaining explanatory variables are standard socio-dernographic control variables, including English as the spoken language, marital status, presence of children in the household, age, urban/rural residence, and region of residence.

Table 3 reports PROBIT estimates of the labour market status expressions: LF, EMP, UNEMP, FTIME. The inclusion of NUM as an explanatory variable requires, that we exclude observations on the least literate individuals. This sample truncation implies that the PROBIT estimates might not achieve consistency. We can consider a binary variable, denoted LITMIN, which has a value of unity if the individual achieves the minimum level of literacy required to assess numeracy and zero otherwise. If LITMIN takes on a value of unity, then we observe the given labour market outcome for that individual; otherwise we do not. As a measure of the significance of the covariance between the probability of achieving LITMIN and a given discrete measure of labour market outcome, we can consider the correlation coefficient between. the distribution of LITMIN and that of the labour market status variable, denoted RHO. If a given RHO equals zero, then the univariate PROBIT estimates of that labour market status expression should not lose consistency owing to sample truncation. The square of the *t*-statistic on the BIVARIATE PROBIT estimate of RHO represents a Wald-statistic (cf. Greene 1990, 692). In the case of labour market outcomes that are measured as continuous variables, we can consider the coefficient estimate on the IMR term, taken from a preliminary PROBIT estimation of LITMIN and included in the WKSEMP and INCOME expressions.The Wald-statistics and IMR coefficient estimates are reported in tables 3. 4, and 5. The BIVARIATE PROBIT procedure failed to converge in the case of the male UNEMP expression, so no estimate of RHO is reported for that expression. In all remaining cases we can accept the hypothesis of a zero value for RHO or a zero valued coefficient on IMR, implying that the respective PROBIT and OLS estimates should not lose consistency owing to exclusion of the least literate from our sample. We should note the marginal significance of the coefficient on IMR in the male INCOME expression.

For both men and women NUM and EDUC exert a positive and significant influence on the likelihood of labour force participation and employment during the previous twelve months. The parameter estimates on LIT are not statistically significant for these labour market outcomes. For males, there is a negative and statistically significant relationship between both LIT and EDUC and the probability of having experienced an unemployment spell. There is a positive and significant relationship between both LIT and EDUC and the probability of full-time employment of males. There is milder evidence of a significant positive relationship between NUM and male full-time employment status. There is mild evidence of a significant negative relationship between female unemployment and EDUC, but no evidence that either LIT or NUM influences this labour market outcome. The probability of female full-time employment is positively related to both NUM and EDUC.

The last three lines of table 3 contain the change in the probability of the given labour market outcome for a one standard deviation change in LIT, NUM, and EDUC.[10] When the change is presented in this form, the most striking result is the relatively strong influence of both NUM and EDUC on female labour market status. Except for the UNEMP expression, the impact of these variables is over three times as great in the female expressions as in the male expressions. Rivera-Batiz (1992) reports similar calculations for the impact of a numeracy variable on full-time employment. In his sample of young adult immigrants and second-generation immigrants age 21 to 25 years, a one standard deviation increase in numeracy score implies a 2.2 per cent increase in the probability of full-time employment of males and an 8.2 per cent increase in the full-time employment of females. Our estimates of the above impact of a one standard deviation increase in numeracy scores are 1.7 per cent for males and 5.4 per cent for females.

The parameter estimates on the socio-demographic variables in the labour market status specifications, reported in table 3 generally are as expected. Overall, except for female unemployment, literacy and/or numeracy levels influence labour market status in a specification that controls for years of schooling. To this extent, either literacy and numeracy are distinct labour market skills or literacy and numeracy are acting as measures of education quality. Measured numeracy tends to dominate LIT as a determinant of labour market status. Recall that NUM is based on a subset of the information used to assess literacy. Successful completion of this subset of questions required both literacy and arithmetic skills. Had LIT dominated NUM as explanatory variables in the labour market status expressions, we would have been able to accept the hypothesis that numeracy skills were not an important determinant of labour market status. Given the relationship between measured numeracy and literacy, however, we cannot reject the notion that literacy skills are an important determinant of labour market status, based on the results reported in table 3.[11]

As an indication of the average labour market status of the individual during the previous year, we consider the number of weeks worked during the previous twelve months, WKSEMP. Table 4 reports the estimation results for expressions explaining WKSEMP. The set of explanatory variables is the same as that used to explain the labour market status variables, The sample includes all individuals who were labour market participants at some time during the previous twelve months.

