The Longitudinal Effects of Disability Types on Incomes and Employment.

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Abstract

I analyze the heterogeneous longitudinal effects of disability shocks on the components of personal income. Disabilities are heterogeneous based on the tasks and abilities they impair. I combine a Canadian panel survey with rich administrative tax records and contrast effects on market income and various partial insurance channels. I apply a recently proposed event study estimator that is robust to bias arising from cohort-based heterogeneity in effect and variation in the timing of disability onset. The effect of disabilities related to physical tasks is driven by labour market exit and primarily due to conditions limiting kinetic ability. The main source of partial insurance for kinetic ability limitations is non-taxable income, notably government transfer programs targeting individuals with disabilities. Disabilities related to cognitive functioning have the largest magnitude effect on market income and receive long-run partial insurance via disability-relevant transfer programs. Last, limitations related to mental health have similar magnitude effects on market income as kinetic ability. However, this group does not receive partial insurance via government transfers. Instead, the income shock is buffered by the progressive tax system in Canada, although insurance gaps remain for this group. Finally, the estimated effect of concurrent disabilities on market income and government transfers appears to be additive as it equals the sum of the effects of physical and cognitive disabilities.

1 Introduction

The onset of a work-limiting disability has far-reaching consequences for an individual's financial independence and imposes a significant societal cost of supporting affected individuals. A disability can restrict or even eliminate a person's ability to perform tasks essential in work and daily life. The onset of disability during working life reduces labour force attachment, earnings, and consumption and increases reliance on government transfers.[1] Economic inequalities related to disability are prevalent across developed and developing nations (Garcia-Mandico et al., 2022). In Canada, 23% of working-aged individuals with disabilities are low income, compared to 9% for their non-disabled counterparts.[2] Disability is a primary income risk facing working-aged adults, as many will have experienced some form of disability before retirement.[3] Consequently, analyses of the economic consequences of disability remain an active area of economics research.[4]

There is substantial variation in the economic effects of disability onset across individuals. Understanding the determinants of this variation is vital for policymakers seeking to design appropriate insurance mechanisms against this risk and to allocate scarce resources to those bearing the greatest burden from their disability. Notably, variation in the level and composition of one's income following onset gives valuable insight into an individual's evolving economic circumstances. For example, the decline in market income relative to the rise in government transfers in the years following the onset of a disability reflect the completeness of public insurance for this income shock. A key driver of the variation in effects across disabilities on personal income is distinguishing conditions based on the types of tasks and activities that are impeded. For instance, Wall's 2017 report on poverty amongst Canadians with disabilities finds that 17% of individuals limited by physical-sensory activities and 27% limited by mental-cognitive activities are classified as low-income, respectively (Wall, 2017).

In this paper, I analyze heterogeneity in the effects of onset across different disability types on disaggregated components of personal income. Disabilities result from one or multiple physiological ailments that can vary significantly in their impediment to daily life and opportunities for productive work. Distinguishing disabling conditions based on the tasks they limit captures a key intermediate step in the mapping from a

[1]For various survey articles related to the economic effects of disability and the behaviour of disabled individuals, see Burkhauser et al. (1993); Bound and Burkhauser (1999); Haveman and Wolfe (2000); Liebman (2015); Prinz et al. (2018).

[2]Low income is defined as those living in a household earning less than one-half of the median Canadian income, adjusted for household size. These statistics are derived from the 2014 wave of the survey dataset applied in this study. For additional details on low-income Canadians with disabilities, refer to Wall (2017)

[3]Disability rates have been rising over the past few decades in Canada, as well as most developed countries. The percentage of Canadians ages 15 and over with a disability rose from 12.4% in 2001 to 22.3% in 2017. This trend is likely to continue with an aging population as disability risk tends to increase with age. This increase may also be partially due to the evolution of the definition of what constitutes disability and changes in an individual's reporting behaviour. For more details on the economic position of Canadians with disabilities, see Morris et al. (2018), and Cossette and Duclos (2002).

[4]See Prinz et al. (2018) for a more recent survey of the literature.

given health condition to one's economic outcomes. For instance, a bricklayer may be rendered unable to work if limited in bending and flexibility, whereas the work of a computer scientist may be unaffected. That is, disabling conditions have the commonality of impairing functionality in some way but can vastly differ in the sort of functions that are impaired.

The primary objective of this paper is to estimate the effect of different disability types in each of the ten years relative to their reported onset. Estimated effects are obtained with a recently proposed variant of a dynamic difference-in-difference estimator that is robust to bias arising from heterogeneity in effects across cohorts and variation in the timing of disability onset. I focus on permanent disabilities, which result in a persistent shock to an individual's earnings capacity.[5] Some disabling conditions degenerate and worsen over time, while others are more readily accommodated. Therefore, longitudinal analyses are essential to understand the scope and duration of disability's impact on earnings capacity, labour supply, and program attachment.

A comprehensive analysis of the dynamics in personal income composition enables me to assess the extent of public insurance available to mitigate the consequences of disability onset. I jointly analyze a large set of partial insurance mechanisms, compare their importance, and identify gaps in insurance across disability types. First, changes to the components of market income give insight into a disability's impact on human capital, labour market participation, and substitution to other earning activities. Second, I compare the effects on components of market income to the changes in resources gained from various partial insurance channels. I separately evaluate income gains from government transfer programs, the incomes from family members in the household, and the progressive tax system. Moreover, I distinguish government transfers that are most relevant for disability shocks from those most relevant for families. These indicators offer valuable information regarding the impact of disabilities on individuals' economic well-being.

This analysis contributes to a vast literature on the dynamics of permanent income shocks and the role of public programs in partially insuring against these shocks. Specifically, my analysis fits among many studies analyzing the longitudinal effect of health and disability shocks on labour supply, incomes, and consumption (Stephens Jr, 2001; Charles, 2003; Mok et al., 2008; Singleton, 2012; Lundborg et al., 2015; Polidano and Vu, 2015; Meyer and Mok, 2019; Fadlon and Nielsen, 2021; Humlum et al., 2023; Collischon et al., 2023). First, I conduct my analysis using rich disaggregated measures of personal income from administrative income tax records. The extent of disaggregation allows me to analyze various components of an individual's market income separately and to evaluate how income from government transfer programs, from other family mem-

[5]Permanent disability shocks, which have been found to have the most substantial effects compared to short-term disabilities that are more transitory in nature (Meyer and Mok, 2019).

bers, and the progressive tax system can mitigate the adverse effects of disability.

More generally, my findings make several novel contributions to sizable literature analyzing the effects of income shocks and the role of partial insurance and consumption smoothing mechanisms. For instance, Blundell et al. (2008); Kaplan and Violante (2010); Blundell et al. (2016) show how transfer programs, family resources, and the tax system are crucial sources of consumption smoothing for transitory shocks and partial insurance for permanent income shocks. These studies use survey panel data sources, notably the Panel Study of Income Dynamics (PSID) and Consumer Expenditure Survey. In contrast, I use administrative data from annual income tax filings, which have important advantages in data quality, further discussed below. Other related studies using administrative data sources include Blundell et al. (2015), who study life-cycle income dynamics using Norwegian registry data, including income tax filings. Of note, they find that the progressive tax-transfer system is central to reducing the level and persistence of income shocks, especially for low-income groups. This paper considers a similar set of partial insurance mechanisms but differs in the specificity of the sources of income shock. The level of specificity is meaningful through the relationship between disability and human capital and allows me to compare the extent of insurance across this margin. Moreover, disability shocks may grant eligibility for additional social insurance resources.

More similar to this paper are several studies that analyze the effect of income shocks related to health and disability. For instance, Lundborg et al. (2015) use Swedish administrative registry data and show how health shocks vary by education level. Autor et al. (2019) also use Norwegian administrative data to evaluate the insurance-incentive trade-off from disability insurance, as well as its effects on income, consumption. They relate to this paper in studying interactions between partial insurance channels but restrict their focus to disability insurance applicants. Fadlon and Nielsen (2021) focus on how family labour supply responds to health shocks using administrative data from Denmark. In a recent working paper, Humlum et al. (2023) analyzes workplace injuries using Danish administrative data and relates the scope for retraining to successful reintegration to work and application to disability insurance. Their empirical exercise is motivated by a similar theoretical model as this paper. My novel contribution is the joint analysis of a large set of partial insurance mechanisms and the specificity of the income shock and transmission mechanism. Partitioning disability into types based on the productive tasks they limit allows me to contrast the role of various partial insurance channels across shocks to market income that are heterogeneous in magnitude and persistence.

I conduct my analysis using a Canadian dataset, the Longitudinal and International Study of Adults (LISA), which combines a short panel survey containing detailed disability and demographic information with an annual panel of administrative tax records, known as the T1 family files (T1FF), which are derived from income tax filings. The tax records partition personal income into either market income, such as paid or self-employment income, and government transfers, encompassing a wide array of federal and provincial transfer policies and tax credits. In these data, I directly observe the dynamics in market income following onset of a disability, the complete set of government transfer programs, an individual's before- and after-tax total income, and the total income of family members in the household.

These Canadian data offer several advantages relative to existing studies on the longitudinal effects of disability shocks, much of which has focused on the United States until recently. The first is the quality of data from administrative income tax filings. Access to income tax records is mostly restricted in the United States, and research about health shocks often relies on large panel survey datasets, such as the PSID or the Health and Retirement Study. Survey-based income measures raise concerns of measurement error, which creates issues with the causal interpretation of findings. The administrative tax records provide detailed measures of incomes and transfers that are less prone to measurement error and under-reporting of incomes, which have increasingly been recognized as problematic in household surveys (Meyer et al., 2009, 2015). Second, my analysis compares the effects across disability types using internally consistent measures of disability. Such a unified framework addresses the problems associated with making comparisons across different studies and datasets. Differences in sampling, methodologies, or the measurement of disability can mislead researchers in comparing estimated effects across studies. Lastly, health insurance in Canada is universal, whereas disability policy in the united states gives access to health insurance. Consequently, the option value of applying to disability programs in the US will encompass the value of this added benefit (Deshpande and Lockwood, 2022). Whereas, in Canada, the labour supply incentives from disability policy are not confounded by access to health insurance.

A limitation of these administrative data is the absence of consumption measures, which can offer more direct insights into welfare changes following a disability shock. I focus on income dynamics, which may not track consumption when smoothing mechanisms, such as savings, public insurance, or credit markets, are readily accessible. However, the data, setting, and nature of income shocks under consideration are such that consumption may track income dynamics fairly well. First, I focus on permanent disabilities, which are less "smoothable" with the tools available for transitory income shocks, such as personal savings, borrowing, or short-term insurance programs (Blundell et al., 2008). Permanent disability shocks cause an unanticipated change in one's permanent income, which induces a proportion change in consumption according to the permanent income hypothesis (Friedman, 1957; Attanasio and Pistaferri, 2016). Additionally, I directly observe a wide range of partial insurance mechanisms available for Canadians, enabling a comprehensive analysis of their rise relative to the decline in earnings. Lastly, income has been shown to track consumption much more closely when correcting for non-classical measurement errors present in household surveys, which is not an issue in the income tax records (Attanasio and Pistaferri, 2016). Hence, the findings of this paper are relevant for normative analyses related to consumption inequality and heterogeneous welfare effects across disabilities.

The second main contribution of this paper is the analysis of heterogeneity in the effects of disability onset by partitioning disability into mutually exclusive types. Disabilities can result from various medical or physiological conditions and vastly differ in their impact on one's daily life. Unsurprisingly, researchers typically find heterogeneity in the impact of different disabling or medical conditions when able.[6] However, it is often unclear how a given health condition may impact behaviour. Focusing on the activity limitations caused by a given health condition can clarify the link between health conditions, productivity, and outcomes in the labour market.[7] A disability can fundamentally alter a worker's human capital vector and create a mismatch between their skill set and the skill requirements of their work. Hence, a disability limiting certain types of tasks will have different implications for labour market outcomes depending on the market valuation of these tasks.

The analysis of type-based heterogeneity proceeds in two steps. First, I partition disabling conditions into those that affect physical tasks and those that affect mental-cognitive tasks. Distinguishing conditions relating to physical tasks from those relating to cognition and socioemotional activity is fairly common in research on disability.[8] Additionally, this partition is common in studies about multidimensional human capital, which often differentiate physical and mental-cognitive skills to study the dynamic relationship between earnings and multidimensional skill accumulation.[9] To the best of my knowledge, no study has conducted a unified analysis into the longitudinal path in the effects of physical and mental-cognitive disability types on

[6]For instance, Von Wachter et al. (2011) find heterogeneity in employment and earnings across types of disabling conditions in their analysis of rejected applicants to disability insurance, Maestas et al. (2013) study heterogeneity across different medical conditions in their analysis of the work incentives of disability insurance, Lundborg et al. (2014) finds heterogeneity in the lifetime effects of specific diseases or physiological conditions that occur in adolescence). Black et al. (2018) study heterogeneity in the relationship between disability insurance and mortality by types of medical conditions.

[7]To illustrate, when left untreated, diabetes can result in a substantial physical impairment, which may restrict the set of physically demanding tasks a worker can perform. However, with proper treatment, diabetes may not limit one's activities or productivity.

[8]For instance, Yi et al. (2015) define a capability vector whose components are physical health, mental health, and cognitive functioning, Deshpande (2016) study heterogeneity in the effect of removing youth from disability support by physical vs. mental or intellectual disabilities. Wall (2017) groups mental-cognitive and physical in their analysis of poverty and persons with disability in Canada, Mori (2019) distinguishes health capital into either mental or physical and models its complimentary to the accumulation of manual and cognitive productive skills. Humlum et al. (2023) focus on physical disabilities related to work accidents and how individuals compensate by investing in their cognitive skills. Finally, Collischon et al. (2023) discuss type-based heterogeneity in their working paper about the effect of disability onset on labour market performance, partitioning disabilities into physical, sensory, or psychological types.

[9]For instance, Poletaev and Robinson (2008); Yamaguchi (2012); Sanders et al. (2012); Lindenlaub (2017); Robinson (2018); Lise and Postel-Vinay (2020)

the components of market income and partial insurance channels in a unified framework, as is done in this paper.

Underlying heterogeneity across the activity limitations within aggregate physical and mental-cognitive disabilities will be masked by this broad partition. In the second step, I separately estimate the effect of onset on mutually exclusive types of activity limitations within the aggregated disability types. Within aggregate physical, I distinguish disabilities to one's kinetic ability, which combines activity limitations to mobility, flexibility, and dexterity, from disabilities that are related exclusively to pain.[10] I also distinguish disabilities related to cognitive functioning, such as limitations to learning, memory, or concentration, from disabilities related to mental health, such as depression, anxiety, or post-traumatic stress disorder. Distinction along these margins of activity limitation is policy-relevant, as mental health-related disabilities and pain-related disabilities have driven rising applications to disability programs (Autor, 2015a). Moreover, this study provides novel estimates on the effects of mental health conditions, which are becoming increasingly recognized as important determinants of economic behaviour and outcomes (Frank and Glied, 2023). The granularity of this analysis reveals critical differences in the longitudinal effects of these types on market incomes and available partial insurance.

The third contribution of this paper is key methodological differences relative to much of the existing research on the longitudinal effects of disability onset. The workhorse approach to estimating the dynamic effect of disability onset is an event study or dynamic difference-in-difference approach, whose empirical analog is some form of two-way fixed effects estimator (Stephens Jr, 2001; Charles, 2003; Mok et al., 2008; Singleton, 2012; Lundborg et al., 2015; Polidano and Vu, 2015; Meyer and Mok, 2019; Fadlon and Nielsen, 2021; Collischon et al., 2023). However, a surging literature has shown bias present in these estimators when treatment effects are heterogeneous and there is variation in the timing of treatment (Borusyak and Jaravel, 2017; De Chaisemartin and d'Haultfoeuille, 2020; Goodman-Bacon, 2021; Callaway and Sant'Anna, 2021; Sun and Abraham, 2021; Imai and Kim, 2021; Baker et al., 2022; Rambachan and Roth, 2023). Disability onset generally occurs at different calendar years. Moreover, cohort-based heterogeneity in the effects of disability onset is likely because of differences in the job composition of the labour market, the market valuation of skills, and the parameters of disability policies in different calendar years. I estimate the longitudinal effects using the interact-weighted (IW) estimator proposed by Sun and Abraham (2021).

