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Working Paper

Income instability and fiscal progression

Working Papers, No. 2016-07

Provided in Cooperation with:

Bank of Mexico, Mexico City

Suggested Citation: Garcia-Medina, B. Cecilia; Wen, Jean-Francois (2016) : Income instability and fiscal progression, Working Papers, No. 2016-07, Banco de México, Ciudad de México

This Version is available at:

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Banco de México
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Banco de México
Working Papers

N° 2016-07

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June 2016

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Income Instability and Fiscal Progression*

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Abstract: We construct the ratio of the post-fisc to the pre-fisc transitory component of the variance of family incomes in Canada from 1993 and 2008. The ratio measures how much the tax and transfer system attenuates market income instability. It is shown that the ratio of variances is equivalent theoretically to the concept of residual income progression. The fiscal system became less stabilizing beginning in the late 1990s, especially for families headed by main earners with less than high school education. The trend is attributable to personal income tax reforms and reductions in transfers for lower income families.

Keywords: Income Instability, Progressive Taxation, Employment Insurance

JEL Classification: H22, H53, J38

Resumen: Construimos la razón de "después de impuestos y transferencias" con respecto a "antes de impuestos y transferencias" del componente transitorio de la varianza del ingreso de las familias en Canadá de 1993 a 2008. La razón indica en qué medida el sistema de impuestos y transferencias atenúa la inestabilidad del ingreso antes de impuestos y transferencias. Se muestra que la razón de varianzas es equivalente teóricamente al concepto de progresividad residual del ingreso. El sistema fiscal se volvió menos estabilizador a partir de finales de los 1990s, especialmente para las familias encabezadas por perceptores de ingreso con educación menor al bachillerato. La tendencia es atribuible a las reformas al impuesto sobre el ingreso personal y a reducciones en transferencias para las familias de menores ingresos.

Palabras Clave: Inestabilidad del Ingreso, Progresividad Fiscal, Seguro de Desempleo

*The analysis was conducted at the Prairie Regional Research Data Centre which is part of the Canadian Research Data Centre Network (CRDCN). The services and activities provided by the CRDCN are made possible by the financial or in-kind support of the SSHRC, the CIHR, the CFI, Statistics Canada and participating universities whose support is gratefully acknowledged. The views expressed in this paper do not necessarily represent the CRDCN's or that of its partners and are solely those of the authors. We thank our colleagues at the University of Calgary and the Banco de Mexico for useful comments, and are grateful to the School of Public Policy for funding.

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1 Introduction

A progressive system of taxes and transfers can improve social welfare not only by reducing long-term income inequality but also by stabilizing the incomes of families against fluctuations due to business cycles or other transitory events.¹ In particular, a schedule of increasing marginal tax rates restricts both income gains and income losses (Kniesner and Ziliak, 2002), while social insurance programs provide benefits to unemployed individuals. Previous empirical work suggests that temporary income instability accounts for about one-quarter of the total variance of a population of workers' pre-tax earnings (Beach *et al.*, 2010).

In Canada, the federal and provincial income tax reforms during the past two decades have reduced tax progressivity, while the Employment Insurance (EI) and Social Assistance (SA) programs became less generous and harder to obtain (Frenette *et al.*, 2009). These observations suggest that the tax and transfer system in Canada may have become relatively less effective for income smoothing.² To the extent that families are credit constrained or lack private means of smoothing incomes, the reduced protection of families against income shocks is an important policy issue.³

In this paper, we examine the changes between 1993 and 2008 in Canada in the ratio of the post-fisc transitory income variance to the pre-fisc transitory income variance, where pre-fisc refers to income before tax payments and transfer benefits, and post-fisc refers to income after taxes and transfers. By construction, the ratio of variances controls for the direct effect of variation in market incomes and can therefore be interpreted as measuring the extent to which the fiscal system attenuates market income instability. A lower ratio implies that the tax and transfer system dampens market volatility relatively more effectively. For this reason, we shall refer to the ratio of transitory variances interchangeably as the *stabilization*

¹See Bibi *et al.* (2014) for a method of decomposing social welfare into a component of inequality in permanent incomes and a component of periodic variability around permanent incomes.

²See OECD (2012) for a review of statutory tax changes in OECD countries between 1981 and 2010. The general trend is toward reductions in the top personal income tax rate and increases in the bottom rate.

³If credit market failures impede consumption smoothing, then social insurance is welfare improving under any standard welfare function. However, our purpose in this paper is to describe the patterns in the data, rather than taking a normative stand on the observed changes in tax and transfer policies. Indeed, tax reforms that cut marginal tax rates may offer less protection against income instability, but they would also increase a family's disposable income and potentially improve economic efficiency.

ratio. The unit of analysis is family income (adjusted for equivalent scales), as certain tax credits are based on family incomes and on the number of dependent children.⁴ To obtain the annual time series of pre- and post-fisc instability variances, we first use the method of multi-year rolling windows introduced by Beach *et al.* (2010), in an otherwise standard non-parametric decomposition of the total income variance of longitudinal data into ‘permanent’ and ‘transitory’ components. As a robustness check, we also analyze the ratio of post-fisc to pre-fisc transitory variances based on cross-sections of the annual growth of family incomes, following the approach of Shin and Solon (2011). In these ways, we are able to identify gradual changes over time in how well the tax and transfer system protects families against income fluctuations, due to legislated changes in fiscal policy or to the interaction between policy and business cycles.

A simple model is used to show a theoretical equivalence between the ratio of variances described above and the concept of residual income progression. ‘Residual progression’ (RP) measures the elasticity of income after taxes and transfers with respect to income before taxes and transfers, and hence it captures overall fiscal progression in a parsimonious manner (Jakobsson, 1976). The elasticity is a simple function of marginal and average effective tax rates (i.e., inclusive of transfers and clawbacks on program benefits). Hence, we can use the RP measure to help explain changes over time in the stabilization ratio by considering how policies impacted marginal or average effective tax rates.

Our approach provides a novel way to examine the evolution of income instability. It is complementary to the method of Frenette *et al.* (2009) who use regressions to estimate the taxes paid and the transfers received by families in different years, according to their socio-economic characteristics, and then use these estimates in counterfactual simulations of post-fisc income distributions, in order to isolate the impacts of each policy change on progressivity. They measure changes in progressivity based on the log of the ratio of income at the 95th percentile to income at the 5th percentile of the post-fisc income distribution and

⁴The instability of family earnings is generally lower than the instability of individual earners, as each spouse provides implicit insurance to the other against idiosyncratic shocks. See Morissette and Ostrovsky (2005) for empirical evidence of this.

they address income inequality rather than instability.⁵ An advantage of our approach over counterfactual simulations is that the behavioral responses of households to policy changes are accounted for in our analysis, since we estimate the transitory variances from the actually observed incomes. The only previous study of the year-by-year evolution of post-fisc income instability that we are aware of is by DeBacker *et al.* (2013). They provide graphical depictions of both the pre-tax transitory income variance and the after-(federal)-tax transitory income variance from 1987 to 2009 in the United States, generated by the estimated autocovariance functions from income regressions. We take a more comprehensive approach to studying the effects of policy by factoring in all of the major social insurance programs, federal and provincial personal income taxes, and all sources of market income.

Our study uses the longitudinal panel data in the Survey of Labour and Income Dynamics (SLID). All previous works on earnings variability in Canada use administrative data.⁶ An advantage of the SLID over the Longitudinal Administrative Database (LAD) is the availability of information on educational attainment.⁷ Education (of the main earner) is used to study subgroups of the population of families. These are interesting because the groups have varying exposures to labour market volatility. We calculate the annual value of RP for each subgroup of the population using the Canadian Tax and Credit Simulator (CTaCS) developed by Milligan (2007).

The main findings are as follows. The measure of fiscal protection against income instability –i.e. the ratio of post-fisc to pre-fisc transitory income variances– was about 67 percent on average over the period 1993-2007.⁸ Hence, the tax and transfer system absorbs about one-third of the volatility of market incomes in Canada. The fiscal system contributes more to stabilizing the incomes of families with less educated main earners: the ratio of variances

⁵Frenette *et al.* (2009) examine the years 1980, 1985, 1990, 1995, and 2000. Hence, there is a partial overlap of periods with our study.

⁶Baker and Solon (2003) use various tax files from the Canada Customs and Revenue Agency. Morissette and Ostrovsky (2005), Ostrovsky (2008), and Beach, *et al.* (2010) all use the Longitudinal Administrative Database.

⁷A drawback of the SLID, however, is that it spans significantly fewer years than the LAD.

⁸The final rolling window that we use for the variance decompositions is 2004-07, while the data for the year 2008 is included in our calculation of the annual transitory variances using the Shin-Solon method. The value of the stabilization ratio using the latter method is smaller in every year than in the case of the variance decompositions.

for the university educated group is about 1.68 times higher than for the less than high school group. The ratio increased (‘worsened’) substantially during the decade following the spate of federal and provincial personal income tax reforms in the late 1990s and early 2000s.⁹ While the upward shift is apparent for the college and university educated groups, the overall pattern most closely mimics the one for the category of families where the main earner has less than high school education. This group exhibits the greatest variance in transitory incomes and it comprises 19 percent of our sample of families. Panel data regressions are used to demonstrate that the ratio of transitory variances is well explained by the measure of residual income progression.