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[10] The marginal probabilities are defined as $\Theta(\bar{X}\beta)^{*}\beta_i$, where $\Theta(\bar{X}\beta)$ is the standard normal density function evaluated at the sample means.

[11] Exclusion of NUM from the specifications presented in table 3 results in a significant coefficient estimate on LIT for all labour market status expressions except female UNEMP.

TABLE 3
Literacy, numeracy, and labour market status (*t*-statistics in parentheses)

Independent variables	Men (probit)				Women (probit)			
	LF	EMP	UNEMP	FTIME	LF	EMP	UNEMP	FTIME
LIT	−0.0009	0.0008	−0.0035	0.0043	0.0002	0.0006	−0.0002	0.0008
	(0.56)	(0.56)	(2.54)	(3.43)	(0.17)	(0.61)	(0.16)	(0.87)
NUM	0.0036	0.0035	−0.0013	0.0019	0.0053	0.0049	−0.00002	0.0033
	(2.58)	(2.71)	(1.10)	(1.65)	(5.12)	(4.89)	(0.02)	(3.64)
EDUC	0.0347	0.0280	−0.0185	0.0072	0.0335	0.0424	−0.0150	0.0294
	(3.88)	(3.31)	(2.09)	(0.91)	(4.73)	(6.07)	(1.73)	(4.28)
DISABLED	−0.3782	−0.2857	−0.0878	−0.1626	−0.3567	−0.3942	−0.1299	−0.2689
	(3.20)	(2.49)	(0.69)	(1.52)	(3.74)	(4.19)	(1.08)	(2.95)
ENG	−0.5092	−0.2962	−0.3988	−0.2580	0.3062	0.2174	0.2686	0.0687
	(3.05)	(1.95)	(2.69)	(1.87)	(2.67)	(1.94)	(2.10)	(0.67)
MARR	0.2898	0.3382	−0.2679	0.3067	−0.0871	0.0092	−0.1765	−0.1682
	(2.82)	(3.63)	(2.98)	(3.71)	(1.36)	(0.15)	(2.47)	(2.93)
CHILD	0.0932	0.2346	−0.2136	0.1712	−0.0726	−0.0947	0.1522	−0.3635
	(0.97)	(2.64)	(2.47)	(2.20)	(1.13)	(1.53)	(2.17)	(6.38)
AGE35	0.0630	−0.1868	−0.0316	−0.1482	0.0205	0.0422	0.0557	0.0599
	(0.40)	(1.49)	(0.36)	(1.55)	(0.28)	(0.61)	(0.81)	(1.01)
AGE45	−0.4986	−0.4732	−0.5175	−0.2223	−0.2221	−0.0935	−0.2806	−0.0091
	(3.59)	(3.76)	(4.50)	(2.13)	(2.74)	(1.19)	(3.13)	(0.13)
AGE55	−1.8203	−1.6360	−0.6371	−1.3723	−1.5362	−1.3322	−0.9219	−1.1990
	(14.41)	(14.26)	(5.45)	(14.28)	(18.40)	(16.46)	(7.75)	(14.91)
CITY	−0.1320	−0.1319	−0.1083	−0.0601	0.0594	0.1010	0.0493	0.1981
	(1.26)	(1.39)	(1.25)	(0.73)	(0.91)	(1.59)	(0.66)	(3.39)
RURAL	0.0558	−0.1636	0.1484	0.0778	0.0272	0.0503	0.2533	0.0574
	(0.45)	(1.39)	(1.50)	(0.78)	(0.35)	(0.66)	(2.97)	(0.82)
ATL	−0.0487	−0.0900	0.5542	0.0225	0.0869	−0.0202	0.4842	0.2386
	(0.32)	(0.61)	(4.33)	(0.18)	(0.85)	(0.21)	(4.57)	(2.68)
PQ	−0.2003	−0.3233	0.1182	−0.1772	0.1922	0.0366	0.4906	−0.0130
	(1.20)	(2.09)	(0.75)	(1.27)	(1.60)	(0.31)	(3.68)	(0.12)
PRA	0.2513	0.1238	0.2388	0.1729	0.0859	0.0623	0.1226	−0.0518
	(1.96)	(1.03)	(2.04)	(1.66)	(1.05)	(0.79)	(1.33)	(0.74)
BC	0.3287	0.1865	0.6885	0.0089	−0.0952	−0.1116	0.4250	−0.0698
	(2.08)	(1.27)	(5.51)	(0.07)	(1.04)	(1.26)	(4.23)	(0.86)
Constant	1.1803	0.4839	0.7099	−0.2559	−0.9554	−1.2274	−1.2474	−1.0600
	(3.77)	(1.70)	(2.54)	(1.01)	(4.02)	(5.28)	(4.49)	(4.81)
RHO – from a bivariate probit with LITMIN	0.1726	0.1551	convergence failed	0.0101	0.0797	0.0345	0.9433	−0.0839
	(0.32)	(0.29)		(0.02)	(0.17)	(0.06)	(0.13)	(0.17)
χ^2	1145.58	1078.91	581.11	970.01	1449.38	1296.41	107.34	583.83
N	2616	2616	2616	2616	3256	3256	3256	3256
Standard deviation	Change in probability resulting from a one standard deviation change in the independent variable							
LIT M 43.52 / F 42.71	−0.004(n.s.)	0.005(n.s.)	−0.022	0.038	0.003(n.s.)	0.009(n.s.)	−0.002(n.s.)	0.014(n.s.)
NUM M 42.73 / F 40.07	0.015	0.019	−0.008(n.s.)	0.017	0.068	0.068	−0.0001(n.s.)	0.054
EDUC M 4.96 / F 4.57	0.016	0.018	−0.013	0.007(n.s.)	0.049	0.067	−0.013	0.053