I document numerous novel findings in this paper. I frame my analysis in terms of short and long-run

[10]Kinetic ability describes the body's ability to move efficiently, exhibit agility, and perform tasks that require coordination and precision. Kinetic abilities include walking, running, jumping, bending, twisting, reaching, grasping, and manipulating objects.

effects, corresponding to five or less and six or more years post-onset, respectively. The first set of results on aggregate types finds substantial heterogeneity in the dynamic effects on the components of personal income and partial insurance mechanisms. First, the onset of an aggregate physical disability has modest negative effects on the primary component of market income (wages, salaries, and commissions), declining by about \$4000 in the short run and persisting around this level into the long run. This effect is driven entirely by labour market exit. The onset of a mental-cognitive disability causes a greater magnitude decline in wages, salaries, and commissions in the short run (-\$6000) and progressively worsens in the long run (-\$16000). A combination of labour market exit and earnings penalties for participants drives the effects of the onset of mental-cognitive disabilities on market income. These results are consistent with a higher valuation of mental-cognitive skills in the labour market, resulting in more considerable wage penalties for mental-cognitive disabilities (Yamaguchi, 2012; Mori, 2019; Lise and Postel-Vinay, 2020; Humlum et al., 2023). Moreover, the onset of physical disabilities can result in substitution to cognitive productive activities, buffering adverse effects (Humlum et al., 2023). Substitution to relatively scarce physically intensive jobs following the onset of a mental-cognitive disability may be difficult in a service-based economy like Canada.

As market income declines following onset, the rise in total government transfers does not significantly differ between the aggregate types. However, this implies that a lower proportion of market income is insured following the onset of a mental-cognitive disability. Compositionally, the rise in government transfers comes entirely from disability-relevant transfer programs following the onset of an aggregate physical disability. Those affected by a mental-cognitive disability only significantly receive disability-relevant transfers in the long run. These individuals receive more resources from government transfer programs targeting families in the short run. Instead, Canada's progressive tax system helps buffer the effect of a mental-cognitive disability on after-tax income, similar to the findings in Blundell et al. (2015). Total family income declines significantly for both aggregate types but only significantly in the long run for mental-cognitive disabilities. Moreover, the income of other household members declines following the onset of an aggregate physical disability, consistent with family members spending more time at home to help care for the affected individual, as discussed in Fadlon and Nielsen (2021). The distinction of the source of income shocks reveals differences in partial insurance that are otherwise confounded when studying generic income shocks. The second part of the empirical analysis takes this a step further and explores more granular heterogeneity within the aggregated disability types.

The second set of results reveals heterogeneity in longitudinal effects within the aggregate disability types.

First, the onset of a disability to one's kinetic ability drive the effects of an aggregate physical disability. The primary source of partial insurance for disabilities to kinetic ability comes from government transfers and non-taxable income. Finally, the onset of a disability to one's kinetic ability negatively impacts total household income, as well as the income of family members. Disabilities related exclusively to pain do not significantly impact wages, salaries, and commissions, or government transfer payments. However, these types do cause modest exit from the labour market. These results illustrate the importance of distinguishing heterogeneity within aggregate physical types and can help inform researchers studying aggregate physical disabilities on what conditions are driving estimates. Disabilities related exclusively to pain induce noise into estimates of the effects of aggregate physical disabilities. Further exploration into exclusively pain limitations is required to isolate those with adverse effects on incomes.

Disabilities related exclusively to mental health have a similar longitudinal path in effects on market income as disabilities related to cognitive functioning, albeit of a smaller magnitude. Both types cause immediate declines in wages, salaries, and commissions in the short run (-$5700 and -$6900, respectively), which become progressively worse in the long run. Despite similarities in the effects on market incomes, these two types have important differences in partial insurance mechanisms. Following the onset of a disability to cognitive functioning, individuals experience a considerable magnitude rise in transfer payments from disability-relevant programs, corresponding to the sharp decline in labour market participation in the long run. Individuals affected by mental health receive no significant increase in income from these programs. Instead, the tax system plays a more prominent role in buffering the effect of the shock to market income for those affected by mental health disabilities. That is, as market income declines for this group, their marginal tax rate declines and helps buffer this shock. Hence, despite the effects of similar magnitude to kinetic ability, those affected by mental health disabilities face gaps in available insurance. At the household level, family total income declines in the long run following the onset of both cognitive and mental health disabilities.

The results for the more granular disability types fit with recent findings in the task-based human capital literature, which can offer insight into the link between disability types and one's skills. For instance, Guvenen et al. (2020) shows that a mismatch in skills related to math and verbal ability has more substantial negative effects than a mismatch in social skills. Hence, if a disability to cognitive functioning has a greater impact on math and verbal skills than a disability to mental health, the resulting earnings scarring will be more substantial. Similarly, Lise and Postel-Vinay (2020) show that manual skills have relatively more moderate returns and adjust quickly, cognitive skills have much higher returns but are slower to adjust, and interpersonal skills have slightly higher returns than manual, but essentially fixed over one's life. The results for kinetic ability are naturally related to manual skills, cognitive functioning to cognitive skills, and mental health to interpersonal skills. That said, the link is more complicated as mental health likely has implications for cognitive skills, and cognitive functioning has implications for interpersonal skills. A complete analysis of the mapping from disability types to a full set of skills is left for future work.

The last section of this paper interprets the empirical results using the optimal benefits framework of Baily (1978) and Chetty (2006), which derives the optimal level of disability benefits as a function of the percentage change in consumption, the coefficient of risk aversion, and the elasticity of time receiving disability benefits with respect to the level of disability benefits. This idea is that optimal benefits weigh the work disincentives against the welfare gains related to smoothing consumption after a disability shock. I assume the change in after-tax income is proportional to the change in consumption after the onset of a disability, consistent with the permanent income hypothesis. Then, taking estimates of the elasticity of time receiving benefits from the related literature, I compare the coefficient of risk aversion consistent with optimal benefits with values estimated from the related literature. Benefits are only optimal if individuals have lower risk aversion than the related literature implies for mental-cognitive disabilities and disabilities to kinetic ability. Those affected by a mental health-related disability deviate the most from optimal benefits.

The remainder of my paper is structured as follows. Section 2 describes a conceptual framework to motivate the importance of distinguishing disability into types. Section 3 details the institutional details of the disability policy in Canada. Section 4 describes the dataset used in my analysis and summarizes its key features, highlighting the demographic composition and differences across the disability types. Section 5 describes the empirical framework and its suitability for this analysis. Section 6 analyzes the empirical model's results. Section 7 explores the welfare implications of the results in Section 6, and Section 8 concludes.

2 Conceptual Framework

In a standard human capital framework, an individual's stock of human capital is a crucial determinant of their marginal productivity and subsequent returns to working. The heterogeneous effects of different types of disabilities are readily illustrated with a task-specific human capital framework. In this setting, an individual's human capital vector is defined relative to the skill requirements of occupations. The skill requirements of occupations are typically derived from a larger set of task requirements associated with each occupation.[11] A main advantage of this approach is the ability to formalize an ordinal concept of skills-jobs mismatch. This mismatch is quantified as the distance between a worker's human capital vector and the skill requirement vector of their occupation through some metric function. A greater distance between these vectors indicates a larger mismatch between the worker's skills and the tasks required by an occupation, resulting in larger wage penalties. In the following, I further develop this framework and show how it is extended to incorporate the effects of disabilities.

Formally, an occupation is represented by a k-dimensional skill requirement vector, $x_t \in \mathbb{R}^k$, where each element, $x_t^j \in \mathbb{R}$, represents the complexity of the corresponding tasks involved in producing output in period t. Complexity measures the importance of these tasks in the production process. For example, critical thinking tasks are essential to the productivity of an economics researcher, indicating a high value for the complexity in that dimension of the skill requirement vector. Occupations are thus differentiated by their skill requirements and by the output they produce. A worker's skills are represented by a k-dimensional vector, $s_t \in \mathbb{R}^k$, where each element, $s_t^j \in \mathbb{R}$, represents the proficiency of skill dimension j when engaging in productive work. For instance, an economics researcher with a Ph.D. will have developed their skills in critical thinking, corresponding to a high value in this dimension of their skill vector. Without loss of generality, workers' skills are ordered in terms of their complementary with the respective element in the skill requirement vector. For instance, if x_t^1 represents manual tasks, s_t^1 will summarize physical human capital, such as strength, dexterity, or mobility.

Following Yamaguchi (2012), a worker's hourly wage, w_t, equals their marginal value product, which is defined as

$$w_t = \pi(x_t) q(x_t, s_t) exp(\eta_t). \tag{1}$$

The labour productivity of a worker with skill s_t at occupation with skill requirement x_t can be further parameterized as $\ln q(x_t, s_t) = \theta'(x_t) s_t$. $\theta(x_t)$ is a k-dimensional vector representing the implicit skill prices, which captures the contribution of skill s_t to production in occupation x_t. The market price of a product characterized by skill requirements x_t is $\pi(x_t)$. Lastly, $\eta_t \sim F(\eta)$ represent i.i.d productivity shocks.

In a competitive setting, workers that are heterogeneous in skills will self-sort into occupations based

[11] A primary source of information on an occupation's task requirements is the O*NET. The dimensionality of task requirements is often higher than that of the skill requirement vector, and dimension reduction methods, such as unrestricted Principal Component Analysis, are often used. For example, Poletaev and Robinson (2008); Yamaguchi (2012); Lindenlaub (2017); Robinson (2018); Guvenen et al. (2020); Lise and Postel-Vinay (2020); Ocampo et al. (2018). Sanders et al. (2012) summarizes the earlier literature on task-based human capital.

on their comparative advantage.[12] Observed wages maximize the product of the match function (q) and market pricing of the skill requirement of an occupation (π). Further assuming that $\frac{\partial \pi(x_t)}{\partial x_t} > 0$ implies that the market valuation of skills is increasing in task complexity. Moreover, assuming $\frac{\partial^2 q(x,s)}{\partial s_k \partial x_k} > 0$ implies that skills are more intensely used and contribute to productivity more, where corresponding tasks are complex.

To incorporate the effects of disabilities, define a disability vector, d_t, as a k-dimensional vector representing the extent of limitation to the respective skills in the human capital vector in period t. The elements of d_t are constrained such that $d_t^j \in [0,1], \forall j \in \{1, ...k\}$. The disability vector captures the degree of impairment in percentage terms, where 1 corresponds to no limitation, and 0 corresponds to total incapacitation in that dimension. Then, redefine wages as

$$\begin{aligned} w_t &= \pi(x_t) q(x_t, h_t) exp(\eta_t). \\ &= \pi(x_t) exp(\theta'(x_t) h_t + \eta_t), \end{aligned}$$

where $h_t = s_t \cdot x_t$.[13] Importantly, wages depend on the dot product of the current stock of skills and the disability vector. This captures the immediate effect of disability onset on productivity, keeping occupation fixed. In the absence of any disability $d_t^j = 1,\ \forall j \in \{1, ..., k\}$ and $q(x_t, h_t) = q(x_t, s_t)$. For any $d_t \neq 1$, optimal pre-onset sorting implies that $q(h_t, x_t) < q(s_t, x_t)$, and the associated wage loss is the size mismatch between "effective skills" and skill requirements scaled by the market valuation of output from this occupation, $\Delta w = (q(s_t, x_t) - q(h_t, x_t))\pi(x_t)$. Or alternatively, the disability-induced mismatch is the weighted sum of the difference between the elements of s_t and $d_t s_t$, where weights are the implicit skill prices, θ, multiplied by the market valuation of these tasks, $\pi(x_t)$.

Certain dimensions of human capital will be more affected by specific types of disabilities. To illustrate, researchers often specify the human capital vector to consist of physical and cognitive skills and occupations to consist of physical and cognitive tasks (Yamaguchi, 2012; Sanders et al., 2012; Mori, 2019). Additionally, assume that a physical disability only affects the stock of physical skills, and a cognitive disability only affects the stock of cognitive skills. The resulting impact on earnings of a given type of disability will depend on two factors. First, some tasks are more important in certain occupations than others. For instance, the productivity of a labourer will have a higher dependence on physical tasks relative to cognitive tasks, which

[12] This aligns with Roy's workhorse framework and the life-cycle model of Yamaguchi (2012) (Roy, 1951).

[13] This takes a specific stance on the relationship between health and human capital. Health is generally viewed as complementary to human capital, and researchers have taken various approaches to formalizing the relationship between the two. For instance, Grossman (2017) models health capital as affecting the amount of productive time, Hanushek and Woessmann (2008) discusses a model of human capital inputs that depend on health among other inputs to skill production, and Mori (2019) considers multidimensional health capital and human capital as being complimentary in human capital productivity.

is captured by θ. Second, the market values the output of certain tasks more than others.[14] For example, if output produced by highly intensive cognitive skills, such as the services of a lawyer, are priced higher by the market, a cognitive disability may result in greater wage scarring for a lawyer compared to an equally severe physical disability.[15] Alternately, the onset of a physical disability may be disastrous for the productivity of a manual labourer and may not meaningfully affect a lawyer's productivity. Hence, the market pricing of physical skills relative to cognitive skills will contribute to the differential impact of disability types on employment income.

A disability shock today can have lasting dynamic effects on earnings through the process of skill accumulation. To illustrate, I follow Yamaguchi (2012) and assume that skills grow from period t to t+1 according to

$$s_{t+1} = Ds_t + a_0 + A_1 x_t + A_2 d_t + \epsilon_{t+1}.$$

The matrix D captures the depreciation rate of skills between periods, b_t allows individual characteristics to affect skill accumulation, and ϵ_{t+1} represents idiosyncratic shocks to skills. The matrix A_1 represents a"learning-by-doing" technology of human capital production, where higher task complexity in a particular dimension results in more rapid skill production in that dimension. The off-diagonal elements of the matrix capture complementarities in skill production across tasks. Similarly, the onset of a disability in t results in a permanent shock to skills in t+1, the scale of which is captured by the matrix A_2. The diagonal elements of A_2 represent the direct effects of limitation in a dimension, and off-diagonal elements capture complementary effects. For instance, the onset of a physical disability in t may result in positive complementarities for cognitive skill development, indicating potential compensatory efforts to overcome the physical limitations. Assuming no occupational change, substituting in for previous period skills,

$$s_{t+1} = D^{t-n} s_{t-n} + \sum_{j=0}^{n} D^j A_1 x_{t-j} + \sum_{j=0}^{n} D^j A_2 d_j + \sum_{j=0}^{n} D^j \epsilon_{t-n+1},$$

which shows that in period t, the dynamic effect of a disability which onset in period t-n is $\sum_{j=0}^{n} D^j A_2 d_j$.

Predicting the full extent of the effects of disability onset on incomes and labour market behaviour

[14]The human capital literature on task-specific human capital typically finds a higher market valuation to output produced by cognitive tasks, relative to physical (Poletaev and Robinson, 2008; Yamaguchi, 2012; Sanders et al., 2012; Lise and Postel-Vinay, 2020)

[15]Research on the effects of different types of health conditions or disabilities typically finds heterogeneity in their impact on productivity, earnings, among other outcomes. These studies often find that disabilities with a degree of cognitive impairment are more detrimental to economic welfare than physical or sensory disabilities. For example, see Case et al. (2005); Lundborg et al. (2014); Mori (2019).

requires embedding the aforementioned wage and skill transition process within a life cycle labour-leisure framework. Formalizing such a model provides the theoretical basis for predicting labour supply responses to disability-induced wage shocks. For instance, in the neoclassical labour supply model, where leisure is a normal good, substitution effects following wage loss predict decreases in labour supply. In contrast, income effects predict increases in labour supply. However, a disability shock may influence these effects and consequently affect the reoptimized labour supply. A disability may alter the marginal utility of consumption and the marginal cost of work (Cutler et al., 2006; Low and Pistaferri, 2015). Additionally, the relative value of non-participation may increase when disability status gives eligibility to social insurance programs, such as disability insurance. Hence, the income effect may be offset by an increase in the outside option to work. The labour response depends on the extent of wage loss from disability-induced mismatch and the ability to substitute to occupations that better match the post-disability skill vector. Lastly, the aforementioned analysis assumes the absence of market frictions, which may lead to situations where the pre-disability job does not maximize the match function q and create challenges in transitioning to new occupations following disability onset.[16] For instance, observed behavioural changes might result from additional costs associated with disability, labour market risks, and discrimination.[17] Formalizing such a model is outside the scope of this paper and is left for future work.