By construction, RP falls with the marginal tax rate and rises with the average tax rate. This observation enables us to use RP as a tool to consider how changes in marginal and average effective tax rates have contributed to changes in fiscal protection against income instability over time. Comparing the mid-1990s with the post-tax reform period, marginal effective tax rates declined for all groups. Average effective tax rates also show a pronounced decline for the group with university education, but almost no change for families with less than high school education. The minimal change in the average effective tax rate for taxpayers with less than high school education, following the period of tax cuts, appears attributable to reductions in transfers, particularly in the generosity of Social Assistance. As the size of government transfers falls, a recipient’s average effective tax rate rises, other things being held constant, since the numerator in the definition is given by taxes minus transfers. This may explain why the erosion of protection against income instability following the period of tax reforms around year 2000 is relatively largest for the less than high school educated families. Finally, the ratio of post-fisc to pre-fisc transitory income variances is negatively

⁹All of the provinces, except Newfoundland, had lower personal income tax rates in 1999 compared to 1996, with rate cuts in 1997, 1998, or 1999. In most provinces the rate change was between one and four percent of the basic federal tax. In Ontario, however, between 1996 and 1999, the provincial personal income tax rate declined from 58 percent to 38.5 percent of the basic federal tax, including a five percentage point across-the-board rate cut in 1998. British Columbia dropped its top income surtax from 26 to 19 percent in 1998. The 3 percent federal surtax was eliminated for taxpayers with incomes up to about \$50,000 and reduced for those with incomes between \$50,000 and \$65,000 in 1998 and then eliminated for all taxpayers in 1999. The federal marginal tax rate was lowered for the income range \$30,004-\$60,009 in 2000, then cut across the board in 2001, except on incomes above \$100,000. The inclusion rate for capital gains taxation was reduced from 75 percent to 50 percent in 2000. Alberta changed from a system of progressive marginal tax rates to a single rate in 2001.

correlated with the national unemployment rate, presumably reflecting the stabilizing effect of Employment Insurance and other counter-cyclical cash transfers.

Our study complements previous studies on income inequality and income instability in several ways. The first is formulating an explicit theoretical relationship between residual income progression and the stabilization ratio, and providing empirical evidence for it. Secondly, our study provides new insights on the transitory variance by levels of educational attainment, using the SLID, which is not possible with administrative data. The results by education add an important dimension to both the characterizations of earnings dynamics and fiscal progressivity, which enhances their policy relevance.

The remainder of the paper proceeds as follows. Section 2 reviews the most relevant literature. Section 3 provides the theoretical model linking the stabilization ratio to the RP measure of progressivity. Section 4 describes the SLID data, the decomposition of the total income variance, as well as the calculation of RP. Section 5 provides a graphical presentation of the results for the ratio of variances and the RP measure, using two alternative approaches for constructing the variance of transitory income, i.e., the methods of Beach *et al.* (2010) and Shin and Solon (2011). The section also contains regression results relating the ratio of variances to RP and the unemployment rate. Section 6 gives our conclusions. Details of the variance decomposition method are provided in an Appendix.

2 Related Literature

A burgeoning literature has emerged from the work of Gottschalk and Moffit (1994), who decomposed the total longitudinal earnings variance in the United States into transitory and permanent components using an algebraic, non-parametric, principal components technique. Moffit and Gottschalk (2011) and Haider (2001) used, instead, parametric approaches to estimating the transitory and permanent variance components. These studies, all based on PSID data, generally found that earnings instability accounts for a substantial part of the increase in cross-sectional inequality in the United States during the 1970s and 1980s.¹⁰

¹⁰Related studies include Shin and Solon (2011), Moffit and Gottschalk (2008), and Heathcote, *et al.* (2010).

The study by DeBacker *et al.* (2013) departs from the use of PSID data by employing a confidential panel of tax returns from the Internal Revenue Service (IRS) to study individual male earnings and total household income, both before and after taxes. Their measure of after-tax income reflects all federal personal income taxes, including all refundable tax credits, as well as payroll taxes. The authors find that the total variance after-tax was about 15 percent below the total variance before-tax throughout the period 1987-2009, and hence that the progressivity of the U.S. federal tax system was insufficient to offset the trend of rising before-tax income inequality. They also find that the rising inequality is attributable to increases in the permanent component, as the transitory component was stable.

Using Canadian data, Baker and Solon (2003) and Ostrovsky (2008) attribute the rise in pre-fisc total earnings variance for men to increases in both the permanent and transitory components. Those studies are based on a dynamic modelling approach to the variance decomposition. In contrast, Beach *et al.* (2010) apply the non-parametric approach of Gottschalk and Moffit (1994) to decompose the variance of earnings in five-year rolling windows to define permanent versus transitory variations in earnings. Unlike the previous Canadian studies, Beach *et al.* find that the rise of earnings inequality has been due to increases in the permanent component of variation. Morissette and Ostrovsky (2005) is the only variance decomposition study for Canada to consider the impact of taxes and transfers. They examine the changes in earnings instability before- and after-taxes between two periods: 1986-1991 and 1996-2001. They find that income taxes and government transfers reduce substantially the instability of post-fisc earnings, with transfers playing the major role.

Frenette, *et al.* (2009) infer from their analysis of counterfactual policy simulations that, in the 1990s, the Canadian tax and transfer system became less progressive than in the previous decade. They point in particular to the reductions in progressivity in the interval 1995 to 2000 due to the decreases in federal and provincial surtaxes on high-income and large cuts to Social Assistance payments, as well as shortened benefit periods for Employment Insurance.

3 Variance and Residual Income Progression

This section provides a simple model linking residual income progression to the ratio of post-fisc to pre-fisc income variances. Let y_t^i be person i 's pre-fisc income at time t and suppose that

$$\ln y_t^i = \ln w^i + \ln z_t \quad (1)$$

where w^i represents a permanent person-specific indicator of skill and z_t is a transitory shock. Differences in w^i across people generates permanent income inequality while the z_t can represents income fluctuations arising from business cycles, or idiosyncratic factors, such as losses from ill health. Assume that $\ln w^i$ and $\ln z_t$ are independent and normally distributed:

$$\begin{aligned} \ln w^i &\sim N(\mu_w, \sigma_w^2) \\ \ln z_t &\sim N(\mu_z, \sigma_z^2). \end{aligned}$$

These assumptions imply that the distribution of the log of income across the population at time t is given by

$$\ln y_t \sim N(\mu, \sigma^2)$$

where $\mu \equiv \mu_w + \mu_z$ and $\sigma^2 \equiv \sigma_w^2 + \sigma_z^2$.

Suppose the tax/transfer system converts an amount of pre-fisc income y_t^i into an amount of post-fisc income x_t^i according to the function

$$x_t = y_t^{1-\tau_t} \hat{y}_t^{\tau_t} \quad (2)$$

where τ_t is an index of marginal tax rate progressivity and \hat{y}_t is the break-even income level implied by the tax and transfer system. Note that if $\tau_t = 0$ then no redistribution occurs since $x_t^i = y_t^i$, while if $\tau_t = 1$ then there is full redistribution as everyone obtains an identical post-fisc amount equal to \hat{y}_t . The exponent $1 - \tau_t$ measures the elasticity of post-fisc income with respect to pre-fisc income, which is commonly called residual income progression (RP). The smaller is RP the more progressive is the tax/transfer system. Specifically, Jakobsson

(1976) shows that if the system can be characterized by a constant value of RP across all income levels, then RP accords with Lorenz dominance for ranking income distributions. RP can also vary across income levels, i.e., RP equal to $(1 - \tau_t(y_t))$.¹¹ In our empirical work we take into account the non-constancy of RP by studying subgroups of the population classified by educational attainment of the main earner in the family, since more years of schooling is known to be a strong predictor of income.

The tax/transfer function (2) implies that

$$\ln x_t \sim N(\tau_t \ln \hat{y}_t + (1 - \tau_t)\mu, (1 - \tau_t)^2 \sigma^2)$$

and hence the ratio of the post-fisc income variance to the pre-fisc income variance (with incomes in logarithmic form) is given by

$$R_t \equiv \frac{V(\ln x_t)}{V(\ln y_t)} = \frac{(1 - \tau_t)^2 (\sigma_w^2 + \sigma_z^2)}{\sigma_w^2 + \sigma_z^2} = (1 - \tau_t)^2. \quad (3)$$

In theory, the ratio of variances (R) equals the residual income progression of the tax/transfer system in a given year. Note also that R can refer to the ratio of total variances or to the ratio of each variance component separately. That is, the long-term component of the ratio of variances is

$$R_{wt} \equiv \frac{(1 - \tau_t)^2 (\sigma_w^2)}{\sigma_w^2} = (1 - \tau_t)^2$$

and similarly the short-term component of the ratio of variances is

$$R_{zt} \equiv \frac{(1 - \tau_t)^2 (\sigma_z^2)}{\sigma_z^2} = (1 - \tau_t)^2.$$

This suggests that the time series variation of R_{zt} (also R_{wt} and R_t) is explainable by changes in $(1 - \tau_t)^2$. Notice that the tax function implicit in (2) is $T(y_t) \equiv y_t - x_t$, from which it follows that $1 - dT/dy_j^i = (1 - \tau)(\hat{y}/y_j^i)^\tau$ and $1 - T/y_j^i = (\hat{y}/y_j^i)^\tau$, where dT/dy_t^i is the marginal tax rate and T/y_t^i is the average tax rate faced by an agent with income y_t^i .

¹¹ See Ebert (1992) for an analysis of local values of RP and their relation to global indexes of progression.

Therefore, empirical values of RP (and RP-squared) can be obtained from the calculation

$$RP \equiv 1 - \tau = \frac{(1 - \text{Marginal tax rate})}{(1 - \text{Average tax rate})}. \quad (4)$$

We explain in more detail in Section 4 how we calculated RP for each subgroup of families using the SLID and CTaCS.

While the equality between the stabilization ratio R_{zt} and RP-squared illustrates nicely a theoretical connection between fiscal policy and income instability, it must be stressed that the model abstracts from some important considerations that would likely make RP-squared deviate from the estimated ratio of variances. In particular, the above tax function $T(y)$ assumes that taxes and transfers depend only on the total market income of a taxpayer. In reality, different sources of income are taxed at different rates (e.g., dividends versus capital gains versus earnings).¹² Perhaps more importantly, social transfers are contingent on events, such as unemployment or having children, and hence two households with the same market income may be treated differently by the tax/transfer system. Consequently, the measure of RP applicable to income instability may not be the same measure that applies to income inequality. Furthermore, an average value of RP-squared across families, even within an educational attainment category, may pose problems of aggregation due to the contingent nature of cash transfers and to the dispersion of incomes within a subgroup.

