Cross-Country Differences in Taxation and Hours Worked: An Updated Perspective with a New Zealand Focus[1]

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Abstract

We document vast differences in total hours worked across OECD countries between 1970 and 2019. We fit a neoclassical growth model augmented with taxes on labour income and consumption expenditures to assess the importance of taxation in accounting for the patterns in total hours worked in New Zealand, in a comparative perspective with Australia and the US. We find that the model often performs poorly in explaining patterns in total hours worked. The quantitative analysis reveals that there is a lack of association between taxes and total hours worked in these countries throughout the post-2000 era. This finding is striking given that the literature often documents that taxes are a dominant factor in explaining patterns in total hours worked. After observing the poor model performance, we study alternative explanations for the patterns in New Zealand's total hours worked. We argue that the factors which have increased New Zealand's extensive margin are promising candidate explanations for the recent increases in New Zealand's total hours worked.

Keywords: Hours of work, labour supply, New Zealand, OECD, taxes, employment

JEL classification: E13, E20, E60, E62, J22, O50

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[1] For this paper, both authors have equal contributions. The views expressed in this paper are those of the authors and do not necessarily reflect the views of the Ministry of Social Development. Some parts of this article are based on the first author's master thesis (Gordon, 2022), which was supervised by the second author.

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1. Introduction

The literature on aggregate labour supply documents vast differences in hours worked across countries. For instance, Prescott (2004) studies the decrease in total hours worked in European countries relative to the United States (hereafter US) between 1970-74 and 1993-96 and attributes virtually all of the differences in hours worked to differences in tax rates. Rogerson (2006) studies 21 OECD countries between 1956 and 2003 and observes that the magnitude of variation in hours worked across countries is large. He finds that technology and government explain a considerable amount of the differences in hours worked across countries. Ohanian et al. (2008) study the same countries between 1956 and 2004 and establish that substantial differences in the changes in hours worked exist across countries. Using a neoclassical growth model Ohanian et al. find that differences in taxes on labour income and consumption expenditures explain most of the differences in hours worked both over time and across countries. Similarly, our sample on total hours worked across 24 OECD countries between 1970 and 2019 reveals that there are substantial cross-country differences in total hours worked. For example, between Korea--which exhibits the highest total hours worked between 1970 and 2019 on average-- and Belgium--which has the lowest total hours worked on average--, there is a difference of 600 hours on average.

In terms of long-run changes in hours worked, a common observation is that total hours worked has been decreasing in several countries over time. For example, Rogerson establishes that mean hours have been decreasing in many countries, while Ohanian et al. note that there are considerable decreases in hours worked for a large number of countries. Likewise, in our sample the majority of countries experience long-run decreases in total hours worked, with Denmark and Germany exhibiting the largest decreases. However, unlike previous studies, a noticeable number of countries experience long-run increases in total hours worked. There are nine countries whose total hours worked increase between 1970 and 2019, with Mexico and Luxembourg exhibiting the largest increases. The long-run increases in hours worked within these countries can be partially attributed to increases in hours worked over the past decade.

In this paper we provide an updated analysis of total hours worked across 24 OECD countries between 1970 and 2019, with a particular focus on New Zealand. We follow Ohanian et al. (2008) and Üngör (2014), among some others, and use a variant of the neoclassical growth model augmented with government consumption, subsistence consumption, and taxes on labour income and consumption expenditures to assess the importance of taxation in accounting for the patterns in total hours worked. We utilise the key equation that equates the marginal rate of substitution of consumption for leisure with the marginal product of labour to compute model hours. Our updated sample allows us to assess whether the model can account for the recent increases in total hours worked that has occurred in a number of countries (Table 1). Interestingly, New Zealand is one of these countries.

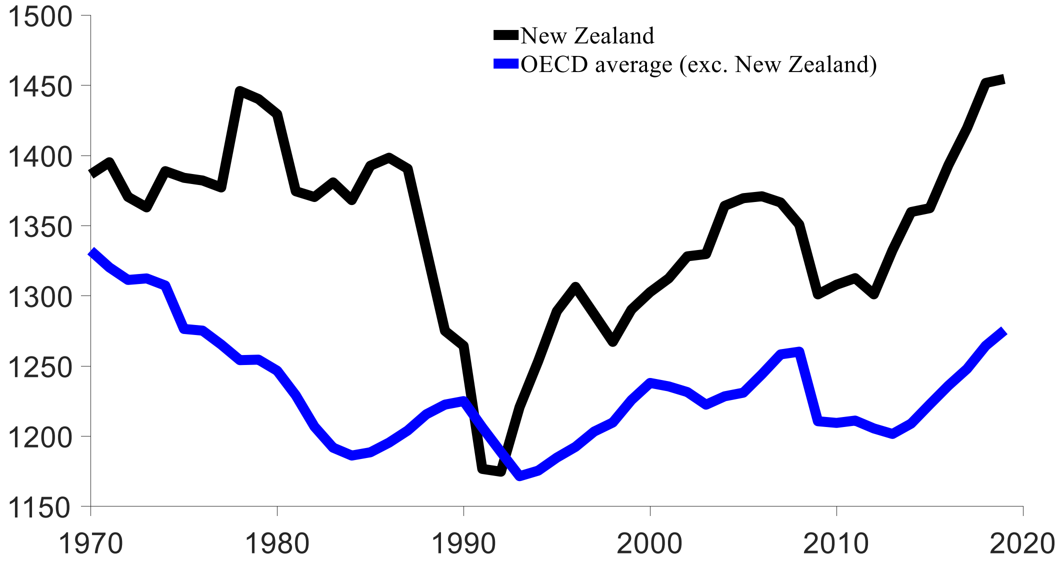
Figure 1 displays the total hours worked in New Zealand and the OECD on average between 1970 and 2019. Total hours worked is measured as the product of total hours worked by employed workers and the employment level. In order to account for differences in population sizes between countries, total hours worked is normalised by the working age population:[4]

$$\text{Total hours worked} = \frac{\text{total hours}}{\text{working age pop.}} = \frac{\text{total hours}}{\text{employed}} \times \frac{\text{employed}}{\text{working age pop.}}$$

$$= \text{Average hours worked per worker} \times \text{Employment rate} \quad (1)$$

The average hours worked per worker and the employment rate are referred to as the *intensive margin* and the *extensive margin* of aggregate labour supply, respectively.

*Figure 1. Total hours worked, New Zealand vs. the OECD, 1970-2019**



* Standardised by working age population. Source: The Conference Board Total Economy Database and the World Bank's World Development Indicators, April 2021.

[4] The working age population refers to a country's population that is aged between 15 and 64.

Figure 1 shows that total hours worked in New Zealand exceeds the OECD average considerably between 1970 and 2019, except for a period of overlap between 1990 and 1992. Noticeably, both New Zealand and the OECD average[5] experience increases in total hours worked in the recent decade, although the increase in New Zealand exceeds that of the OECD. Between 2012 and 2019 total hours worked in New Zealand and in the OECD increased by 154 hours and 70 hours, respectively. Due to the large increases in the recent decade New Zealand has the third highest level of aggregate labour supply in 2019 among the OECD countries considered. Since total hours worked increase in both New Zealand and the OECD over the past decade, gaining an understanding of the factors behind the increase in hours worked in New Zealand may also reveal what has driven the increases in hours worked in other OECD countries. Moreover, studying historical trends in total hours worked in New Zealand presents an opportunity to investigate the impact of a major economic reform on total hours worked. In 1984 the New Zealand government initiated vast economic reforms that had major implications for the economy. The reforms involved macroeconomic stabilisation and structural change which led to reduced government involvement in New Zealand's economy. Figure 1 displays that New Zealand experienced large fluctuations in total hours worked during the reform period. Total hours worked decreased significantly by 224 hours between 1986 and 1992 before recovering by 132 hours between 1992 and 1996. We consider if certain aspects of the reform may account for the large fluctuations in total hours worked over this period. This work complements a study by Bridgman and Greenaway-McGrevy (2022) who investigated the impact of public enterprise reforms on labour share in a range of countries, including New Zealand.

We fit a neoclassical growth model augmented with taxes on labour income and consumption expenditures and provide model results for New Zealand, the US, and Australia. We find that the model performs poorly in explaining the patterns in New Zealand's total hours worked. Total hours worked in New Zealand decrease by 224 between 1986 and 1992, and the model is only able to account for 17% of that decrease. Also, the model fails to explain the increase in New Zealand's total hours worked between 2012 and 2018. Moreover, the model initially

[5] The OECD member countries included in the sample include Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the UK, and the US. The OECD member countries excluded from the sample includes Chile, Colombia, Costa Rica, Czech Republic, Estonia, Hungary, Iceland, Israel, Latvia, Lithuania, Poland, Slovak Republic, Slovenia, and Turkey. OECD average refers to the average of 23 OECD countries (excluding New Zealand).

succeeds in explaining the patterns in total hours worked in the US, as it accounts for 70% of the decrease in total hours worked between 1970 and 1982. However, the explanatory power of the model decreases significantly for the US over the remainder of the sample period. Similarly, the model initially has some explanatory power in explaining the patterns in Australia's total hours worked, although the performance of the model worsens considerably after 2008.

To complement the benchmark model results for New Zealand, the US, and Australia we perform sensitivity analyses for these countries. We find that government consumption and subsistence consumption are not particularly important for New Zealand's model results. Also, when the model ignores taxes on labour income and consumption expenditures its explanatory power decreases between 1986 and 2006 but improves between 2006 and 2012. This indicates that the inclusion of taxes is important for the quantitative performance of the model between 1986 and 2006, but relatively unimportant thereafter. Relatedly, the sensitivity analysis for the US reveals that when the model ignores taxes its explanatory power decreases between 1970 and 1982 but improves thereafter. Also, the sensitivity analysis for Australia reveals that when the model ignores taxes its explanatory power decreases between 1998 and 2008 but improves thereafter. The lack of association between taxes and total hours observed in these countries in recent times is striking given that the literature often documents that taxes are a dominant factor in explaining patterns in total hours worked.

After observing that the neoclassical growth model struggles to account for the patterns in New Zealand's total hours worked, we study alternative explanations for the patterns observed. In particular, we focus on explanations that may explain the recent increases in total hours worked where the model fails. We argue that the factors which have increased New Zealand's extensive margin are promising candidate explanations for the recent increases in New Zealand's total hours worked. The increasing labour force participation rate (hereafter LFPR) of older workers and female workers appear to be particularly important demographic changes that have contributed to the recent increases.