3 Institutional Setting

The policy environment in Canada is comprised of various programs at the provincial and federal levels. These can be partitioned into social security programs for the retired and elderly, economic security programs for families, targeted insurance for specific economic shocks, and welfare programs to fight poverty.[18] Moreover, the Canadian tax system offers economic support for families and individuals with a disability through various tax credits and benefits.

For the population affected by disability, these programs provide income insurance for earnings lost because of their disability, rehabilitation for reintegration into the workforce, and welfare transfers for individuals unable to reintegrate (Torjman and Makhoul, 2016). Programs differ in their eligibility requirements, the screening of the population covered, the duration of aid provided, and the generosity of aid provided.

[16]The implications of disability onset are most likely to be similar in a setting with market frictions. However, the worker-job match at the time of onset may not be efficient in the sense of optimizing wages for a worker. Guvenen et al. (2020) consider an environment where information frictions about one's ability results in a mismatch. Lise and Postel-Vinay (2020)

[17]Kitao (2014) studies disability-specific labour market risks. Baldwin and Johnson (2006) survey research on disability-related discrimination in the labour market.

[18]My population of interest is working-aged adults, so I will not focus on social security and old-age security programs.

In this paper, I distinguish transfers most relevant for individuals affected by disability. These "disability-relevant" programs include disability-specific tax credits and income replacement programs from worker's compensation, employment insurance, federal disability insurance, and provincial social assistance programs. This section outlines the main features of these disability-relevant programs.

The federal pension program in Canada, the Canadian Pension Plan (CPP), administers disability insurance, which delivers monthly financial transfers to individuals that are deemed eligible for the program. Eligibility requires that recipients be younger than 65, are not currently receiving CPP retirement benefits, have made a predetermined number of contributions to CPP, and are markedly restricted by a physical or mental disability.[19] Importantly, to receive CPP-D, an applicant must prove that their disability is both prolonged and severe. A disability is prolonged if it is expected to be indefinite or likely to result in death.[20] The severity of the disability concerns the applicant's ability to engage in "substantially gainful activity" in the labour market. Substantially gainful is subjectively determined based on an applicant's perceived productivity in the labour market, given the barriers imposed by their disability.[21]

The generosity of disability insurance equals the sum of two components. The first component is equal to 75% of the applicant's potential CPP retirement benefits at the date of application. Potential CPP retirement benefits are equal to 25% of the earnings index that summarizes an applicant's bounded average earnings over their contributory period.[22] The minimum bound to their earnings has been \$3,500 per year since 1996, and the maximum, which was \$55,900 in 2018, is updated yearly based on a measure of average wages. The second component is a deterministic flat-rate benefit indexed by the CPI each year.[23]

Provincial social assistance programs provide means-tested antipoverty relief for individuals with barriers to sustained employment and who have insufficient or volatile sources of income. Each province separately administers its own social assistance program. As such, these programs vary by province in eligibility criteria and generosity of transfers. However, all provinces have a similar structure to their social assistance programs (Employment and Social Development Canada, 2016). The generosity of aid is based on a means

[19] The contribution requirement is that applicants must have contributed to the CPP in four of the previous six years or three of the previous six years if the applicant has contributed to the CPP for twenty-five years or more. Contributions are mandatory if employed and earning above a specified threshold. The size of contributions to CPP determines the generosity of disability insurance transfers. The contributory period begins at age 18 and ends at age 65 or the year of death and excludes years in which the applicant was receiving CPP-D benefits.

[20] Disability insurance is a program for long-term disabilities and not designed to insure against short-term injuries.

[21] That is, how productive a disabled individual is in a job they could be expected to hold given their qualifications relative to others doing the same work but who do not have a disability. Adjudicators account for an individual's personal characteristics when determining an individual's capacity for substantial gainful activity. Most notably, personal characteristics include age, education, and work experience (Government of Canada, 2022).

[22] The earnings index is a similar object as the average indexed monthly earnings used by the Social Security Administration in the United States.

[23] In 2018, the average disability insurance transfer amount was just under \$1000 per month, half of which was the deterministic flat rate component (Employment and Social Development Canada, 2018).

test, which calculates the net difference between an applicant's "assessed needs" and their financial assets. An applicant is deemed eligible if their assessed needs exceed the sum of their income and assets, up to an upper threshold. An applicant's "needs" may include living expenses, family size and composition, and disability status. On the other side of the means test, an applicant's financial assets include liquid assets, such as cash or convertible assets, and fixed assets, such as property. Exempt assets include those used for employment or transport, such as tools or automobiles, and assets related to savings plans used for education purposes, such as registered education savings plans. The combined fixed and liquid assets must not exceed a predetermined threshold, which varies by provincial jurisdiction. Assessed income combines all earnings from market activities, such as paid employment or self-employment, and transfers from other government programs, such as disability insurance.[24] Beneficiaries of social assistance typically receive monthly financial transfers equaling a basic assistance amount and, in some cases, a special assistance amount. The basic assistance amount covers the costs of living, such as food, shelter, and clothes. A disability may create additional living expenses, and all provinces allocate additional resources available for individuals affected by a disability. Additional details on SA programs can be found in Employment and Social Development Canada (2016) or Hillel et al. (2020).

Worker's compensation provides income replacement paid in respect of an injury, disability, or death to a worker. The main idea of worker's compensation programs is that workers receive insurance for injuries on the job in exchange for forgoing the right to sue the employer. Each province and territory in Canada has its own worker's compensation board/ commission (WCB). WCBs are funded by employers, who pay a certain dollar amount called a "premium." These premiums differ provincially and by industry within that province. Premiums are a fixed amount out of every 100 dollars of payroll. Also, the rate paid depends on each employer's experience rating, which summarizes the number of injuries in that workplace. Premiums go into an accident fund and the resources from the fund may be used to provide wage loss benefits, medical aid, rehabilitation, or to pay for the program's administration. Monies paid to injured workers by WCB are known as benefits. The most common types of benefits are the replacement of lost wages and compensation for permanent disability. Benefits may also be paid out for rehabilitation or for dependent spouses of people who died on the job. Maximum compensated earnings in the provinces range from $52000 to no maximum. The percentage of pre-injury earnings that determine generosity of benefits varies between 75% to 90%.

Disability insurance and social assistance are the primary sources of income assistance for general dis-

[24] Individuals may receive social assistance while earning from other sources, but this may reduce benefits according to the program's replacement rate. SA may be revoked if sufficient effort is not taken on the beneficiary's part to receive income support from other sources.

ability shocks in Canada, and worker's compensation is the main program for workplace injuries. Another source of monetary support is the Disability Tax Credit. The disability tax credit is a non-refundable tax credit that reduces the income tax individuals with disabilities have to pay. Eligibility is similar to disability insurance in that applicants must show they have a severe and prolonged impairment. However, the disability tax credit does not depend on employment histories.[25]

A final relevant federal program is employment insurance, which provides short-term income replacement for individuals laid off from their job. Employment insurance is typically allocated to individuals experiencing structural, seasonal, or cyclical employment. However, individuals unable to work for medical reasons can also apply, granted they prove their medical condition and inability to work. Beneficiaries can receive up to 55% of their earnings, to a maximum of 650$ per week, for up to fifteen weeks.

Canada's second main category of government transfer programs are designed to aid families with the costs of raising children. At the federal level, parents may apply for tax-free monthly transfers through the Canada Child Benefit. This is a means-tested program, and the generosity of payments depends on the number of children, their ages, and the total income of the household. In 2021, beneficiaries could receive up to 570$ per month for each child under the age of six and 480$ for each child aged size to seventeen. Moreover, Canadian families may receive supplementary benefits from provincial governments.

4 Data: The Longitudinal and International Study of Adults

To estimate the longitudinal effects of disability types, I use the Longitudinal and International Study of Adults (LISA). LISA is a panel survey of over 11,000 Canadian households aged 15 and older. LISA consists of four biennial survey waves, starting in 2012, that cover a broad range of topics, including health, education, the labour market, social participation, and income. These data allow me to identify individuals with disabilities, the types of activities limited by the disability, and the timing of onset. Moreover, LISA is supplemented with several administrative datasets. Most relevant are the T1 family files (T1FF), which contain rich disaggregated measures of personal income and transfer payments from individual annual income tax filings.

The T1FF spans from 1982 to 2017 and is linked to each respondent in the main survey waves of LISA. These data contain details on an individual's demographic characteristics relevant to their tax filings, such as age, marital status, province of residence, and the number of children. A notable advantage of these tax

[25] Additionally, the federal government introduced the Working Income Tax Benefit in 2007. This program is intended to raise the income of low earners. As people with disabilities are often at the lower end of the earnings distribution, this program targets relatively more disabled.

records is that they are less likely to suffer from the measurement and coverage issues often associated with survey data. For instance, Meyer et al. (2009) show that survey measures of public transfers often suffer from respondents under-reporting, which can lead to overestimation of total income declines following the onset of disability.

For this analysis, the outcomes of interest are the components of market income, government transfers, total before- and after-tax income, and income of family members. Within market income, I focus on paid employment income in the form of wages, salaries, and commissions (WSC), which are by far the largest component of market income and are the most directly related to one's human capital. I use this to define a measure of labour market participation, where I flag someone as a market participant in a given year if they have any positive WSC in that year. Moreover, I analyze changes in the combination of self- and other employment income to explore substitution to other earnings activities. Within government transfers, I distinguish disability-relevant transfers, which are the sum of programs outlined in the institutional background section, from transfers that target families. Total before-tax income combines market income and government transfers, and total after-tax income represents the market income and government transfers individuals take home after taxation. The difference between these two reveals the buffering effects of the tax system. Last, family total income combines total before-tax incomes for all members of one economic household. I also consider a measure of family members' income, which nets out an individual's total before-tax income from the family's total income. For a more detailed breakdown of the income concepts covered in these data, please refer to Section 2 in the Appendix.

4.1 Measuring disability

The 2014, 2016, and 2018 survey waves of LISA include measures of activity limitations and other characteristics of health conditions used to derive disability status.[26] The set of limitations to daily activities included in LISA is derived from the short version of the "Disability Screening Questions," a survey model developed by Statistics Canada for use in general population surveys (Grondin, 2016). This model distinguishes five main areas of activity limitation: Seeing, Hearing, Physical, Cognitive, and Mental Health. Physical combines limitations to mobility, flexibility, dexterity, and pain. Cognitive disabilities combine developmental disabilities, limitations to learning, such as dyslexia or hyperactivity, and limitations to memory and concentration.[27] Mental health conditions encompass many emotional, psychological, and mental health

[26]The 2012 wave comprises only a small set of questions about the disability. Notably, the 2012 wave excludes the variable determining the age of disability onset.

[27]It is important to note that developmental disabilities such as Down syndrome, Autism spectrum disorder, Asperger syndrome, or brain damage due to lack of oxygen at birth typically manifest early in life rather than as late-onset disabilities.

conditions, including anxiety, depression, bipolar disorder, substance abuse, and anorexia.[28]

The first section of my empirical analysis distinguishes heterogeneity by two mutually exclusive aggregated disability types, aggregate physical and mental-cognitive. The distinction between conditions that inhibit physical tasks from those impacting cognitive or socioemotional tasks is common in the literature on the heterogeneous effect of disability.[29] Moreover, a similar distinction is often made with respect to productive tasks and human capital in labour economics.[30] A simple correlation matrix amongst the disaggregated activity limitations supports these aggregate groupings.[31] Moreover, labour market and demographic descriptive statistics and outcomes are more similar among activity limitations within physical than with cognitive and mental health. Similarly, these statistics are similar amongst the limitations and conditions within cognitive and mental health disabilities. However, this aggregation can mask underlying heterogeneity across the specific activity limitations within these categories.

The second part of my empirical analysis explores heterogeneity within the aggregate disability types. Within physical, I distinguish disabilities to one's kinetic ability, which combines activity limitations related to mobility, flexibility, and dexterity, from disabilities related exclusively to pain.[32] Additionally, I separate mental-cognitive into disabilities related to cognitive functioning (learning, memory, or concentration), from disabilities related exclusively to mental health. Distinction along these margins of activity limitation is policy-relevant, as mental health-related disabilities and pain-related disabilities have driven rising applications to disability programs (Autor, 2015b). Moreover, this study provides novel estimates on the effects of mental health conditions, which are becoming increasingly more recognized as significant impediments to economic independence (Frank and Glied, 2023).

The activity limitations are self-reported in LISA. For each type of activity limitation, respondents are asked a flow of categorical questions about the magnitude of difficulty and frequency of limitation for each limitation type.[33] The short version of the DSQ flags disability based solely on the reported frequency of limitation. A respondent is flagged for a type of disability if reporting their condition to limit their activities

[28]More details on the survey questions can be found in Section 1 of the Appendix.
[29]See footnote 8.
[30]See footnote 9.
[31]That is, mobility, pain, dexterity, and flexibility limitations are positively correlated with each other and negatively correlated with limitations due to mental health and cognitive functioning. Limitations to mental health and cognitive functioning are positively correlated with each other and negatively correlated with physical limitations.
[32]Kinetic ability describes the body's ability to move efficiently, exhibit agility, and perform tasks that require coordination and precision. Kinetic abilities include walking, running, jumping, bending, twisting, reaching, grasping, and manipulating objects.
[33]Some cognitive conditions, such as developmental disability or learning conditions, are initially flagged based on diagnosis from medical professionals instead of the level of difficulty. Refer to Section 1 in the Appendix for details.

"sometimes," "often," or "always."[34] The age of disability onset is derived from a self-reported retrospective question,"at what age did you first start having difficulty or activity limitation?" I interpret all disabilities as persistent between the survey years and the year of reported onset. Due to the retrospective nature of this question and the panel structure of the survey waves, there are instances where an observation reported different ages of onset. To address this, I use the minimum reported age of onset as the truth.

Related studies into variation in the effects of disability often consider heterogeneity by the severity of their impairment.[35] Unfortunately, the severity of a disabling condition at the time of onset is unobserved in these data. Instead, I only observe measures of self-reported severity at the time of the survey. However, as I flag disability based on any positively reported activity limitation, the disabled population in this study is a relatively broad coverage. This approach minimizes the type 2 error of incorrectly flagging someone as not disabled when they have a disability in truth. Although, my disabled population will include individuals with milder conditions that may not be considered disabled in other settings. Consequently, I interpret my results as a lower bound to the average effects of disability onset.

Much research in health economics has focused on the validity of self-reported measures of one's health. One concern relates to the inherent subjectivity of how one assesses their own health. For example, two otherwise identical individuals may differ in the reported severity of their disability. Additionally, critics of self-reported health measures argue that individuals may exaggerate the existence or severity of their health condition to justify poor economic outcomes or attachment to government programs, a phenomenon referred to as justification bias. The evidence on the endogeneity of self-reported health measures and the extent of measurement error are mixed (Black et al., 2017). Although, it is important to note that recent articles tend to find evidence for state-dependent reporting.[36]

My disability measure is derived from a respondent reporting any positive limitations to a specified activity and abstracts from the degree of impairment. This approach mitigates concerns related to subjectivity in the scale of impairment from a self-reported activity limitation, as I do not distinguish conditions along the severity margin. Moreover, much of the evidence on justification bias is based on broad questions

[34] I flag disability based on the frequency of limitation alone, as there are inconsistencies in questions about the magnitude of difficulty across the survey waves.