4 Data and Empirical Methods

4.1 SLID

We use confidential files of the Survey of Labour and Income Dynamics (SLID) collected annually by Statistics Canada. The survey has a structure of six-year overlapping panels, and interviews 15,000 households from 10 Canadian provinces excluding Indian reserves. Each household is interviewed for six consecutive years. Every three years a new sample of households is surveyed, making two panels overlap for three years. The panels of the SLID

¹²Since labour earnings are the main source of income for most families, we shall assume the marginal tax rate is based on an increase in earnings.

commenced in 1993, 1996, 1999, 2002, 2005, and 2008. The data include detailed information from the respondent's personal tax and transfers files and a rich set of individual and family socio-economic characteristics.¹³ Our sample consists of 478,968 main income earners aged 20 to 64 years who reported earnings over \$1,000 (in constant 2010 dollars) for at least two consecutive years, with self-employment income not greater than employment earnings, and income reported for at least four years. In constructing the variance decomposition, we use a balanced sample by restricting the sample to families with consecutive years of data equal to the number of years in the rolling window and we apply the longitudinal weights to deal with attrition in the SLID. Information on the main earner's spouse and the number and age of dependent children is also present. Main earners who are full-time students are excluded as their limited labour force participation would increase the measurement error of the estimates. We construct four education groups defined by degree completion: Less than High School (19% of main earners), completed High School (27%), non-university College (32%), and University including post-graduate studies (16%). A further 6 percent of the sample do not report the education of the main earner; these families are included in the variance decomposition for all families, but are excluded in the education-specific variance decompositions.¹⁴

4.2 Definitions of Pre-Fisc and Post-Fisc Family Incomes

The definition of pre-fisc income, i.e. before taxes and transfers, consists of labour earnings, dividends, capital gains, rental incomes, alimony, etc. The amounts are expressed in constant dollars of 2010 by deflating with the Consumer Price Index. The unit of study is the family, hence the sum all of the family members' incomes is scaled using the family equivalent scale.¹⁵

¹³Over 80% of respondents grant consent to Statistics Canada for the extraction of their information from the T1 tax and income administrative files, the rest report tax information directly through the questionnaire.

¹⁴The correlation between number of years of schooling and market income is 25 percent on average over 1993-2007. This indicates that educational categories are a reasonably good proxy for broad income groups. At the same time, it would be inappropriate for our purposes to define groups by income ranges directly, because this would artificially restrict the variance of incomes. Furthermore, since family incomes change over time, classifying families by education is less problematical than a classification based on income level.

¹⁵To account for economies of scale within a family (an additional family member increases expenses but at a lower rate), family income is scaled assigning weights of 1 to the oldest member of the family, 0.4 to other

Table 1. Summary Descriptives of Canadian Families by Main Earner's Education Attainment: 1993-2008 (thousands of 2010 dollars).

Year	(1) All	(2) Less than HS	(3) High School	(4) College	(5) University	(6) All	(7) Less than HS	(8) High School	(9) College	(10) University
Pre-fisc income					Post-fisc income					
1993	36.42	23.60	32.63	37.43	56.24	32.57	25.66	30.03	32.95	44.29
1994	37.22	22.92	33.31	38.37	57.96	32.96	24.68	30.30	33.51	45.56
1995	37.31	23.33	33.71	37.82	57.34	32.74	25.11	30.16	33.12	44.41
1996	37.75	23.49	34.91	37.99	57.62	33.13	24.83	31.35	33.18	45.14
1997	38.52	23.95	35.03	39.35	58.88	33.52	25.14	31.24	34.08	45.58
1998	40.65	24.52	37.19	40.43	62.74	35.07	25.50	32.85	34.82	48.58
1999	41.01	25.59	37.31	40.65	63.54	35.38	26.22	33.01	35.07	49.27
2000	42.77	26.57	38.39	42.23	66.97	36.67	27.02	33.84	36.32	51.81
2001	44.38	27.35	38.98	42.75	70.20	38.89	28.45	35.19	37.69	55.45
2002	43.74	27.86	39.86	42.54	64.76	38.59	28.69	35.74	37.70	52.36
2003	44.07	27.93	39.84	42.40	65.25	38.70	28.56	35.80	37.40	52.57
2004	45.00	28.48	40.27	42.91	65.98	39.47	29.16	36.00	38.02	53.26
2005	45.42	27.43	39.77	44.44	65.59	39.89	28.42	35.89	39.24	53.05
2006	46.91	28.01	39.71	45.44	67.59	41.21	29.01	36.14	40.31	54.86
2007	48.67	29.07	40.61	46.81	70.41	42.92	30.22	37.38	41.74	57.34
2008	48.26	27.78	40.57	46.48	69.17	42.78	29.64	37.56	41.62	56.65
EI benefits					SA benefits					
1993	1.38	1.79	1.33	1.37	0.96	1.08	2.36	1.14	0.61	0.19
1994	1.22	1.55	1.05	1.25	0.99	0.99	2.21	1.10	0.51	0.15
1995	1.02	1.31	0.86	1.05	0.88	1.03	2.26	1.05	0.66	0.22
1996	0.98	1.20	0.88	1.08	0.74	1.05	2.26	1.14	0.63	0.21
1997	0.89	1.13	0.87	0.90	0.68	0.95	2.13	0.91	0.56	0.20
1998	0.87	1.10	0.87	0.88	0.66	0.88	2.00	0.93	0.47	0.19
1999	0.72	0.92	0.71	0.78	0.49	0.74	1.86	0.73	0.42	0.12
2000	0.69	0.82	0.64	0.80	0.46	0.65	1.77	0.62	0.33	0.11
2001	0.78	1.02	0.75	0.78	0.54	0.64	1.62	0.62	0.35	0.13
2002	0.92	1.07	0.84	0.97	0.78	0.58	1.30	0.67	0.36	0.09
2003	0.84	1.00	0.81	0.85	0.72	0.55	1.26	0.67	0.33	0.10
2004	0.85	0.98	0.81	0.87	0.83	0.53	1.33	0.62	0.33	0.09
2005	0.77	0.98	0.80	0.78	0.62	0.56	1.45	0.62	0.34	0.12
2006	0.78	0.93	0.79	0.84	0.61	0.52	1.39	0.61	0.34	0.10
2007	0.83	1.04	0.80	0.87	0.71	0.51	1.40	0.63	0.35	0.11
2008	0.84	1.03	0.81	0.90	0.70	0.57	1.79	0.62	0.35	0.16
Income tax					Gov transfers					
1993	8.12	4.89	6.90	8.04	14.04	4.27	6.94	4.30	3.55	2.10
1994	8.25	4.68	7.07	8.17	14.39	3.99	6.44	4.07	3.32	2.00
1995	8.48	4.77	7.26	8.17	14.94	3.91	6.55	3.71	3.47	2.01
1996	8.45	4.87	7.38	8.16	14.49	3.83	6.21	3.82	3.36	2.00
1997	8.63	4.84	7.34	8.35	15.30	3.62	6.03	3.55	3.08	1.99
1998	9.16	5.00	8.00	8.65	16.06	3.58	5.98	3.65	3.05	1.90
1999	8.95	5.02	7.66	8.48	15.94	3.32	5.65	3.36	2.90	1.67
2000	9.29	5.02	7.69	8.73	16.89	3.20	5.47	3.13	2.82	1.73
2001	8.94	4.75	7.22	8.04	16.75	3.45	5.84	3.43	2.98	2.00
2002	8.60	4.76	7.70	7.86	14.49	3.46	5.59	3.57	3.03	2.08
2003	8.69	4.74	7.64	7.86	14.67	3.33	5.37	3.60	2.86	1.99
2004	8.89	4.85	7.81	7.82	14.83	3.36	5.54	3.53	2.93	2.11
2005	8.87	4.52	7.34	8.21	14.64	3.34	5.51	3.46	3.00	2.11
2006	9.12	4.51	7.11	8.41	14.92	3.42	5.51	3.55	3.28	2.19
2007	9.27	4.59	6.92	8.41	15.41	3.52	5.73	3.70	3.33	2.34
2008	9.11	4.48	6.88	8.25	14.93	3.63	6.34	3.87	3.38	2.41

Notes: All income definitions are annual averages of family aggregates, scaled by family size and composition and expressed in thousands of real (2010) Canadian dollars. Family equivalent scale is used to scale family amounts. Pre-fisc income is the before personal income tax and government transfers, also known as market income. Post-fisc income is income after tax and transfers. Employment Insurance and Social Assistance refer to benefits received by all family members. Income tax is the tax paid by all family members. Source: Author's calculations using the SLID 1993-2008.

We use family income because some government transfers and tax credits are granted based on family characteristics. Income is scaled by family size and composition to standardize the unit of analysis. Post-fisc income is income after federal and provincial income adults older than 16 years, and 0.3 to each person younger than 16.

taxes and transfers.¹⁶ The transfer programs included in the SLID definitions include Employment Insurance (EI), Social Assistance (SA), Workers' Compensation, Canada Pension Plan (CPP), Child Tax Benefit (CTB), etc.¹⁷

Table 1 provides summary statistics for our sample of families; the income variables are expressed in terms of equivalent family scale. The average family over the 1993-2008 period had \$42,381 of pre-fisc income and \$37,156 of post-fisc income (in 2010 dollars). The average EI benefit for families was \$899 and the average SA benefit was \$739. The average family paid \$8,801 in income tax. There are, however, important differences when the population is grouped by the main earner's education.

On average, a family with a main earner with less than high school education obtained 41 percent of the amount earned by a family with a main earner having university education. The percentage increases to 54 percent when comparing post-fisc incomes. As for program benefits, families with heads with less than high school received 57 percent more in EI benefits than families with heads with university. The latter group received on average only 8 percent of the SA benefits received by the former group. Income tax paid by families with less than high school was 31 percent the amount paid by families with university educated heads. As expected, EI benefits are counter-cyclical, while SA benefits show a clear decline since the program reforms in the mid-1990s.

4.3 Variance Decomposition

We follow the methodology of Beach *et al.* (2010). We first eliminate life-cycle effects from the income profile of each family in the data. This is done because we are not interested in the variation in income due solely to the predictable influence of age (of the main earner). Hence, we regress the log of pre-fisc family income on a quartic polynomial in age using the full panel of data and we define the adjusted log of income by $ya_{it} = \ln y_{it} - \widehat{\ln y_{it}}$, where $\widehat{\ln y_{it}}$ denotes the fitted values of the quartic function.