This paper complements the literature on aggregate labour supply by providing the first extended and detailed study on aggregate labour supply in New Zealand, to the best of our knowledge, in a comparative perspective with other OECD countries. Also, we update the data on total hours worked, average hours worked per worker, and the employment rate for 24 OECD countries between 1970 and 2019.[6]

This paper is organised as follows. Section 2 presents stylised facts relating to cross-country differences in total hours worked, the intensive margin, and the extensive margin. Section 3 presents the model. Section 4 provides a quantitative analysis that assesses the model's fit with the data. Section 5 explores alternative explanations for the patterns in New Zealand's total hours worked. Section 6 concludes by providing policy implications of the results and areas for future research. Proofs, data discussions, and further analysis is provided in the related appendices.

2. Total hours worked

A secular decreasing trend in total hours worked is a common observation for many countries in the literature on aggregate labour supply. This section provides an update of the patterns in aggregate labour supply for 24 OECD countries between 1970 and 2019. Stylised facts relating to total hours worked, the intensive margin, and the extensive margin are established. Specific attention is also paid to patterns in New Zealand's aggregate labour supply.

2.1 Cross-country differences in hours worked: Stylised facts

2.1.1 Total hours

A prominent stylised fact includes that there are substantial differences in long run changes in total hours worked across the countries studied.[7] Table 1, which is motivated by Ohanian et al. (2008), displays the distribution of total hours worked across 24 OECD countries. Panel (b) of Table 1 compares total hours worked in each country in 2019 relative to 1970 and splits the countries into three distinct groups.

[6] This data has been collected by many authors over time, including Rogerson (2006), Ohanian et al. (2008), and McDaniel (2011).

[7] There is an extensive literature that proposes alternative explanations in an attempt to explain the cross-country differences in aggregate hours. Among them are differences in taxes and transfer policies (See Prescott, 2004; Dhont and Heylen, 2008; Rogerson, 2006, 2007, 2008; Ohanian et al., 2008; McDaniel, 2011; Ngai and Pissarides, 2011; Ragan, 2013); differences in labour market regulations/employment protections/unions/unemployment benefits/wage bargaining practices and policies (see Hunt, 1998; Blanchard and Wolfers, 2000; Blanchard, 2004; Alesina et al., 2005; Bassanini and Duval, 2006); differences in product market regulation (see Bertrand and Kramarz, 2002; Fang and Rogerson, 2011; Messina, 2006); differences in social security programs (see Wallenius, 2013; Alonso-Ortiz, 2014; Torres, 2022); the marketisation hypothesis (i.e., the extensive shift of traditional household production to the market) and the increases in female labour market participation (see Greenwood et al., 2005; Freeman and Schettkat, 2005; Ngai and Petrongolo, 2017).

Table 1. Distribution of total hours worked across 24 OECD countries

Panel (a): Summary statistics					
		Average			Standard deviation
OECD					
Min (Year)		1,174 (1993)			141.27 (1975)
Max (Year)		1,334 (1970)			187.80 (1987)
Panel (b): Country-specific patterns					
Total Hours Worked in 2019 relative to 1970:					
≤ 0.90		(0.90, 1.00)		≥ 1.00	
Denmark	0.79	Austria	0.93	Australia	1.01
Finland	0.84	Belgium	0.92	Canada	1.08
France	0.79	Italy	0.97	Greece	1.00
Germany	0.77	Japan	0.96	Luxembourg	1.37
Ireland	0.85	Netherlands	0.98	Mexico	1.35
Korea	0.90	Norway	0.91	New Zealand	1.05
Spain	0.86	United Kingdom	0.97	Portugal	1.08
Switzerland	0.87			Sweden	1.01
				United States	1.06
Group 1	0.83	Group 2	0.95	Group 3	1.11

Source: Conference Board Total Economy Database and the World Bank's World Development Indicators, April 2021.

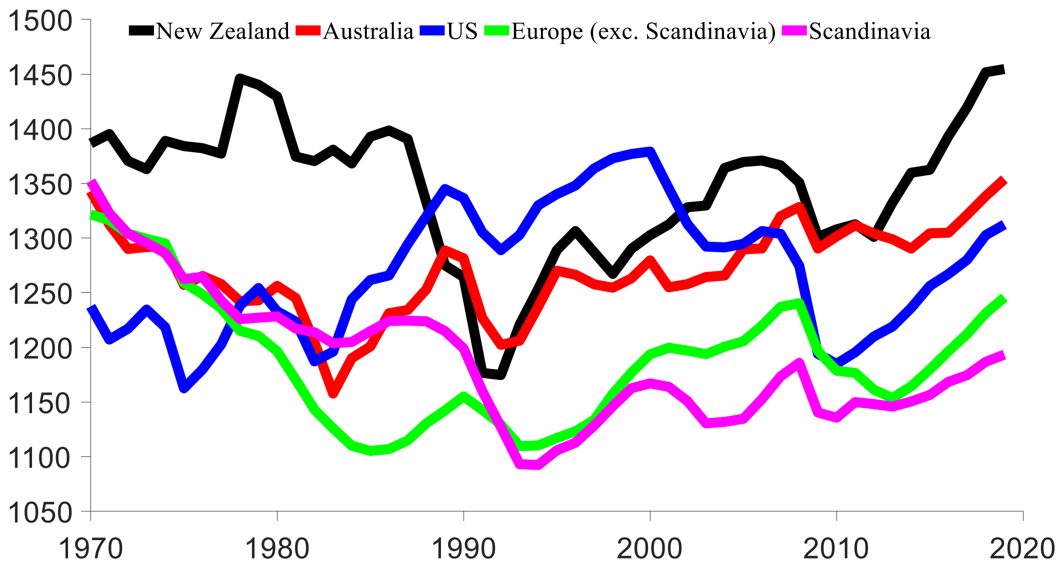
Group 1 is comprised of countries that experience a 10% decrease or more in total hours worked in 2019 relative to 1970. This group includes Denmark, Finland, France, Germany, Ireland, Korea, Spain, and Switzerland. On average, total hours worked decrease by 17% for countries in Group 1. Group 2 is comprised of countries that experience a change in total hours worked ranging from a 10% decrease to no change (excluding the end points). This group consists of Austria, Belgium, Italy, Japan, the Netherlands, Norway, and the United Kingdom (hereafter UK). On average, total hours worked decrease by 5% for countries in Group 2. Finally, Group 3 is comprised of countries that experience either no change or increases in total hours worked. This group includes Australia, Canada, Greece, Luxembourg, Mexico, New Zealand, Portugal, Sweden, and the US. On average, total hours worked increase by 11% for countries in Group 3. Overall, Table 1 highlights the vast cross-country differences in the changes in total hours worked over the period studied.

Another stylised fact includes that many countries experience increases in total hours worked over the period studied. This is demonstrated through nine countries residing in Group 3 in panel (b) from Table 1, which implies that these countries experienced either no change or increases in total hours worked. The country with the largest increase in total hours worked was Luxembourg at 37%, while Australia, New Zealand, and the US experience increases of

1%, 5% and 6%, respectively. This regularity is striking given that past work[8] frequently documents decreases in total hours worked across countries over time.

Figure 2 provides additional evidence to support this regularity by displaying total hours worked in New Zealand, Australia, Scandinavia, Europe (excluding Scandinavia), and the US, between 1970 and 2019.[9] The figure displays that total hours worked increased for each country grouping from 2013 onwards. Moreover, Figure 2 displays that total hours worked in New Zealand is higher than in the US over most of the sample period. However, between 1989 and 2001 total hours worked was higher in the US than in New Zealand and a maximum difference of around 129 hours was achieved. Despite this, total hours worked in New Zealand exceeds total hours worked in the US by around 74 hours on average over the sample period. Similarly, Figure 2 reveals that total hours worked in New Zealand has been higher than total hours worked in Australia over the majority of the sample period. This is illustrated through total hours worked in New Zealand exceeding that in Australia over the entire period studied except for periods of close overlap between 1989 and 1993 and between 2008 and 2012. On average, total hours worked in New Zealand exceeded total hours worked in Australia by around 75 hours on average over the sample period.

*Figure 2. Total hours worked, New Zealand vs. other OECD countries, 1970-2019**



* Standardised by working age population. Source: The Conference Board Total Economy Database and the World Bank's World Development Indicators, April 2021.

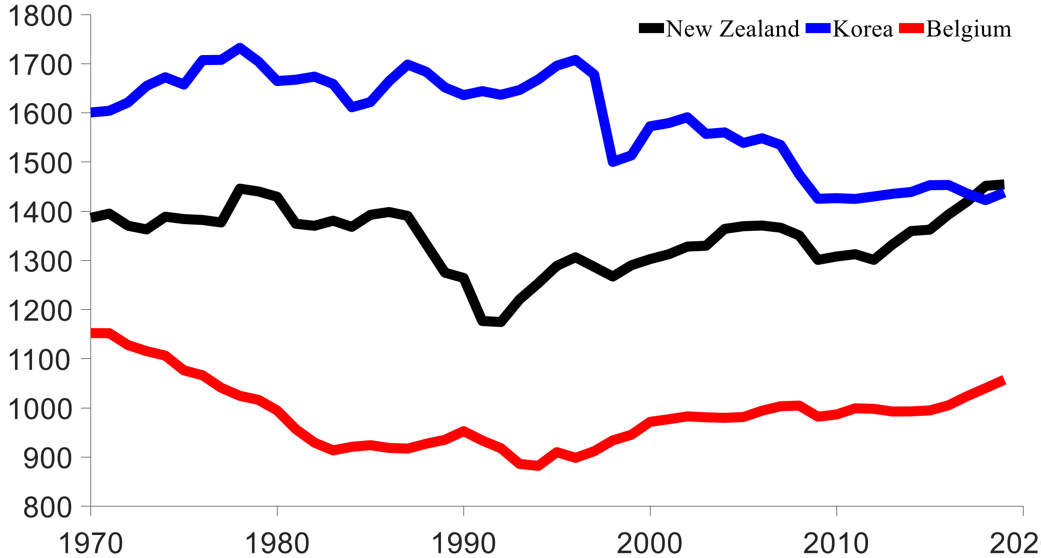
[8] See Prescott (2004), Rogerson (2006), Ohanian et al. (2008) and the references therein.

[9] *Scandinavia* refers to the average of Denmark, Finland, Norway, and Sweden. *Europe (excluding Scandinavian countries)* includes Austria, Belgium, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Switzerland, and the UK.

Furthermore, there is a large amount of variability in total hours worked across countries over the period studied. Panel (a) of Table 1 reveals that the standard deviation for total hours worked across countries in a given year ranges from 141.27 in 1975 to 187.80 in 1987. This demonstrates that there is a considerable amount of cross-country variability in total hours worked throughout the entire period. Figure 2 visually depicts the high degree of variability in total hours worked across countries over time. Within the country groupings studied total hours worked ranges from 1,092 in Scandinavia in 1994 to 1,455 in New Zealand in 2019.