[35] Some examples of studies estimating the heterogenous labour market effects of disability by some measure of severity include Stern (1989), Burkhauser et al. (1993), Acemoglu and Angrist (2001), Charles (2003), Baldwin and Johnson (2006), Campolieti and Riddell (2012), Low and Pistaferri (2015), Ameri et al. (2018), Meyer and Mok (2019), and Kostøl et al. (2019)

[36] It has been found that self-reported disability is close to exogenous, may actually under-represent the extent disabled population, and may even underestimate the true impact of disability on relevant labour market outcomes (Stern, 1989; Bound and Burkhauser, 1999; Burkhauser et al., 2002). Others have found evidence of justification bias related to labour market states inflating the prevalence of health conditions (Benítez-Silva et al., 2004; Baker et al., 2004; Black et al., 2017). Moreover, alternate approaches to identify individuals with disabilities, for instance, by using disability insurance beneficiaries to define the population with a disability, have been found to under-represent the population of individuals who are limited enough in the labour market to be classified as "disabled" (Bound, 1989)

about one's health or disability, such as "do you have a medical or physiological condition that impairs the type or amount of work you can do." The questions about activity limitations in this survey are linked to specific tasks, such as walking on a flat surface for fifteen minutes, grasping a small object like scissors, or experiencing ongoing memory problems or periods of confusion. Additionally, the presence of some activity limitations is elicited based on whether the respondent has been diagnosed with a specific condition, such as a learning or developmental disorder, by a healthcare professional.[37] Last, mental health is identified using specific examples of diagnoses, such as anxiety, depression, bipolar disorder, or anorexia. These approaches narrow the scope of justification bias to be anchored to the activities in question, base the existence of a limiting condition on the diagnosis of a medical professional, or frame limitations related to mental health with specific examples of diagnoses. I follow much of the related literature and take the responses to questions on limitations to daily activities as given. However, I acknowledge the empirical concerns that are inherent to any self-reported measures of health.

4.2 Sample Selection

I observed detailed information on disability types and onset in the 2014, 2016, and 2018 survey waves. I retain the 2012 wave to extract relevant demographic information and survey weights that are representative of the Canadian population in 2012. I choose to omit individuals who are blind or deaf because of small sample counts and only focus on the mental-cognitive and physical types of disabilities.[38] I restrict my sample to individuals aged 22-61 who have been observed for at least four years. I replace missing demographic information using adjacent survey waves and drop observations that are missing key demographics.[39] I drop observations whose reported onset is younger than 23 or greater than 56 to focus on disability shocks in working life and abstract from retirement incentives. Additionally, I drop individuals whose disability onset occurred before 1984, and I trim year observations more than ten years after disability onset. I exclude observations living in the Canadian Territories. I include both males and females in my sample to increase the size of the ever-disabled sample, and I include rich controls for sex in the empirical framework.[40] The final sample includes working-aged individuals living in the Canadian provinces that ever and never become disabled, the latter serving as the control group.

[37] This type of question has been used to assess the validity of self-reported health measures in Baker et al. (2004)

[38] I explored these conditions in some analyses, but the results are mostly insignificant due to the small sample size.

[39] Notably, education level and date of completion are filled in when able, keeping in mind that observations can complete their education during the span of the survey.

[40] The trade-off of including both sex's is that males and females may have different experiences in labour market factors, which I control for in the empirical specifications. That said, the general results hold when conditioning on male or female, although there are some differences in magnitude of effects for some outcomes, which should be mitigated by the rich controls included in the estimating specification.

4.3 Summary/ Descriptive statistics

The sample of individuals ever experiencing a disability is selected, as one's unique life experiences and economic situation expose them to differing risks of disability onset. These factors must be accounted for in the empirical analysis to isolate the effect of disability. For example, a highly educated individual, such as a lawyer or surgeon, may have a higher risk of developing a cognitive disability related to work stress. At the same time, a low-skilled labourer may be more susceptible to a physical disability due to strain on their body. Such relationships manifest into a socioeconomic status (SES)-health gradient, the nature of which may differ by disability type.

Table 1: Prevalence of Disability and Distribution of Types

No Disability		0.816
Disabled		0.184
Aggregate Physical		0.587
	Non Mutually Exclusive	
	Mobility	0.391
	Flexibiltiy	0.359
	Dexterity	0.136
	Pain	0.757
	Mutually Exclusive	
	Exclusively Pain	0.377
	Kinetic Ability	0.623
Cognitive		0.103
	Mutually Exclusive	
	Exclusively Mental Health	0.681
	Exclusively Cognitive Functioning	0.183
	Both	0.137
Concurrent		0.311

Note: The sample reflects working age (25-55) Canadians from provinces who have or have not experienced a late onset disability. Survey weights have been applied so the sample reflects the demographic composition of Canada in 2012.

Table 1 shows the proportion of the population with a disability and the distribution of types within the people with disabilities. 18.4% of the sample reports the onset of an activity limitation during working life. The majority of these are physical in nature, accounting for 58.7% of cases. Mental-cognitive disabilities make up 10.3% of disabilities, while 31.1% are concurrently physical and mental cognitive.

There is a strong correlation among the activity limitations underlying physical disabilities. Limitations to mobility, flexibility, and dexterity are often present simultaneously. Moreover, three-quarters of individuals with a physical disability report some degree of pain-induced limitation. Differentiating the limitations within aggregate physical disabilities into mutually exclusive groups reveals 37.7% of physical disabilities are due exclusively to pain, whereas 62.3% have some impairment to kinetic ability. Limitations exclusively related to mental health comprise approximately two-thirds of mental-cognitive disabilities. Disabilities related to cognitive functioning that onset in working life are less common, accounting for about one-third of mental-cognitive disabilities.

Table 2 shows how demographic characteristics differ by disability status and across the aggregate disability types. The first two columns compare statistics between individuals with disabilities and the never-disabled control sample. Individuals who ever experience a disability shock have lower average education levels, are more likely female, and have a lower likelihood of marriage. The lower section of Table 2 reports the predicted average labor market outcomes before onset from models controlling for age and age squared and evaluated at age 40. Individuals who ever experience a disability shock exhibit lower employment levels, less employment income from wages, salaries, and commissions, and receive more government transfers. Once again, these findings are consistent with a disability-related SES-health gradient.

The rightmost three columns in Table 2 compare statistics based on mutually exclusive aggregate disability types. The average age of individuals with a physical disability tends to be higher, and the onset of physical disabilities occurs at older ages relative to mental-cognitive disabilities.[41] Mental-cognitive and concurrent disabilities drive lower marriage rates or common law status rates amongst the population with disabilities. However, this difference may be related to other characteristics, such as the age of those with cognitive disabilities. Individuals experiencing mental-cognitive disability tend to have higher education levels than those with aggregate physical disabilities and the never-disabled sample.

Key differences in income and employment prior to onset by aggregate disability types are also highlighted. Individuals experiencing an aggregate physical disability are less likely to be employed and earn less than those who never receive a disability. Conversely, individuals who experience a mental-cognitive shock exhibit similar employment and pre-onset earnings as the never-disabled group. Once again, these patterns are consistent with different exposure risks associated with various occupations and demographics. Individuals experiencing mental-cognitive disabilities tend to work more, have higher earnings prior to onset, and receive

[41]The average age of onset for concurrent disabilities falls in between physical and cognitive disabilities. However, I do not observe which condition occurred first or if both types of disabilities occurred simultaneously.

Table 2: Demographic Summary Statistics by Disability Status and Aggregate Disability Type

	No Disability	All Disability	Aggregate Physical	Mental-Cognitive	Concurrent
Age	37.6	38.6	39.8	34.6	37.8
	(8.7)	(7.1)	(7.1)	(6.3)	(6.7)
Age of Onset	-	42.1	43.5	37.6	40.7
		(9.4)	(9.1)	(9.2)	(9.2)
Female	0.488	0.578	0.563	0.592	0.601
Dropout	0.064	0.117	0.119	0.041	0.138
High School	0.181	0.209	0.203	0.172	0.231
Post Secondary	0.750	0.667	0.674	0.783	0.618
Married	0.719	0.647	0.722	0.634	0.510
Number of Children	0.8	0.7	0.7	0.9	0.6
	(1.1)	(1.0)	(1.0)	(1.1)	(0.9)
Pre-Onset					
Labour Market Participation Rate	0.845	0.796	0.808	0.843	0.756
Wages, Salaries, and Commissions	46,770	37,389	37,998	42,022	34,648
Total Government Transfers	2,181	3,038	2,778	2,380	3,806
Disability Relevant Transfers	1,188	1,857	1,683	1,229	2,429
Family Transfers	900	1,044	976	1,053	1,189
Family Total Income	102,909	80,518	82,396	90,931	73,253
After-Tax Income	44,271	36,482	36,860	40,318	34,485

Note: Standard deviations are in parentheses. The sample reflects working age (25-55) Canadians from provinces who have or have not experienced a late onset disability. Survey weights have been applied so the sample reflects the demographic composition of Canada in 2012. Pre-onset outcomes derived from OLS regression controlling for 2nd order polynomial in age.

fewer disability-related transfers, primarily driven by other sources of support.

In Table 3, I contrast differences by the more granular disability types.[42] Within aggregate physical, individuals with exclusively pain-related conditions tend to have higher levels of education and earn more through employment prior to the onset of their disabilities. The opposite is true for disabilities related to

[42] Demographic characteristics and pre-onset incomes and employment are very similar across mobility, flexibility, and dexterity activity limitations.

Table 3: Demographic Summary Statistics By Disability Types Within Aggregate Groupings

	Exclusively Mental Health	Cognitive Functioning	Kinetic Ability	Exclusively Pain
Age	33.8	36.3	40.88	37.9
	(6.1)	(6.4)	(7.15)	(6.51)
Age of Onset	36.9	39.3	44.51	41.89
	(9.1)	(9.3)	(8.74)	(9.47)
Female	0.646	0.477	0.576	0.540
Dropout	-	-	0.149	0.070
High School	0.213	0.226	0.219	0.178
Post Secondary	0.787	0.774	0.630	0.746
Married	0.645	0.611	0.700	0.758
Number of Children	0.9	0.8	0.59	0.8
	(1.1)	(1)	(0.95)	(1.07)
Pre-Onset				
Labour Market Participation Rate	0.857	0.819	0.811	0.804
Wages, Salaries, and Commissions	43,444	40,933	36,011	41,587
Total Government Transfers	2,192	2,739	3,005	2,391
Disability Relevant Transfers	1,066	1,534	1,884	1,333
Family Transfers	1,029	1,115	984	967
Family Total Income	92,579	89,162	78,634	88,788
After-Tax Income	41,314	39,809	34,285*	

Note: Standard deviations are in parentheses. The sample reflects working age (25-55) Canadians from provinces who have or have not experienced a late onset disability. Survey weights have been applied so the sample reflects the demographic composition of Canada in 2012. Pre-onset outcomes derived from OLS regression controlling for 2nd order polynomial in age.

kinetic ability. This observation is intriguing because it shows opposite signs for the SES-health gradient among individuals experiencing limitations to their kinetic ability compared to exclusively pain.

Within mental-cognitive, disabilities due exclusively to mental health limitations tend to manifest earlier in working life than cognitive functioning. Disabilities in cognitive functioning tend to be related to work or aging, and mental health conditions are more likely related to work or diseases.[43] Additionally, a higher proportion of females experience mental health disabilities, but there are no noticeable differences in family composition between the two groups. In terms of socioeconomic factors, both mental health and cognitive disabilities have comparable levels of education, employment, and income before the onset of their disability. However, there are notable differences in the attachment to government programs before the reported onset. Individuals limited in cognitive functioning tend to rely more on disability-related transfers provided by the government.

These summary statistics highlight observable differences in demographic characteristics across the types of disabilities. These demographics are directly related to the levels and components of personal income. These demographics will need to be controlled for in the empirical section so as not to confound the effects of disability. In the next section, I outline the empirical framework used, which controls for these observable differences, as well as unobservable differences, in the ever and never-disabled populations to better isolate the effects of the types of disability.

5 Empirical Framework

I estimate the effect of disability types in each of the $k \in \{-5, ..., 10\}$ years relative to onset using the interaction-weighted (IW) estimator proposed by Sun and Abraham (2021). The IW estimator is one among a surging literature of alternatives to dynamic difference-in-difference and event study estimators that are robust to bias occurring in settings with variation in the timing of treatment and with cohort-specific heterogeneity in treatment effects (Borusyak and Jaravel, 2017; De Chaisemartin and d'Haultfoeuille, 2020; Goodman-Bacon, 2021; Callaway and Sant'Anna, 2021; Sun and Abraham, 2021; Imai and Kim, 2021; Baker et al., 2022; Rambachan and Roth, 2023). My empirical specification explicitly distinguishes heterogeneity in the effect of disability by disaggregated type and by time relative to onset, and the IW estimator is robust to bias that can arise in the presence of treatment effect heterogeneity related to the timing of onset. The IW estimator is a convenient regression-based estimator that has been shown to be as efficient as the alternate proposed estimators for this setting (Baker et al., 2022). I recover my estimates using the Stata command `eventstudyinteract` (Sun, 2021).

To build intuition, I describe the estimand of interest and the identifying assumptions.[44] Following Sun and Abraham's notation, consider a sample of $i \in \{1, ..., N\}$ individuals observed over $t \in \{0, ..., T\}$ time

[43]Descriptive statistics about reasons for onset can be found in Section 3 of the Appendix

[44]Refer to Sun and Abraham (2021) or Rambachan and Roth (2023) for a more in depth descriptions of this estimator.

periods. I observe outcome Y_{it} and treatment status $D^g_{it} \in \{0,1\}$. In my application $D^g_{it} = 1$ if i has a type g disability in period t, and $D^g_{it} = 0$ otherwise. I assume disabilities are permanent, so treatment is absorbing. The time period of disability onset is given by $E^g_i = min\{t \,:\, D^g_{it} = 1\}$, which characterizes the treatment cohort. I represent the observed outcome of individual i, l periods to the onset of disability type g, if onset occurred in period e as $Y^g_{i,e+l}$, and Y^{∞}_{it} as individual i's counterfactual outcome l periods relative to the onset of disability type g if onset never occurred. Now, define the cohort-specific average treatment on the treated l periods relative to disability onset as,

$$CATT^g_{e,l} = E(Y^g_{i,e+l} - Y^{\infty}_{i,e+l} | E^g_i = e).$$

The $CATT^g_{e,l}$'s is the building block of the IW estimator. The treatment effect of interest l periods relative to onset is

$$v^g_l = \sum_e CATT^g_{e,l} \cdot Pr\{E_i = e | E_i \in [-l, T-l]\}.$$

That is, the effect of interest is simply a weighted average of the $CATT^g_{e,l}$'s for that relative period. The weights of interest are the shares of the treatment cohorts in the relative period.

For each disability type, g, and outcome, Y_{it}, the in estimator is implemented in three steps. The first step is to estimate the cohort-specific treatment on the treated, δ^g_l, with the following two-way fixed effect regression,

$$Y_{it} = \alpha_i + \gamma^g_t + X'_{it}\beta + \sum_e \sum_l \delta^g_k A^g_{lit} A^g_{ei} + \epsilon_{it}, \tag{2}$$

where indicator variables for the k periods relative to treatment interacted with cohort indicators estimate a set of $CATT_{e,l}$'s. The A^g_{kit} are indicator variables equaling one in year $t \in \{1982,\ ...,\ 2017\}$, $k \in \{-5, ..., 10\}$ years relative to onset. The A^g_{eit} are indicator variables equaling one in year t if i is in treatment cohort e. The specification controls for individual specific fixed effects, α_i, and time period fixed effects, γ_t. Moreover, the vector X_{it} controls for observable differences between the treatment and control populations. Lastly, ϵ_{it} is a potentially serially correlated error term.

In the second step, the weights of the $CATT_{e,l}$'s are calculated as $Pr(E_i = e | E_i \in \{-l, T-l\})$. Last, the IW estimator is recovered by taking a weighted average of $CATT_{e,l}$'s from the first step and the respective weights from the second step.