¹⁶The variables we refer to as pre-fisc and post-fisc family income, adjusted for scale, are SLID variables given by the names `admindc27` and `adainc27`, respectively.

¹⁷As we have restricted our sample to exclude main earners aged 65 or older from the sample, and OAS and GIS is available only at age 65, these program benefits affect the families in the sample only if the non-main earner of a family is a benefit recipient.

The variance of the adjusted log of income ya_{it} is then decomposed into long-term and short-term components using an algebraic, non-parametric, principle components technique introduced by Gottschalk and Moffit (1994). This yields

$$var_{total} = var_{permanent} + var_{transitory}$$

which corresponds to $\sigma^2 = \sigma_w^2 + \sigma_z^2$ using the notation of Section 3, where σ_w^2 is associated with persistent income inequality and σ_z^2 is associated with transitory income instability. The formulas for the variance decomposition are described in the Appendix. The variance decomposition technique is applied to rolling windows of years as in Beach *et al.* (2010). There is a necessary tradeoff between the length of the window and the number of annual variances that can be calculated. Our choice of five years for the windows is the same as Beach *et al.*, although the six-year length of the panels in the SLID does oblige us to make due with four years in three of the rolling windows.¹⁸ Thus we estimate the transitory variances using 12 windows spanning 15 years: 1993-1997, 1994-1998, 1995-1998, 1996-2000, 1997-2001, 1998-2001, 1999-2003, 2000-2004, 2001-2004, 2002-2006, 2003-2007, 2004-2007.¹⁹ Rolling windows imply that the ‘permanent’ income of a given family at any given year is based on the family’s average income (net of life-cycle effects) over the next five (or four) years, while the family’s transitory income refers to fluctuations around this average. The overlap of years across windows implies a moving average process over five (or four) consecutive years, but despite the autocorrelation in the estimated variances, distinct turning points can be discerned. The whole procedure is then repeated with the log of post-fisc family incomes.

4.4 Residual Income Progression

To obtain an annual time series of the residual income progression (RP), we calculate the average value of RP for the population of families each year, and we do this also for each subgroup of families. To obtain the RP for a given family, we determine the family’s average

¹⁸Since two different panels overlap every three years, the length of every third rolling window is four years.

¹⁹The 2005-2009 window is excluded because of missing data on the post-fisc income variable in 2009 at the time of our study. However, we use the data up to 2008 in applying the Shin-Solon technique.

and marginal effective tax rates, using the Canadian Tax and Credit Simulator (CTaCS). We proceeded as follows. The amount of each source of income in the family (from both spouses in the case of married couples), as well as each tax deduction, and the family's characteristics, notably the number of dependent children, is inputted from the SLID into CTaCS. CTaCS then calculates the net tax burden of the family. This is defined as the sum of federal and provincial tax liabilities minus all non-refundable and refundable tax credits. Any EI or SA benefits reported in the SLID are also subtracted from the total net tax amount to represent the family's overall *net fiscal position* with respect to government taxes and transfers. We then add \$5,000 to the labour earnings of the family head and we recalculate the net fiscal position of the family. CTaCS takes into account the clawback on EI benefits that may arise. However, it cannot calculate the clawback on SA benefits, so some inaccuracies will arise in the calculation of the change in the net fiscal position of certain families.

The marginal tax rate (MTR) of the family is then simply the change in its net fiscal position divided by \$5,000. The family's average tax rate (ATR) is its original net fiscal position divided by its total market income. RP equals $(1 - \text{MTR}) / (1 - \text{ATR})$. The calculation of RP is undertaken for subgroups of the population of families defined by categories of educational attainment of the main earner. As income and education are positively correlated, the average value of RP in each subgroup reflects broadly the degree of progressivity over different income ranges.

5 Graphical Results

The time points in all of the graphs represent the third year of the rolling window (which corresponds to the mid-year of a five year window). Thus, the point for 1995 is constructed with data from 1993-1997, 1996 refers to data from 1994-1998, and 1997 for data in the years 1995-1998. For convenience, henceforth, we will state specific years in our discussions, but each year corresponds to the variance over the period of the rolling window.

5.1 Pre-Fisc Variance

5.1.1 All Families

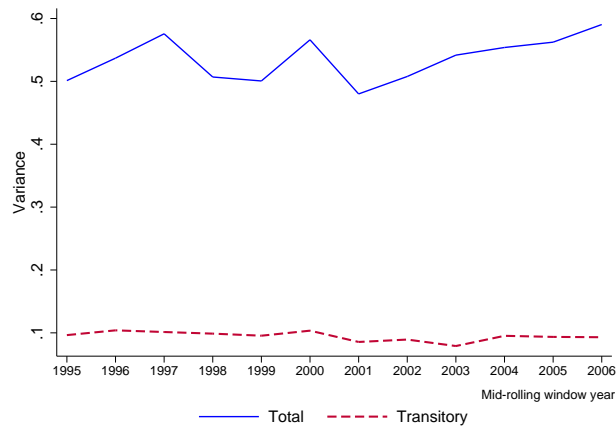
Figure 1 depicts the 1995-2006 time series of the total variance of pre-fisc family income and the variance of the transitory component, using the rolling windows from 1993-97 to 2004-07. (The inequality variance is the difference between the two series). The total variance of market income based on all families shows a rising trend starting in 2001, and by 2006 the total variance of earnings is 18 percent higher than in 1995. The transitory variance is on average 18 percent of the total variance over the sample period. It is fairly constant throughout, but with a slight decline in the interval of 2000 to 2003, followed by an increase. Overall, the increase in the total variance over the 1995-2006 period is attributable to widening inequality, rather than increasing instability of family incomes.²⁰ In contrast to Figure 1, a graph of the transitory variance of *post-fisc* incomes (not shown) exhibits almost none of the decline in the early 2000s, while still increasing in 2004. By 2006, the transitory variance of post-fisc income is slightly higher than it was in 1995, even though the transitory variance of pre-fisc income is slightly lower in 2006 compared to 1995. In other words, reductions in the transitory variance of market incomes were ‘undone’ by changes in fiscal policies. The observation will be examined below with a graph showing the ratio of the post-fisc transitory variance to the pre-fisc transitory variance.

5.1.2 Families by Education

Figure 2 shows the pre-fisc total variance and the pre-fisc transitory variance by educational category. The temporal patterns are similar across the educational groups, but not surprisingly the sizes of both the total and the transitory variances are ordered by educational attainment.

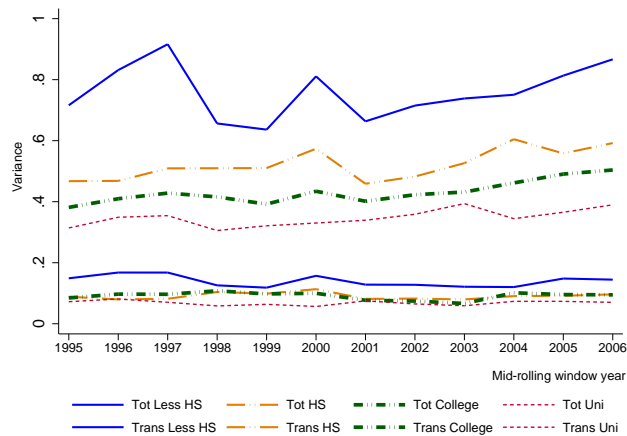
²⁰These findings on family incomes are broadly consistent with the results on individuals’ labour earnings reported in Beach *et al.* (2010) over the period 1995-2004 (using our scheme for reporting the third year of a rolling window). They found that the total earnings variance increased over that period for men, whereas for women the increase began around 1999. The authors also found that the transitory variance rose over the whole period since 1995 for women, while declining for men until the early 2000s, after which it trended upwards. Garcia-Medina (2013) decomposed the variance of labour market earnings for men and women, separately, as in Beach *et al.* (2010). For the period of overlap between the SLID and the LAD, the levels and trends of the variances are similar to Beach *et al.* For the United States, Shin and Solon (2011) reported an increase in the transitory variance of log earnings over the period 1996-2004.

Figure 1. Pre-fisc Income Variance of all families



Notes: Author's estimates of the longitudinal pre-fisc income variance decomposition over rolling windows using the SLID 1993 - 2007. The third year of the rolling window is shown in the horizontal axis. Pre-fisc income is the before tax and transfers income for the family reported by the main income earner, and is scaled by family size and composition and expressed in thousands of constant 2010 Canadian dollars.

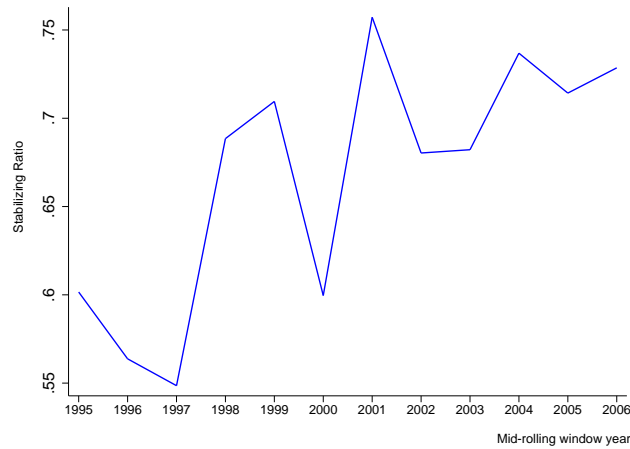
Figure 2. Total and Transitory Variance of Pre-fisc Income by Education.



Notes: Author's estimates of the longitudinal pre-fisc income variance decomposition over rolling windows using the SLID 1993 - 2007, shown by group of the main income earner's education. The third year of the rolling window is shown in the horizontal axis. Pre-fisc income is the before tax and transfers income for the family reported by the main income earner, and is scaled by family size and composition and expressed in thousands of constant 2010 Canadian dollars.

Families in which the main earner has less than high school education have total variances that are about 2.19 times higher than families in which the main earner has a university degree; similarly, their instability variance is about 2.05 times higher.

Figure 3. Ratio of Post- to Pre-fisc Income Instability of All Families.