TABLE 4
Literacy, numeracy, and weeks employed (*t*-statistics in brackets)

Independent variables	Men WKSEMP OLS	Women WKSEMP OLS
LIT	0.0343	0.0324
	(3.64)	(2.23)
NUM	0.0185	0.0262
	(2.09)	(1.79)
EDUC	0.1489	0.3750
	(2.02)	(3.26)
DISABLED	−0.3233	−1.0613
	(0.35)	(0.71)
ENG	2.6264	0.0882
	(2.48)	(0.06)
MARR	3.3532	1.6835
	(5.01)	(1.89)
CHILD	1.4233	−4.0510
	(2.38)	(4.77)
AGE35	0.7144	2.6302
	(1.18)	(3.08)
AGE45	2.3143	2.6866
	(3.27)	(2.57)
AGE55	−1.4877	1.6910
	(1.69)	(1.14)
CITY	0.7212	0.3893
	(1.19)	(0.43)
RURAL	−0.0733	−4.2383
	(0.09)	(3.86)
ATL	−5.0104	−6.8346
	(5.23)	(5.04)
PQ	0.0260	−1.7932
	(0.02)	(1.09)
PRA	−0.8178	−1.8043
	(1.11)	(1.71)
BC	−2.8253	−6.3903
	(3.13)	(5.08)
Constant	26.591	24.497
	(12.39)	(6.83)
IMR – from a PROBIT on LITMIN	−3.8840	6.1241
	(0.69)	(0.64)
$\bar{R}^2$	0.10	0.07
F	16.81	10.96
N	2195	2032

Both LIT and NUM, in addition to EDUC, exert a Significant effect on WKSEP. Evaluated at the sample means, the elasticities of WKSEMP with respect to LIT NUM are: 0.19 and 0. 10, respectively, for males and 0.21 and 0.16, respectively, for females. The socio-demographic control variables generally perform as expected in the WKSEMP expression.

Table 5 reports OLS estimates for expressions explaining the logarithm of 1 INCOME. So that we may focus more closely on labour market earnings, the INCOME sample includes only individuals who were employed at some time during the previous twelve months and who reported positive income.[12] Estimates are reported for a sample selection version of the model, which includes an IMR term from a PROBIT estimation on EMP. The specification for the PROBIT on EMP is as reported in table 3. The coefficient estimates on IMR are positive and significant.