5.1 Identifying Assumptions

The main idea for identification is that the control sample of never- and not-yet-disabled individuals are a suitable counterfactual for the treatment group if they had not experienced a disability shock. Causal interpretation of estimates is thus achieved conditional on satisfying assumptions to ensure the control group's outcomes serve as a valid counterfactual to never being treated. This involves assuming parallel trends before onset and no anticipation of disability onset.[45]

The estimation sample includes a large control group of individuals who have never become disabled. A large control sample can be advantageous in addressing collinearity in dynamic event study designs, which can arise when using pre-treatment observations as the control group (Borusyak and Jaravel, 2017). This control group remains the same regardless of disability type of interest. I include a rich set of time-varying controls to account for the differences in populations that never and ever experience a disability onset, shown in Table 2. Following Meyer and Mok (2019), I include a second-order polynomial in age to control for life cycle effects on outcomes. The conceptual framework illustrates how the consequence of disability depends crucially on one's pre-onset skills, so I interact the second-order polynomial in age with education level to control for differences in pre-disability skill types.[46] Moreover, I interact education levels with a second-order polynomial of time since 1989 to control for trends in the effect of skills over time. I control for marital status, sex, and number of children under the age of eighteen, which are determinants of government transfers and tax rates, interacted with second order polynomial's in age and in time since 1989 to account for trends effects from these variables over the life-cycle and over time. Last, I include province dummy variables to control for average differences by province. The empirical specification includes five periods of pre-onset effect, as in Meyer and Mok (2019) and Collischon et al. (2023).

Next, I assume there are no anticipatory treatment effects before disability onset. Violations in this assumption can be addressed by adjusting the treatment period such that the start of anticipatory effects becomes the new treatment date. It is worth noting that significant effects in the year before onset may capture gradual increases in the extent of limitation before the individual becomes labeled disabled, the anticipation of disability, or may reflect measurement error in the reported timing of disability onset. Due to the nature of my data, I cannot distinguish between these phenomena. In the results below, I note the few cases where the treatment timing was adjusted treatment window.

[45] See Callaway and Sant'Anna (2021) or Sun and Abraham (2021) for variations of these identifying assumptions in dynamic settings.

[46] Education categories include high school dropout, college graduate, bachelor's degree, and above a bachelor's degree. I note that pre-onset occupation is an ideal control for pre-disability skills, but this information is not available for the years covered by the T1FF.

Last, my empirical specification explicitly models various dimensions of heterogeneity in effects. First, the dynamic design separately estimates treatment effects in each period relative to disability onset, accounting for heterogeneity in treatment effects across time. Second, I separate the ever-disabled sample by disaggregated disability types and separately estimate a series of models for each type to distinguish heterogeneity by this type. Finally, the IW estimator is robust to any residual contamination that results from cohort-specific heterogeneity in the effect of disability onset. The timing of onset may have occurred between 1984 and 2014. Any changes in labour market structure, such as the composition of jobs and valuation of skills, may induce heterogeneity in the effect of a given type of disability on one's market income, notably their employment earnings. For instance, the shift from manual task jobs to service sector jobs, which may place a greater value on cognitive skills, will alter the effect of the onset of a cognitive disability, as there is less scope to substitute into the more scarce manual jobs. Additionally, changes in the parameters governing social insurance policy over this time frame can also introduce cohort-specific treatment effect heterogeneity.

6 Results

I begin the analysis by comparing the effect of disability types on market income. I then analyze how government transfers respond to partially insure the impact on market income in the years following onset. Lastly, I examine the tax system's role and family members' income as alternate channels for smoothing consumption following the income shock from disability onset. I frame the discussion around the short run, which corresponds to five or fewer years post-onset, and long-run effects, referring to more than five years post-onset.

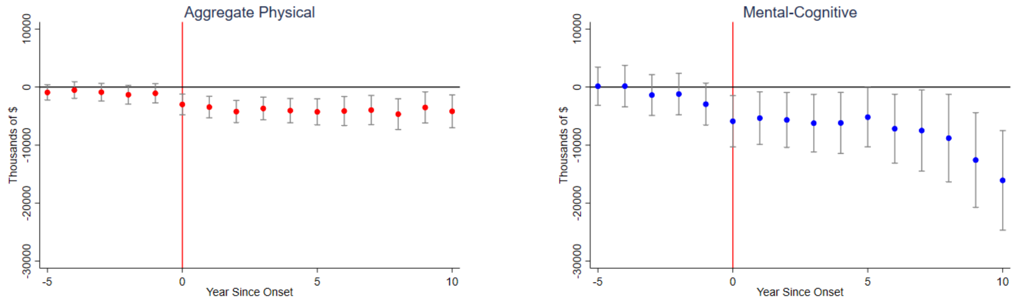
6.1 Market Income

Market income combines all incomes earned through market activities. The largest component is paid employment income in the form of wages, salaries, and commissions (WSC).[47] An individual's employment income is most directly related to their productivity, reflecting the effect of that type of disability on the stock and accumulation of corresponding skills in the human capital vector. Figure 1 plots the point estimates of the average effect of a physical disability (left) and a mental-cognitive disability (right) in each of the $k \in \{-5, ..., 10\}$ years relative to it's reported onset. The vertical lines represent the 95% confidence intervals for each point estimate. The dependent variables for each graph are unconditional WSC (top row),

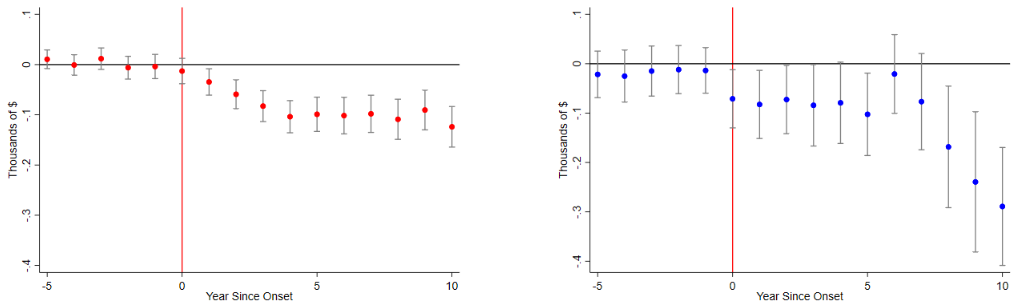
[47] I do not separately analyze market income from business and investment activities, which is only relevant for a small proportion of the sample.

Figure 1: Effect of Aggregate Disability Types on Market Income

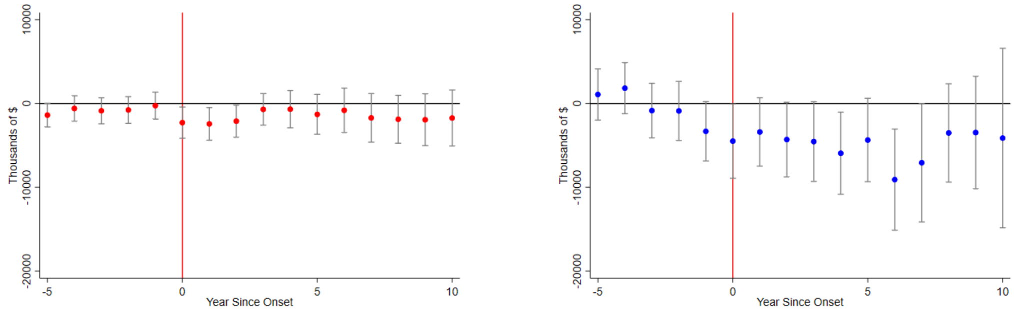
Wages, Salaries, and Commissions (Level)



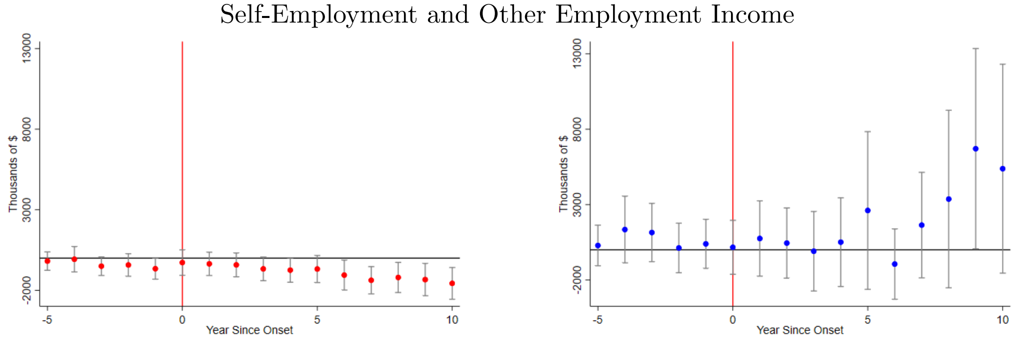
Labour Market Participation



Wages, Salaries, and Commissions for Participants



Self-Employment and Other Employment Income



Note: Figures plot point estimates from an IW estimation, whose specification is outlined in Section 5. The models for WSC are top-coded at the 99 percentile. Underlying estimates for graphs are reported in Appendix 4.

labour market participation (second row), WSC conditional on participation (third row), and the combination of self-employment income and other employment income (bottom row).

The results for total WSC reveal clear differences in the longitudinal effects of aggregate physical and mental-cognitive disabilities following onset. The onset of an aggregate physical disability results in modest reductions in WSC, and the longitudinal profile is flat and persistent. The average effect on WSC is -$3940 in the short and long run. A mental-cognitive disability immediately affects WSC of approximately -$5750 in the short run, which worsens in the long run, culminating to less than -$16000 ten years after onset. It is often valuable to analyze income shocks in terms of the percentage of prior earnings to understand the breadth of the shock.[48] I obtain percentage effects with a back-of-the-hand calculation based on the average pre-onset WSC from Table 2.[49] The implied percentage changes for aggregate physical and mental-cognitive are plotted in Figure 2. The longitudinal path of percentage effects is similar for both aggregate types in the short run, with mental-cognitive disabilities resulting in a 3.7% larger average decline of WSC income than aggregate physical. The percentage effect of mental-cognitive substantially grows in magnitude in the long run, dropping by 38% ten years after onset, which is a 27 percentage point larger decline than that of aggregate physical. The onset of a mental cognitive disability results in a greater loss in the level and proportion of pre-onset income than the onset of an aggregate physical disability, and the difference is substantial in the long run.

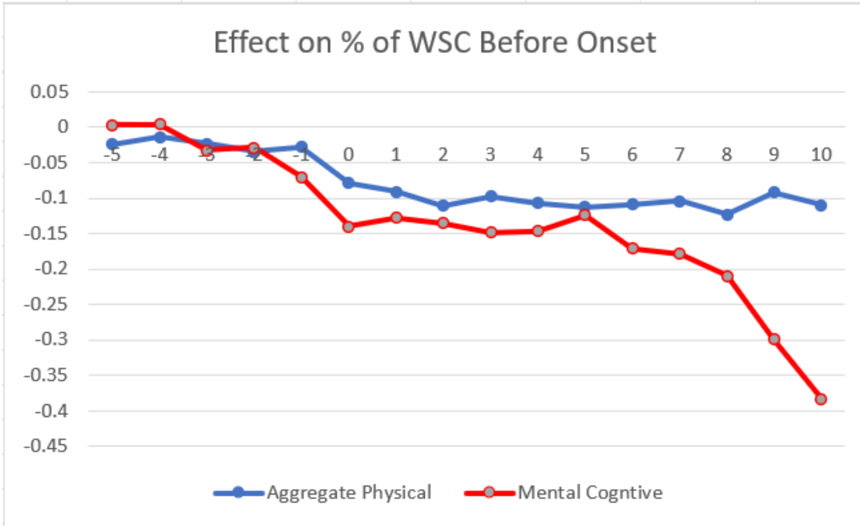
The effects on WSC may result from labour supply responses at the intensive or extensive margin. With a lower return to working, individuals may choose to supply fewer working hours or exit the labour market entirely. As discussed in Section 2, a disability may distort incentives to work by imposing additional costs and barriers to working, such as the need for costly workplace accommodations, or by altering the value of the social insurance environment. The second and third rows of Figure 1 help to discern whether intensive or extensive margin effects drive the results on total WSC. The second row of Figure 1 plots the effects of onset on labour market participation.[50] The third row of Figure 1 plots the estimated effect of onset on WSC

[48] For instance, a $10,000 loss of income is substantially more impactful on someone whose income was $30,000 compared to someone whose income was $300,000.

[49] A more direct approach to obtain estimates of the percentage effects is with a log transformation of the dependent variable or with a Poisson regression. However, each approach results in a loss of observations related to outcome values of zero (for log transformation) or little variation in outcomes (for Poisson regression). This issue causes a residual disclosure risk that can prevent vetting results from the RDC. Moreover, these lost observations are not constant across various income measures, creating a tradeoff in sample sizes if choosing to omit them entirely. However, the back-of-hand calculations of the percentage effects were compared to the estimated effects from a Poisson regression, and there was no meaningful difference in the estimated longitudinal path of effects for the aggregate types. Due to residual disclosure risk, I opted not to extract the results from the Poisson regressions.

[50] These results are robust to defining employment based on lower thresholds of WSC. I check two lower bounds, 3000 and 4000, which are the amount from earning 5$ per hour for 20 hours per week for six weeks or eight weeks, respectively.

Figure 2: Percentage Effect of Aggregate Disability Types on Wages, Salaries and Commissions



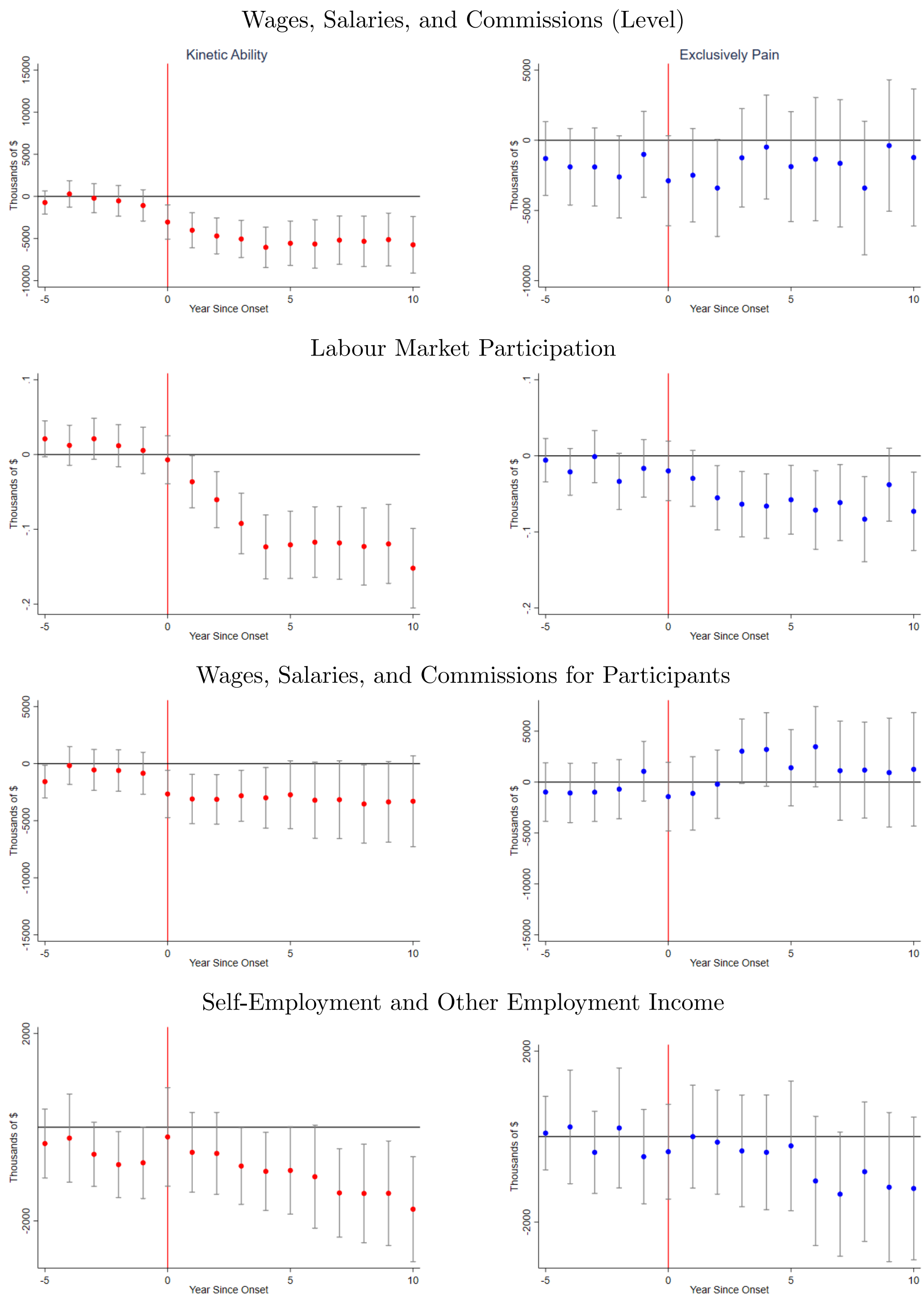
conditional on participation, reflecting the combined effect on wages and the intensive margin.[51] The onset of an aggregate physical disability causes gradual labour market exit in the short run, which persists and flattens out at -8.3% of pre-onset levels into the long run on average. The effect of an aggregate physical disability on WSC for participants is modest in the first couple of post-onset years but is otherwise insignificant and of low magnitude. Hence, the effect of physical disabilities is primarily due to labour market exit at the extensive margin. In contrast, a mental-cognitive disability immediately affects labour market participation, which drops 8.2% on average in the short run and rapidly declines by -29% in the tenth year after onset. The effect of mental-cognitive on WSC for participants significantly falls by -$4500 on average in the short and mid-run, but estimates become noisy and insignificant in the long run. Hence, following the onset of a mental-cognitive disability, the decline of unconditional WSC is primarily driven by labour market exit in the long run. However, participants experience significant effects on their earnings as well, especially in the short run.