Notes: Author's estimates of the ratio of post-fisc to pre-fisc income variances using the SLID 1993 - 2007 for all families. Pre-fisc income is Pre-fisc income is the before tax and transfers income for the family reported by the main income earner and post-fisc income refers to the income after taxes and transfers for the family. The two income definitions are scaled by family size and composition and expressed in thousands of constant 2010 Canadian dollars. The third year of the rolling window is shown in the horizontal axis.

5.2 Ratio of Transitory Variances

5.2.1 All Families

The ratio of the post-fisc to pre-fisc variance of the transitory component of family incomes, i.e., the stabilization ratio, captures the extent to which the tax and transfer system attenuates volatility in market incomes; the lower the ratio the more stabilizing is the fiscal system. The ratio of variances is shown in Figure 3 for all families. Over the 1995-2006 period the ratio averaged 0.67, indicating that about one-third of the volatility of market incomes was absorbed by the tax and transfer system.

The reductions in progressivity reported in Frenette *et al.* (2009) between 1995 and 2000, due to the tax reforms and reduced program benefits, are clearly observable in Figure 3, even if the series displays volatility.²¹ To emphasize the point, it is useful to divide the years

²¹A possible reason for the drop in the value of the stabilization ratio in 2000 (i.e., the rolling window 1998-2001) is the slowing of economic growth in 2001 and the related increase in the unemployment rate in that year. However, the explanation seems not fully satisfactory and the spikes may simply reflect randomness in the data. Another possibility is that the drop in the ratio in 2000 has to do with a change in the panel in that year, since the 1998-2001 window is from the second panel, while the 1999-2003 window comes from the third panel. However, when we calculate the ratio of transitory variances using the cross-sectional variance of annual

1995-2006 into pre-tax reform and post-tax reform segments. Since the major provincial and federal tax reforms occurred especially between 1998 and 2001, we divide the whole period into a 1995-1997 segment (i.e., the rolling windows 1993-97, 1994-98, and 1995-98) and a 1998-2006 segment (i.e., spanning the windows 1996-00 to 2004-07). The average value of the ratio of variances for 1995-1997 in Figure 3 is 0.57, whereas the average is 0.70 for 1998-2006, a 23 percent increase.²² Hence, our hypothesis is that the period of significant tax reforms, 1998-2001, together with a falling trend in government transfers, led to a permanent upward shift in the stabilization ratio.²³ Another way to gauge the impacts of the policy changes is to observe that the proportion of the variance of market incomes absorbed by the fiscal system declined by 0.13. Recall the isomorphism between the stabilization ratio and RP-squared, as well as the fact that RP itself (not squared) is an elasticity. Then the observed change in the stabilization ratio, due to the policy reforms, implies, e.g., that a 10 percent shock to a family's market income translated into a shock to its income after taxes and transfers that is on average 0.82 percent ($= 10 \times [\sqrt{0.70} - \sqrt{0.57}]$) more than was the case before the reforms, which is an important incremental percentage change in the value of income after taxes and transfers. For example, a family with a usual market income of \$50,000, but which suffers an income loss of \$5,000, would on wind up with about \$410 less after the policy reforms compared to before the reforms. In the context of protection against income instability, families have become more exposed to income shocks.

5.2.2 Families by Education

Figure 4 shows the ratio of transitory variances by educational category. It suggests that the broad pattern for the ratio of variances seen previously for all families in Figure 3 is driven mainly by families headed by earners with less than high school education. This is not surprising since families with relatively low education exhibit the most unstable incomes.

changes in income, using the approach of Shin and Solon (2011), we do not find the downward fluctuation in the series, which suggests that the spikes are unlikely to be due to the change of panels.

²²There is an inevitable overlap of years in the rolling windows that separate the pre- and post-tax reform segments. However, the general observation that the ratio of variances increased after the tax reforms is robust to excluding any 'middle' set of years, such as comparing the segments 1995-1997 with 2002-2006, or including 1998 in the pre-tax reform period.

²³Testing formally for evidence of a structural break is infeasible because of the paucity of observations.

In Figure 4, the stabilization ratio for the less than high school group averages 0.41 in the pre-tax reform period of 1995-97, whereas the average rises to 0.62 over the post-tax reform period 1998-2006, representing a 50 percent increase in the ratio, which is by far the largest increase among the education groups. In contrast, the ratio for university educated heads of households rises by only seven percent between the pre- and post-tax reform periods. Furthermore, the average, across all years, of the ratio of variances for the university educated group is about 1.68 times higher than for the less than high school group, indicating that the system contributes much more to stabilizing the incomes at the lower end of the income distribution. In the case of college educated families, the level and changes in the stabilization ratio broadly resemble the group with less than high school. For the families with just high school education the intertemporal pattern is less in synchrony with the other groups, and the ratio of transitory variances lies above the curve for the college educated group in many of the years. Nevertheless, the ratio for the high school group also rises between the post- and pre-tax reform periods. Thus the tax reforms around 2000 and changes to SA program benefits reduced family protection against market income instability. The fact that, in Figure 4, there are relatively small differences in the average levels of the stabilization ratio across the lowest three educational categories is also interesting. It may reflect the fact that the Canadian federal personal income tax system has few tax brackets and a comparatively small progression of tax rates.

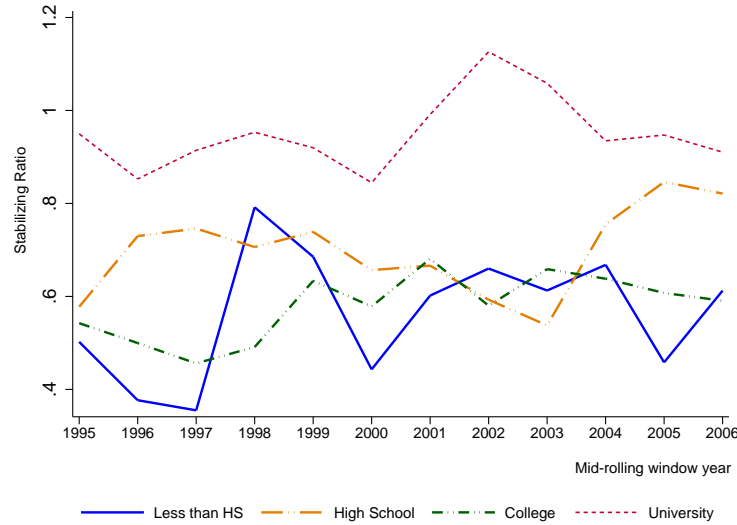
In order to better understand the sources of the changes in the ratio of variances, we turn to the estimates of residual income progression and its marginal and average effective tax rate components.

5.3 Residual Income Progression

5.3.1 All Families

The size of RP captures a measure of fiscal progressivity. As with the stabilization ratio, the closer is RP (and RP-squared) to zero the more redistributive is the system of taxes and transfers. Figure 5 depicts the squared value of RP for all families, along with the (squared) numerator and (squared) denominator of RP, as per equation (4). Broadly speaking, RP-

Figure 4. Ratio of Post- to Pre-fisc Income Instability by Education.



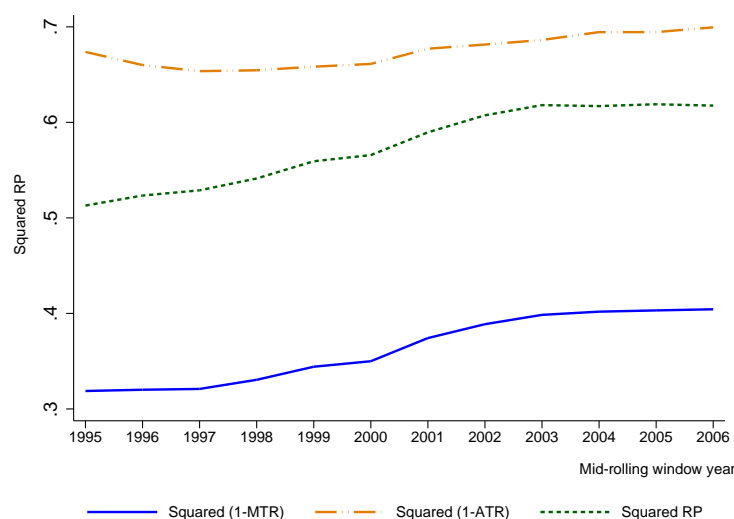
Notes: Author's estimates of the ratio of post-fisc to pre-fisc income variances using the SLID 1993 - 2007 for all families by education as reported by the main income earner. Pre-fisc income is the before tax and transfers income for the family reported by the main income earner, and post-fisc income refers to the income after taxes and transfers for the family. Income is scaled by family size and composition and expressed in thousands of constant 2010 Canadian dollars. The third year of the rolling window is shown in the horizontal axis.

squared captures a pattern of decreasing progressivity over the entire period, but especially after 1997, consistent with the intertemporal pattern of the ratio of transitory variances in Figure 3, but without exhibiting the volatility of that series. The average value of RP-squared over the period 1995-1997 in Figure 5 is 0.52, whereas the average is 0.59 over the post-tax reform period of 1998-2006, representing about a 14 percent increase. Looking at the components of RP in Figure 5, we can see that the changes in RP are driven by a decreasing marginal tax rate (which increases the numerator of RP), even while the average tax rate is also falling (which increases the denominator of RP).

5.3.2 Families by Education

Figure 6 shows RP-squared by educational attainment. The heights of the curves are ordered by educational attainment, which fits the observation from Figure 4 that the less than high school group has the lowest ratio of variances and the university educated group has the highest. The intertemporal pattern of RP for each group is similar to the pattern for all

Figure 5. Squared Residual Income Progression of All Families.