LIT and EDUC exert a significant influence on INCOME for both males and females. NUM has a significant effect on the income of females. There is milder evidence of a positive relationship between NUM and male income. Evaluated at the sample means of the explanatory variables, the elasticities of INCOME with respect to LIT, NUM, and EDUC are 0.77, 0.18 and 0.24, respectively, for males and 1.07, 1.12, and 1.23, respectively, for females. Rivera-Batiz (1990) reports similar elasticities of earnings with respect to an objective, continuous measure of reading literacy. In his sample of young adult immigrants and second generation immigrants aged 21 to 25 years, this elasticity was 0.54 for males and 0.82 for females. The socio-demographic variables generally perform as expected in the INCOME expressions.

The income expressions can be used to provide a better understanding of the role of literacy and numeracy as determinants of labour market outcomes. Recall that the positive influence of literacy and numeracy might result from their role either as distinct forms of human capital or as measures of the quality of education. If literacy and numeracy are distinct measures of human capital, and if they are omitted from the income specifications reported in table 5, then the parameter estimates on education should be biased upward. This follows from the expected positive coefficients on literacy and numeracy and the positive partial correlations between literacy and numeracy and education (cf. Greene 1990, 259-61). If years of schooling is not an accurate measure of education, then the resulting measurement error should asymptotically bias the parameter estimates on years of schooling towards zero. If in this case literacy and numeracy are acting as measures of the quality of a given number of years of education, then exclusion of these variables from the specifications reported in table 5 should result in parameter estimates on years of schooling that are biased downward (cf. ibid., 294-300). The two effects could be at work simultaneously, the positive omitted variable bias offsetting the negative measurement error bias.

Table 6 reports the parameter estimates on years of schooling from re-estimation of the specification reported in table 5, excluding in turn LIT, NUM, and both LIT and NUM. The most striking result of this exercise is that the 'net' role of literacy and numeracy differs for males and females. For males inclusion of the literacy and numeracy terms results in a decrease in the point estimate on years of schooling of approximately 20 per cent. Most of this 'net' omitted variable bias appears to result from the exclusion of LIT.

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[12] The LSUDA age class variable has a limit on the upper age class of 69 years. Exclusion of individuals who did not work a positive number of weeks during the previous twelve months should eliminate the retired individuals from our sample.

TABLE 5
Literacy, numeracy, and income (*t*-statistics in parentheses)

Independent variables	Men Ln(INCOME) OLS	Men Ln(INCOME) SELECT on EMP	Women Ln(INCOME) OLS	Women Ln(INCOME) SELECT on EMP
LIT	0.0027	0.0029	0.0032	0.0039
	(6.65)	(6.79)	(4.52)	(2.54)
NUM	0.0003	0.0007	−0.0004	0.0042
	(0.86)	(1.59)	(0.60)	(2.11)
EDUC	0.0180	0.0201	0.0562	0.0962
	(5.99)	(6.30)	(9.85)	(5.96)
DISABLED	−0.0078	−0.0419	−0.0026	−0.4653
	(0.19)	(0.95)	(0.03)	(2.29)
ENG	0.0711	0.0445	−0.0287	0.1281
	(1.55)	(0.92)	(0.37)	(0.74)
MARR	0.2044	0.2339	−0.1531	−0.0788
	(6.86)	(7.09)	(3.50)	(0.82)
CHILD	0.0269	0.0419	−0.2221	−0.3853
	(1.02)	(1.51)	(5.32)	(3.80)
AGE35	0.1640	0.1583	0.1884	0.2578
	(6.18)	(5.74)	(4.53)	(2.75)
AGE45	0.2679	0.2603	0.1126	0.1350
	(8.61)	(8.05)	(2.21)	(1.19)
AGE55	0.2207	0.0249	0.1269	−1.5427
	(5.60)	(0.28)	(1.74)	(3.26)
CITY	0.0721	0.0667	0.1802	0.2412
	(2.72)	(2.44)	(4.13)	(2.51)
RURAL	−0.1128	−0.0991	−0.1498	−0.1019
	(3.41)	(2.88)	(2.78)	(0.87)
ATL	−0.1284	−0.1399	−0.1069	−0.1349
	(3.04)	(3.20)	(1.59)	(0.93)
PQ	0.0290	−0.0121	−0.1288	−0.1749
	(0.61)	(0.23)	(1.63)	(1.01)
PRA	−0.0945	−0.0902	−0.1345	−0.1119
	(2.93)	(2.72)	(2.66)	(1.02)
BC	−0.0152	0.0446	−0.0896	0.2468
	(0.39)	(0.11)	(1.46)	(1.77)
IMR		0.3560		2.1702
		(2.41)		(3.72)
Constant	8.9430	8.7571	8.3829	5.7049
	(93.54)	(69.63)	(46.87)	(7.02)
IMR – from a PROBIT on LITMIN	0.3897		0.0661	
	(1.77)		(0.12)	
$\bar{R}^2$	0.19	0.19	0.19	0.21
F	30.73	29.29	27.79	28.09
N	2040	2040	1813	1813