Finally, the bottom row of Figure 1 plots estimates from models on market income from self-employment and other employment income. After the onset of a mental-cognitive disability, individuals substitute for other forms of market income. Although, this evidence is noisy and taken as merely suggestive, as the only significant estimate is eight years after onset. In contrast, the onset of a physical disability results in a significant decline in all sources of market income, including self-employment and other employment income.

Relating these findings to the conceptual framework, the results for market income are consistent with a

[51]Unfortunately, I cannot discern between wages and the work hours supplied within the data.

Figure 3: Effect of Disability Types within Aggregate Physical on Market Income



Note: Figures plot point estimates from an IW estimation, whose specification is outlined in Section 5. The models for WSC are top-coded at the 99 percentile. Underlying estimates for graphs are reported in Appendix 4.

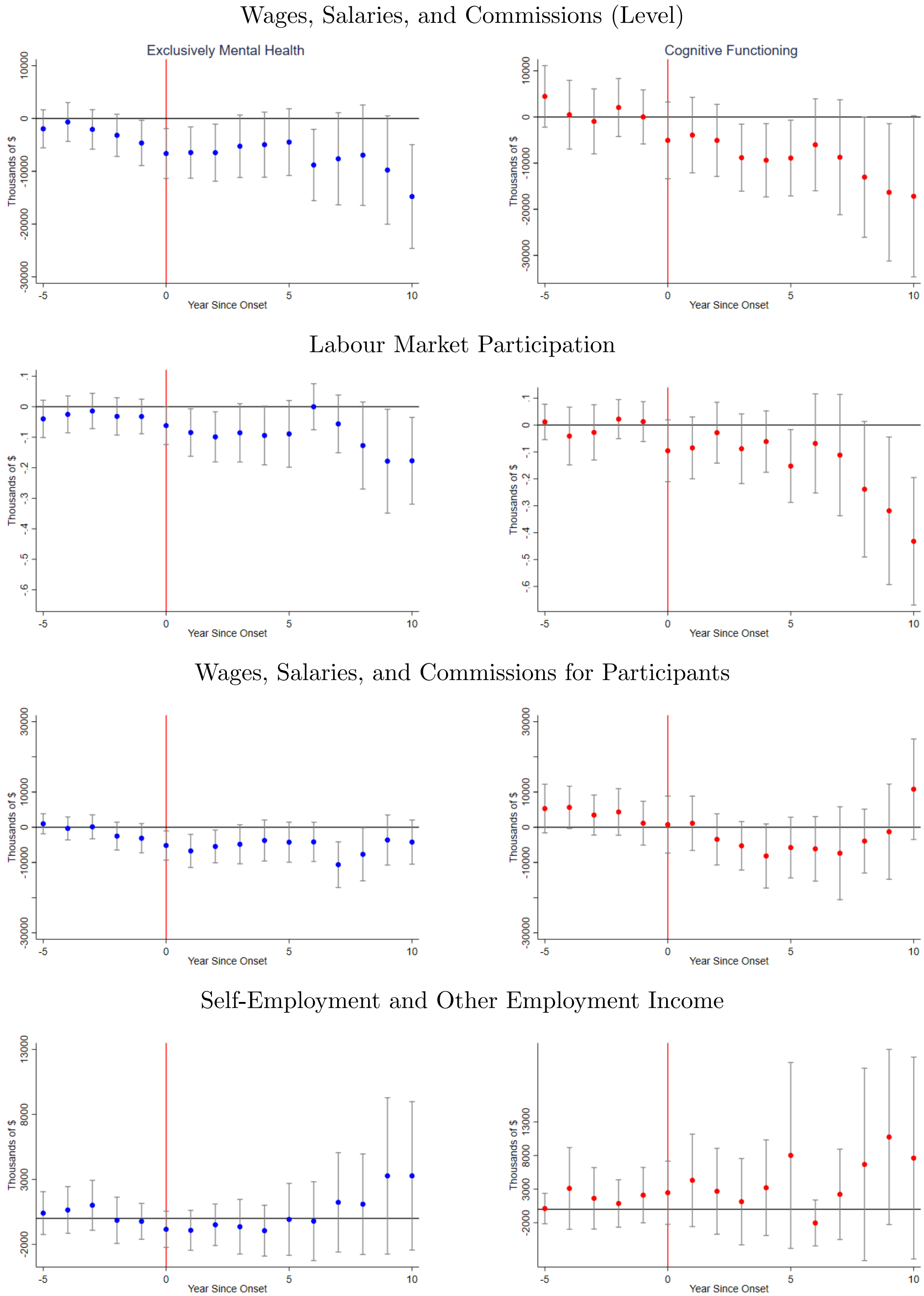
higher market valuation for mental-cognitive skills (π) or a higher implicit skill price (θ) of mental-cognitive skills. These findings are consistent with much of the related literature that finds manual skills to have moderate returns and be more easily adjusted (Yamaguchi, 2012; Lise and Postel-Vinay, 2020; Humlum et al., 2023). In contrast, cognitive and interpersonal skills have higher returns and are more difficult to adjust. Hence, the cost of mismatch following a mental-cognitive disability results in a greater impact on market income and does not rebound as well as a physical disability. Cognitive skills are likely valued more than physical skills in a service-based economy like Canada. Moreover, in Canada, individuals may have greater scope for substituting to work with higher complexity in mental-cognitive tasks following the onset of an aggregate physical disability, given the relative abundance of these jobs. In contrast, jobs with greater complexity in physical tasks are more scarce.

Next, I analyze the heterogeneous effects of the onset of the more granular types within aggregate physical and mental-cognitive disabilities. Figure 3 plots the results when partitioning aggregate physical types into disabilities related to kinetic ability (left) and exclusively pain (right). First, the onset of an aggregate psychical disability on market income is mainly due to impairments to one's kinetic ability. The point estimates on unconditional WSC, labour market participation, and WSC for participants follow an analogous longitudinal path and are greater in magnitude. In contrast, the effects from the onset of a disability due exclusively to pain are noisy and mostly insignificant. The exception is labour market participation, which declines by an average of 5.6% in the ten years after onset. The activities that are limited by a disability to kinetic ability have a clearer link to productive tasks. For instance, mobility and flexibility limitations will impede productivity in tasks related to manual labour, and limitations to dexterity will impede the productivity of hands-on work, such as carpentry, landscaping, or even musician. It is less obvious what productive tasks a disability induced exclusively by pain will impact.

Lastly, Figure 4 reports the results for models partitioning aggregate mental-cognitive types into limitations due exclusively to mental health (left) and limitations related to cognitive functioning (right column). The onset of disability related to either of these types has substantial effects on WSC that progressively worsen over time relative to onset. The estimated effect of exclusively mental health is of similar magnitude to that of kinetic ability but becomes progressively worse in the long run, culminating to -$14,800 in the tenth year after onset.[52] Following the onset of disabilities related to cognitive functioning, WSC declines by

[52] Of note is the marginal significance of the estimate one year prior to the onset of mental health, which can be due to gradual degeneration of mental health or a greater challenge to verifying when mental health limitations onset (measurement error). More problematic is if deteriorating labor market conditions causes onset of a mental health limitation. However, the eye test for parallel trends seems to hold when disaggregating WSC into labor market participation and WSC conditional on participation.

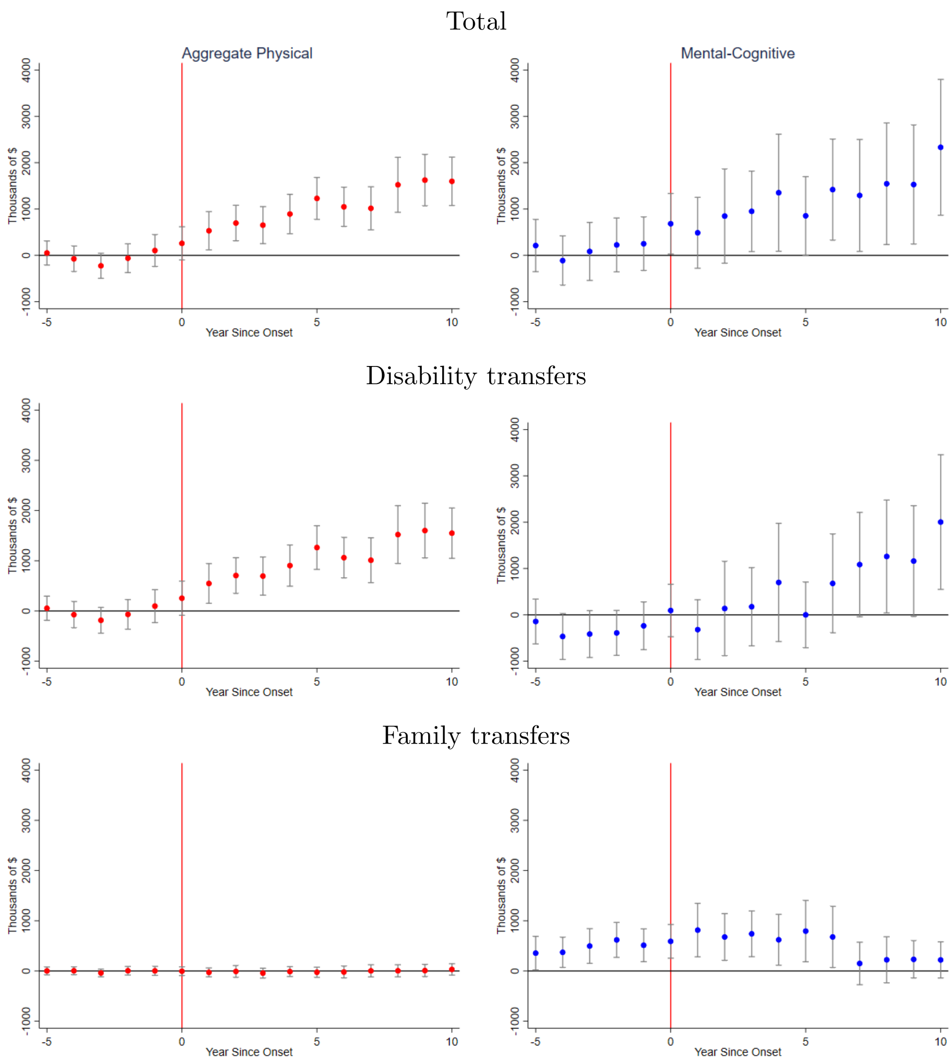
Figure 4: Effect of Disability Types Within Mental-Cognitive on Market Income



Note: Figures plot point estimates from an IW estimation, whose specification is outlined in Section 5. The models for WSC are top-coded at the 99 percentile. Underlying estimates for graphs are reported in Appendix 4.

-$6900 on average in the short run and progressively worsens to -$17,200 in the long run. The longitudinal path in effects on participation is similar for disabilities related exclusively to mental health compared to cognitive functioning. The short-run effects in both are modest, around -10% lower than pre-onset levels, and the effects worsen in the long run. That said, the magnitude decline for cognitive in the long run is substantial (-40%), whereas the point estimates are noisy for mental health. The effect of onset on WSC for participants becomes progressively worse in the short run, although point estimates are all insignificant for cognitive functioning.

Figure 5: Effect of Aggregate Disability Types on Government Transfers



Note: Figures plot point estimates from an IW estimation, whose specification is outlined in Section 5. Underlying estimates for graphs are reported in Appendix 4.

6.2 Government Transfers

The results for market income find significant effects on WSC and labour market participation following the onset of each type of disability. This section analyzes how the takeup of government transfer programs responds to the impact on market income. Government transfer programs make up the majority of Canada's social safety net, offering income assistance and tax credits to individuals with barriers to their economic independence. As productivity declines following onset, labour market exit can be driven by the uptake of government programs designed to insure disability shocks. The increase in government transfers around onset reflects relative differences in coverage and eligibility across the types of disabilities. Moreover, comparing the effects on market income with government transfers reveals differences in the extent of partial insurance across disability types.

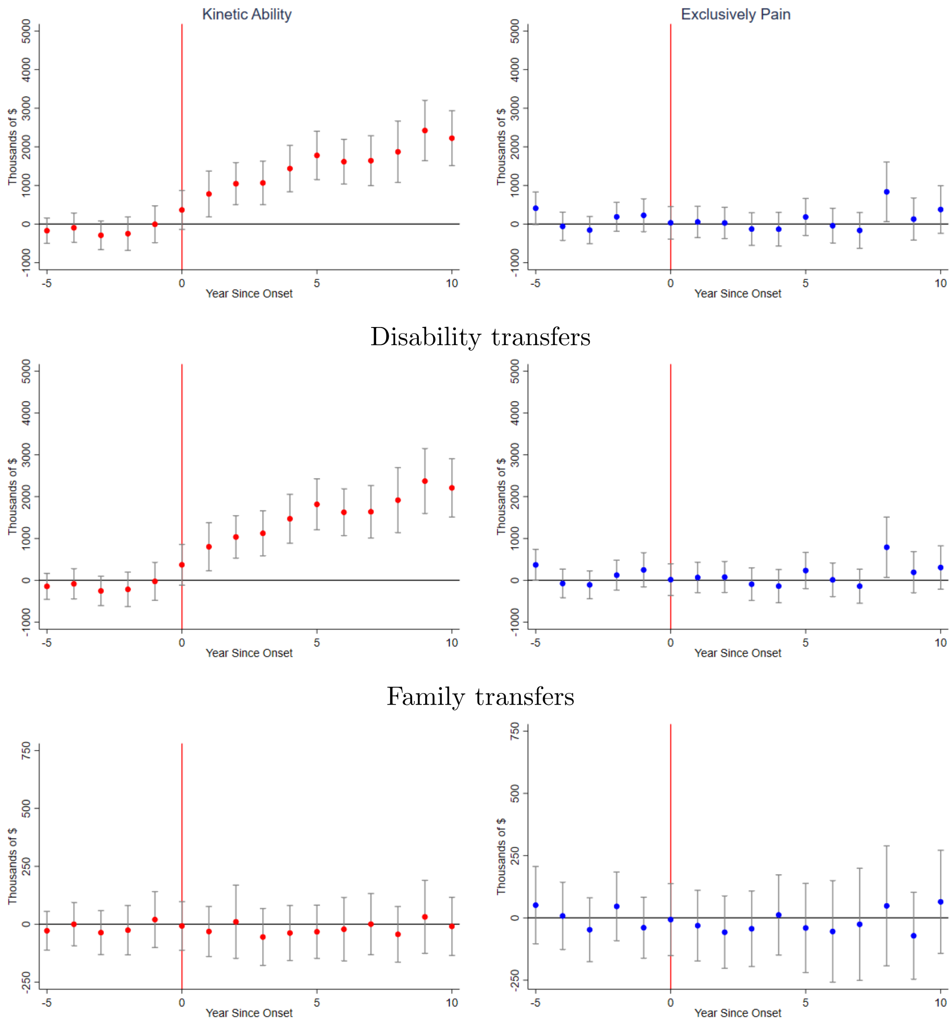
Again, I start by comparing the aggregate disability types and then explore heterogeneity within aggregate types. Figure 5 reports results from models where the dependent variable is total government transfers (top row), disability-relevant transfers (2nd row), and family-relevant transfers (3rd row). The effect on total government transfers in the ten years following onset is similar for aggregate physical and mental-cognitive types, culminating to approximately \$1500 ten years following onset. That said, there are composition differences between these two types. The rise in transfers for aggregate physical is driven entirely by disability-relevant transfers. Disability-relevant transfers only significantly increase in the long run following the onset of a mental-cognitive disability. Instead, the mental-cognitive type receives more transfers from family-relevant programs, which tend to be means-tested and increase as total income levels decline. However, estimates of the rise in family transfers are interpreted as descriptive and not causal due to the significance of pre-onset coefficients, which clearly violates parallel trends.

