The Effect of Taxes on Labor Supply in the Underground Economy

By THOMAS LEMIEUX, BERNARD FORTIN, AND PIERRE FRÉCHETTE*

This paper uses micro data from a randomized survey carried out in the Metropolitan area of Quebec City, Canada, to analyze the decision to evade taxes and work in the "underground" economy. The results indicate that taxes distort labor-market activities away from the regular sector to the underground sector, but the distortion is small for the average worker. The distortion is large, however, for particular groups of the population such as welfare claimants. (*JEL* H26, J22)

A central question in public policy is how taxation affects work incentives.[1] Taxes affect labor–leisure choices, but they also stimulate labor-market activities in the "underground," or untaxed sector of the economy. While there have been many theoretical studies of tax evasion over the last two decades, there have been very few empirical studies of the underground economy.[2] This is partly a result of the difficulty of collecting information on the number of hours worked by workers who illegally evade taxes, which makes it impossible to measure the effect of taxes on the allocation of time.

To remedy these difficulties, this paper empirically analyzes labor-supply decisions in the underground economy using micro data from a survey conducted in Quebec City, Canada, by two of the authors of this paper.[3] In our survey, labor-market activities are classified on the basis of whether their proceeds are reported (regular-sector job) or unreported (underground-sector job) to the tax authorities. This enables us to look directly at how the income tax and the welfare system distort occupational and hours choices of workers away from the regular sector to the underground sector. In particular, we give some economic content to the size of this distortion by examining

*Lemieux: Department of Economics and CRDE, Université de Montréal, Montréal, Canada, H3C 3J7; Fortin: Department of Economics and GREPE, Université Laval, Québec, Canada, G1K 7P4; Fréchette: Department of Economics and CRAD, Université Laval. We have received many helpful comments from a large number of people. In particular, we thank Joseph Altonji, Paul Beaudry, Dwayne Benjamin, John DiNardo, Ross Finnie, John Ham, Guy Lacroix, Bruce Meyer, Whitney Newey, Alain Trannoy, two anonymous referees, and especially David Card for very helpful comments. We also thank Louis Beauséjour for the computer program used to compute the marginal tax rates. The excellent research assistance of Joelle Noreau for the construction of the data is gratefully acknowledged. Financial support was provided by the Social Sciences and Humanities Research Council of Canada and by the Fonds F.C.A.R. of Québec. All remaining errors are ours.

[1]See, for instance, Jerry Hausman (1985) on taxes and labor supply and Robert Moffitt (1992) on the incentive effects of welfare programs.

[2]The modern theoretical literature on tax evasion starts with Michael G. Allingham and Agnar Sandmo (1972); see also Frank Cowell (1990) and the other studies mentioned there. Most empirical studies in North America are based on data from the Compliance Measurement Program (TCMP) of the IRS (Charles T. Clotfelter, 1983; Ann D. Witte and Diane F. Woodbury, 1985; Jonathan Feinstein, 1991). See also James D. Smith (1985) for survey on consumer purchases from informal vendors, and Alejandro Portes et al. (1989) for a collection of case studies on the informal economy.

[3]See Fortin and Fréchette (1987) for a full description of the data set (Fortin and Fréchette, 1986). Related surveys that were done in Europe are reported in Pierre Pestieau (1985) and Victor Ginsburg et al. (1987) for Belgium; Arne Jon Isachsen et al. (1985) for Norway; and Robert Van Eck and Brugt Kazemier (1988) for the Netherlands.

whether an increase in the tax rate would actually reduce total tax revenues.

We also address the delicate measurement issues involved in a survey like ours on the underground economy. Section I describes the data and identifies some key empirical regularities about work in the untaxed sector. It also presents evidence that these empirical regularities are not artifacts of measurement error.

In Section II, we develop a model to explain the basic facts uncovered in Section I. The model is based on the idea that labor earnings in the underground sector are a concave function of hours of work, while in the regular sector labor earnings are a linear function of hours of work. The concavity of the earnings function in the underground sector implies that the marginal revenues of underground producers decrease as producers reach the limits of the informal markets in which they operate. By contrast, the wage rate of a worker in the regular sector does not vary with the number of hours worked. We discuss the empirical implementation of the model in Section III and estimate the model in Section IV. The results of our study suggest that hours worked in the underground sector are quite responsive to changes of the net wage in the regular sector. The model also provides a natural link between the slope of the relationship between tax revenues and tax rates (the "Laffer curve") and a more conventional measure of the marginal excess burden of taxes due to the misallocation of productive resources from the regular to the underground sector.[4] In Section V, we discuss and present our estimates of the economic consequences of taxes. We conclude that the welfare distortions are small on average, but that they may be large for certain segments of the population, such as welfare claimants, who are more likely to work in the underground sector.

[4]For a good summary of the debate surrounding the Laffer curve, see Don Fullerton (1982).

I. Data and Preliminary Analysis

A. *The Survey*

The data used in this paper were obtained from a survey conducted during the spring of 1986 in the census metropolitan area of Quebec City (population of 603,267 in 1986). The sample includes 2,134 adults aged 18 years and over. The sample design was based on the methodology used by Statistics Canada in its Labor Force Survey. The main sample (1,878 persons) is of the random-cluster type. It was supplemented by a small quota sample (256 persons) to compensate for difficulties in reaching people in some areas and some socioeconomic groups.

In addition to standard questions on the socioeconomic background of respondents, the survey also included a battery of questions on jobs in the regular sector and jobs in the underground sector, and on purchases of goods and services from the underground sector. We classify a job as a regular-sector job when its proceeds are declared in the income-tax statement, and as an underground-sector job otherwise. The term "underground" is simply a label we use to characterize jobs from which the proceeds are not reported in the income-tax statement.[5] In theory, this definition of underground jobs could encompass both criminal activities and tax evasion (legal activities not reported to the tax authorities). In practice, however, criminal underground activities such as the sale of drugs or prostitution were rarely reported in the survey. This, however, is of little concern for our re-

[5]The key question used in the survey to distinguish regular-sector jobs from underground-sector jobs literally refers to "... *les emplois dont vous déclarez actuellement les revenus dans votre rapport d'impôt*." A close translation would be "...the jobs for which you actually report the proceeds in your income-tax statement." The term "underground" or its French translation "*travail au noir*" is never used in the questionnaire.

TABLE 1—DESCRIPTION OF THE DATA

Characteristics	Percent of total sample (i)	Participation in the "underground" sector: Percent (ii)	Hours ($H > 0$) (iii)	Earnings ($Y > 0$) (iv)	Earnings ($Y \geq 0$) (v)	Purchases of goods from the "underground" sector: Percent (vi)	Purchases (C) ($C > 0$) (vii)	Purchases (C) ($C \geq 0$) (viii)
Total	100.0	8.5	357	2,006	171	16.8	1,390	234
Sex:								
Male	48.7	9.9	331	2,294	227	19.6	1,503	295
Female	51.3	7.1	391	1,628	116	14.1	1,239	175
Age:								
18–24	15.3	23.3	340	1,761	410	10.6	398	42
25–39	43.1	8.2	370	2,125	174	20.2	1,582	320
40–59	33.6	3.8	378	2,475	92	17.4	1,391	242
60+	8.0	1.2	120	490	6	7.7	1,278	98
Marital status:								
Married	71.0	4.1	354	2,266	93	17.7	1,614	286
Head of one-parent family	4.5	14.9	522	1,835	273	25.5	759	194
Living with parents	12.7	20.2	297	1,521	307	10.9	394	43
Single (or other)	11.8	19.7	382	2,265	446	14.5	966	140
School completed:								
Less than high school	36.2	5.4	538	2,632	142	7.7	1,205	93
High school	31.7	8.8	363	1,984	175	17.5	1,287	225
College	15.2	15.3	237	1,608	246	20.9	997	208
University	16.9	8.2	306	1,837	151	31.0	1,838	570
Labor-market status:								
Student	11.4	28.2	332	1,976	557	12.0	364	44
Retired	5.1	1.9	120	490	9	5.6	463	26
Housekeeper	17.6	6.2	581	2,251	140	10.3	986	102
Unemployed	4.0	27.4	369	1,904	522	10.7	970	104
Worker	61.9	4.8	297	2,034	98	20.8	1,591	331
Social-assistance claimant	4.8	32.4	451	2,488	806	17.1	852	146
Regular-labor income:								
0–10,000	51.4	12.9	400	1,984	256	11.4	1,011	115
10,000–20,000	17.2	7.0	286	2,302	160	16.2	1,184	192
20,000–30,000	15.5	3.9	190	1,943	75	19.0	1,093	207
30,000–40,000	9.9	2.0	58	1,431	29	23.1	1,803	417
40,000+	11.0	2.3	104	1,790	41	34.1	2,116	721

search, which tries to measure legal, but untaxed, market activities.

Interviewers were specially trained to convince people to participate in the survey by explaining its purposes and stressing its anonymous, confidential, and strictly academic character. The interviewers were clearly identified as working for the University (Laval) which is well known in Quebec City. Since the survey included questions on general attitudes toward taxation and tax evasion, as well as on the supply (hours and income) and demand (purchases) of underground production, each respondent could relate directly to at least a part of the questionnaire. The interviewers delivered the questionnaires in person, offered to help explain or answer the questions in the survey, and asked the respondents to put the filled-in questionnaire in a sealed envelope

TABLE 1—*Continued*.