Conversely, for females inclusion of the literacy and numeracy terms results in an increase in the point estimate on years of schooling of almost 40 per cent, with most of this 'net' measurement error bias attributable to the exclusion of NUM.[13] The above results are consistent with the notion that literacy and, to a lesser extent, numeracy are distinct elements of human capital, but that for females, unlike males, years of schooling is not a particularly good measure of level of education. It might be that, as is commonly believed, female education choices are biased towards the arts, humanities, and social sciences and away from the sciences. In addition, if there is a larger variance in the content of female education, then years of female schooling will be a less accurate measure of the human capital value of education. In this case, the quality of education role of LIT and NUM is likely to dominate.

The parameter estimate on the years of schooling variable in an income (or wage) determination expression is often used to infer the private or the public return to years of schooling. In this respect, the sensitivity of the parameter estimate on the years of schooling term to the exclusion of LIT and NUM is somewhat troubling. Our results indicate that expressions that do not control for a broader set of human capital characteristics and/or quality of years of schooling will result in return to schooling estimates that suffer from a mix of omitted variable and measurement error bias. Further, although these errors should tend to offset, the 'net' omitted variable/measurement error bias could be substantial. In our empirical work, which considers only the role of literacy and numeracy, the 'net' bias ranges from a negative 40 per cent for females to a positive 20 per cent for males.

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[13] This general pattern is repeated in male and female income expressions that include weeks worked during the year (WKSEMP) as an additional explanatory variable. When the estimates reported in table 6 for the income expression are repeated for WKSEMP and the labour market status expressions reported in table 3, there is evidence of net omitted variable bias for both males and females. That is, the parameter estimates on EDUC are lower with the inclusion of either LIT and NUM individually or both LIT and NUM. The interpretation of the PROBIT parameter estimates in the presence of omitted variables and measurement error is less clear (cf. Yatchew and Griliches 1985).

There might also be a signalling/screening or 'sorting' interpretation for some of the results reported here. Given that the sample is not limited to new entrants or recent re-entrants, however, it is not clear to what extent inferences concerning the sorting role of the various explanatory variables would be appropriate.

4. Summary and conclusions

The broader hypothesis, that the formal education system acts as the primary source of literacy acquisition and/or an effective literacy screening device, cannot be rejected. After the endogeneity of years of schooling is controlled for, variables such as parental education and immigration status generally are not significant determinants of literacy and numeracy. There is evidence that the younger cohorts are more literate than are older cohorts. This pattern is most evident among females. There is evidence that the younger cohorts are less numerate than are older cohorts. The decline in numeracy is most evident among males. Regional differences in literacy, and to a lesser extent numeracy are evident.

Numeracy is generally a statistically significant determinant of labour market status, while literacy is most often not statistically significant. Based on the design of the LSUDA numeracy measure, it is not possible to exclude literacy as an independent determinant of labour market status. Both literacy and numeracy contribute to the explanation of weeks worked, and both exert a positive influence on the income of individuals who work.

Overall, the empirical results indicate that both literacy and numeracy have important roles to play in labour market outcome specifications that account for years of schooling. The estimates of the parameters of the income expression are consistent with the notion that literacy and numeracy are distinct elements of human capital, and that for females, years of schooling is a relatively poor measure of level of education. In the case of males the role of LIT and NUM as measures of distinct skills appears to dominate, while in the case of females the role of LIT and NUM as measures of quality of education appears to dominate. We find that years of schooling remains a significant determinant of most measures of labour market outcome, implying a contribution to human capital, on the part of the formal education system, which is distinct from its role in the determination of literacy and numeracy. Nonetheless, our results indicate the potential for serious omitted variable bias and/or measurement error bias in parameter estimates on years of schooling from specifications that do not control for a wider set of human capital characteristics and the quality of years of schooling.

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