When partitioning aggregate physical disabilities in Figure 6, we see that the rise in government transfers is driven entirely by disabilities related to kinetic ability. This finding is expected given the effects on employment income. The onset of a disability due exclusively to pain does not significantly increase government transfers from either source. The onset of exclusively pain limitations does not result in any significant increase in government transfers. Again, this insignificance is consistence with the effects on total WSC, although there was significant labour market exit following the onset of a disability-related exclusively to pain. In addition, these results may be partly related to difficulties verifying pain-related disabilities. Neither type within aggregate physical significantly affects family-relevant transfers.

The results when partitioning mental-cognitive disabilities in Figure 7 reveal differences in the support received across these conditions. The magnitude rise in government transfers in the long run following the

Figure 6: Effect of Disability Types Within Aggregate Physical on Government Transfers

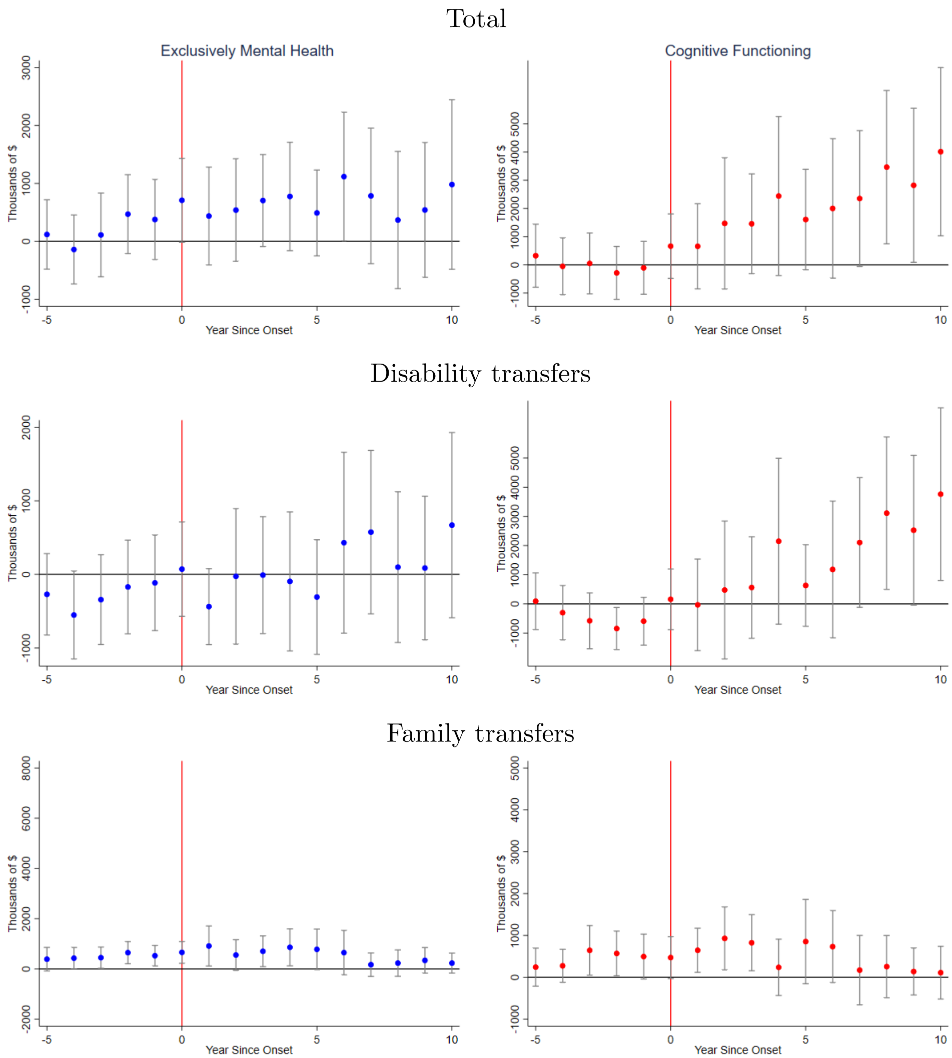
Total



Note: Figures plot point estimates from an IW estimation, whose specification is outlined in Section 5. Underlying estimates for graphs are reported in Appendix 4.

onset of a disability to cognitive functioning is substantial, with a point estimate reaching almost 4000$. However, the point estimates are noisy for this group and insignificant in the short run. This is almost certainly due to the small sample size of this group. The source of government transfer comes mostly from disability-relevant programs. There appears to be a substitution away from family-relevant transfers in the short run to disability-relevant transfers in the long run for this type. The onset of a disability-related to mental health does not result in any significant increase in total government transfers. This finding is notable given the magnitude of effects on WSC and labour market participation was comparable to kinetic ability in the short run and became progressively worse in the long run.

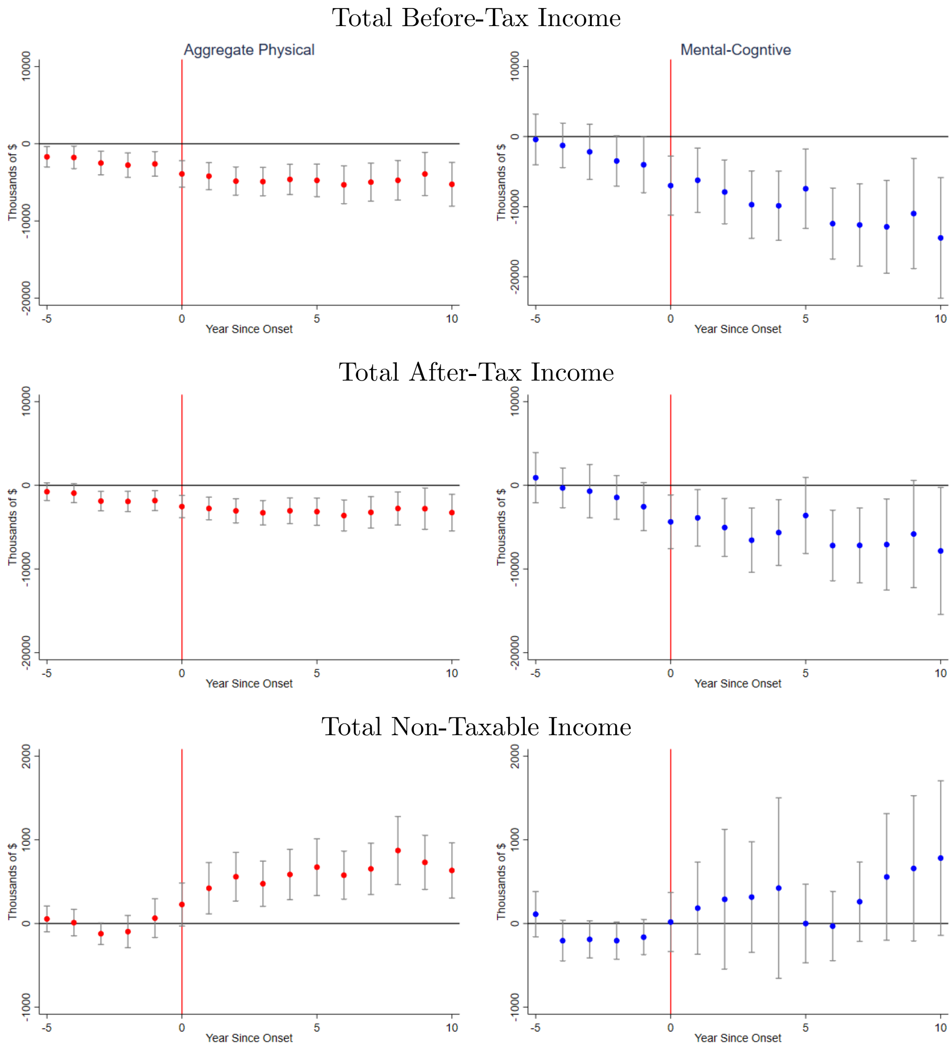
Figure 7: Effect of Disability Types Within Mental-Cognitive on Government Transfers



Note: Figures plot point estimates from an IW estimation, whose specification is outlined in Section 5. Underlying estimates for graphs are reported in Appendix 4.

There appear to be sizeable gaps in partial insurance from government transfers following the onset of a mental health-related disability and a lower percentage of income insured for disabilities to cognitive functioning. Relative to physical disabilities, mental-cognitive disabilities can be harder to verify, especially for mental health. Moreover, only recently has mental health received acknowledgment for its impacts on the labour market. Consequently, individuals affected by the onset of a mental health disability in working life must resort to alternate mechanisms to smooth their consumption.

Figure 8: Effect of Aggregate Disability Types on Before-Tax, After-Tax, and Non-Taxable Income



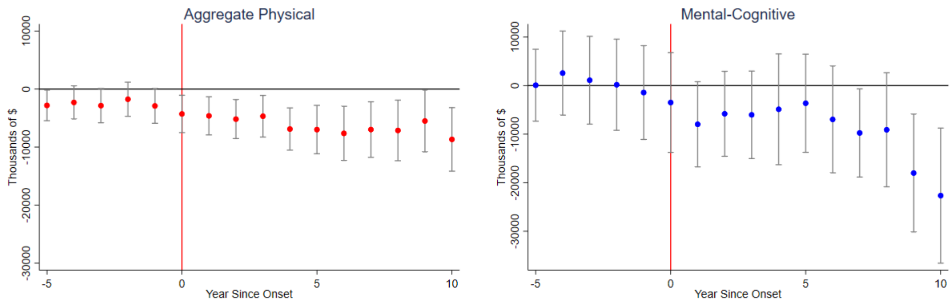
Note: Figures plot point estimates from an IW estimation, whose specification is outlined in Section 5. Total before-tax and after-tax income top-coded at the 99 percentile for aggregate physical. Underlying estimates for graphs are reported in Appendix 4.

6.3 Alternate Smoothing Mechanisms

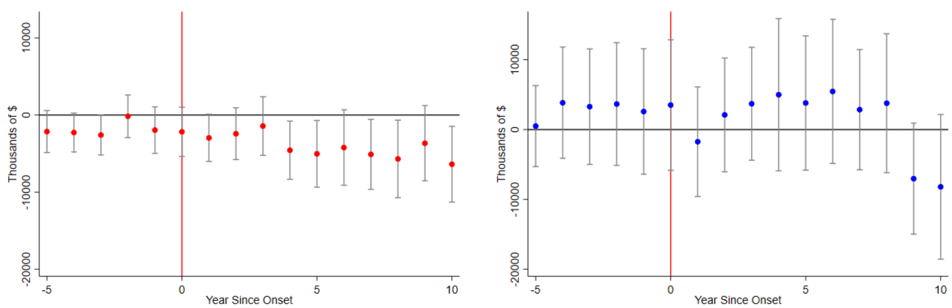
The final set of results considers alternate mechanisms that individuals may use to smooth their consumption in response to a disability shock. First, the Canadian income tax system is progressive and exempts various sources of income from taxation, notably many government transfers. Hence, the impact of a disability shock on take-home income may be buffered when falling into a tax bracket with a lower marginal tax rate. I analyze the effect of disability onset on total after-tax income to gauge how take-home resources are affected and total before-tax income to understand the buffering role of the tax system. In addition, I compare this to the change in total non-taxable income. Lastly, the earnings activities of members of one's household can be an important source of insurance against income shocks. I also estimate the effect of disability onset on the total income of one's family members and the impact on total household income, including the individual.

Figure 9: Effect of Aggregate Disability Types on Total Family Income and Income of Family Members

Total Family Income



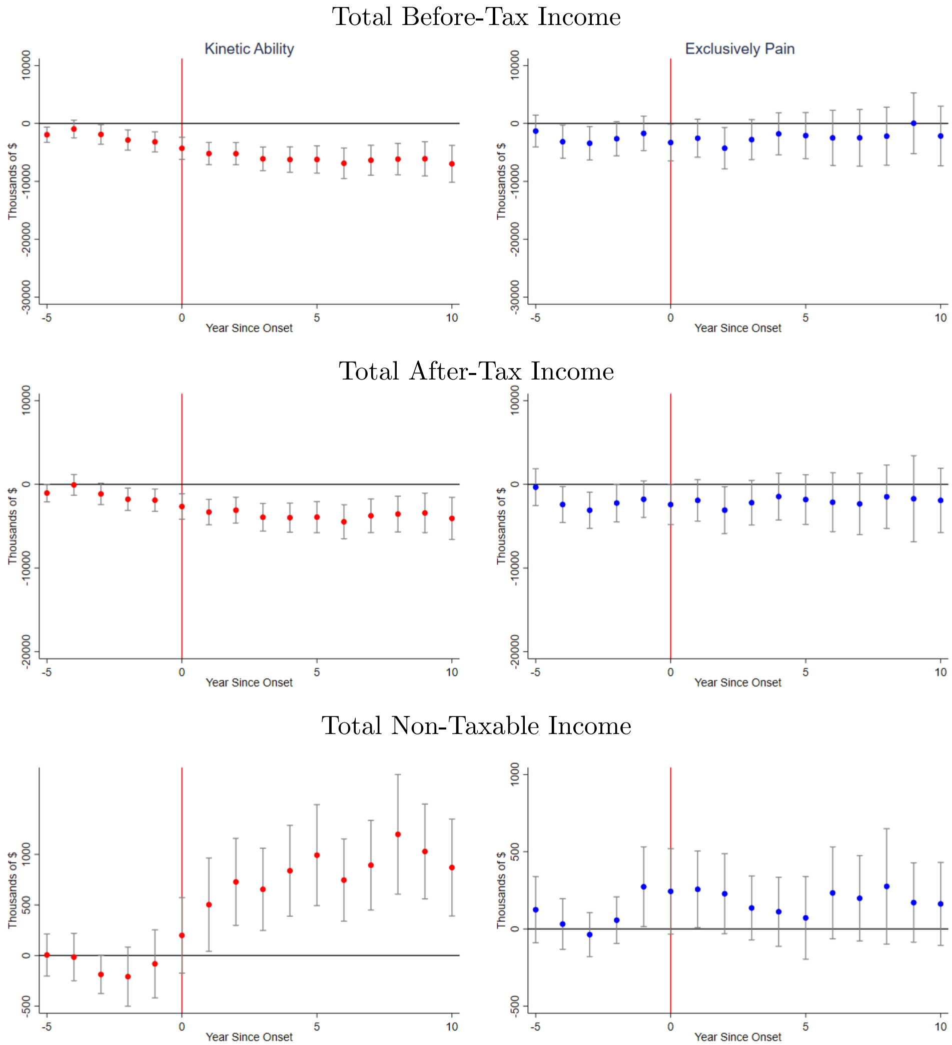
Income of Family Members



Note: Figures plot point estimates from an IW estimation, whose specification is outlined in Section 5. Family total income is top-coded at the 99 percentile for aggregate physical. Underlying estimates for graphs are reported in Appendix 4.