Characteristics	Percent of total sample (i)	Participation in the "underground" sector: Percent (ii)	Hours ($H>0$) (iii)	Earnings ($Y>0$) (iv)	Earnings ($Y\geq 0$) (v)	Purchases of goods from the "underground" sector: Percent (vi)	Purchases (C) ($C>0$) (vii)	Purchases (C) ($C\geq 0$) (viii)
Hours of work in the regular sector:								
0	31.7	11.4	507	2,500	285	11.4	966	110
1–500	6.8	18.9	247	1,093	207	10.5	965	101
500–1,000	8.6	12.7	269	1,693	215	16.0	1,016	163
1,000–1,500	10.1	7.1	178	1,645	117	21.7	1,456	316
1,500–2,000	33.7	4.1	199	1,807	74	20.0	1,512	302
2,000+	9.1	4.2	522	2,694	113	23.6	2,037	481
Industry in the regular job:								
Primary	1.4	17.2	572	2,706	465	37.9	1,023	388
Manufacturing	5.6	7.6	262	2,351	179	21.2	1,397	296
Construction	3.0	9.4	220	2,363	222	12.5	3,738	467
Transportation	4.9	6.8	44	665	45	17.5	1,620	284
Trade	9.8	8.2	243	1,643	135	13.0	1,671	217
Finance, insurance	7.2	2.0	217	2,462	49	16.5	2,052	339
Services	21.6	8.4	249	1,357	114	19.8	1,123	222
Public administration	14.8	5.5	154	1,767	97	23.4	2,421	567
No regular job	31.7	11.4	518	2,455	280	11.4	872	99
Industry in the underground job:								
Unclassified	2.0	100.0	247	1,537	1,537	15.8	842	133
Construction	2.8	100.0	333	2,072	2,072	30.0	1,430	429
Transportation	0.2	100.0	270	1,508	1,508	25.0	1,400	350
Trade	0.5	100.0	289	1,494	1,494	55.5	1,126	625
Finance	0.6	100.0	403	3,065	3,065	54.6	1,250	683
Services	2.7	100.0	467	2,163	2,163	30.4	960	292

Note: The results are based on 2,106 observations.

which was picked up a few days later.

These techniques insured a relatively high response rate: for 63.8 percent of the sampled households, at least one individual answered the questionnaire. In these same households, 81.1 percent of household members answered the questionnaire, for an overall response rate of 51.7 percent. Older citizens are slightly underrepresented while middle-aged persons are slightly overrepresented in the sample. Table 1 summarizes the socioeconomic characteristics of the sample and the magnitude of both the supply and demand of underground production. Because of missing data or gross inconsistencies in responses, a sample of 2,106 persons (of whom 285 are from the quota sample) is usable for the analysis.

Starting with the supply of labor to the underground sector, 8.5 percent of the people in the sample [column (ii)] report working in the underground sector, for an average of 357 hours per year [column (iii)]. The average underground income of these underground-sector participants is 2,006 Canadian dollars. The demographic groups with the highest participation rates are males, youth, and unmarried people. The effect of education on the participation rate in the underground sector is more ambiguous: it reaches a maximum for the category "some college" and then goes down. This may reflect cohort effects, as young people in Quebec are more educated than their elders. Moreover, 28 percent of the people who report that being in school or unemployed was their main labor-market status during the year also participated in the underground sector.[6] This participation rate rises to 32.4 percent for welfare recipients, who often face an implicit marginal tax rate as high as 97 percent.[7]

Table 1 also indicates that both the participation rate and the number of hours worked in the underground sector are inversely related to labor income in the regular sector.[8] Participation rates and hours worked in the underground sector also tend to be inversely related to the number of hours worked in the regular sector.[9] This suggests a large degree of substitutability between labor-market activities in the two sectors.

The lower portion of Table 1 provides information on the industrial composition of the jobs held by workers in both the regular and the underground sector. The participation rate in the underground sector is the highest for workers with a regular-sector job in primary industries (17.2 percent), followed by workers with a regular-sector job in the construction industry (9.4 percent). Furthermore, two-thirds of the jobs in the underground economy are in construction and services, including repairs.

B. *Reliability of the Data: The Income – Expenditure Gap*

In spite of the efforts made to elicit truthful responses, it is possible that a substantial fraction of the income earned in the underground sector was underreported in the survey. We assess the reliability of these income data by comparing them to the data on purchases of goods and services from the underground sector which were also collected in the survey. The idea is to reconcile aggregate income and expenditure (purchases) data in the same way national income and expenditures are reconciled in the national accounts. In the absence of systematic reporting errors, aggregate income and expenditures from the underground sector should be statistically equal. The discrepancy between income and expenditure is thus used as an estimate of how much income is not reported in the survey. The implicit assumption is that there is no incentive for buyers to misreport purchases of goods and services from the underground sector, since it is typically the seller of these goods and services who is liable for tax evasion.[10]

The percentage of people who purchased goods and services produced in the underground economy is reported in column (vi) of Table 1. Conditional on buying some goods and services, the average amount bought is reported in column (vii). The unconditional average is reported in column (viii). As a general rule, purchases of goods and services from the underground economy tend to increase with regular-sector income and with the socioeconomic variables associated with higher regular-sector

[6]The labor-market status reported in Table 1 is the activity, among work, school, unemployment, housework, or retirement, on which the individual spent the most weeks during the year. Someone who worked during 27 weeks and was unemployed during 25 weeks is thus classified as a worker.

[7]Very high participation rates of welfare mothers in the underground economy has been documented in the United States by Christopher Jencks and Kathryn Edin (1990).

[8]Similar results are obtained when total reported income (regular labor income and nonlabor income with the exception of transfer payments) is used instead of regular labor income.

[9]Workers who supply 2,000 hours or more in the regular sector are the only exception to that rule. The precision of this estimate is quite low, however, since only four workers in that cell supply positive hours to the underground sector.

[10]This argument implicitly ignores the balance of trade in underground services between the Quebec City area and other areas of the country. More importantly, purchases from the underground sector are biased downward if buyers do not know that suppliers fail to report their income to the tax authorities. On the other hand, the price of underground goods might include intermediate inputs, and this tends to bias upward the dollar amount of consumption relative to the net income reported by underground producers in the survey.

income. For instance, 7.7 percent of people who only have completed primary school purchase goods and services from the underground sector, while 31.0 percent of people who hold a university degree do so.

Unconditional average underground earnings are equal to 171 dollars [column (v)], which accounts for 73 percent of reported average purchases of goods and services from the underground sector [234 dollars in column (viii)]. This suggests substantial but not dramatic underreporting of labor earnings in the underground sector. Table 1 also indicates that underground goods and services are produced by workers with low (regular) incomes but are consumed by workers with high (regular) incomes. For example, people earning less than 10,000 dollars in the regular sector earn 256 dollars and spend 82 dollars in the underground sector, while people earning 40,000 dollars and more in the regular sector earn 41 dollars and spend 660 dollars in the underground sector. These systematic patterns reflect fundamental forces operating in the underground economy that simply cannot be reconciled with random responses due to widespread or even systematic lying on the part of the respondents to the survey.

C. *Internal Validity of Earnings, Hours, and Wage Data*

In addition to annual purchases and annual earnings in the underground sector, our survey also contains independent information on wage rates and annual hours of work in the underground sector. We can thus construct two independent measures of the wage rate in the underground sector. A first measure is the underground-sector wage directly reported in the survey, W_1. A second measure is average hourly earnings, AHE_1, defined as annual earnings in the underground sector, Y_1, divided by annual hours in that sector, h_1. These two independent measures can then be used in an instrumental-variables context to assess the robustness of the empirical results to measurement error in the wage rate. A similar procedure can be used in the regular sector since the survey contains independent information on regular-sector annual earnings, Y_0, and hours, h_0, and on the wage rate in the regular sector, W_0.

Before presenting the instrumental-variables estimates, we first report in Table 2 the means and the correlations of log hours, log wages, and log earnings, in both the regular and in the underground sector. These means and correlations are only reported for the 93 workers for whom complete information is available on wages, hours, and earnings in the two sectors.[11] The average annual hours and earnings reported in Table 2 are larger in the regular sector than in the underground sector. The average *gross* log wage in the regular sector (2.08, geometric mean of 7.98 dollars) is 13-percent larger than the average log wage in the underground sector (1.95, geometric mean of 6.99 dollars), but the average *net* log wage in the regular sector which takes account of marginal tax rates and tax-back rates associated with social transfers is only 1.32.[12] It is smaller than the average wage in the underground sector.

The standard deviation of annual log hours is 28.4-percent larger in the underground sector than in the regular sector. This suggests that hours of work are more flexible in the underground sector than in the regular sector.[13] The standard deviation of the wage rate in the underground sector is also larger than the standard deviation of the wage rate in the regular sector, suggest-

[11] Two observations for which average hourly earnings in the underground sector exceeded 100 dollars were also eliminated. The means and covariances for all workers who participated in the regular sector (1,369 observations) and all workers who participated in the underground sector (163 observations) are similar to the corresponding means and covariances reported in Table 2; in order to save space, these are not shown.

[12] Since the mean of $\log W_1$ exceeds the mean of $\log(W_0)$ (net), this implies that the geometric mean of the relative wage in the underground sector (W_1 over W_0, net) is smaller than 1.

[13] The choice of hours worked might depend on more institutional constraints in the regular than in the underground sector. See Shulamit Kahn and Kevin Lang (1991) for some evidence on hours constraints in the regular sector.