On average, Korea has the highest level of total hours worked between 1970 and 2019 at 1,587, whereas Belgium has the lowest at 987. Figure 3 displays total hours worked in New Zealand, Korea, and Belgium between 1970 and 2019. Interestingly, total hours worked in New Zealand overtook total hours worked in Korea in 2018. This illustrates that New Zealand has a relatively high level of aggregate labour supply compared to other OECD countries in recent times.

*Figure 3. Total hours worked, New Zealand, Korea, and Belgium, 1970-2019**



* Standardised by working age population. Source: The Conference Board Total Economy Database and the World Bank's World Development Indicators, April 2021.

2.1.2 Hours per worker

The direction of change in the intensive margin of aggregate labour supply is consistent across each country studied. Specifically, every country experiences a decline in the intensive margin between 1970 and 2019. Table 2 displays the distribution of average hours worked per worker across 24 OECD countries. Panel (b) of Table 2 compares average hours worked in 2019 relative to 1970 and splits the countries into three distinct groups.

Table 2. Distribution of average hours worked per worker across 24 OECD countries

Panel (a): Summary statistics

	Average	Standard deviation
OECD		
Min (Year)	1,669 (2019)	199.03 (2019)
Max (Year)	2.003 (1970)	297.06 (1986)

Panel (b): Country-specific patterns

Average hours worked in 2019 relative to 1970:

≤ 0.80		(0.80, 0.95)		≥ 0.95	
Denmark	0.75	Australia	0.89	Greece	0.97
Finland	0.80	Austria	0.85	New Zealand	0.95
France	0.76	Belgium	0.84		
Germany	0.70	Canada	0.88		
Ireland	0.76	Italy	0.84		
Japan	0.79	Luxembourg	0.82		
Korea	0.68	Portugal	0.89		
Netherlands	0.78	Spain	0.84		
Norway	0.75	Sweden	0.94		
Switzerland	0.78	United Kingdom	0.89		
		United States	0.93		
Group 1	0.76	Group 2	0.87	Group 3	0.96

Source: The Conference Board Total Economy Database and the World Bank's World Development Indicators, April 2021.

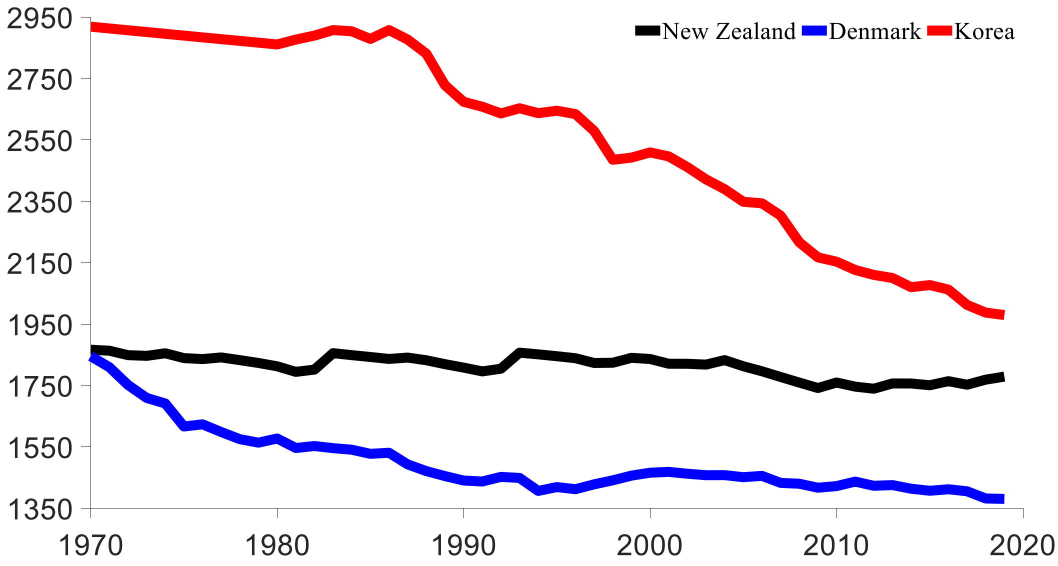
Group 1 is comprised of ten countries[10] that experience at least a 20% decrease in average hours worked per worker. On average, average hours worked per worker decrease by 24% for countries in Group 1. Group 2 is comprised of 11 countries[11] that experience decreases between 20% and 5% (excluding the end points). On average, average hours worked per worker decrease by 13% for countries in Group 2. Finally, Group 3 consists of two countries that experience a decrease of 5% or less; namely Greece and New Zealand. Greece and New Zealand experience decreases of 3% and 5%, respectively. Thus, panel (b) of Table 2 reveals that each country's intensive margin decreases.

On average, Korea has the highest average hours worked per worker between 1970 and 2019 at 2,560, whereas Denmark has the lowest at 1,500. Figure 4 displays the average hours worked per worker in New Zealand, Korea, and Denmark between 1970 and 2019. In 1970 the average hours worked per worker in Korea (2,919) was approximately 50% higher than the average hours worked per worker in New Zealand (1,867) and Denmark (1,845). Korea experienced a

[10] Denmark, Finland, France, Germany, Ireland, Japan, Korea, the Netherlands, Norway, and Switzerland.
[11] Australia, Austria, Belgium, Canada, Italy, Luxembourg, Portugal, Spain, Sweden, the UK, and the US.

substantial decline in their intensive margin over time whereas New Zealand's intensive margin remained relatively constant. These differing trends have led to average hours worked in Korea being approximately only 10% higher than average hours worked in New Zealand in 2019.

Figure 4. Average hours worked per worker, New Zealand, Korea, and Denmark, 1970-2019



Source: The Conference Board Total Economy Database, April 2021.

2.1.3 Employment rates

Similar to the intensive margin, the direction of change in the extensive margin of aggregate labour supply is consistent across each country studied. Specifically, every country experiences an increase in the extensive margin between 1970 and 2019. Table 3 presents the distribution of employment rates across 24 OECD countries. Panel (b) of Table 3 compares the employment rate in 2019 relative to 1970 for each country and splits the countries into three distinct groups.

Table 3. Distribution of employment rates across 24 OECD countries

Summary statistics					
		Average			Standard deviation
OECD					
Min (Year)		0.65 (1984)			0.07 (Multiple years)
Max (Year)		0.77 (2019)			0.10 (Multiple years)
Panel (b): Country-specific patterns					
Employment rate in 2019 relative to 1970:					
≤ 1.10		(1.10, 1.20)		≥ 1.20	
Austria	1.09	Australia	1.13	Canada	1.24
Belgium	1.09	Ireland	1.11	Japan	1.21
Denmark	1.06	Italy	1.15	Korea	1.32
Finland	1.04	Switzerland	1.12	Luxembourg	1.68
France	1.04	United States	1.14	Mexico	1.37
Germany	1.10			Netherlands	1.25
Greece	1.03			Norway	1.20
New Zealand	1.10			Portugal	1.22
Spain	1.02				
Sweden	1.07				
United Kingdom	1.09				
Group 1	1.07	Group 2	1.13	Group 3	1.31

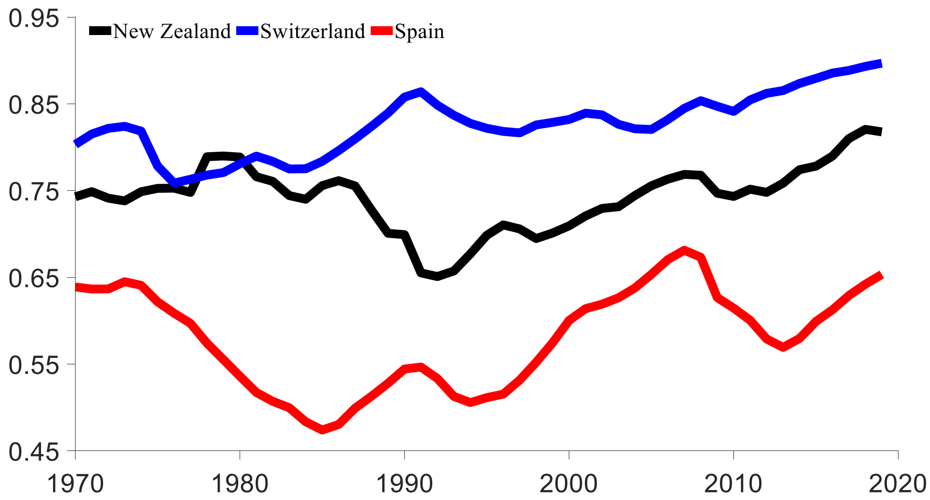
Source: The Conference Board Total Economy Database and the World Bank's World Development Indicators, April 2021. Notes: The minimum standard deviation of 0.07 was achieved each year between 1974 and 1979. The maximum standard deviation of 0.10 was achieved each year between 2011 and 2019.

Group 1 is comprised of 11 countries[12] that experience an increase less than 10%. The average employment rate increases by 7% for countries in Group 1. Group 2 is comprised of five countries[13] that experience increases between 10% and 20% (excluding the end points). On average, the employment rate in Group 2 increases by 13%. Group 3 is comprised of eight countries[14] that experience increases greater than 20%. Luxembourg recorded the highest increase at 68%. On average, the employment rate in Group 3 increases by 31%.

On average, Switzerland has the highest employment rate between 1970 and 2019 at 0.83, whereas Spain has the lowest at 0.58. Figure 5 displays the employment rate in New Zealand, Switzerland, and Spain between 1970 and 2019. The figure illustrates that New Zealand's employment rate is lower than Switzerland's at the beginning of the sample period. The employment rates in the two countries converge during the mid-1970s and eventually diverge following the mid-1980s. New Zealand's employment rate follows a similar trend and remains fairly close to Switzerland's employment rate throughout the remainder of the sample period.

[12] Austria, Belgium, Denmark, Finland, France, Germany, Greece, New Zealand, Spain, Sweden, and the UK.
[13] Australia, Ireland, Italy, Switzerland, and the US.
[14] Canada, Japan, Korea, Luxembourg, Mexico, the Netherlands, Norway, and Portugal.

Figure 5. Employment rate, New Zealand, Switzerland, and Spain, 1970-2019



Source: The Conference Board Total Economy Database and the World Bank's World Development Indicators, April 2021.