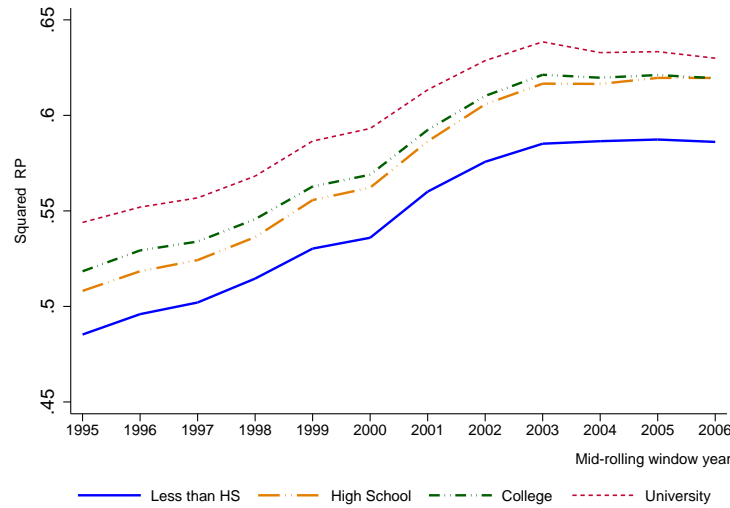


Author's estimates of the income replacement rate calculated for each main income earner using the socioeconomic information of his family from the SLID 1993 - 2007 and the Canadian Tax and Credit Simulator (CTaCS by Milligan (2007)). To compute the marginal tax rate five thousand dollars were added to the income reported in the SLID, so as the CTaCS calculates the tax and transfers the same person would have paid and perceived had have such hypothetical augmented income. The RP is averaged for the corresponding moving window period and is displayed on the horizontal axis as the third year of the rolling window.

families, but the increase in RP after 1997 is a bit larger for the groups with less than high school or high school education than for the college or university groups.²⁴ This too is consistent with our earlier observation that the rise in the ratio of post-fisc to pre-fisc transitory variances is being driven in large part by what is happening to the group with less than high school education, even though the other groups have also faced a rising stabilization ratio. Figure 7 pursues this observation further by showing the numerator and the denominator of RP-squared for each educational group. The fall in the marginal tax rate in every group corresponds to the tax cuts previously described. What is somewhat striking in Figure 7 is the relative constancy of the average tax rate — i.e. the nearly flat line represented by the square of $(1 - ATR)$ — faced by families in the less than high school education group, compared to falling average tax rate for the university educated families, starting in 1998. We discuss this point in more detail below.

²⁴Comparing the average value of RP-squared over 1998-2006 with the average over 1995-1997, the rate of change was 14.1 percent for the less than high school group, 14.7 percent for the high school group, 13.2 for the college group, and 11.5 for the university group.

Figure 6. Squared Residual Income Progression by Education.

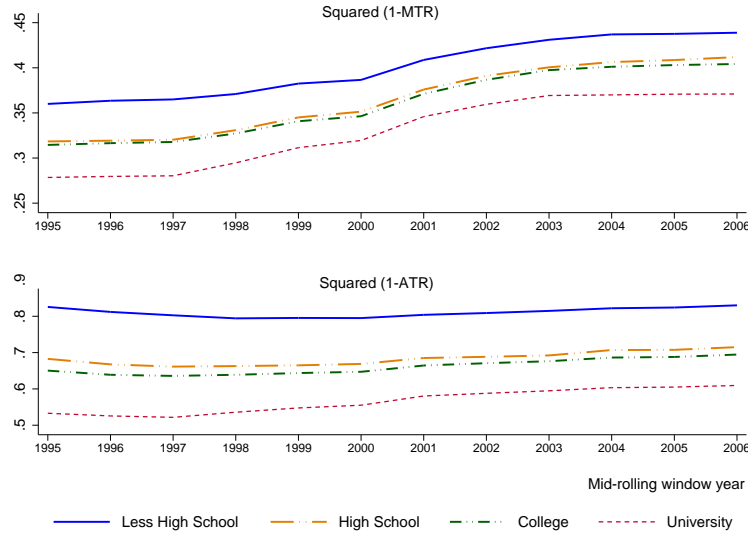


Author's estimates of the income replacement rate calculated for each main income earner by education, based on the SLID 1993 - 2007 and the Canadian Tax and Credit Simulator (CTaCS by Milligan (2007)). The marginal tax rate was computed adding five thousand dollars to the earnings reported in the SLID and using CTaCS to simulate the taxes and transfers the same person would have paid having such hypothetical augmented income. The RP is averaged for the corresponding moving window period and is displayed on the horizontal axis as the third year of the rolling window.

5.3.3 Discussion of the Results for Families with Less Than High School

We have remarked previously that the overall pattern of the ratio of post-fisc to pre-fisc transitory variances resembles closely the pattern for families in which the head has less than high school education, and that these families in particular became more exposed to income instability following the period of tax reforms. Furthermore, the marginal effective tax rate declined for these families, yet their average effective tax rate did not, which helps to explain the relatively large rise in the size of their stabilization ratio. Here we discuss policy changes that eroded the protection of low-income families against income instability. Figure 8 depicts the 'implicit' personal income tax rate of each income quintile, as reported directly by Statistics Canada. This is defined as the average personal income tax paid as a fraction of the average pre-tax total income in each quintile, where total income includes government transfers. The lowest quintile, which is most likely to be representative of many earners with

Figure 7. RP's Numerator and Denominator by Education.



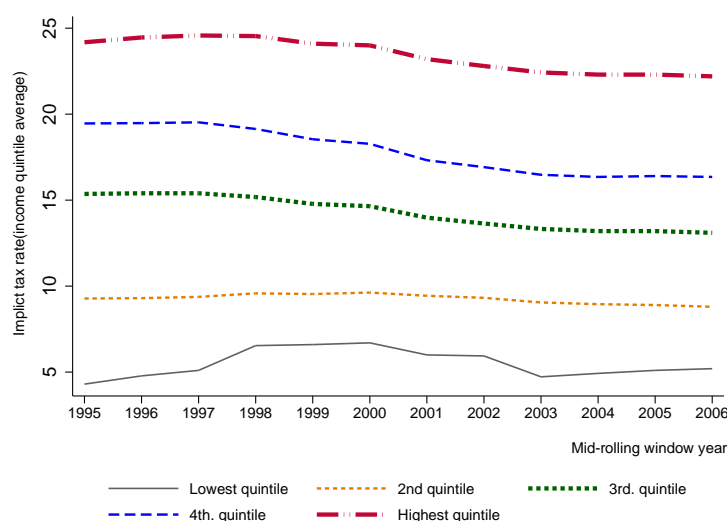
Author's estimates of the income replacement rate calculated for all main income earner by their reported education, based on the SLID 1993 - 2007 and the Canadian Tax and Credit Simulator (CTaCS by Milligan (2007)). The marginal tax rate was constructed adding five thousand dollars to reported earnings in the SLID and then introduced into CTaCS for computing taxes and transfers that the same person would have paid had such hypothetical augmented income. The RP is averaged for the corresponding moving window period and is displayed on the horizontal axis as the third year of the rolling window.

less than high school education, is the only one among the quintiles to exhibit a persistently higher implicit tax rate after 1995, and with upward jump in 1998.²⁵ This fact appears to be attributable to a reduction in government transfers received by lower income families. In particular, the implicit government transfer rate — the average government transfer as a share of average total income — declined steadily between 1993 and 2005 (Statistics Canada, 2007: Chart 4). This, in turn, suggests that the total income of many lower income families may have decreased relative to their income tax burden, thus raising their implicit personal income tax rates. Hence, reductions in personal income tax rates and less generous transfers have eroded the protection of low income families against income fluctuations by lowering their marginal tax burdens while tending to raise their average tax burdens. These observations, which have not been previously noted in the literature, help to explain why the less

²⁵For consistency with the previous graphs, the implicit tax rates are averaged over the years corresponding to each rolling window.

than high school group saw almost no change (or even a slight increase during the 1990s) in its average effective tax rate in Figure 7, despite its declining marginal tax rate.²⁶ In contrast, the university educated group (and to a lesser extent the high school and college groups) saw falling average tax rates over the same period.

Figure 8. Implicit Personal Income Tax Rate, 1993-2007.



Notes: Implicit personal income tax rate by income quintile average. Source: Table 202-0501 of Statistics Canada. Averages by rolling window are displayed for the window's third year.

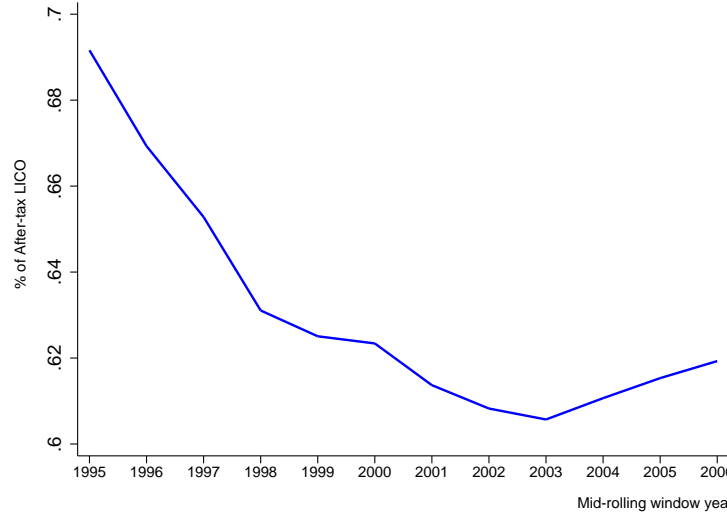
Changes to the Social Assistance program likely contributed to the reduction in government transfers, relative to income, received by families with less than high school education. Social Assistance payments often serve as a 'backup' source of benefits when an unemployed individual ceases to qualify for Employment Insurance benefits. Figure 9 shows the generosity of Social Assistance from 1995-2006, as measured by SA payments as a percentage of Statistics Canada's after-tax Low Income Cutoff (LICO) for couples with two children.²⁷ The percentage declined substantially from 1995 to 2003 and then rose moderately from 2003 to

²⁶The curve for the squared value of $(1 - ATR)$ depicted in Figure 7 will tend to decrease when government transfers are cut, because the numerator of ATR is the 'net fiscal position' of a family, i.e. taxes minus transfers. As transfers fall, the net fiscal position of the family 'worsens' (increases), making ATR rise and $1 - ATR$ decline. Unlike with Statistics Canada's 'implicit tax rate' the denominator of ATR is market income, rather than total income, and hence is unaffected by transfers.

²⁷The graph gives the average value of SA over the years corresponding to each rolling window, with the third year of the window plotted on the abscissa.