TABLE 2—MEANS AND CORRELATION MATRIX OF HOURS, EARNINGS, AND WAGE RATE FOR WORKERS HOLDING JOBS IN BOTH SECTORS

Variable (in logs)	Mean (standard deviation) Regular	Underground
Hours (h)	6.664 (0.841)	5.033 (1.007)
Wage (W)	2.077 (0.559)	1.945 (0.718)
Net wage ($W_0[1-\tau]$)	1.314 (1.241)	—
Earnings (Y)	8.689 (1.291)	6.990 (0.999)

Correlation matrix (p values shown in brackets)

	Regular sector h_0	W_0	Y_0	Underground sector h_1	W_1	Y_1
Regular hours (h_0)	1.000					
Regular wage (W_0)	0.520 [0.000]	1.000				
Regular earnings (Y_0)	0.851 [0.000]	0.814 [0.000]	1.000			
Underground hours (h_1)	−0.156 [0.137]	−0.231 [0.026]	−0.185 [0.077]	1.000		
Underground wage (W_1)	0.427 [0.000]	0.533 [0.000]	0.512 [0.000]	−0.346 [0.001]	1.000	
Underground earnings (Y_1)	0.128 [0.220]	0.118 [0.257]	0.154 [0.139]	0.762 [0.000]	0.328 [0.001]	1.000

Notes: The above results are based on 93 valid observations. The net wage is the regular wage net of an imputed marginal tax rate that takes account of income taxes, payroll taxes, and tax-back rates embodied in the social transfer system.

ing that wages might be measured with more noise in the underground sector than in the regular sector. This explanation is unlikely to hold, however, for earnings that are more dispersed in the regular sector than in the underground sector.

A fundamental difference between the covariance structures of earnings, hours, and wages in the two sectors is that hours and wages are positively correlated (0.520) in the regular sector, but negatively correlated (−0.346) in the underground sector. The negative correlation of wages and hours in the underground sector cannot be attributed to the division-bias problem (George J. Borjas, 1980) since wages, hours, and earnings are measured separately in our survey. Moreover, the estimated correlation between wages and hours in the regular sector might still be afflicted by this division bias, which makes the contrast between the correlations in the two sectors even more striking.[14] Finally, the correlations of regular-

[14]For the regular sector, respondents were asked separate questions about their labor earnings for the year, the number of weeks worked, the number of hours worked per week, and then either their hourly or weekly earnings. In the latter case, the wage rate was computed by dividing weekly earnings by weekly hours. This generates a mechanical connection between measurement error in yearly hours (weeks worked times weekly hours) and measurement error in the hourly wage rate (weekly earnings divided by weekly hours).

TABLE 3—ORDINARY LEAST-SQUARES (OLS) AND TWO-STAGE LEAST-SQUARES (2SLS) ESTIMATES OF HOURS AND EARNINGS EQUATIONS FOR WORKERS HOLDING JOBS IN BOTH SECTORS

A.		Regular sector		Underground sector	
	Dependent variable:	h_0	h_0[a]	h_1	h_1[a]
	Estimation method:	OLS	2SLS	OLS	2SLS
Row	Independent variable	(i)	(ii)	(iii)	(iv)
1	Regular-sector wage (W_0)	0.566 (0.183)	0.507 (0.179)	−0.770 (0.265)	−0.689 (0.253)
2	Underground-sector wage (W_1)	0.281 (0.110)	0.297 (0.117)	−0.612 (0.151)	−0.647 (0.159)
3	Regular-sector wage (W_0)	0.441 (0.207)	0.376 (0.191)	−0.360 (0.289)	−0.298 (0.254)
4	Underground-sector wage (W_1)	0.156 (0.123)	0.188 (0.134)	−0.510 (0.172)	−0.561 (0.179)

B.		Regular sector		Underground sector	
	Dependent variable:	Y_0	Y_0[b]	Y_1	Y_1[b]
	Estimation method:	OLS	2SLS	OLS	2SLS
Row	Independent variable	(i)	(ii)	(iii)	(iv)
1	Regular-sector hours (h_0)	1.096 (0.089)	—	—	—
2	Regular-sector hours (h_0)[c]	1.065 (0.101)	1.519 (0.324)	—	—
3	Underground-sector hours (h_1)	—	—	0.743 (0.062)	—
4	Underground-sector hours (h_1)[d]	—	—	0.703 (0.079)	0.679 (0.121)

Notes: Standard errors are reported in parentheses. Additional regressors are sex dummy, years of education, regular-sector experience, and its square. There are 93 observations unless otherwise indicated.

[a] Average hourly earnings (AHE) are instrumented with the wage rate (W).

[b] Hours (h) are instrumented with hours in 1984 (when available).

[c] There are 83 observations for which regular hours are available in 1984 and 1985.

[d] There are 61 observations for which underground-sector hours are available in 1984 and 1985.

sector variables with underground-sector variables can be summarized as follows. On the one hand, underground-sector hours are negatively correlated with regular hours (−0.156), regular wages (−0.231), and regular earnings (−0.185). On the other hand, the wage in the underground sector is positively correlated with the same regular-sector variables (correlations of 0.427, 0.533, and 0.512, respectively).

We next investigate the robustness of the correlation between hours and wages in the two sectors by fitting a series of log-linear regressions of wages to annual hours of work. The estimated effects of wages on regular-sector hours are reported in column (i) of Table 3A, while the estimated effects of wages on underground-sector hours are reported in column (iii). All the estimated regressions also include age, age squared, education, and a gender dummy as regressors. The results indicate that wages always have a positive effect on hours worked in the regular sector, but a negative effect on hours worked in the underground sector. This finding holds irrespective of whether the regular wage (row 1), the underground wage (row 2), or both wages (row 3) are included in the hours regressions.

We assess the robustness of these findings to the presence of measurement error in wages by exploiting the availability of two different measures of the wage rate: the wage rates directly reported in the survey (W_0 and W_1), and the average hourly earnings obtained by dividing annual earnings by annual hours (AHE_0 and AHE_1). In general, alternative measures of the wage rates can be used as instrumental variables for each other to eliminate error-in-variables biases.[15] For the problem considered here, consistent estimates of the effect of wages on hours can be obtained by fitting to hours an instrumental-variables regression of average hourly earnings in which directly reported wages are used as instruments. This instrumental-variables approach is preferable to the alternative approach of instrumenting directly reported wages with average hourly earnings, since measurement error in average hourly earnings (the instrumental variable) is mechanically connected to measurement error in hours of work (the error term). This invalidates the condition that the instrumental variable must be uncorrelated with the error term.

The instrumental-variables estimates of the hours equations are reported in columns (ii) and (iv) of Table 3A. The results indicate that the instrumental-variable estimates are almost identical to the ordinary least-squares (OLS) estimates. The results reported in Table 3A are thus unambiguous: for every wage measure and every estimation method, the wage has a positive effect on the number of hours worked in the regular sector, but a negative effect on the number of hours worked in the underground sector. These results are remarkably robust and are clearly not artifacts of measurement error.

We complete the preliminary data analysis by estimating several log-linear regressions of earnings on hours in both the regular and the underground sector. In columns (i) and (iii) of Table 3B, we report OLS estimates of earnings equations that also include age, age squared, education, and a gender dummy as regressors. The estimated elasticity of regular-sector earnings with respect to regular-sector hours (1.096) is not statistically different from 1. By contrast, the OLS estimate of the elasticity of underground-sector earnings with respect to hours worked in the underground sector is significantly smaller than 1 (0.743). Since the earnings function in the regular sector is approximately linear, this suggests that the wage rate in the regular sector does not depend on hours worked in that sector. By contrast, earnings are a concave function of hours in the underground sector, suggesting that the wage rate in the underground sector decreases as hours increase. The instrumental-variables estimates reported in columns (ii) and (iv) also indicate that these findings are robust to measurement error. The estimated elasticity in the regular sector is equal to 1.519 and is not significantly different from 1, while the estimated elasticity in the underground sector is equal to 0.679 and is significantly different from 1. These instrumental-variables estimates are obtained by instrumenting hours worked in 1985 with hours worked in 1984.[16]

D. *Summary of the Findings*

The main empirical findings of this section can be summarized as follows:

1. Labor earnings in the underground sector are concentrated among workers with low earnings in the regular sector, while expenditures on goods and services produced in the underground sector are typically undertaken by people with high earnings in the regular sector. Average reported incomes are 37-percent lower than average reported expenditures on goods and services from the underground sector.
2. The wage rate in the regular sector and the wage rate in the underground sector are positively correlated with hours worked in the regular sector but negatively correlated with hours worked in the underground sector.
3. Earnings in the regular sector are a linear or slightly convex function of regular-sector hours, while earnings in the underground sector are a concave function of underground-sector hours.

[15]See Joseph G. Altonji (1986) for a related procedure using data from the Panel Study of Income Dynamics (PSID).

[16]Both the number of hours worked in 1984 and those worked in 1985 were obtained retrospectively at the time of the survey in 1986.

These patterns are clearly not spurious consequences of measurement error. Rather, they represent fundamental empirical regularities that need to be taken into account when modeling the impact of taxes on labor supply in the underground sector.