3. Model

The model is a variant of the neoclassical growth model and it follows Ohanian et al. (2008) and Üngör (2014). Time is indexed by t. We consider an economy comprised of a large number of similar, infinitely-lived households, each of which acts at time t to maximise their utility function:

$$\sum_{t=0}^{\infty} \beta^t U(C_t + \lambda G_t, \bar{H} - H_t) . \tag{2}$$

Here C_t denotes the household's private consumption in period t and G_t denotes the per-household consumption of public services, i.e., the public expenditure on utility-generating government services in period t. Note that G_t is determined outside the household's control. Amano and Wirjanto (1997), among many others, provide evidence to support the claim that a general model of consumption should allow for the direct effect of public expenditure on a consumer's utility.[15] Leisure time is given by $\bar{H} - H_t$, where $\bar{H}$ denotes the number of available hours for work and H_t denotes actual hours worked. The parameter β is the subjective discount factor $(0 < \beta < 1)$ that reflects a preference for current over future consumption-leisure bundles. The parameter λ measures the relative weights on private and government consumption $(0 \leq \lambda \leq 1)$.

[15] Several studies allow consumer preferences to depend on public expenditure. See, among many others, Aschauer (1985), Djajic (1987), Barro (1990), Baxter and King (1993), Karras (1994), and Trabandt and Uhlig (2011).

We specify the utility function as

$$U(C_t, G_t, \bar{H} - H_t) = \alpha log(C_t + \lambda G_t - \bar{C}) + (1-\alpha)\frac{(\bar{H}-H_t)^{1-\gamma}-1}{1-\gamma}, \tag{3}$$

where $\gamma \geq 0, 0 \leq \alpha \leq 1, 0 \leq \lambda \leq 1$, and $\bar{C} \geq 0$. Here $\bar{C}$ denotes subsistence consumption. Steger (2000) states that subsistence consumption refers to a standard of living that allows for the satisfaction of the minimum basic needs of life. Only consumption in excess of $\bar{C}$ generates utility for the household.[16] It is also worth noting that the linear combination $C_t + \lambda G_t$ represents effective consumption. Aschauer (1985) states that when assuming a constant marginal rate of substitution, a one unit increase in G_t generates the same amount of utility as a λ unit increase in C_t. Karras (1994) discusses that a higher value of λ implies that G_t is a better substitute for C_t. The parameter γ denotes the elasticity of substitution between leisure and consumption, and the parameters α and $(1-\alpha)$ measure the relative weights on consumption and leisure in the utility function respectively.

The household starts with an initial stock of physical capital K_0, and decides how much to add to it in the form of new investment. Every period physical capital depreciates at a rate δ, where $0 < \delta < 1$. The law of motion for physical capital is then $K_t = I_t + (1-\delta)K_{t-1}$, and the real interest rate is r_t. The capital income of the household in period t is $r_t K_t$. The wage rate is w_t and the pre-tax labour income is $w_t H_t$.

The household's problem is

$$max \sum_{t=0}^{\infty} \beta^t \left\{\alpha log(C_t + \lambda G_t - \bar{C}) + (1-\alpha)\frac{(\bar{H}-H_t)^{1-\gamma}-1}{1-\gamma}\right\} \tag{4}$$

subject to

$$(1+\tau_{c,t})C_t + I_t \leq r_t K_t + (1-\tau_{l,t})w_t H_t + \Pi_t + T_t. \tag{5}$$

The government implements proportional taxes on labour income and consumption which are denoted by $\tau_{l,t}$ and $\tau_{c,t}$, respectively. Π_t denotes the firms' profit and T_t represents government transfers. The government levies taxes on labour income as well as consumption

[16] Additional papers that consider a subsistence level of consumption include King and Rebelo (1993), Kongsamut et al. (2001), and Ravn et al. (2008).

expenditures in order to finance spending on utility-enhancing government purchases. The government budget constraint is $G_t + T_t = \tau_{c,t}C_t + \tau_{l,t}w_tH_t$. The government budget is balanced as government transfers are determined residually in each period. The tax wedge, denoted $(1-\tau_t)$, combines the tax rates of interest in a simple ratio:

$$1-\tau_t \equiv \frac{1-\tau_{l,t}}{1+\tau_{c,t}}. \tag{6}$$

Technology is specified by a Cobb-Douglas production function:

$$Y_t = A_tF(K_t, H_t) = A_tK_t^{\theta}H_t^{1-\theta}. \tag{7}$$

Here A_t denotes efficiency, K_t denotes capital, and H_t denotes labour. The parameters θ and $(1-\theta)$ are the elasticities of output with respect to capital and labour, respectively. The problem of the firm is a sequence of static profit maximising problems, where profit (Π_t) is defined as $\Pi_t = A_tK_t^{\theta}H_t^{1-\theta} - w_tH_t - r_tK_t$. The price of output is normalised to unity.

We focus on the competitive allocation for this economy. Studying the competitive allocation allows a comparison of model hours generated with the actual data on total hours worked. The key equation that facilitates this comparison involves equating the marginal rate of substitution between consumption and leisure to the tax-adjusted marginal product of labour:

$$\frac{U_2(C_t, +\lambda G_t, \bar{H}-H_t)}{U_1(C_t+\lambda G_t, \bar{H}-H_t)} = (1-\tau_t)A_tF_2(K_t, H_t). \tag{8}$$

After applying functional form assumptions we obtain the key equation:

Proposition 1:

$$\frac{H_t}{(\bar{H}-H_t)^{\gamma}} = (1-\tau_t)\cdot\frac{\alpha(1-\theta)}{(1-\alpha)}\cdot\frac{Y_t}{C_t+\lambda G_t-\bar{C}}. \tag{9}$$

Proof: See Appendix A.1.1.

Lemma 1: When $\gamma = 1$ the closed form solution for total hours worked is:

$$H_t = \frac{(1-\tau_t)\alpha(1-\theta)\bar{H}Y_t}{(1-\alpha)(C_t+\lambda G_t-\bar{C})+(1-\tau_t)\alpha(1-\theta)Y_t}. \tag{10}$$

Proof: See Appendix A.1.2.

By inputting data for the variables on right-hand side of Equation (9) we can compute model hours. The generated series for model hours can be compared with the actual data. This enables an assessment of the model's performance by considering the extent to which the model can account for the observed patterns in the data. Following this, we carry out a sensitivity analysis which breaks down the relative importance of the changes in taxes as well as the values assigned to other model parameters for the model's performance.

4. Quantitative analysis

4.1 Data and model parameterisation

Consumption tax: We follow the approach of Mendoza et al. (1994) to compute time series data for $\tau_{c,t}$ for each country.[17] This approach calculates $\tau_{c,t}$ by expressing all forms of tax revenue earnt from consumption as a fraction of the consumption tax base. Specifically, $\tau_{c,t}$ is obtained by dividing the sum of general taxes on goods and services (tax code 5110) and excise taxes (5121) by the consumption tax base. The consumption tax base is given by the sum of household's private consumption, C, and government final consumption expenditure, G, less total compensation of employees paid by the government, GW, and the indirect taxes mentioned above: $\tau_{c,t} = \frac{5110+5121}{C+G-GW-\ 5110-5121}$.

We obtain time series data for the tax revenues from OECD revenue statistics.[18] Time series data for the remaining variables are obtained from the OECD national accounts database.[19] C uses time series data from "Households and Non-profit institutions servings households," G uses time series data from "Final consumption expenditure of general government," and GW uses time series data from "Total compensation of employees paid by the government."[20]

Labour tax: We follow the approach of Mendoza et al. (1994) to compute time series data for $\tau_{l,t}$ for each country.[21] Computing $\tau_{l,t}$ involves calculating the household's average tax rate

[17] Carey and Rabesona (2002) and McDaniel (2007) offer alternative approaches to compute $\tau_{c,t}$. Appendix A.2 provides an explanation of the methods used by Carey and Rabesona and McDaniel to compute $\tau_{c,t}$, and presents a comparative analysis across the alternative methods.
[18] OECD revenue statistics: https://stats.oecd.org/Index.aspx?DataSetCode=REV
[19] OECD.Stat, which contains the OECD national accounts database: https://stats.oecd.org/
[20] See Appendix A.5 for specific data challenges for New Zealand and how we handle them.
[21] Similar to the consumption tax, Carey and Rabesona (2002) and McDaniel (2007) offer alternative approaches to compute $\tau_{l,t}$. Appendix A.3 provides an explanation of the methods used by Carey and Rabesona and McDaniel to compute $\tau_{l,t}$, and provides a comparative analysis across the alternative methods.

on total income ($\tau_{h,t}$): $\tau_{h,t} = \frac{1100}{OSPUE+PEI+W}$. Here the code 1100 denotes taxes on income, profits, and capital gains of individuals, *OSPUE* denotes the operating surplus of private unincorporated enterprises, and *PEI* denotes household's property and entrepreneurial income. Time series data for 1100 are obtained from OECD revenue statistics. Time series data for the remaining variables are obtained from the OECD national accounts database. The variable $OSPUE$ is obtained by subtracting the time series "Consumption of fixed capital" from "Operating surplus and mixed income (gross)." The variable PEI is obtained by subtracting the time series "Property income paid" from "Property income received," and the variable W uses time series data from "Wages and salaries."

After calculating $\tau_{h,t}$ we estimate the revenue earnt from income taxes on wages and salaries as $\tau_{h,t} \cdot W$. Additional tax revenues included in the formula for $\tau_{l,t}$ include total social security contributions (2000) and taxes on payroll and workforce (3000). To obtain $\tau_{l,t}$ the sum of these labour tax revenues is divided by the sum of wages and salaries (W) and employer's contributions to social security (2200): $\tau_{l,t} = \frac{\tau_{h,t} \cdot W + 2000 + 3000}{W + 2200}$.

Data sources for the remaining variables: The remaining variables included in Equation (9) are Y_t and H_t. The variable Y_t denotes gross domestic product and uses data from the time series "Gross domestic product (expenditure approach)" which is available from the OECD national accounts database. The variable H_t denotes total hours worked, which is the product of the intensive margin and the extensive margin. The intensive margin uses times series data from "Average annual hours worked per worker" from the Conference Board Total Economy Database. The extensive margin is calculated by dividing a country's employment level by the working age population. The working age population is defined as the share of the population between the age of 15 and 64 in a country. To calculate the extensive margin time series data for the employment level called "Persons employed (thousands)" is used from the Conference Board Total Economy Database. For the working age population time series data called "Population ages 15-64, total" is used from the World Bank Development Indicators.