2006. In contrast, reforms to the Employment Insurance program during the 1990s probably had little effect on the decline in progressivity after 1998. In particular, the ratio of EI beneficiaries to the number of unemployed was virtually constant at 44 percent between 1997 and 2006.

Figure 9. Social Assistance Generosity, 1993-2007



Notes: Social Assistance Generosity measured as the provincial weighted average of Social Assistance income as a percentage of After-tax LICOS. Source: Welfare Income Report 2009 by the National Council of Welfare, and the SLID for provincial percentages of couples with two children. Averages by rolling window are displayed for the window's third year.

5.4 Cross-Sectional Variance of Annual Income Growth

The robustness of our insights from the variance decompositions are examined using an alternative measure of the transitory variance of income, based on the approach of Shin and Solon (2011). To illustrate it, suppose family i 's age-adjusted log of income in year t , ya_{it} , is given by

$$ya_{it} = p_t \alpha_i + \varepsilon_{it} \quad (5)$$

where α_i is a family-specific fixed effect with population variance σ_a^2 , p_t is a loading factor, which could reflect, e.g., year-specific returns to human capital, and ε_{it} is a transitory income component with time-varying variance σ_t^2 . Then the variance of ya_{it} is

$$var_{total} = p_t^2 \sigma_a^2 + \sigma_t^2 \quad (6)$$

The object of interest to us in (6) is the transitory variance σ_t^2 , which corresponds to σ_z^2 in the notation of Section 3, except that here the variance is time-varying. As Shin and Solon (2011) show, the variance of *year-to-year changes* in adjusted log income (equivalently, annual income growth) is

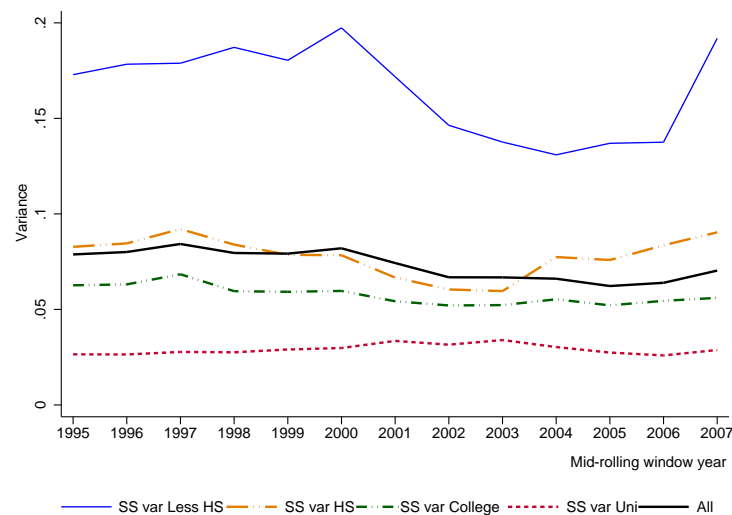
$$var(ya_{it} - ya_{it-1}) = (p_t - p_{t-1})^2 \sigma_a^2 + \sigma_t^2 + \sigma_{t-1}^2 \quad (7)$$

The cross-sectional variance of annual income changes represented by (7) is Shin and Solon’s proposed measure of income instability.²⁸ As the authors discuss, their measure contains both the transitory income variance and a permanent component. However, since it is generally expected that the loading factor changes little year by year, $p_t - p_{t-1}$ is likely to be small, compared to the transitory variances. We follow their procedure of regressing the annual change in the log of family-adjusted income on a quadratic of the age of the main earner and taking the Mean Square Error from the regression as the estimate of $var(ya_{it} - ya_{it-1})$. We report the values of the pre-fisc and post-fisc transitory incomes as $\frac{1}{2} \times var(ya_{it} - ya_{it-1})$; the division by two scales the variance to make it comparable to the transitory variance calculated from the variance decomposition method of the previous section.

Figure 10 shows that the variances of annual pre-fisc income growth have similar values and follows a similar pattern of decline after 2000 as the transitory variances obtained with the rolling windows structure previously displayed in Figure 2. This is the case for all families and for each education group, with the exception of families with university educated heads, who have even lower levels of annual variation than their transitory variance from the variance decomposition approach. The average values of the transitory variances over the years 2005 to 2008 correspond to the year 2007 in the graph; the effect of the recession in 2008 appears in the increase in the transitory variances of all groups, but especially for families with less than high school education. The average variance of the annual change in pre-fisc log income over the whole period for all families combined is 0.15, which compares with about 0.1 for the average of the transitory variance computed with rolling windows.

²⁸We should note that Shin and Solon (2011) apply the method to two-year changes in income, rather than one-year changes, due to data gaps in the PSID.

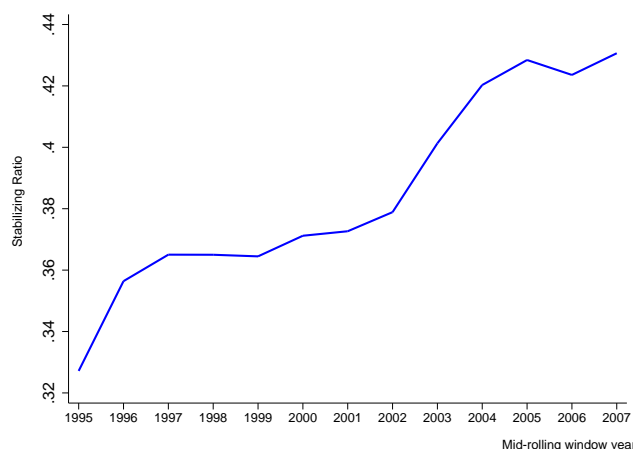
Figure 10. Variance of Annual Pre-fisc Income Growth of all Families by Education.



Notes: Author's estimates of the variance of annual income changes from the method of Shin and Solon (2011) using the SLID 1993 - 2008, displayed by group of the main income earner's education. The horizontal axis shows the average of the biennial difference for the rolling window at the third year. Pre-fisc income is the before tax and transfers income for the family reported by the main income earner, and is scaled by family size and composition and expressed in thousands of constant 2010 Canadian dollars.

The ratio of post-fisc to pre-fisc variances of annual income growth for all families is plotted in Figure 11. As explained above, lower values of the ratio represent a greater capacity of the personal income tax and transfer system to reduce the variance of the annual income changes of families. As with the rolling windows approach, the increasing ratio of the annual variation confirms the declining capacity of the fiscal system to smooth income variation over time, particularly since the early 2000s.

Figure 11. Ratio of Post- to Pre-fisc Variance of Annual Income Growth of all Families.



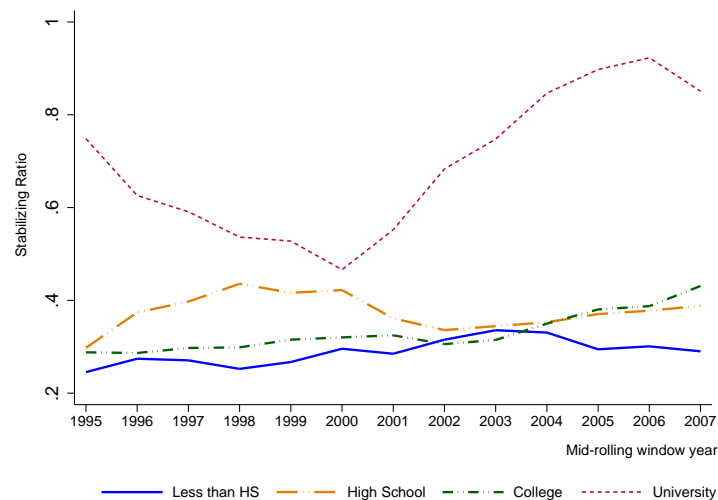
Notes: Author's estimates of the ratio of post-fisc to pre-fisc variances of annual income change using the SLID 1993 - 2008 for all families. Pre-fisc income is Pre-fisc income is the before tax and transfers income for the family reported by the main income earner, and post-fisc income refers to the income after taxes and transfers for the family. Income is scaled by family size and composition and expressed in thousands of constant 2010 Canadian dollars. The year in the middle of the rolling window is shown in the horizontal axis.

When comparing the ratio of variances of annual income growth based on the educational attainment of a family's main earner, shown in Figure 12, it can be observed that the ratio for the university group is the highest and the less than high school group the lowest, again suggesting that the system reduces income instability by more among families with less educated main income earners. An anomaly in Figure 12, which was also the case in Figure 4, is the fact that the curve for the high school group tends to lie above the curve for the college group. The general erosion of the stabilizing effects of taxes and transfers after the tax reform period around 2000 is evident in Figure 12 for all the groups, except for the high school educated one.

5.5 Empirical Relationship between the Ratio of Variances and RP

In this section, we use regression techniques to validate the theoretical link between the ratio of variances and RP-squared described in Section 3. The model posits what is essentially an accounting identity, rather than a behavioral relationship. Hence, an ideal fit would produce a slope coefficient equal to unity and a constant equal to zero. We also examine the effect

Figure 12. Ratio of Post- to Pre-fisc Variance of Annual Income Change by Education.



Notes: Author's estimates of the ratio of post-fisc to pre-fisc variances of annual income change using the SLID 1993 - 2008 by the education of family's main earner. Pre-fisc income is Pre-fisc income is the before tax and transfers income for the family reported by the main income earner, and post-fisc income refers to the income after taxes and transfers for the family. Income is scaled by family size and composition and expressed in thousands of constant 2010 Canadian dollars. The third year of the rolling window is shown in the horizontal axis.

of the unemployment rate (UR) on the ratio of transitory variances. This permits us to observe whether government policies dampen income fluctuations by more during episodes of high income volatility. A negative coefficient for UR would be expected if the fiscal system responds counter-cyclically by providing cash transfers, particularly Employment Insurance benefits. At the same time, some individuals may be more exposed to income losses during slumps, if they do not qualify for EI benefits, and more than half do not. Note that it would be inappropriate to include both RP-squared and UR as explanatory variables in the same regression, since the RP measure that we constructed already embodies Employment Insurance and Social Assistance benefits received by families, as reported in the SLID. The sample for the regression analysis consists of the annual values of the stabilization ratio for each of the four educational groups, as well as a fifth group, containing families where the educational status of the head was not reported in the data set. Thus there are 60 observations from the variance decomposition approach (5 categories times 12 years) and 65 observations from the Shin-Solon approach (5 categories times 13 years). The explanatory variables are

constructed as average values for the corresponding windows of years used in the variance decompositions.