II. The Model

The empirical regularities uncovered in the data suggest modeling earnings in the underground sector as a concave function of hours worked in that sector, while modeling earnings in the regular sector as a linear function of hours of work. A similar approach has been used by Reuben Gronau (1977) to explain the allocation of time among home production, market work, and leisure. Gronau postulates that the value of home production is a concave function of hours worked at home, which explains why hours worked at home are negatively related to the market wage, just as hours in the underground sector are negatively related to the regular-sector wage in this paper. One explanation for the concavity of the earnings function in the underground sector is based on the principle that the informal nature of economic activities in that sector imposes a limit on the scope of these activities. Because of these market limitations, the underground-sector worker faces a downward-sloping demand for his or her output. As hours of work and output expand, the output price goes down, which tends to reduce the value of the marginal product of labor when there are constant (or decreasing) returns to scale in production. Labor earnings in the underground sector are thus typically a concave function of hours worked in that sector.[17]

Why does the informal nature of economic activities in the underground sector impose a limit on the scope of these activities? The simplest answer to this question is a corollary of Adam Smith's famous theorem that the division of labor is limited by the extent of the market: as labor becomes more specialized in a larger market, it also becomes more visible to the tax authorities. Because of this visibility problem, underground producers will tend to operate in small informal markets that government authorities cannot monitor very well. These informal markets are typically based on a network of connections and acquaintances that compensate for the absence of formal warranties in the underground sector.

A. *A Model for the Allocation of Time*

Our model is based on a concave Cobb-Douglas earnings function in the underground sector, $Y_1 = A_1 h_1^{\theta}$, where $\theta < 1$, and on a linear earnings function in the regular sector, $Y_0 = W_0 h_0$. The variable h_0 represents hours of work in the regular sector; h_1 represents hours of work in the underground sector; W_0 is the wage in the regular sector; A_1 is a revenue-shifter in the underground sector. To simplify the presentation, consider the quasi-linear utility function:

$$(1) \qquad U(\ell, C) = \gamma C + v(\ell)$$

where the function $v(\cdot)$ is a strictly concave utility function ($v' > 0$, $v'' < 0$). C represents a composite consumption good (the numeraire), while ℓ is the number of hours of leisure that satisfies the time constraint $T = h_0 + h_1 + \ell$. The budget constraint is given by

$$(2) \qquad C = I + W_0 h_0 + A_1 h_1^{\theta}$$

where I represents nonlabor income, including any lump-sum transfer. The worker's problem is

$$(3) \qquad \max_{\{c, h_0, h_1\}} \gamma C + v(T - h_0 - h_1)$$

subject to equation (2), $h_0 \geq 0$, and $h_1 \geq 0$.

[17]Marginal revenues decrease as production increases, provided that the demand elasticity for output is constant and larger than 1. Furthermore, marginal revenues always decrease in production when the producer is a discriminating monopolist. Workers need not face a demand curve in the conventional sense; similar results would be obtained in a model with search costs that become prohibitive as the size of the informal market expands.

For workers who supply positive hours in both sectors (interior solution), the first-order conditions for hours yield:

$$(4)\quad \partial U/\partial h_0 = -v'(T-h_0-h_1) = -\gamma W_0$$

$$(5)\quad \partial U/\partial h_1 = -v'(T-h_0-h_1) = -\gamma\theta A_1 h_1^{\theta-1}.$$

These two conditions imply the following equality for the marginal revenue of an hour of work in the two sectors:

$$(6)\quad W_0 = \theta A_1 h_1^{\theta-1}.$$

Hours of work in the underground sector are thus determined by setting the marginal revenue in the underground sector equal to the regular-sector wage. This implies that, conditional on the regular-sector wage, underground-sector hours *do not* depend on preferences. This "separation" between the determination of hours in the underground sector and preferences is similar to the separation result in the development literature on farm households which states that the labor demand of a farm is determined independently of the preferences of household members.[18]

This separation result has several implications that are consistent with the empirical regularities discussed in Section I. First consider the average wage rate in the underground sector:

$$(7)\quad W_1 = Y_1/h_1 = A_1 h_1^{\theta-1}.$$

Equations (6) and (7) imply that $W_0 = \theta W_1$. Since $\theta < 1$, it follows that the regular-sector wage, W_0, is smaller than the underground-sector wage W_1. This prediction holds, on average, when the measure of W_0 used is the regular wage net of the tax rate (Table 2).

Additional predictions are obtained by considering the comparative statics of a change in the regular wage W_0. Differentiating the first-order conditions and equation (7) yields

$$(8)\quad dh_0/dW_0 = -(\gamma/v'') - [\theta(\theta-1)A_1 h_1^{\theta-2}]^{-1} > 0$$

$$(9)\quad dh_1/dW_0 = [\theta(\theta-1)A_1 h_1^{\theta-2}]^{-1} < 0$$

$$(10)\quad dW_1/dW_0 = 1/\theta > 0.$$

For simplicity, consider the case in which workers share the same preferences and the same underground-earnings function, and where W_0 is an arbitrary random variable. Equation (8) then predicts a positive correlation between W_0 and h_0, while equation (9) predicts a negative correlation between W_0 and h_0. Furthermore, equation (10) predicts a positive correlation between W_0 and W_1, which implies that W_1 is positively correlated to h_0 and negatively correlated to h_1. These predictions are consistent with the results reported in Section I. Of the three inequalities in (8)–(10), only (8) depends on the assumption that the utility function is quasi-linear and thus that there is no income effect. A sufficient condition for the inequality $dh_0/dW_0 > 0$ to hold is that the uncompensated elasticity of labor supply is positive.

B. *A Model with Taxes and Probability of Getting Caught*

Next, we enrich the model to analyze the impact of the tax system on the allocation of time. For simplicity, consider the case of a flat tax rate τ. Net earnings in the regular sector are given by $(1-\tau)W_0 h_0$. Following the basic model of tax evasion, we postulate that workers who supply positive hours to the underground sector face a probability P

[18] In that literature, it is typically assumed that farmers face the choice between cultivating their land according to a concave production function or working in the market at a given wage rate that does not depend on hours of work (see e.g., Mark Rosenzweig, 1980; Dwayne Benjamin, 1992).

of being detected by the authorities.[19] Getting caught entails a penalty proportional to the amount of tax evaded.[20] The penalty rate on underground income can be written as $\lambda\tau$, λ being the penalty rate on evaded tax (with $\lambda \geq 1$). The expected rate of tax penalty on evaded income is thus given by $P\lambda\tau$. This expected rate of tax penalty has to be smaller than the tax rate, τ, for a risk-neutral worker to prefer not to report his or her earnings to the tax authorities. It is thus reasonable to expect that $P\lambda$ is smaller than 1. The stochastic budget constraint faced by the individual is given by

$$(11) \quad C = (1-\tau)W_0 h_0 + (1 - D\lambda\tau)A_1 h_1^{\theta} + I$$

where D is a dummy variable which equals 1 with probability P, and 0 with probability $1-P$. Assume that the individual is an amoral expected-utility maximizer. The problem to be solved by the individual is thus given by

$$(12) \quad \max_{\{c, h_0, h_1\}} E[\gamma C + v(T - h_0 - h_1)]$$

subject to the budget constraint and to the nonnegativity constraints on h_0 and h_1. Since

$$(13) \quad E(C) = (1-\tau)W_0 h_0 + (1 - P\lambda\tau)A_1 h_1^{\theta} + I$$

the first-order conditions for an interior solution now imply that

$$(14) \quad v'(T - h_0 - h_1) = \gamma(1-\tau)W_0$$

$$(15) \quad v'(T - h_0 - h_1) = \gamma(1 - P\lambda\tau)\theta A_1 h_1^{\theta-1}.$$

Once again, underground-sector hours do not depend on preferences conditional on W_0 and τ. The solution to the choice problem under uncertainty takes this simple form because the utility function is linear in consumption, which implies risk-neutrality in consumption.

The case in which workers are risk-averse but face a parametric wage in both the regular and the underground sector has been analyzed by several authors (e.g., Sandmo, 1981; Cowell, 1985; Claude Fluet, 1987). This case leads to few interesting comparative-statics results, however, even with strong restrictions on preferences for consumption and leisure.[21] As noted by Cowell (1984 p. 21), the basic reason for these ambiguities is that "in reaction to any perturbation, the individual can substitute across two margins (risk/no-risk and labor/leisure), so that in principle all sorts of behavior could be consistent with rational expected utility maximization."[22] In this branch of the literature, risk aversion provides the concavity required for interior solutions in which the worker supplies positive hours in both sectors. Risk-neutral agents would fully specialize in only one of the two sectors with probability 1.

By contrast, the existence of interior solutions does not rely on risk aversion in our model. In fact, interior solutions would still exist even if the probability of detection P, were equal to zero. Another advantage of our model is that it has clear predictions for the effect of taxes on hours of work in the two sectors.[23] Differentiating the first-order

[19] In the survey, only 6.9 percent of the workers who supplied positive hours to the underground sector thought that the probability of getting caught by the authorities was either "high" or "very high"; 14.8 percent of the whole sample expressed a similar view.

[20] This formulation was first proposed by Shlomo Yitzhaki (1974).

[21] For a critical analysis of this approach, see Jonathan Kesselman (1989).

[22] However, Fluet (1987) has shown that, under the assumption that $W_1 < W_0$, there necessarily exists a threshold tax rate above which there exists a positive relationship between the tax rate and labor supply in the underground sector. Fluet assumes that the degree of absolute risk aversion is decreasing in consumption and that there is an interior solution for h_0 and h_1.

[23] Related models have been considered by authors dissatisfied with the lack of predictive power of models based on risk aversion (see e.g., Ingemar Hansson, 1985; Dan Usher, 1986; Kesselman, 1989). These models suppose that tax-evasion activities are foolproof (no chance of being discovered) but entail real or psychic costs.

conditions (14) and (15) yields:

$$(16)\quad \frac{dh_0}{d\tau} = \frac{\gamma W_0}{v''} - \frac{h_1(1-P\lambda)}{(1-\tau)(1-P\lambda\tau)(1-\theta)} < 0$$

$$(17)\quad \frac{dh_1}{d\tau} = \frac{h_1(1-P\lambda)}{(1-\tau)(1-P\lambda\tau)(1-\theta)} > 0.$$

Provided that $P\lambda < 1$, these conditions imply that an increase in the tax rate has a positive effect on hours of work in the underground sector, but a negative effect on hours of work in the regular sector.