Notable differences emerge between aggregate physical and mental-cognitive disabilities in the role of the tax system as a smoothing mechanism. Figure 8 reports the results on models for total before-tax income (top), total after-tax income (middle), and total non-taxable income (bottom). Relative to its impact on WSC, the effect of the onset of mental-cognitive appears to be buffered by the tax system. However, due to the large confidence intervals, I can not significantly reject the equality of treatment paths. Despite this, I still conclude that the onset of a mental-cognitive disability results in significantly less take-home income after taxation. The point estimates imply the percentage of the effect of onset on after-tax total income is 63% that of before-tax income in the short run and 55% that of before-tax income in the long run. Additionally, the effect on before or after-tax income does not exhibit a sharp drop in the long run, which was the case for market income WSC and labour market participation. This suggests that the sharp increase in disability-relevant transfers for this group is partially insuring total after-tax income for this type in the long run. That said, we do not recover a significant rise in total non-taxable income following the onset of a mental-cognitive disability. However, this is likely the result of this group substituting family-relevant transfers in the short run to disability-relevant transfers in the long run.

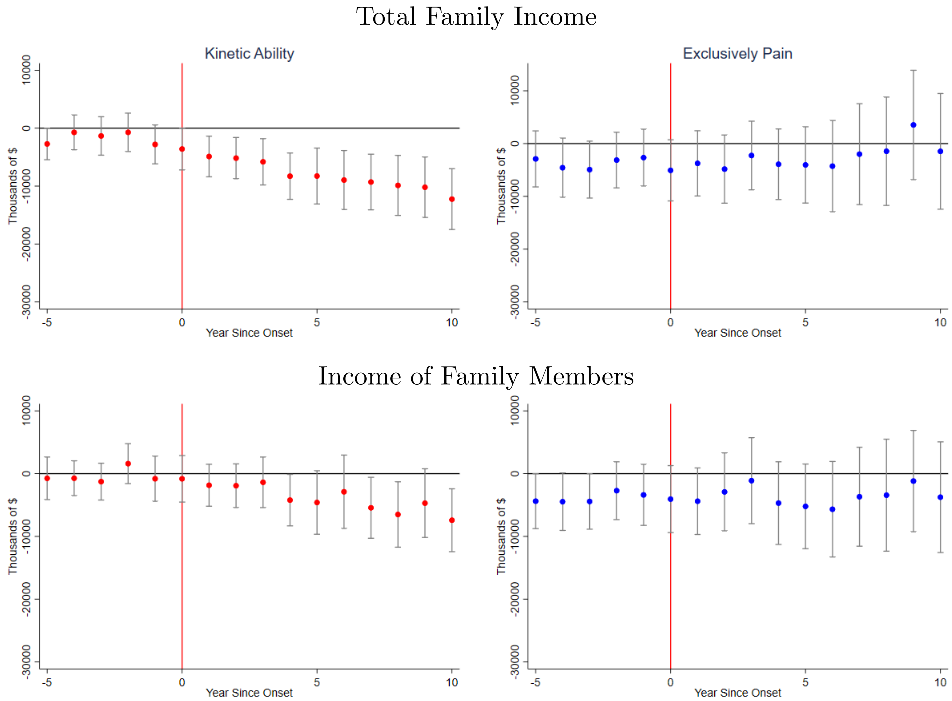
Figure 10: Effect of Disability Types Within Aggregate Physical on Before-Tax, After-Tax, and Non-Taxable Income



Note: Figures plot point estimates from an IW estimation, whose specification is outlined in Section 5. Total before-tax and after-tax income are top-coded at the 99 percentile. Underlying estimates for graphs are reported in Appendix 4.

On the other hand, the main source of partial insurance following the onset of an aggregate physical disability comes from non-taxable incomes. The results for total before-tax and after-tax income following the onset of an aggregate physical disability have significant point estimates in pre-onset coefficients, and their dynamic profiles are fairly flat. For this group, the effect of onset on after-tax income is 65% that of before-tax income in both the short and long run.

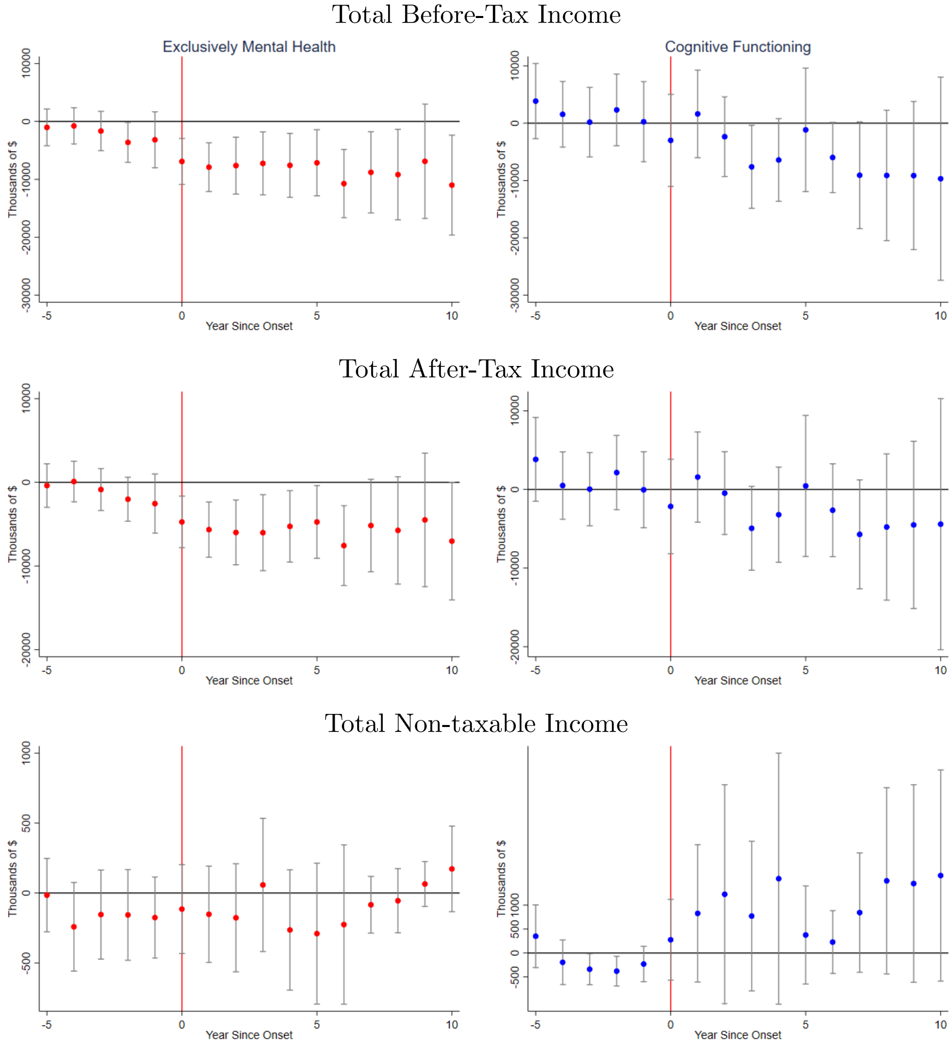
Figure 11: Effect of Disability Types Within Aggregate Physical on Total Family Income and Income of Family Members



Note: Figures plot point estimates from an IW estimation, whose specification is outlined in Section 5. Family total income is top-coded at the 99 percentile. Underlying estimates for graphs are reported in Appendix 4.

Figure 9 analyzes how disability shocks disseminate through the household. The effect of onset on total household income is reported in the top row, and the effect on the total household income after netting out income from the survey respondent is reported in the bottom row. First, the onset of an aggregate physical disability immediately impacts total household income, which remains flat and persists into the long run. The onset of a mental-cognitive disability only has significant long-run effects on total family income, but the effect is more than -20,000$ in magnitude. We observe some reduction in the income of other family members following the onset of a physical disability, consistent with a mechanism of family members substituting work for homecare as discussed in Fadlon and Nielsen (2021).

Figure 12: Effect of Disability Types Within Mental-Cognitive on Before-Tax, After-Tax, and Non-Taxable Income



Note: Figures plot point estimates from an IW estimation, whose specification is outlined in Section 5. Total before-tax and after-tax income are top-coded at the 99 percentile. Underlying estimates for graphs are reported in Appendix 4.

In Figure 10, we see that much of the action within aggregate physical types is driven by kinetic ability. Disabilities related exclusively to pain have low-magnitude effects in point estimates and are mostly insignificant. In contrast, disabilities related to kinetic ability show clear increases in non-taxable income. The effects of the tax system buffer some of the effects of a kinetic ability disability. However, these results show violations in parallel trends and are not interpreted as causal. Hence, income insurance via government transfers seems to be the main channel for physical disabilities that are not exclusively due to pain.

At the household level, Figure 11 reports that disabilities to kinetic ability result in a drop in total family income, progressively worsening in the long run, culminating to -$12000 ten years after reported onset. Moreover, the income of family members drops in the long run, again consistent family members spending more time at home to care for their family member with a disability. Exclusively pain disabilities do not significantly affect family income and have large standard errors, suggesting much variation in the effects following onset.

Figure 13: Effect of Disability Types Within Mental-Cognitive on Total Family Income and Income of Family Members

Note: Figures plot point estimates from an IW estimation, whose specification is outlined in Section 5. Underlying estimates for graphs are reported in Appendix 4.

The last set of results distinguishes the effects of onset on alternate smoothing mechanisms by disabilities related to mental health and those related to cognitive functioning. In Figure 12, the tax system helps offset the effect of mental health disabilities. There is no significant rise in total non-taxable income following the onset of a mental health condition. These types of disabling conditions receive partial insurance solely from the progressive tax system, which lowers marginal tax rates as their market income decline following onset. Those affected by disabilities related to cognitive functioning smooth their consumption via government transfers, many of which are non-taxable. Whereas those affected by the onset of a mental health disability rely on lower marginal tax rates after their experience income declines following onset. This result is partially reflected in the results for non-taxable income, which are insignificant for the mental health group. The point estimates for the group limited in cognitive functioning are large in magnitude, but they are insignificant at 95% confidence.

Finally, both types of disabilities within mental-cognitive cause significant declines in total family income, shown in Figure 13. The path of effects becomes progressively worse in the long run, and point estimates are larger in magnitude for disabilities related to cognitive functioning. However, I find no significant changes in the income of family members following the onset of either type.

7 Welfare Implications and Optimal Benefits

The last section of this paper discusses the implications of these results for individual welfare. To do so, we adopt the optimal insurance framework of Baily (1978), generalized to analyze programs including disability benefits by Chetty (2006). The idea of this framework is that the optimal level of benefits balances the moral hazard relating to the work disincentives inherent to any insurance program with the ability to smooth consumption following an income shock. The model The Bailey-Chetty optimal benefit condition is,

$$\gamma \frac{\Delta c}{c}(b) = \epsilon_{D,b}$$

.

Here, γ is the coefficient of risk aversion $(\frac{-u''c}{u'})$, $\frac{\Delta c}{c}(b)$ is the drop in mean consumption with benefits evaluated at its optimal level, and $\epsilon_{D,b}$ is the elasticity of time receiving benefits (i.e., not working) with respect of benefit level. The idea is that if the left-hand side of this equation is lower than the right-hand side, then benefits are below their optimal level.

I make several simplifying assumptions in the following analysis. First, I assume the change in consumption is proportional to after-tax income. Hence the percentage change in consumption equals the change in an individual's after-tax income. This assumption is reasonable if savings are not a large source of consumption smoothing in the face of a permanent disability shock. Moreover, this assumption ignores the income of family members that may change in response to a disability shock to income consumption. In the disability types analyzed below, I found no significant change in family income following the onset of mental-cognitive disability or disaggregated disability types making up mental-cognitive disability. Following the onset of a disability to kinetic ability, I observe a decline in the income of family members, suggesting that the decline in consumption may be greater than the fall in after-tax income following the onset of a disability to kinetic

Table 4: Consumption Change After Onset and Coefficient of Relative Risk Aversion Consistent with Optimal Benefits for Select Disability Types

	Cognitive Ability	Mental Health	Exclusively Cognitive	Kinetic Ability*
Pre-Onset Consumption	40318	41314	39809	34285
Average Fall in Consumption	-4288	-5674	-2802	-3655
% Fall in Consumption	-0.11	-0.14	-0.07	-0.11
γ Consistent with Optimal Benefits	1.64	1.27	2.47	1.63

Note: Consumption is assumed be proportional to after-tax income. Hence, percentage fall in consumption is the same as the percentage fall in after-tax income.

ability. Second, I assume the marginal utility of consumption is the same before and after the disability onset occurs, an assumption similar to Deshpande and Lockwood (2022) and Meyer and Mok (2019). Under these assumptions, the average decline in after-tax income divided by the total after-tax income in the five years before onset gives a measure of $\frac{\Delta c}{c}$. Third, I assume the elasticity of time receiving benefits with respect to benefit level is 0.174, as in Meyer and Mok (2019).[53] In the table below, I use these assumptions to calculate the implied CRRA that is consistent with optimal benefits. I can then compare this to values of γ in the literature to understand the optimality of disability benefits.

The coefficient of relative risk aversion consistent with optimal benefits in the Bailey-Chetty conditions, shown in Table 4, ranges from 1.27 to 2.47 across disability types. These values of γ are on the lower end of estimates and values found in the related literature. Notably, the implied optimal γ for the mental health group is lowest, implying that this group would have to be relatively less risk-averse in order for benefits to be optimal. In the related literature, values of γ typically range from 1.5 to 7 (French, 2005; Chandra and Samwick, 2009; Lockwood, 2018; Low and Pistaferri, 2015; Kostøl et al., 2019; Seitz, 2021; Deshpande and Lockwood, 2022; Jacobs, 2023). In his meta-study of empirical estimates of the intertemporal elasticity of substitution, Havranek (2015) finds the mean estimate in the micro literature in the range of 0.3-0.4, implying a γ of 2.5-3.3 in utility specifications where consumption and leisure are additively separable. Hence, within this range, benefits are lower than optimal for those affected by a mental health disability. Moreover, benefits are only optimal if those affected by a disability to their kinetic ability are the least risk averse in this range. Hence, this exercise suggests that benefits are lower than optimal for these disability types. Moreover, benefits are much too low for those with a mental health disability.

[53]See Meyer and Mok (2019) for description of calculating this elasticity

8 Conclusion

This paper analyzes the dynamic effects of the onset of disability types on measures of personal income. The analysis is theoretically founded with a task-specific human capital framework. My findings suggest there is considerable variation in the impact of the types on these outcomes. Disaggregating disability into types of functional limitations is important to account for the heterogeneity of disabilities.

The onset of mental-cognitive disabilities results in relatively larger declines in market income than physical ones. This is mainly driven by declines in WSC, which most closely reflect the effect of disability on human capital and productivity. The mental-cognitive group receives fewer disability-relevant government transfers on average relative to those affected by an aggregate physical disability, despite inuring a larger penalty to their market income. This group sees increases in government transfers from other programs, such as family benefits.

Within aggregate types, much of the effect of aggregate physical onset is attributed to limitations in kinetic ability. Disabilities related to exclusively pain experience some declines in labour market participation. However, they do not experience any increase in government transfers. Both types of mental-cognitive have substantial effects on employment income via WSC and on labour market participation. That said, mental health types do not experience significant support from government transfers. Instead, this group receives partial insurance via the tax system, which helps buffer effects on after-tax income. These results reveal gaps in support for mental health conditions, which are becoming increasingly more prominent and recognized as important determinants of economic success.

The welfare analysis suggests that the level of disability benefits is lower than optimal and differs by disability type. Current benefit levels are only optimal if individuals who experience a disability shock are less risk-averse than what much of the related literature suggests. The difference in optimal benefits seems to be greatest for those with a mental health disability.

The results from this paper are motivated by a theoretical model that relates types of disability to task-specific human capital and job requirements. I provide novel estimates of the effect of disability types. However, this paper does not have the information to account for heterogeneity in skills and the tasks that make up work at the time of disability onset. Such an analysis, combining multidimensional skills, job skill requirements, and multidimensional disability types, is left for future work.

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