A pooled OLS regression of the ratio of transitory variances against RP-squared yields a coefficient close to one, when binary variables for education groups are included. The statistical significance of some of the dummy variables suggests that our measure of RP by itself cannot fully capture differences in the average values of the stabilization ratio across education groups. This is likely due to the aggregation issues arising from using a single annual value of RP to represent progressivity for a broad range of families (see Section 3). Consequently, we estimate alternative specifications that allow for group-specific differences in the average value of the stabilization ratio. These results are shown in Table 2. The top half of the table uses the variance decomposition, while the bottom half uses the cross-sectional variance of annual income growth. The odd numbered columns correspond to the regressions with RP-squared as the explanatory variable, while the even numbered columns are the regressions with UR.

We discuss first the models with RP-squared as the explanatory variable, beginning with the top half of the table. Column (1) gives the results of panel regressions with fixed effects. The coefficient on RP-squared is now virtually equal to one (1.031) in column (1). Estimates of a random effects model are shown in column (3). It is flexible enough to allow for group-specific intercepts, while remaining consistent with the theoretical link between the ratio of variances and RP-squared, insofar as the random effects estimator assumes that the expected value of each group-specific intercept is zero and uncorrelated with the RP variable. The random effects model produces a coefficient on RP-squared that is also very close to one (1.085) and an intercept term that is close to zero, which supports the theoretical model. Finally, in column (5), we apply the GMM Arellano-Bond estimator for a dynamic panel to account for possible serial correlation in the stabilization ratio by including a lagged term of the dependent variable.²⁹ While this model performs better in panels with many cross-sectional

²⁹The construction of the variances using rolling windows implies that the period-by-period variances are likely to be serially correlated, as noted by Beach *et al.* (2010). It does not necessarily follow that the ratio of variances will be serially correlated. The Arellano test shows weak evidence of autocorrelation in the first-differenced errors with 10% significance, and there is no statistical evidence of serial correlation at order 2 in

Table 2. Panel regression estimates of the ratio of post-fisc to pre-fisc transitory variance and of post-fisc to pre-fisc variance of annual income growth.

	(1)	(2)	(3)	(4)	(5)	(6)
	Fixed effects		Random effects		Dynamic panel	
	RP	UR	RP	UR	RP	UR
Transitory variance by rolling windows						
RP squared	1.031*** (0.203)		1.085*** (0.214)		0.926** (0.417)	
Unemployment rate		-0.039*** (0.007)		-0.039*** (0.007)		-0.043** (0.017)
Intercept	0.100 (0.117)	0.957*** (0.046)	0.069 (0.141)	0.957*** (0.041)	0.052 (0.151)	0.884*** (0.198)
L1.Ratio of variances					0.157 (0.158)	0.140 (0.158)
Number of observations	60	60	60	60	50	50
Number of groups			5	5	5	5
R-squared	0.195	0.202	0.239	0.059	0.491	0.321
Variance of annual growth						
RP squared	0.894 (0.610)		0.938 (0.640)		0.302 (0.433)	
Unemployment rate		-0.035 (0.018)		-0.035* (0.018)		-0.012 (0.018)
Intercept	-0.093 (0.352)	0.656*** (0.121)	-0.119 (0.316)	0.656*** (0.187)	-0.163 (0.232)	0.089 (0.141)
L1.Ratio of variances					0.999*** (0.051)	1.003*** (0.060)
Number of observations	65	65	65	65	55	55
Number of groups			5	5	5	5
R-squared	0.114	0.131	0.170	0.039	0.939	0.939

Notes: General Least Squares estimators of the ratio of post-fisc to pre-fisc transitory variance with fixed effects are shown in the first two columns, and with random effects in columns (3) and (4). The dynamic panel with Arellano-Bond estimators with robust standard errors and a two-step bias-correction are in the last two columns. Residual income progression (RP) is a measure of progresivity of the tax and transfer system and when squared is expected to be equivalent to the ratio of post-fisc to pre-fisc variance. The rolling-window time-series observations for all education groups are pooled and treated as a panel data for the 1993-2007 period. The bottom half of the table shows the results for models with rolling-window average of the variance of annual growth as the dependent variable from 1993-2008. Estimates of the R-squared for Arellano-Bond model are computed as the squared correlation between the observed and the predicted ratio of variances. Standard errors in parenthesis and the notation ***, **, * indicates statistical significance at the 1%, 5% and 10% levels.

observations and a few time-periods, we include it as an alternative specification. The model shows a modest autoregressive factor (0.16) and a coefficient for RP-squared of 0.926. Thus the time variation of RP-squared explains quite well the changes in the stabilization ratio.

The bottom half of the table reports the same regressions as above, but using the Shin- the first-differenced errors. This suggests the idiosyncratic errors are independently and identically distributed. In addition, time-series models for each education group were estimated with Maximum Likelihood, allowing for a third-order moving average process. The coefficients for RP are near one in each case, providing evidence consistent with the model.

Solon estimates of the transitory variances. The magnitudes of the coefficients are for the most part similar the ones discussed above, but statistically insignificant. In particular, the random effects model produces a coefficient on RP-squared of 0.938, and an intercept close to zero. The Arellano-Bond model shows the smallest coefficient for RP-squared and a high coefficient for the lagged stabilization ratio (0.99), suggesting a stronger autoregressive pattern in the stabilization ratio constructed with the Shin and Solon method, than in the construction by rolling windows.

Turning to the regressions with the unemployment rate, shown in columns (2), (4) and (6), the coefficients are negative and statistically significant and are very similar across all of the specifications in the top half of Table 2, but statistically significant only in the case of the random effects model for the Shin-Solon estimates of the transitory variances in the bottom half of the table.

Overall, the regression results provide evidence of an adequate relationship between the ratio of post-fisc to pre-fisc transitory income variance and the measure of residual income progression in Canada. That is, observations about RP and its components can indeed provide a practical lens for analyzing the changes in fiscal protection against income shocks.

6 Conclusions

This paper describes the changes in the capacity of the tax and transfer system to stabilize family incomes in Canada over the period 1993-2008. The analysis is based on the ratio of the post-fisc to the pre-fisc variance of the transitory component of incomes, which we also call the ‘stabilization ratio.’ This ratio can be interpreted as the proportion of the market income fluctuations of families that is not absorbed by government policies. The closer the stabilization ratio is to zero the more stabilizing the fiscal system. The variances of the post- and pre-fisc transitory incomes are calculated using a standard non-parametric variance decomposition of the total longitudinal variation in incomes into a long-term (permanent) and a short-term (transitory) component. The decomposition of variances is undertaken with overlapping rolling windows of years in order to obtain an annual time series, following Beach et al. (2010). The ratio of transitory variances is calculated for all families and for

families categorized by the educational attainment of the head of the family.

Our principal finding is that the ratio of transitory variances increased substantially after the period of provincial and federal personal income tax reforms, concentrated in the years 1998-2001, compared to the earlier years, indicating a turn toward less progressivity. This change appears to be due to a combination of less personal income tax progressivity and to reductions in the generosity of government transfers, particularly Social Assistance benefits for lower income households. The pattern is evident for all categories of families, but is driven especially by the families with heads having less than high school education, who account for almost one-fifth of all families in our sample. At the same time, the fiscal system contributes much more to stabilizing the incomes of families with less educated heads, since the ratio of variances for the university educated group is 1.68 times higher than for the less than high school group. An alternative analysis, using the approach of Shin and Solon (2011) to calculate transitory variances based on cross-sections of annual income growth, reinforces our main findings from the rolling windows technique.

We also provide a novel theoretical model to show an isomorphism between the stabilization ratio and the residual income progression (RP) measure of fiscal progressivity. Regression analysis suggests that the relationship between the ratio of transitory variances and our construction of RP, using the Canadian Tax and Credit Simulator, performs well for explaining changes over time. RP is a simple function of marginal and average tax rates. This observation allows us to interpret the changes in the stabilization ratio in terms of policy reforms affecting either the marginal or average effective tax rates, where these rates factor in program benefits as well as personal income tax rates. Thus our paper offers a parsimonious tool for describing and analyzing the impacts of fiscal policies on income instability.

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7 Appendix: Variance Decomposition

The literature on earnings inequality uses an algebraic, non-parametric, principal components technique of Gottschalk and Moffit (1994) to decompose the total variance of income (net of life-cycle effects) into two orthogonal factors, representing the long-term and short-term components of the total variance. The variance of the predicted income is decomposed as follows:

$$\begin{aligned} var_{total}(y_{it}) &= var_{permanent}(y_{it}) + var_{transitory}(y_{it}) \\ \sigma_{total}^2 &= \sigma_{perm}^2 + \sigma_{trans}^2 \end{aligned}$$

where the total variance is defined by

$$var_{total}(y_{it}) = \sigma_{total}^2 = \left(\frac{1}{K-1} \right) \sum_{i=1}^N \sum_{t=1}^{T_i} (y_{it} - \bar{\bar{y}})^2$$

and the short-term or transitory variance is given by

$$var_{transitory}(y_{it}) = \sigma_{trans}^2 = \left(\frac{1}{N} \right) \sum_{i=1}^N \left[\left(\frac{1}{T_i-1} \right) \sum_{t=1}^{T_i} (y_{it} - \bar{y}_i)^2 \right]$$

and the long-term or permanent variance is given by

$$var_{permanent}(y_{it}) = \sigma_{perm}^2 = \left(\frac{1}{N-1} \right) \sum_{i=1}^N (\bar{y}_i - \bar{\bar{y}})^2 - \frac{\sigma_{trans}^2}{\bar{T}}$$

where $\bar{\bar{y}}$ is the mean income across families over time, \bar{y}_i is the mean income of a family over time, T_i is the number of periods where family i is observed, N is the number of families, and K is the sum of year-periods observed by all the individuals. The assumption that every family is observed over the full time period, $T_i = T$ ensures the variance of earnings is fully decomposed into the transitory and permanent components. $K = \sum_{i=1}^N T_i$