One interpretation of our model is that it seeks to explain the behavior of informal workers, as opposed to tax evaders operating at the margin of being discovered by the tax authorities. This focus is deliberate and reflects the belief that a survey like ours should reveal accurate information on informal workers who face a very small probability of detection by the authorities. Our survey might be less accurate, however, for tax evaders operating at the margin of being detected. Data based on extensive audits (like the TCMP of the IRS) might be more revealing for these tax evaders. The two measurement approaches, micro surveys and tax audits, should thus be viewed as complementing each other.

III. Estimation Strategy

Our analysis focuses on the determination of hours and earnings in the underground sector for workers who supply positive hours in the two sectors. The advantage of working with this sample of workers is that the separation result allows us to ignore the structure of preferences and thus most of the complications that arise in standard analyses of labor supply.[24]

A. Stochastic Specification

The model is implemented empirically by first introducing individual heterogeneity in the revenue-shifter A_1:

$$(18)\quad A_{1i} = \exp(\beta_0 + \mathbf{x}'_{1i}\boldsymbol{\beta}_1 + \varepsilon_{1i})$$

where $\mathbf{x}_{1i}$ is a vector of explanatory variables that is uncorrelated with the error term ε_{1i}. The first-order conditions (14) and (15) can be combined as follows:

$$(19)\quad (1-P\lambda\tau_i)\theta A_{1i}h_{1i}^{\theta-1} = (1-\tau_i)W_{0i}.$$

A labor-supply function in the underground sector is then obtained by substituting equation (18) into equation (19), taking logs, and solving for h_{1i}:

$$(20)\quad \ln(h_{1i}) = \frac{\ln\theta + \beta_0 + a_0}{1-\theta} - \frac{\ln(W_{0i})}{1-\theta} - \frac{(1-a_1)\ln(1-\tau_1)}{1-\theta} + \frac{\mathbf{x}'_{1i}\boldsymbol{\beta}_1}{1-\theta} + \frac{\varepsilon_{1i}}{1-\theta}$$

where the following linear approximation has been used:

$$(21)\quad \ln(1-P\lambda\tau_i) \approx a_0 + a_1\ln(1-\tau_i)$$

and where $a_1 = [P\lambda(1-\bar{\tau})]/(1-P\lambda\bar{\tau})$, with $\bar{\tau}$ denoting the sample mean of τ_i.[25] Equation (20) restates the separation result in a stochastic context: conditional on W_{0i}, τ_i, and x_{1i}, hours worked in the underground sector do not depend on preferences.

The curvature parameter θ determines the elasticity of underground hours with

[24]See, however, Guy Lacroix and Fortin (1992) and Chapter 2 of Lemieux (1989), which model the determination of hours in both the regular and the underground sector.

[25]The approximation is obtained by redefining $\ln(1-P\lambda\tau_i)$ as $\ln(1-P\lambda[1-\exp(x_i)])$, with $x_i = \ln(1-\tau_i)$, and taking the first-order Taylor-series expansion of this function of x_i around $x_0 = \ln(1-\bar{\tau})$. It is thus possible to estimate $P\lambda$ using the estimated value of a_1.

respect to the regular wage, $-1/(1-\theta)$. This elasticity is thus closely related to the elasticity of underground earnings with respect to underground hours, which is equal to θ. The parameter θ can thus be estimated directly by fitting the underground-earnings equation, or indirectly by fitting the underground-hours equation. The stochastic specification for underground-sector earnings is obtained by substituting equation (18) into the Cobb-Douglas earnings function $Y_{1i} = A_{1i}h_{1i}^{\theta}$, and staking the natural logarithm of the resulting expression:

$$(22) \quad \ln(Y_{1i}) = \beta_0 + \theta \ln(h_{1i}) + \mathbf{x}'_{1i}\boldsymbol{\beta}_1 + \varepsilon_{1i}.$$

One problem with estimating equations (20) and (22) is that both underground hours (h_{1i}) and underground earnings (Y_{1i}) depend on the same error term (ε_{1i}). The underground-sector hours are thus endogenous, and the estimate of θ obtained by fitting equation (22) with ordinary least squares is inconsistent.

Similarly, the ordinary least-squares estimates of the underground-hours equation (20) are only consistent when the regular wage W_{0i} is exogenous. Consider a standard human-capital equation for the regular-sector wage:

$$(23) \quad \ln(W_{0i}) = \gamma_0 + \mathbf{x}'_{0i}\boldsymbol{\gamma}_1 + \varepsilon_{0i}$$

where the error term ε_{0i} is uncorrelated with $\mathbf{x}_{0i}$. The error term ε_{0i} has to be uncorrelated with ε_{1i} for the OLS estimates of equation (20) to be consistent. However, the two error terms could be correlated for a variety of reasons. For example, unmeasured productivity in the two sectors could be correlated. Alternatively, equation (23) could be the reduced form of a hedonic wage equation in which the wage rate depends on hours of work. Under these circumstances, hours of work in the two sectors would be jointly determined, and ε_{0i} would be a function of ε_{1i} (see Appendix A).

It is still possible, however, to estimate the parameters in equations (20) and (22) by instrumental-variables techniques. Valid instrumental variables for the regular wage W_{0i} in equation (20) have to be correlated with W_{0i} but not with the error term ε_{1i}. The variables included in $\mathbf{x}_{0i}$ but not in $\mathbf{x}_{1i}$, such as union status and the industry affiliation in the regular sector, satisfy precisely this condition. These variables are also valid instruments for h_{1i} in equation (22), since underground hours h_{1i} are a function of the regular wage W_{0i} in equation (20). This assumes, however, that the error term ε_{1i} is uncorrelated with the union status and the industry affiliation. This might not be true if workers are sorted into union jobs and industries on the basis of unobserved productive abilities that are imbedded in the error terms ε_{0i} and ε_{1i}.

B. *Treatment of the Marginal Tax Rate*

The marginal-tax-rate variable, τ_i, used in the empirical analysis takes into account the marginal tax rate associated with the payroll taxes and the federal and provincial income taxes, as well as the tax-back rates embodied in the social-transfer system. This marginal tax rate is a complicated nonlinear function of labor income, nonlabor income, and household composition. It is imputed for each worker using an appropriate computer program.

In the discussion above, the marginal tax rate τ_i was treated as an exogenous variable. This assumption is known to be inappropriate in the regular sector, however, since regular-sector earnings and the marginal tax rate are mechanically connected by the nonproportionality of the tax and transfer system. The assumption is more appropriate when analyzing labor supply in the underground sector since, conditional on earnings reported to the tax authorities, there is no mechanical connection between the marginal tax rate and labor supply in the underground sector. Nonetheless, there is a indirect connection between the marginal tax rate τ_i and the error term ε_{1i} to the extent that ε_{1i} is correlated with ε_{0i}, or with unmeasured preferences. We address this problem by instrumenting the marginal tax rate with a predicted tax rate based on a measure of the predicted gross income in the regular sector.[26]

C. *Self-Selection*

The underground-hours equation in (20) only holds for workers who supply positive hours in both sectors. Conditional on working in the regular sector, the Cobb-Douglas specification for underground-sector earnings implies that everybody should work in the underground sector, since $\partial Y_{1i}/\partial h_{1i} \to +\infty$ as $h_{1i} \to 0$. This implication of the model is not very realistic, however, given that the Cobb-Douglas specification is only a local approximation to the true earnings function and that there might be fixed costs of participating in the underground sector. Estimates of equations (20) and (22) based on that sample might thus suffer from self-selection biases, since most people holding a job in the regular sector do not work in the underground sector.

A complete derivation of a model with fixed costs is presented in Appendix B. It is only necessary to mention here that consistent estimates can be obtained using standard two-step selectivity adjustments. There is also a second selectivity bias because a substantial fraction of the population does not work in the regular sector. Adjusting for the two sources of selection is difficult and cannot be done by simply including two inverse Mills' ratio terms. The second type of selectivity bias is thus ignored, although results presented in Lemieux (1989) indicate that this omission does not substantially affect the results.

D. *Joint Estimates of the Earnings and Hours Equations*

The underground-hours equation (20) and the underground-earnings equation (22) both depend on the structural parameters θ, β_0, and $\boldsymbol{\beta}_1$. The parameters θ, β_0, and $\boldsymbol{\beta}_1$ can thus be estimated more efficiently by jointly fitting equations (20) and (22). Furthermore, the internal validity of the model can be verified by testing whether the cross-equation restrictions embedded in equations (20) and (22) are satisfied.