Parameterisation: Throughout the analysis the parameter $\bar{H}$ is set to be 5110 ($= 14\ hours \times 365\ days$). In the benchmark model preferences are logarithmic in consumption and leisure. Therefore, we consider the limiting case, and set γ=1. Further, we assume that per-household consumption of public services (G) is a perfect substitute for private consumption

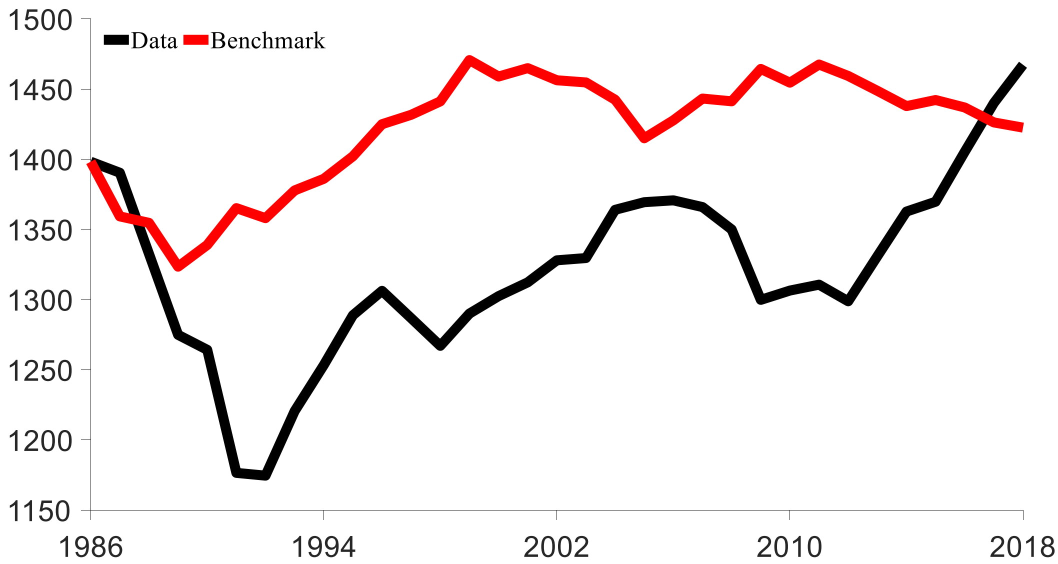
(C), which implies that $\lambda = 1$. The benchmark model assumes away subsistence consumption by setting $\bar{C} = 0$. Finally, the model is calibrated such that the base year occurs in the initial year of the sample period. In doing this, we choose the value of $\frac{\alpha(1-\theta)}{1-\alpha}$ so that the model hours are equal to the data in the base year. Since α and θ enter the right-side of Equation (9) as a constant of proportionality, then the values of these variables are irrelevant for accounting for changes in hours relative to a base year (see Ohanian et al., 2008; Üngör, 2014). Consequently, model hours equal the data in the initial year.

4.2 New Zealand results

Figure 6 compares model hours predicted by the benchmark model and the actual data on total hours worked in New Zealand between 1986 and 2018. The model performs poorly in explaining the patterns in New Zealand's total hours worked. The model is only able to account for around 17% of the decrease in total hours worked between 1986 and 1992;[22] and it accounts for 32.4% of the increase in total hours worked between 1992 and 2006. After 2006 the performance of the model deteriorates as it fails to account for the changes in New Zealand's total hours worked. In particular, the model fails to generate the large increase in New Zealand's total hours worked between 2012 and 2018. Model hours worked decrease from around 1459 in 2012 to 1422 in 2018, whereas total hours worked in the data increase from 1299 in 2012 to 1467 in 2018. Additionally, the benchmark model has difficulty emulating the magnitude of total hours worked in New Zealand. On average, model hours exceed total hours worked in the data by around 103 hours between 1987 and 2018. This suggests that the model may exclude important factors that contribute to the patterns in total hours worked in New Zealand. The importance of other factors that potentially contribute to total hours worked in New Zealand are explored in Section 5.

[22] This calculation is performed as follows: the benchmark model predicts that total hours worked in New Zealand decreased from around 1398 in 1986 to 1358 in 1992. This represents a $100 \cdot ln(1398/1358)/6 = 0.484\%$ annual decrease in model hours worked. In the data total hours worked in New Zealand decreased from approximately 1398 in 1986 to 1174 in 1992. This represents a $100 \cdot ln(1398/1174)/6 = 2.91\%$ annual decrease in total hours worked. Therefore, the model is able to account for $100 \cdot 0.484/2.91 \approx 16.75\%$ of the decrease in total hours worked in New Zealand between 1986 and 1992.

Figure 6. Total hours worked, model versus data, New Zealand, 1986-2018

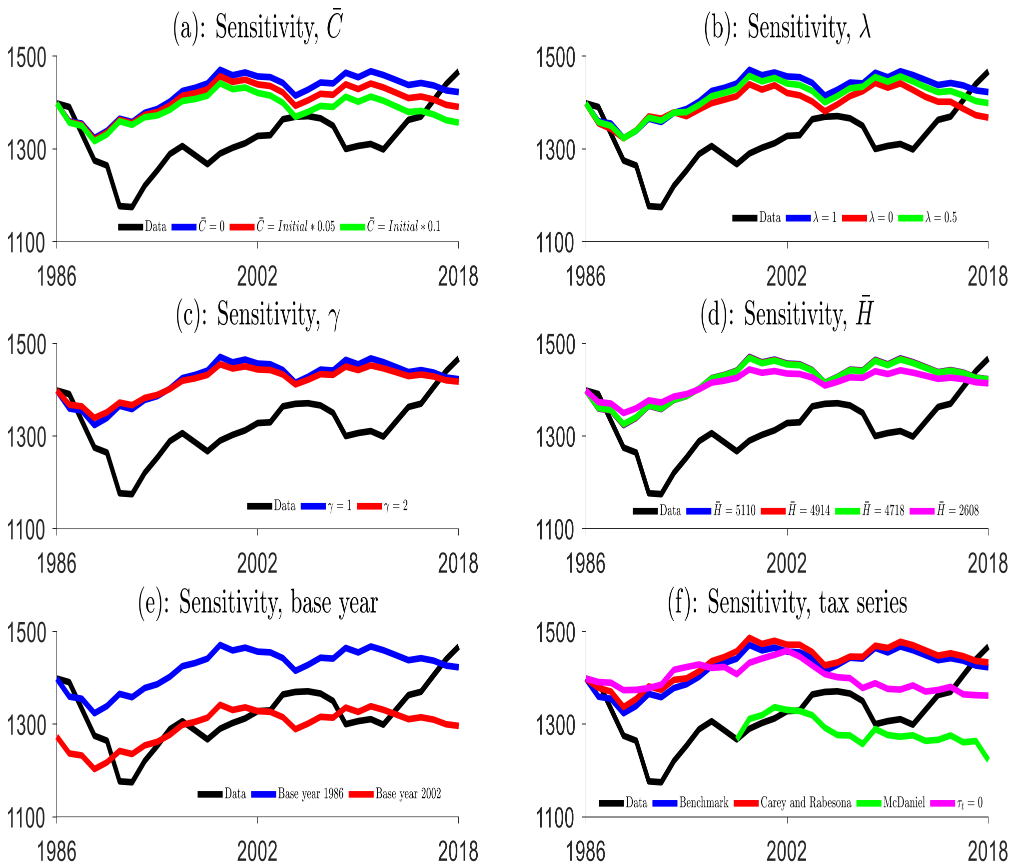


Source: The Conference Board Total Economy Database, the World Bank's World Development Indicators, and OECD.Stat, April 2021.

Figure 7 displays a sensitivity analysis for New Zealand. Panel (a) displays the sensitivity analysis for $\bar{C}$. We compute model hours for two additional calibrations involving $\bar{C}$; $\bar{C} = 5\%$ of initial total consumption and $\bar{C} = 10\%$ of initial total consumption. The results of the experiments are very close to those of the benchmark, although there are some magnitude differences.

Panel (b) displays the sensitivity analysis for λ. We compute model hours for two additional calibrations involving λ; $\lambda = 0$ and $\lambda = 0.5$. The additional calibrations do not change the results between 1986 and 1993 and the remaining results are very similar to those obtained by the benchmark model. Despite having a reasonably low explanatory power, the benchmark model (with λ =1) performs better in accounting for the patterns in New Zealand's total hours worked between 1993 and 2006 compared to the additional calibrations. Specifically, the benchmark model accounts for 30.7% of the increase in total hours worked between 1993 and 2006, whereas the calibrations that set $\lambda = 0.5$ and $\lambda = 0$ explain 22.2% and 10.6% of these increases, respectively. Therefore, when the model is calibrated such that G_t is a perfect substitute for C_t this leads to an improved explanatory power of the model. The benchmark model and additional calibrations fail to explain the patterns in New Zealand's total hours worked between 2006 and 2018. Overall, the model results are fairly robust to small changes in the value of λ, although the model performance is improved when $\lambda = 1$.

Figure 7. Sensitivity analysis, New Zealand, 1986-2018



Source: The Conference Board Total Economy Database, the World Bank's World Development Indicators, and OECD.Stat, April 2021.

Panel (c) displays the sensitivity analysis for γ. We compute model hours for an extra calibration involving γ; $\gamma = 2$. The additional calibration obtains model results that are very similar to the benchmark model. This occurs because the trend and magnitude of model hours computed by the benchmark model and the calibration that sets $\gamma = 2$ are very similar. The correlation between the two model hours series is almost 1 and the model hours computed by the benchmark model exceed those computed by the recalibrated model by only 5 hours on average between 1987 and 2018 Therefore, the model results are fairly robust to small changes in the value of γ.

Panel (d) displays the sensitivity analysis for $\overline{H}$. We compute model hours for three additional calibrations involving $\overline{H}$; $\overline{H} = 4914$, $\overline{H} = 4718$ and $\overline{H} = 2608$.[23] The calibration $\overline{H} = 2608$ is intended to approximate the number of available hours for work in New Zealand. The standard working week in New Zealand is 40 hours, which suggests that a New Zealand worker has 8 hours available to work each day (assuming a worker spreads their hours of work evenly across the working week). Also, a New Zealand worker is entitled to a minimum of four weeks paid annual leave if they work in a full time or part-time job.[24] In addition, there are 11 recognised public holidays in New Zealand, which suggests that if a standard full time New Zealand worker takes full advantage of their paid annual leave entitlements and public holidays they will have 326 available work days (=365 days–28 days–11 days).[25] Thus, the available hours for work per year in New Zealand is approximated as being $\overline{H} = 2608$ (=8 hours $\times$ 326 days). Each of the additional calibrations obtain model results that are very similar to the benchmark model. The occurs because the trend and magnitude of the model hours produced by the calibrations that set $\overline{H} = 4914$ and $\overline{H} = 4718$ are virtually identical to those computed by the benchmark model. The model hours produced by the calibration that sets $\overline{H} = 2608$ does not match the benchmark model hours as closely compared to the other calibrations. Despite this, the model results are very similar. Overall, the model results are fairly robust to changes in the value of $\overline{H}$.

Panel (e) displays the sensitivity analysis for the base year. We compute model hours for an extra calibration where the base year is set at 2002. This alternative base year was selected as it corresponds to the half-way point in the sample period for New Zealand's model hours series. The additional calibration obtains model results that are very similar to the benchmark model. This occurs because the trend of the model hours computed by the benchmark model and the calibration with a base year of 2002 are very similar. The correlation between the two model hours series is almost 1. However, adjusting the base year does alter the magnitude of the model hours. On average, the model hours computed by the benchmark model exceed those computed

[23] Setting $\overline{H} = 4914$ alters the number of hours available for work per year by assuming that each individual has 14 hours available to work each day across 351 days (i.e., the worker takes two weeks of leave). Setting $\overline{H} = 4718$ alters the number of available hours for work per year by assuming that each individual has 14 hours available to work each day across 337 days (i.e., the worker takes four weeks of leave).

[24] Annual leave entitlements in New Zealand: https://www.govt.nz/browse/work/annual-leave/how-much-annual-leave-you-get/#:~:text=You're%20entitled%20to%20at,day%20you%20started%20work%2C%20or

[25] Employsure provides a discussion of public holidays observed in New Zealand: https://employsure.co.nz/guides/annual-leave-and-other-leave/public-holidays/#:~:text=Employers%20across%20New%20Zealand%20are,comes%20to%20public%20holiday%20pay

by the recalibrated model by 126 hours between 1986 and 2018. Overall, the model results are fairly robust to changes in the base year.

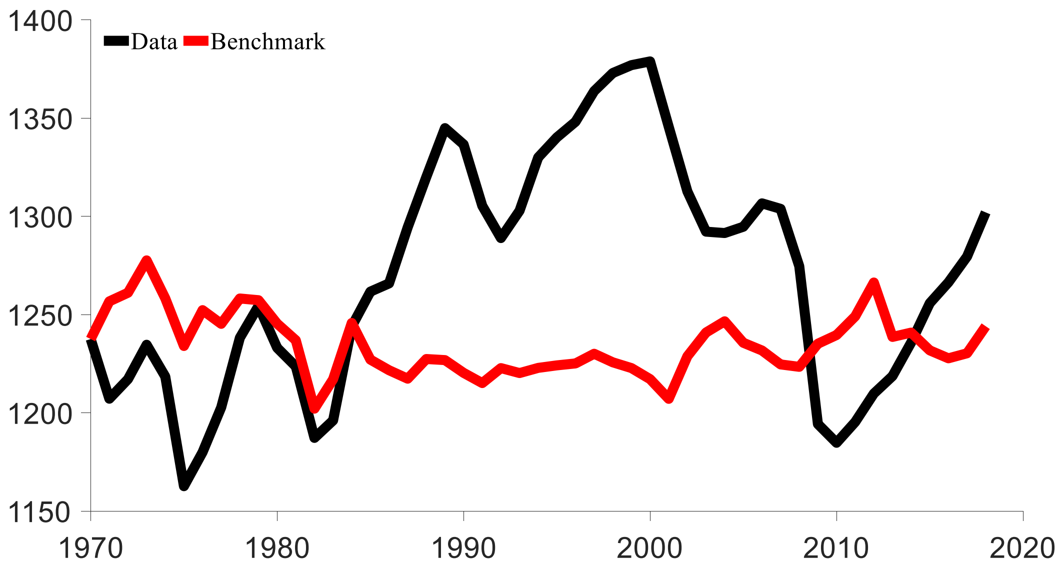
Panel (f) displays the sensitivity analysis for the tax series.[26] We compute model hours using three additional tax wedge series. The first recalibration involves computing the tax wedge à la Carey and Rabesona (2002). This is achieved by computing the tax wedge using $\tau_{c,t}^{CR}$ and $\tau_{l,t}^{CR}$. The recalibrated model obtains model results that are very similar to the benchmark model. The second recalibration involves computing the tax wedge à la McDaniel (2007). This is achieved by computing the tax wedge using $\tau_{c,t}^{M}$ and $\tau_{l,t}^{M}$. This recalibrated model has a base year of 1998 as it computes model hours between 1998 and 2018. This model performs poorly in explaining the patterns in New Zealand's total hours worked. For instance, the model has low explanatory power between 1998 and 2006 as it only accounts for 9.37% of the increase in New Zealand's total hours over this period. Additionally, the model fails to explain the increase in New Zealand's total hours worked between 2012 and 2018; model hours decrease by 60 hours over this period whereas total hours worked in the data increases by around 169 hours. The recalibrated model has difficulty emulating the magnitude of total hours worked in New Zealand. On average, total hours worked in the data exceed the model hours by 60 hours between 1998 and 2018. Finally, the third recalibration involves ignoring the influence of the tax wedge. This recalibrated model performs worse than the benchmark model between 1986 and 2006. The benchmark model accounts for 16.75% of the decrease in New Zealand's total hours worked between 1986 and 1992, whereas the recalibrated model is only able to account for 5.44%. Also, the benchmark model accounts for 32.41% of the increase in New Zealand's total hours worked between 1992 and 2006, whereas the recalibrated model is only able to account for 7.51%. However, despite having low explanatory power, unlike the benchmark model the recalibrated model is able to account for the decrease in New Zealand's total hours worked between 2006 and 2012. Specifically, the recalibrated model accounts for 23.58% of the decrease in New Zealand's total hours worked between 2006 and 2012. Similar to the benchmark model the recalibrated model fails to explain the increase in New Zealand's total hours worked between 2012 and 2018.

[26] See Appendix A.4 for details.

4.3 US results

Figure 8 compares model hours predicted by the benchmark model and the actual data on total hours worked in the US between 1970 and 2018. Initially the benchmark model performs well in explaining the patterns in total hours worked in the US. This is demonstrated through the model accounting for 70% of the decreases in total hours worked between 1970 and 1982. Therefore, the explanatory power of the model is fairly high over this period. In addition, the model overpredicts total hours worked in the US by around 35 hours on average between 1971 and 1982. The performance of the model deteriorates dramatically after 1982. The model accounts for only 8.3% of the increase in total hours worked between 1982 and 2000. The model fails to explain the decrease in total hours worked between 2000 and 2010. Additionally, the model accounts for only 3.8% of the increase in total hours worked between 2010 and 2018. The model underpredicts total hours worked in the US by around 58 hours on average between 1982 and 2018. The poor model performance after 1982 suggests that the model may exclude important factors that contribute to the patterns in total hours worked in the US.

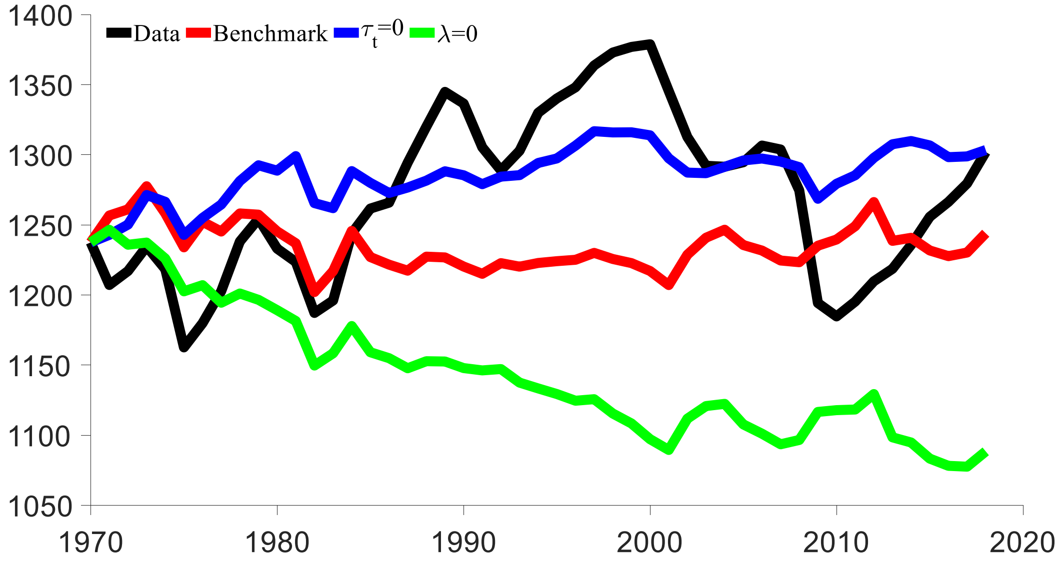
Figure 8. Total hours worked, model versus data, United States, 1970-2018



Source: The Conference Board Total Economy Database, the World Bank's World Development Indicators, and OECD.Stat, April 2021.

Figure 9 displays a sensitivity analysis for the US between 1970 and 2018. Here we decompose the relative importance of the tax wedge (1-τ_t) and the presence of per-household consumption of public services (G_t) in the utility function in accounting for the patterns in total hours worked in the US. This is achieved by performing a sensitivity analysis which computes model hours excluding the tax wedge (i.e., setting $1-\tau_t=1$) and the per-household consumption of public services (i.e., setting $\lambda=0$), respectively.

Figure 9. Sensitivity analysis, United States, 1970-2018



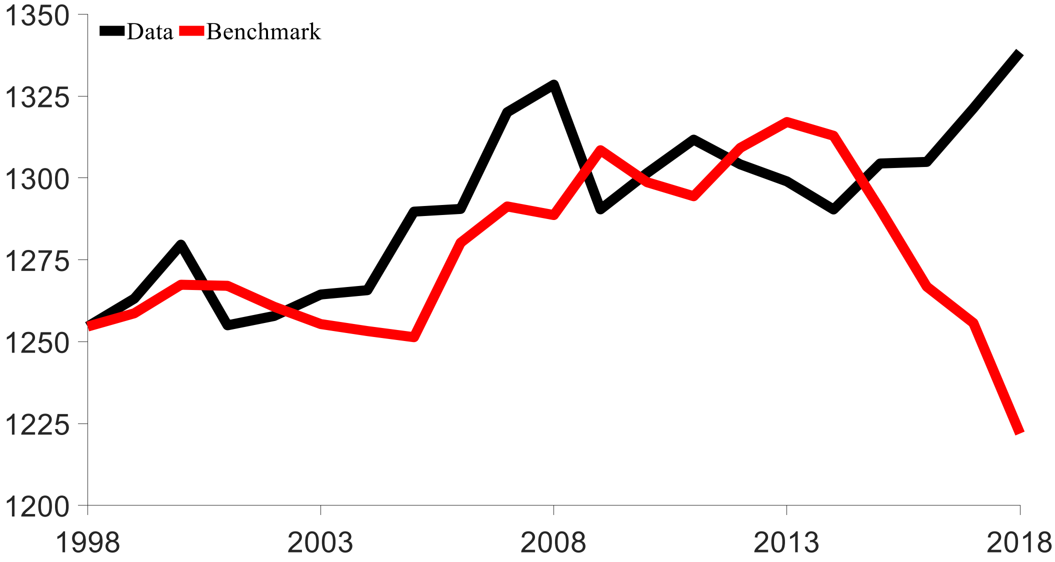
Source: The Conference Board Total Economy Database, the World Bank's World Development Indicators, and OECD.Stat, April 2021.