We jointly estimate the structural parameters of the earnings and hours equations in two stages. We first estimate unrestricted reduced forms for $\ln(h_{1i})$ and $\ln(Y_{1i})$ using OLS with an adjustment for self-selection. The reduced-form equations for $\ln(h_{1i})$ and $\ln(Y_{1i})$ are obtained by substituting equation (23) into equations (20) and (22):

$$(24)\quad \ln(h_{1i}) = c_{0h} - \frac{(1-a_1)\ln(1-\tau_i)}{1-\theta} + \frac{\mathbf{x}'_{1i}\boldsymbol{\beta}_1 - \mathbf{x}'_{0i}\boldsymbol{\gamma}_1}{1-\theta} + \frac{\varepsilon_{1i}-\varepsilon_{0i}}{1-\theta}$$

$$(25)\quad \ln(Y_{1i}) = c_{0y} - \frac{\theta(1-a_1)\ln(1-\tau_1)}{1-\theta} + \frac{\mathbf{x}'_{1i}\boldsymbol{\beta}_1 - \theta\mathbf{x}'_{0i}\boldsymbol{\gamma}_1}{1-\theta} + \frac{\varepsilon_{1i}-\theta\varepsilon_{0i}}{1-\theta}$$

where $c_{0h} = (\ln\theta + \beta_0 + a_0 - \gamma_0)/(1-\theta)$ and $c_{0y} = [\beta_0 + \theta(\ln\theta + a_0 - \gamma_0)]/(1-\theta)$. Each reduced-form coefficient is a function of the structural parameters.

We then estimate the structural parameters using a minimum-distance procedure. This procedure consists of choosing the

[26] More precisely, we estimate a reduced-form equation for regular labor income, using all the exogenous variables of the model as explanatory variables, to construct a predicted labor income. The marginal tax rate is then computed at that predicted labor income. This tax rate based on predicted income is then used as an instrumental variable for the actual tax rate in the first-stage regression (it is never included directly in the second-stage regression). Alternatively, higher-order functions of the exogenous regressors could be used as instruments to capture nonlinearities in the reduced forms that result from the nonlinear nature of the tax schedule.

value of the structural parameters that minimizes the distance between the coefficients predicted by equations (20) and (22) and the coefficients estimated from the unrestricted reduced forms for $\ln(h_{1i})$ and $\ln(Y_{1i})$.[27] Additional restrictions are obtained by jointly estimating the equations for underground hours and earnings [equations (24) and (25)] with the equation for the regular-sector wage [equation (23)].[28] Adding the equation for the regular-sector wage also helps the efficiency of the estimates since the regular-sector wage is observed for all workers holding jobs in the regular sector. The minimum-distance approach is convenient for incorporating the information from reduced-form equations estimated on different samples, as is the case here. When the model is true, the minimand of the distance function is distributed as $\chi^2_{[k]}$, where k is the number of restrictions embedded in the model (see Gary Chamberlain, 1982). Testing whether this minimand is equal to zero is thus a general specification (or goodness-of-fit) test of the model.

Another advantage of the minimum-distance approach is that it yields a unique estimate of the curvature parameter θ. Such an estimate is necessary for measuring the elasticity of underground hours with respect to the regular-sector wage ($-1/[1-\theta]$). Estimates of this elasticity are required to evaluate the claim that higher taxes might distort the allocation of time from the regular to the underground sector, thereby limiting the ability of governments to increase their tax revenues (Laffer curve).

[27] Minimum-distance estimates correspond to the vector of structural parameters $\boldsymbol{\delta}$ that minimizes the quadratic form $[\hat{\boldsymbol{\pi}} - f(\boldsymbol{\delta})]'\mathbf{V}^{-1}[\hat{\boldsymbol{\pi}} - f(\boldsymbol{\delta})]$, where $\hat{\boldsymbol{\pi}}$ is a stacked vector of unrestricted reduced-form parameters, $\mathbf{V}$ is their estimated covariance matrix, and the function $f(\boldsymbol{\delta})$ relates the structural parameters to the coefficients in equations (24) and (25).

[28] For example, the coefficient on the union status (included in $\mathbf{x}_{0i}$ but not in $\mathbf{x}_{1i}$) is γ_u in equation (23), $-\gamma_u/(1-\theta)$ in equation (24), and $-\theta\gamma_u/(1-\theta)$ in equation (25). There are thus three reduced-form coefficients to be fitted with the two parameters γ_u and θ. The minimum-distance estimator picks values of γ_u and θ so that γ_u, $-\gamma_u/(1-\theta)$, and $-\theta\gamma_u/(1-\theta)$ are as close as possible to their three corresponding unrestricted reduced-form estimates.

IV. Results

In this section, we present three sets of results. We first present probit estimates of the participation decision for the underground sector. We then present separate estimates of the underground-hours equation (20) and of the underground-earnings equation (22) adjusted for self-selection using James J. Heckman's (1976) two-step procedure. Finally, we jointly estimate the underground-hours equation, the underground-earnings equation, and the regular-wage equation using a minimum-distance procedure. Since the regular wage is not observed for underground workers who do not also work in the regular sector, the empirical analysis is limited to the subsample of underground workers who also supply positive hours to the regular sector.

A. *Participation Decision*

Probit estimates of the decision to participate in the underground sector are presented in Table 4. The first column presents estimates from a model in which neither the regular wage nor the marginal tax rate is instrumented. The estimated effect of the gross regular wage, $\ln(W_0)$, is negative (-0.59), while the estimated effect of the marginal tax rate, $-\log(1-\tau)$, is positive (0.21) and significant. Both estimated effects are statistically different from zero. The effect of the tax rate on the probability of participating is smaller than the effect of the regular wage, suggesting either a large value of $P\lambda$ (0.76) or substantial measurement error in the marginal tax rate. One source of measurement error in the marginal tax rate is that the take-up rate of welfare programs is lower than 100 percent.

The estimated effect of the remaining variables is generally consistent with the tabulations presented in Table 1. We have included in all the estimated specifications a variable that reflects the excess employment in the industry with which the worker is

TABLE 4—PARTICIPATION DECISION FOR THE UNDERGROUND SECTOR

Independent variable	Probit (i)	Probit (ii)	Two-stage probit (iii)	Two-stage probit (iv)	Two-stage probit (v)
Age	0.125	0.133	0.130	0.167	0.115
	(0.063)	(0.064)	(0.075)	(0.085)	(0.073)
Age squared divided by 100	−0.179	−0.192	−0.187	−0.231	−0.170
	(0.091)	(0.091)	(0.102)	(0.112)	(0.107)
Sex dummy (1 = women)	−0.481	−0.451	−0.501	−0.555	0.146
	(0.129)	(0.132)	(0.162)	(0.193)	(0.134)
Experience in regular market	−0.024	−0.017	−0.028	−0.004	−0.035
	(0.029)	(0.030)	(0.035)	(0.042)	(0.030)
Experience squared divided by 100	0.048	0.034	0.068	0.032	0.076
	(0.087)	(0.088)	(0.091)	(0.096)	(0.082)
Education	0.044	0.051	0.050	0.091	0.033
	(0.023)	(0.024)	(0.042)	(0.065)	(0.038)
Nonlabor income	0.003	0.005	0.005	0.009	0.004
	(0.008)	(0.008)	(0.008)	(0.010)	(0.006)
Regular wage (W_0)	−0.593	−0.617	−0.659	−1.212	−0.432
	(0.140)	(0.148)	(0.476)	(0.897)	(0.475)
Marginal tax rate [$-\ln(1-\tau)$]	0.212	0.210	0.332	0.364	0.321
	(0.090)	(0.090)	(0.304)	(0.315)	(0.353)
Marital status (1 = married)	−0.559	−0.618	−0.535	−0.502	−0.573
	(0.142)	(0.146)	(0.182)	(0.215)	(0.161)
Excess employment in industry	−3.705	—	−3.290	—	−2.919
	(3.407)		(3.843)		(3.678)
Industry dummies:	no	yes	no	yes	no
Excluded instruments:	—	—	$\tilde{\tau}$,D,U	$\tilde{\tau}$,U	$\tilde{\tau}$,D
Log-likelihood:	−292.6	−283.7	−302.8	−293.7	−303.7
Number of observations:	1,390	1,390	1,380	1,390	1,390

Notes: The results above are for the participation decision conditional on supplying positive hours to the regular sector. Instrumental variables include industry dummies (D), the union status (U), and $\tilde{\tau} = -\ln(1-\hat{\tau})$ where $\hat{\tau}$ is the "predicted" implicit marginal tax rate. Numbers in parentheses are standard errors; the standard errors were adjusted for the two-stage procedure.

affiliated in the regular sector. This variable reflects potential hours constraints in the regular sector.[29] The estimated effect of the excess-employment variable is not statistically significant in any of the specifications considered. In addition, none of the estimated coefficients changes substantially when industry dummies are included in column (ii). The excess-employment variable is not included in the specification presented in column (ii) since it is a linear combination of the industry dummies.

The simple probit estimates presented in columns (i) and (ii) are inconsistent when

[29]This excess-employment variable is simply the residual in 1985 from an aggregate employment equation at the industry level, for the industry with which the regular job is affiliated. The employment equation is specified as an AR(1) with a quadratic trend. The industry employment is at the one-digit level for the Province of Quebec.

the regular wage and the tax rate are endogenous. In columns (iii) and (iv), we present the two-stage probit version of the probit models reported in columns (i) and (ii). Two-stage probit estimates are consistent even when the regular wage rate and the marginal tax rate are endogenous. The instrumental variables used for the model estimated in column (iii) are the union status, the predicted tax rate, and the industry dummies. For the model presented in column (iv) the industry dummies are directly included in the probit equation instead of being used as instrumental variables. The two-stage probit procedure increases the magnitude of the estimated coefficients associated with the regular wage and the marginal tax rate. However, the estimated standard errors increase by even more, and the estimated coefficients are no longer statistically different from zero. As a result, Hausman specification tests (0.187 and 0.574, both distributed as $\chi^2_{[2]}$) do not reject the standard probit specifications of columns (i) and (ii) in favor of the two-stage probit estimates of columns (iii) and (iv). Finally, column (v) reports the estimates from a model in which the union status is not included in the set of instrumental variables. The estimated effect of wages is smaller than in the other columns, but not significantly so. Overall, the results are not very sensitive to the choice of instruments.

B. *Separate Estimates of the Underground-Hours and Underground-Earnings Equations*

Table 5 presents estimates of the underground-hours equation (20) and of the underground-earnings equation (22). The inverse Mills' ratio constructed from an unrestricted reduced-form probit is included in all the specifications, along with the vector of regressors $\mathbf{x}_{1i}$ which consists of age, age squared, regular-sector actual experience (as opposed to potential experience) and its square, years of education, excess employment in the industry, and dummy variables for gender and marital status.

The OLS estimates of the hours equation adjusted for selectivity are reported in column (i).[30] The estimated elasticity of underground hours with respect to the regular wage is negative (-0.519) and statistically different from zero. The sign of the elasticity is thus consistent with the predictions of the model. The estimated effect of the marginal tax rate is negative but is not statistically different from zero.

The results are qualitatively similar when both the regular wage and the marginal tax rate are instrumented. For instance, column (ii) presents two-stage least-squares (2SLS) estimates with a selectivity adjustment of a model in which the set of regular-sector industry dummies and the predicted tax rate are used as instrumental variables. The point estimate of the elasticity of underground hours with respect to the regular wage is larger in absolute value (-0.972) than the elasticity estimated by OLS, but it is not significantly different from zero. The results are essentially unchanged when the union status is added to the set of instrumental variables in column (iii).

The OLS estimates of the earnings equation adjusted for selectivity are reported in column (iv). The elasticity of underground earnings with respect to underground hours is precisely estimated at 0.729. Furthermore, the estimated elasticity is reduced by only 0.02 when the underground-earnings equation is estimated by 2SLS in columns (v) and (vi).

The estimates of θ obtained by fitting the earnings equation thus imply an elasticity of underground-sector hours with respect to the regular-sector wage ($-1/[1-\theta]$) on the order of -3.5. This estimated elasticity is larger in absolute value than the estimated elasticity obtained directly by fitting the underground-hours equation [-0.962 in column (iii) of Table 5]. Although the dif-

[30]All the standard errors reported in Table 5 are calculated using the bootstrap method. They are robust to heteroscedasticity and to the fact that the probit coefficients used to construct the inverse Mills' ratio were estimated from the same sample (the probit and the hours and earnings equation are "jointly" bootstrapped). The bootstrap standard errors are very similar to the corresponding asymptotic standard errors.

TABLE 5—HOURS AND EARNINGS EQUATIONS IN THE UNDERGROUND SECTOR

	Hours			Earnings		
Independent variable	OLS (i)	2SLS (ii)	2SLS (iii)	OLS (iv)	2SLS (v)	2SLS (vi)
Underground hours	—	—	—	0.729 (0.068)	0.708 (0.161)	0.709 (0.144)
Regular wage	−0.519 (0.246)	−0.972 (0.517)	−0.962 (0.511)	—	—	—
Tax rate $[-\ln(1-\tau)]$	−0.125 (0.113)	−0.623 (0.313)	−0.595 (0.307)	—	—	—
Age	−0.039 (0.124)	−0.222 (0.181)	−0.211 (0.178)	0.069 (0.075)	0.069 (0.075)	0.069 (0.075)
Sex dummy (female = 1)	0.050 (0.284)	0.306 (0.387)	0.289 (0.382)	−0.478 (0.174)	−0.476 (0.175)	−0.476 (0.175)
Experience in regular market	0.085 (0.056)	0.145 (0.070)	0.142 (0.069)	0.034 (0.035)	0.035 (0.036)	0.035 (0.036)
Education	−0.037 (0.048)	0.021 (0.064)	0.019 (0.064)	−0.039 (0.028)	−0.041 (0.031)	−0.041 (0.030)
Marital status (married = 1)	−0.032 (0.343)	0.248 (0.408)	0.233 (0.403)	−0.307 (0.218)	−0.309 (0.219)	−0.309 (0.219)
Excess industry employment	−7.860 (5.608)	−5.519 (6.481)	−5.667 (6.411)	−6.716 (3.631)	−6.889 (3.818)	−6.878 (3.772)
R^2:	0.249	0.065	0.083	0.691	0.690	0.690
Standard error of regression:	0.924	1.031	1.020	0.595	0.595	0.595
Instrumental variables:	—	D, $\tilde{\tau}$	D, $\tilde{\tau}$, union	—	D, $\tilde{\tau}$	D, $\tilde{\tau}$, union

Notes: The results are based on 96 observations. Age squared and experience squared were also included as regressors. Standard errors (in parentheses) are calculated using the bootstrap method. Wage, hours, and earnings variables are expressed as natural logarithms. The estimates are adjusted for self-selection using the Heckman two-step procedure. See Table 4 for a description of the instruments.

ference between the two estimates is large, a Wald-type test does not reject the null hypothesis that they are equal. The probability value of the test that the estimates of θ from columns (iii) and (vi) are equal is 0.76, while the probability value of the test that the elasticities $(-1/[1-\theta])$, are equal is 0.20.[31] The outcome of the test suggests that it is legitimate to estimate a unique θ by jointly fitting the underground-earnings and underground-hours equations.

[31]The tests for both θ and $-1/(1-\theta)$ are presented since the Wald test is well known not to be invariant to the formulation of the null hypothesis.

C. *Joint Estimates of the Hours and Earnings Equations*

The minimum-distance estimates of θ based on the joint estimation of equations (23), (24), and (25) are reported in Table 6. Column (i) presents the estimates from a model in which industry dummies, the union status, and the predicted tax rate are used to instrument the regular wage and the marginal tax rate. The point estimate of θ is equal to 0.655. The estimated value of θ slightly increases to 0.67 when the union status is included on the right-hand side of the underground earnings and hours equations, instead of being used as an instru-

TABLE 6—MINIMUM-DISTANCE JOINT ESTIMATES OF THE UNDERGROUND EARNINGS AND HOURS EQUATIONS

Estimate	(i)	(ii)
Curvature parameter (θ)	0.655	0.670
	(0.088)	(0.103)
Implied elasticities:		
Regular wage elasticity	−2.897	−3.029
	(0.737)	(0.948)
Tax-rate elasticity	−0.589	−0.560
	(0.298)	(0.319)
Excluded instruments:	$\tilde{\tau}$, D, U	$\tilde{\tau}$, D
Goodness-of-fit statistic:	36.02	35.95
(degrees of freedom)	(24)	(23)
[p value]	[0.0546]	[0.0417]

Notes: The industry dummies (D), as well as union status (U) in column (i), are excluded from the structural hours and earnings equations, and τ is excluded from the regular-sector wage equation. The common set of regressors in Table 5 is included in all structural equations.

ment. In both cases, the estimated value of θ is statistically different from either 0 or 1.

The minimum-distance estimates of θ are thus close to the estimates of θ obtained by fitting the earnings equation only (0.71–0.73 in Table 5). This is not surprising since the minimum-distance procedure puts more weight on the earnings equation (which is precisely estimated) than on the hours equation (which is not precisely estimated). Putting more weight on the earnings equation than on the hours equation increases the efficiency of the estimates. The goodness-of-fit statistics reported at the bottom of columns (i) and (ii) are essentially equal to their critical values at a 95-percent significance level, suggesting that the model fits the data reasonably well.

The minimum-distance estimates of θ imply that hours worked in the underground sector are quite responsive to changes in the regular-sector wage. The estimated elasticity is equal to −2.9 in column (i) and to −3.0 in column (ii). Given the magnitude of these estimates, it is surprising to find that the tax rate has a negative estimated effect on the number of hours worked in the underground sector (−0.589 and −0.560). The estimates presented in Table 6 imply that $P\lambda$ is equal to 1.10 in column (i) and to 1.11 in column (ii). Such large estimates of $P\lambda$ imply that both the perceived probability of detection (P) and the perceived penalty rate (λ) are quite large. It is also hard to reconcile this finding with the previous finding that the tax rate had a positive effect on the probability of participating in the underground sector. One possible explanation for this puzzle is that the probability of detection increases with the number of hours of work. Alternatively, the implicit costs of avoiding detection might increase as the number of hours worked in the underground sector increases. In either case, the elasticity ($-1/[1-\theta]$) overestimates the impact of taxes on labor supply in the underground sector. This elasticity is still appropriate, however, for underground-sector activities in which the probability of detection is equal to zero.

V. Implications for Tax Policy

The model of Section II suggests a simple measure for some welfare effects of the tax system: since taxes distort economic activities from the regular sector ($dh_0/d\tau < 0$) to the underground sector ($dh_1/d\tau > 0$), which is characterized by decreasing marginal returns, it creates an excess burden in production.