When the tax wedge is excluded the performance of the model worsens between 1970 and 1982 as it fails to explain the decrease in total hours worked in the US over this period. However, the performance of the model improves after 1982 when the tax wedge is excluded. Specifically, the model with $1-\tau_t=1$ is able to account for 25.1% of the increase in total hours worked between 1982 and 2000, 17.6% of the decrease in total hours worked between 2000 and 2010, and 19.7% of the increase total hours worked between 2010 and 2018. The improved performance of the model provides evidence that taxes are of limited quantitative importance in accounting for the patterns in total hours worked in the US after 1982. This finding is striking given that the literature often documents that taxes are a dominant factor in explaining patterns in total hours worked (see Ohanian et al. (2008) and the references therein). When G_t is excluded the model overpredicts the decrease in total hours worked between 1970 and 1982, and fails to explain the patterns in total hours worked in the US thereafter. This highlights how the presence of G_t in the utility function is quantitatively important when accounting for the patterns in total hours worked in the US.

4.4 Australia results

Figure 10 compares model hours predicted by the benchmark model and the actual data on total hours worked in Australia between 1998 and 2018. Initially, the benchmark model has some explanatory power in accounting for the patterns in Australia's total hours worked. For instance, the model accounts for 51.3% of the increase in total hours worked in Australia between 1998 and 2000, and 29.7% of the increase in total hours worked between 2001 and 2008. The performance of the model worsens considerably after 2008. The model fails to explain the decrease in total hours worked between 2008 and 2014 and the subsequent increase in total hours worked between 2014 and 2018. Despite this, the magnitude of the model hours and the data on total hours worked in Australia is reasonably similar between 1999 and 2014. The model underpredicts total hours worked in Australia by around 6 hours on average over this period. However, the model underpredicts total hours worked in Australia by around 42 hours on average between 2014 and 2018, emphasising the poor performance of the model towards the end of the sample period. The poor performance of the model after 2008 suggests that the model may exclude important factors that have contributed to the recent patterns in total hours worked in Australia.

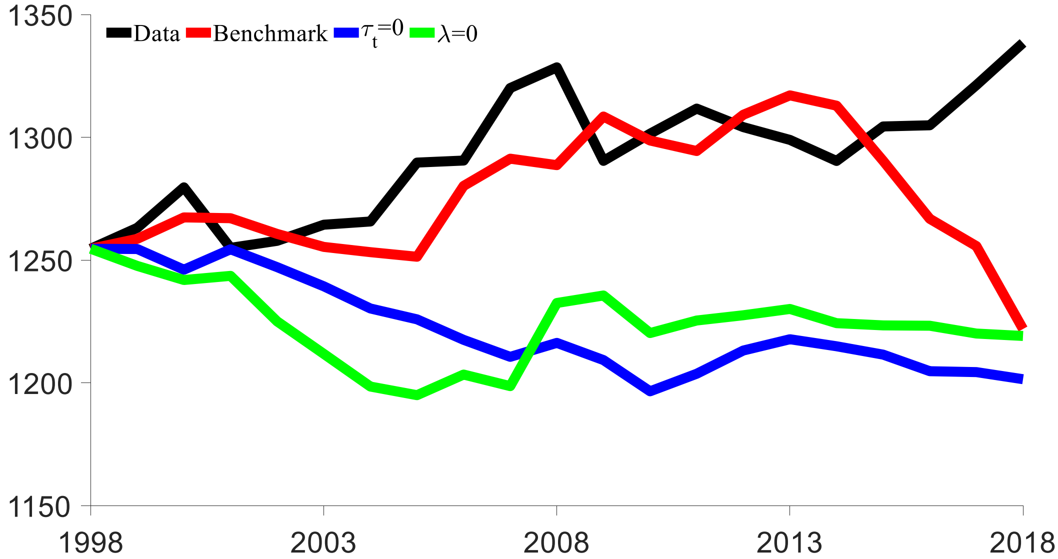
Figure 10. Total hours worked, model versus data, Australia, 1998-2018



Source: The Conference Board Total Economy Database, the World Bank's World Development Indicators, and OECD.Stat, April 2021.

Figure 11 displays a sensitivity analysis for Australia between 1998 and 2018. We decompose the relative importance of the tax wedge $(1-\tau_t)$ and the presence of per-household consumption of public services (G_t) in the utility function in accounting for the patterns in total hours worked in Australia.

Figure 11. Sensitivity analysis, Australia, 1998-2018



Source: The Conference Board Total Economy Database, the World Bank's World Development Indicators, and OECD.Stat, April 2021.

When the tax wedge is excluded the performance of the model worsens between 1998 and 2008 as it fails to explain the increase in total hours worked in Australia over this period. However, the performance of the model improves after 2008 when the tax wedge is excluded. Unlike the benchmark model, the model that excludes taxes accounts for 3.9% of the decrease in total hours worked in Australia between 2008 and 2014. Despite failing to explain the patterns in Australia's total hours worked between 2014 and 2018, the model that excludes taxes fails to a lesser extent than the benchmark model over this period. The improved explanatory power of the model that excludes taxes after 2008 provides suggestive evidence that taxes are of limited quantitative importance in accounting for the recent patterns in total hours worked in Australia. Similarly, when G_t is excluded the explanatory power of the model decreases for Australia between 1998 and 2008 but improves thereafter. This provides evidence that the inclusion of G_t in the utility function is of limited quantitative importance in accounting for the recent patterns in total hours worked in Australia.

5. Alternative explanations

5.1 Patterns in total hours worked in New Zealand

Earlier figures display that between 1970 and 1986 total hours worked in New Zealand remained at a fairly steady level, with some minor fluctuations occurring. Between 1986 and 1992 total hours worked decreased significantly by around 224 hours. This large decrease aligns with a period of vast economic reform that began in 1984.[27] An aspect of the reform that may have contributed to this decrease includes the State-Owned Enterprises Act introduced in 1986. This act was implemented to corporatise public enterprises in New Zealand and led to substantial decreases in public sector employment. Bridgman and Greenaway-McGrevy (2018) report that corporatisation redundancies accounted for between 53% and 67% of unemployed people in 1987. The substantial decrease in public sector employment would have decreased total hours worked in New Zealand along the extensive margin. This may partially explain the decrease in New Zealand's total hours worked between 1986 and 1992.

New Zealand experienced a recovery in total hours worked of around 132 hours between 1992 and 1996. Aspects of New Zealand's economic reform may have contributed this recovery, such as the deregulation of New Zealand's labour market. Bridgman and Greenaway mention that the Employment Contracts Act (hereafter ECA) implemented in 1991 contributed to a more flexible labour market environment in New Zealand by removing compulsory union membership. New Zealand subsequently experienced employment gains, which would have increased total hours worked along the extensive margin. Also, Evans et al. (1996) argue that the reduction in New Zealand's social welfare provisions in the early 1990s may have incentivised unemployed workers to enter the workforce. Further, Dalziel and Lattimore (1999, p. 81) discuss the Employment Equity Act which was introduced in 1990 to address discrimination against women in the workplace. This may have contributed to higher employment of women in New Zealand, which in turn would have increased total hours worked along the extensive margin.

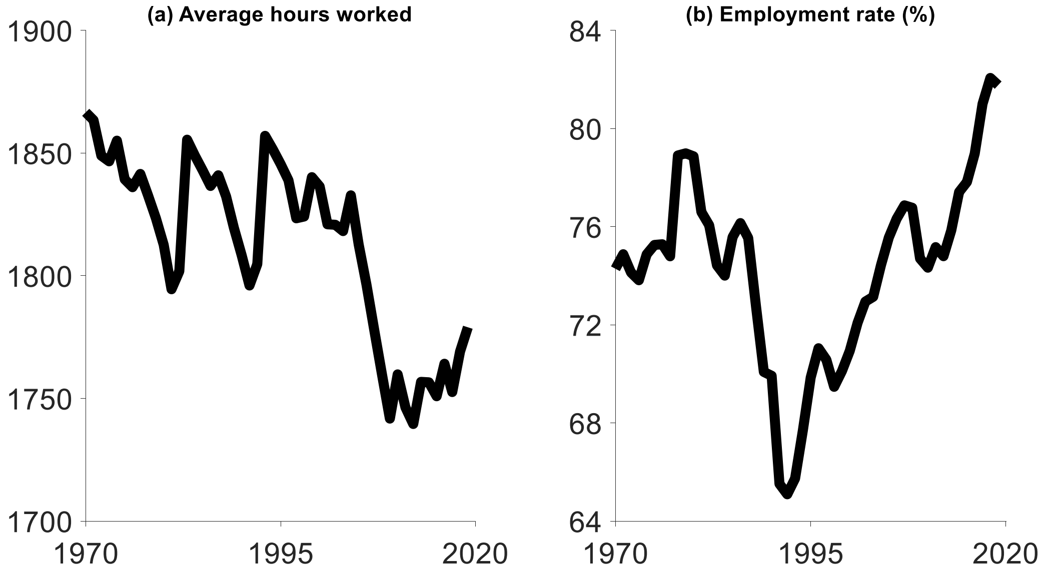
[27] In 1984 the New Zealand government initiated vast economic reforms that had major implications for the economy. Prior to this reform, the New Zealand economy had structural problems which resulted in poor economic performance (see Evans et al. (1996) for a comprehensive review).

Despite decreases between 1996 and 1998, the recovery in New Zealand's total hours worked continued until 2006. Between 2006 and 2012 total hours worked stabilised and eventually decreased.

A further increase in New Zealand's total hours worked occurred between 2012 and 2019. Specifically, total hours worked in New Zealand increased by around 154 hours from 1301 hours in 2012 to 1455 hours in 2019. In 2016 total hours worked surpassed its level in 1970. These increases led to New Zealand having the third highest aggregate labour supply out of the OECD countries studied in 2018 and 2019. Only Japan and Luxembourg had a higher aggregate labour supply than New Zealand over this period. The recent increases in New Zealand's total hours worked may have been supported by an increasing labour force participation rate. Culling and Skilling (2018) and Hyslop et al. (2019) document that New Zealand's LFPR has increased since 2000 and reached a record high of 71.1% in September 2017. Increasing rates of participation among older workers and female workers appear to be important demographic changes that have supported this trend.