The goal of this paper is not to measure the elasticity of regular-sector hours with respect to the tax rate.[32] Instead, we consider a simple experiment in which total hours worked in the two sectors do not depend on the marginal tax rate. In response to a change in the tax rate, people therefore reallocate a given hour of work from the regular to the underground sector, so that $dh_0/d\tau = -dh_1/d\tau$. The excess burden (EB) caused by the misallocation of

[32] The estimation of the effect of taxes on labor supply in the regular sector entails a series of econometric problems that will not be addressed in this paper (see the special Summer 1990 issue of the *Journal of Human Resources* on taxation and labor supply).

hours between the two sectors is given by:

$$(26)\quad EB = W_0[h_1(\tau) - h_1(0)] - A_1\left[(h_1(\tau))^\theta - (h_1(0))^\theta\right]$$

where $h_1(\tau)$ and $h_1(0)$ are the hours worked in the underground sector with and without a tax rate τ respectively. The marginal excess burden, MEB, measures how much the excess burden has to increase in order to raise an additional dollar of taxes:

$$(27)\quad MEB = \partial EB/\partial T = (\partial EB/\partial\tau)(\partial\tau/\partial T) = \left[W_0 - \theta A_1 h_1^{\theta-1}\right] \times (dh_1/d\tau)(\partial\tau/\partial T)$$

where T represents total tax revenues ($T = \tau W_0 h_0$). The expression $\partial T/\partial\tau$ represents the slope of the Laffer curve. This slope depends on how hours of work respond to a change in the tax rate. By simple differentiation,

$$(28)\quad \partial T/\partial\tau = W_0 h_0 + \tau W_0 \partial h_0/\partial\tau = W_0 h_0 - \tau W_0 \partial h_1/\partial\tau.$$

Consider the case in which the probability of detection (P) is equal to zero, so that $P\lambda = 0$. In this case, the expression for $\partial h_1/\partial\tau$ in equation (17) can be simplified to

$$(29)\quad dh_1/d\tau = h_1/[(1-\tau)(1-\theta)].$$

Substituting equation (29) into equation (28) and noting that $W_0 = \theta Y_1/[(1-\tau)h_1]$ yields the following expression for $\partial T/\partial\tau$ in elasticity terms:

$$(30)\quad \eta = \partial\ln(T)/\partial\ln(\tau) = 1 - [Y_1/Y_0][\tau/(1-\tau)^2][\theta/(1-\theta)].$$

Since $\theta A_1 h_1^{\theta-1} = (1-\tau)W_0$, it is easy to show that

$$(31)\quad MEB = \tau W_0(dh_1/d\tau)(\partial\tau/\partial T) = (1-\eta)/\eta.$$

The estimates of η and MEB computed from equations (30) and (31) when $\theta = 0.67$ [estimate from column (ii) of Table 6] are reported in Table 7 for various subsamples of the population. Since both η and MEB depend on the ratio of underground to regular income Y_1/Y_0 and on the marginal tax rate τ, their respective values vary considerably across the different groups of the population.

The estimates of the elasticity of the Laffer curve (η) reported in Table 7 range from 0.407 for workers who received some welfare payments during the year to 0.994 for workers aged 40 and more. These two extreme values of η yield values of the marginal excess burden in production (MEB) of 1.457 and 0.006, respectively. The conclusion we draw from Table 7 is that, on average, an increase in the tax rate does not substantially distort labor-market activities from the regular sector to the underground sector. On the other hand, the same increase in the tax rate, or in the tax-back rate embodied in social-welfare programs, has a very substantial effect on the allocation of time of social-welfare claimants. These con-

TABLE 7—MARGINAL EXCESS BURDEN IN PRODUCTION AND LAFFER CURVE (FOR INDIVIDUALS WORKING IN BOTH MARKETS)

Sample	Sample size	MEB	η
Whole sample	1,390	0.016	0.984
Positive hours in underground-sector	96	0.603	0.624
Welfare claimant	32	1.457	0.407
Regular income smaller than $10,000	380	0.107	0.903
Age 18–24	219	0.066	0.938
Age 25–39	676	0.016	0.984
Age 40+	495	0.006	0.994
Men	800	0.020	0.980
Women	590	0.011	0.989

Notes: The results above are based on the estimates of θ in Table 7. MEB is the marginal excess burden in production associated with raising an additional dollar of taxes: $MEB = \partial EB/\partial T$; η represents the elasticity of the Laffer curve, or $\partial\ln(T)/\partial\ln(\tau)$.

clusions only hold, however, when the probability of detection by the authorities and the penalty rate are negligible ($P\lambda = 0$). Although this might be true for some underground-sector activities, the results of Section IV suggest that this is not true in general. Government enforcement policies might thus be offsetting some of the distortions due to the presence of the tax and transfer system.

VI. Conclusion

This paper looks at the determinants of labor-supply decisions in the underground economy using a data set collected in Quebec City, Canada. We find that labor-market activities in the underground economy are concentrated among people at the low end of the income distribution. More precisely, hours worked in the underground sector depend negatively on the wage rate in either the regular or the underground sector. We attribute this finding to the fact that labor earnings in the underground sector are a concave function of hours of work. The paper also establishes that these findings are robust to the potential sources of biases attributable to the nature of survey data on the underground economy.

We estimate a structural model of labor supply in the underground economy using OLS, 2SLS, and minimum-distance methods. The results suggest a large negative elasticity of underground-sector hours with respect to the wage rate in the regular sector. For an average worker, who is unlikely to work in the underground sector, the tax and transfer system does not significantly distort the allocation of hours of work from the regular to the underground sector. These distortions might nevertheless be quite important for some specific groups in the population such as social-welfare claimants.

Appendix A

Consider a convex earnings function in the regular sector, $Y_0 = A_0 h_0^{\alpha}$, where $\alpha > 1$. Since marginal earnings in the regular sector are equal to $\alpha A_0 h_0^{\alpha-1}$ instead of W_0, the first-order condition [equation (2)] becomes:

$$\text{(A1)} \quad \gamma \alpha A_0 h_0^{\alpha-1} = \gamma \theta A_1 h_1^{\theta-1} = v'(T - h_0 - h_1).$$

Workers with identical earnings functions $Y_0 = A_0 h_0^{\alpha}$ and $Y_1 = A_1 h_1^{\theta}$ but different preference parameters γ will choose different hours of work in the two sectors. Simple comparative statics with respect to γ yield

$$\text{(A2)} \quad dh_0 / d\gamma = v'\theta(\theta - 1) A_1 h_1^{\theta-2} / \Delta > 0$$

$$\text{(A3)} \quad dh_1 / d\gamma = v'\alpha(\alpha - 1) A_0 h_0^{\alpha-2} / \Delta < 0$$

where $\Delta < 0$ from the second-order conditions for an interior solution. Workers with a low shadow value of leisure (high γ) thus work more hours in the regular sector but fewer hours in the underground sector than workers with a high shadow value of leisure (low γ). In addition, the average wage rates $W_0 = Y_0 / h_0$ and $W_1 = Y_1 / h_1$ are both increasing in γ. This simple model thus fits the facts mentioned in Section I quite well. It also provides a rationale for the assumption maintained in Section II that the regular wage rate varies across workers who face the same earnings function in the underground sector.

Appendix B

In the text, it was assumed that the individual was working in both sectors at the optimum. Under the assumption that individuals work in the regular sector and that, following John Cogan (1980), they must entail a fixed cost of C dollars to participate in the underground sector, the condition that determines whether hours worked in the underground sector are positive or not is

$$\text{(B1)} \quad h_1^* \lesseqgtr h_1^{\mathrm{C}}$$

where h_1^* denotes the desired hours of work in the underground sector and h_1^{C} denotes the reservation hours in the underground sector; h_1^{C} is the solution to the following equation:

$$\text{(B2)} \qquad f(h_1^{\mathrm{C}}) - C = f'(h_1^{\mathrm{C}})h_1^{\mathrm{C}}$$

where $f(\cdot)$ is the underground earnings function. Equation (B2) means that, at the reservation hours h_1^{C}, the net expected earnings $[f(h_1^{\mathrm{C}}) - C](1 - P\lambda\tau)$ in the underground sector are just equal to what an individual working $h_0 = h_1^{\mathrm{C}}$ at the net critical wage given by

$$W_0^{\mathrm{C}}(1-\tau) = f'(h_1^{\mathrm{C}})(1 - P\lambda\tau)$$

would earn in the regular sector.

To estimate the model with fixed costs, note that the reservation-hours equation (B2) takes the following form when the earnings function $f(\cdot)$ is Cobb-Douglas:

$$\text{(B3)} \quad (1-\theta)\exp[\theta \ln(h_{1i}^{\mathrm{C}}) + \beta_0 + \mathbf{x}'_{1i}\boldsymbol{\beta}_1 + \varepsilon_{1i}].$$

Assume that the fixed cost of working in the underground sector (in logs) is a linear function of a vector of explanatory variables $\mathbf{x}_{\mathrm{C}i}$ and of an error term $\varepsilon_{\mathrm{C}i}$:

$$\text{(B4)} \qquad C_1 = \exp(\delta_0 + \mathbf{x}'_{\mathrm{C}i}\boldsymbol{\delta}_1 + \varepsilon_{\mathrm{C}i}).$$

Substituting equation (B4) into equation (B3) and taking logs yields the following reservation-hours equation:

$$\text{(B5)} \quad \ln(h_1^{\mathrm{C}}) = \frac{\delta_0 - \beta_0}{\theta} - \frac{\ln(1-\theta)}{\theta} + \frac{\mathbf{x}'_{\mathrm{C}i}\boldsymbol{\delta}_1}{\theta} - \frac{\mathbf{x}'_{1i}\boldsymbol{\beta}_1}{\theta} + \frac{\varepsilon_{\mathrm{C}i} - \varepsilon_{1i}}{\theta}.$$

The stochastic specification for the decision to participate in the underground sector is then obtained by taking the difference between equation (20) in the paper and equation (B5). This participation condition provides some overidentifying restrictions to the overall model whenever some of the variables in the vector $\mathbf{x}_{\mathrm{C}i}$ are different from the variables in the vector $\mathbf{x}_{1i}$.

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