Figure 12 presents the intensive margin and extensive margin of aggregate labour supply in New Zealand between 1970 and 2019. Evidently, the recent increase in total hours worked in New Zealand has occurred due to a significant increase in New Zealand's extensive margin. The extensive margin in New Zealand increased from 74.79% in 2012 to 81.77% in 2018, an increase of almost 7 percentage points. In contrast, the contribution of the intensive margin to the recent increases in total hours worked is negligible. The intensive margin experienced a moderate increase from 1740 hours in 2012 to 1779 hours in 2018, an increase of around 39 hours.

Figure 12. Two margins of aggregate labour supply, New Zealand, 1970-2019



Source: The Conference Board Total Economy Database, the World Bank's World Development Indicators, and OECD.Stat, April 2021.

5.2 Alternative explanations for the recent patterns in total hours worked in New Zealand

There is a general consensus in the literature on aggregate labour supply in New Zealand that the main driver of the recent increases has been the extensive margin. Hyslop et al. (2019) and Culling and Robinson (2020) provide support for this view, as they respectively state that the extensive margin is the dominant factor in determining aggregate labour supply in New Zealand, and that adjustment in the labour market over the long term in New Zealand is driven by the extensive margin. Therefore, the most promising explanations for the patterns in total hours worked in New Zealand are those explanations that account for the behaviour of the extensive margin. With reference to the literature on aggregate labour supply in New Zealand these explanations are explored below.

The recent increases in New Zealand's extensive margin appears to be driven by an increasing LFPR.[28] Culling and Skilling (2018) and Hyslop et al. document that New Zealand's LFPR has consistently increased since 2000 and reached a record high level of 71.1% in September 2017. New Zealand's high LFPR has been driven by strong labour force growth of 1.9% between

[28] The LFPR is calculated as the total labour force as a percentage of the working age population: https://figure.nz/chart/qw2LqNPRh59zfkKP-UHhKLTQVkufqFzb3

2000 and 2016, which is more than twice the OECD average. Therefore, the increasing LFPR in New Zealand has significantly contributed to the expansion observed in the extensive margin.

There is an agreement in the literature that various long-term demographic trends are associated with the recent increases in New Zealand's LFPR. As discussed above, the increases in New Zealand's LFPR have contributed to increases in the extensive margin, which in turn has been driving the patterns in New Zealand's total hours worked. Hyslop et al. outline the important long-term demographic trends that have contributed to New Zealand's recent participation patterns; increases in the participation of older workers, secular increases in female participation, and decreases in the participation of younger workers.

The most important demographic change associated with New Zealand's increasing LFPR is increases in the participation of older workers, namely those workers aged 55 or older. Culling and Skilling provide support for this, stating that increases in the participation of older workers accounts for the majority of the upward trend in New Zealand's aggregate participation. They reveal that the LFPR of older workers has increased by more than 20 percentage points since 2000 for both men and women. It is evident that the substantial increase in the participation of older workers has contributed significantly to the recent increases in New Zealand's extensive margin. Culling and Skilling argue that the increasing LFPR among older workers has emerged due to policy changes targeted at older workers. For instance, the eligibility age for New Zealand's Superannuation increased from 60 years in 1992 to 65 years in 2001. Also, changes in human rights legislation banning compulsory retirement on the basis of age was enacted in 1999. Moreover, Prados and Perez-Arce (2021) postulate that increased participation among older workers may occur because recent cohorts of older workers are more likely to have higher levels of education than preceding cohorts, and educated people tend to work more at higher ages. Additional explanations for the higher participation among older workers suggested by Culling and Skilling include improved health and life expectancy among older workers and technological change reducing the manual intensity of work.

Another salient feature associated with New Zealand's increasing LFPR includes secular increases in the participation of female workers. According to Hyslop et al. female participation increased from 55% in 1986 to 66% in 2017. Relatedly, the female share of the labour force increased from 42% in 1986 to 47% in 2017. The increase in female participation has contributed to an increase in New Zealand's extensive margin, which in turn has driven the recent increases in New Zealand's total hours worked. Hyslop et al. propose various explanations for the increases in the participation of female workers. These explanations include strong growth in service-industry employment, higher educational attainment among females, lower fertility rates, greater access to maternity leave and childcare, and increasing debt-servicing costs for homeowners. Culling and Skilling emphasise the importance of changes in social norms and attitudes towards women working as well as targeted policies aiming to increase female participation. A related policy includes the Working for Families[29] policy package which supports families with dependent children with the cost of raising a family. Further, Bouchard et al. (2021) find that a New Zealand policy that provides 20 hours per week of free early childhood education (ECE) for all three and four-year-olds has had tangible effects on the participation of female workers. The authors find that single child mothers who were eligible for the policy lowered their LFP in response, whereas mothers of two children who were eligible increased their LFP.

As an aside, it is worth mentioning that increases in the LFPR of older and female workers in New Zealand have contributed to decreases in the intensive margin. Culling and Skilling state that workers in these demographic groups are more likely to work in part-time jobs, which in turn puts downward pressure on average hours worked. Therefore, the overall increase in New Zealand's total hours worked has been attenuated by a decrease in the intensive margin which can be partially attributed to higher participation among older and female workers.

Moreover, increasing levels of education has influenced New Zealand's LFPR. Hyslop et al. argue that rising levels of education are estimated to have increased participation across demographic groups, leading to an increase in New Zealand's LFPR by 3.1 percentage points since 2000. However, a trade-off exists between higher levels of education and the participation of younger workers. Hyslop et al. note that the increases in participation driven by higher levels of education have also been accompanied by decreases in the participation of teenagers and young adults by more than ten percentage points between 1986 and 2017.

Additionally, population ageing has moderated the recent increases observed in New Zealand's

[29] Description of the Working for Families payment: https://www.govt.nz/browse/family-and-whanau/financial-help-for-your-family/working-for-families-payments/

LFPR. Culling and Skilling explain that population ageing tends to decrease the LFPR, as older workers often participate less in the labour market compared to prime-aged workers. Hyslop et al. quantify the extent of population ageing in New Zealand, calculating that the average age in the working age population increased from 40.4 years to 45 years between 1986 and 2017. Culling and Skilling calculate that population ageing has contributed to a 3% decrease in New Zealand's LFPR since 2000. Relatedly, Prados and Pèrez-Arce argue that population ageing may have implications for the participation of female workers. This is because population ageing indicates an increased need for caregiving resources and women are more likely to provide caregiving services at home or in the market.

Overall, the moderating effects of younger workers attaining higher levels of education and population ageing on New Zealand's LFPR have been more than offset by the increased participation among older and female workers. This is demonstrated through New Zealand's LFPR increasing in recent years, which has in turn contributed to increases in the extensive margin and subsequently total hours worked in New Zealand.

6. Concluding remarks

6.1 Policy implications

Our findings about taxes suggest that New Zealand could implement changes in taxes without facing considerable changes in total hours worked. This flexibility could be important given that New Zealand's ageing population may result in higher levels of government spending on NZ Superannuation and healthcare in future. To prepare for this higher spending the government could consider raising taxes to lower the current budget deficit. It is unlikely that this would have major implications for New Zealand's total hours worked. However, it is important to consider other implications of higher taxation, such as the possibility of depressing private consumption expenditure and investment, and the welfare losses associated with taxation. Moreover, since the extensive margin dominates the patterns in New Zealand's total hours worked it is likely that policies that target the driving forces of the extensive margin will meaningfully affect total hours worked in New Zealand. For instance, increasing old-age pension eligibility by linking it to life expectancy, as recommended in the 2022 OECD Economic Survey on New Zealand, would likely increase total hours worked in New Zealand along the extensive margin (OECD, 2022). Along with lowering spending on NZ

Superannuation, this policy would extend the working lives of older workers and contribute to further increases in their LFPR.

In addition, government subsidisation of childcare and elderly care would likely increase total hours worked in New Zealand by supporting marketisation. Government policies in these areas, such as the 20 hours free ECE policy and the residential care subsidy, would contribute to a shift in the care performed at home to the market.[30] Since women tend to perform most household work, similar polices would contribute to further increases in the female LFPR. Further, policies that affect incentives to attend tertiary education would alter total hours worked in New Zealand along the extensive margin. For instance, the fees-free policy introduced by the government in 2018 increased the incentive for school leavers to attend tertiary education, which likely lowered the LFPR of younger workers.[31]

6.2 Discussions for future research

Given the lack of association between taxes and total hours worked observed in New Zealand in recent times, future research could focus on accurately quantifying the effect of labour market variables that have contributed to the recent increases in New Zealand's total hours.[32] This work would explicitly quantify the main drivers behind the recent increases in New Zealand's total hours worked, and could provide insights regarding the recent increases observed in other OECD countries.

Also, future research could perform a more granular analysis by quantifying the importance of taxation as well as other labour market variables on the total hours worked by male workers, female workers, older workers, and younger workers. This analysis would explicitly quantify the important factors that affect the total hours worked by these demographic groups. Further disaggregation could involve breaking down total hours worked by ethnicity, income level, education level, and marital status. There are some recent studies that assess the importance of different demographic groups for explaining cross-country differences in total hours worked.

[30] The residential care subsidy helps with the cost of elderly care: https://www.workandincome.govt.nz/products/a-z-benefits/residential-care-subsidy.html
[31] The fees-free policy introduced by the government in 2018 provides first time tertiary students with a free year of study: https://www.feesfree.govt.nz/
[32] Labour market variables that were used in an econometric analysis by Velasquez and Vtyurina (2019) and could be considered in this analysis include social benefits, business regulation, labour market regulation, migration, remittances, and openness.

Bick et al. (2018) investigate how hours worked vary with income across and within countries. They find that average hours worked per worker are substantially higher in low-income countries, as adults in low-income countries work about 50% more hours per week than adults in high-income countries. Relatedly, Bick et al. (2019b) study differences in hours worked between European countries and the US along four demographic dimensions: gender, age, education, and sector of employment. Their evidence suggests that only educational composition is a significant driver of aggregate differences, as the employment rate increases substantially with education levels in all countries. Their analysis reveals that both the more generous holiday allowance and the higher share of low and medium educated individuals in Europe account for between one quarter and one half of the lower hours per person in Europe than in the US. Further, Bick et al. (2019c) analyse employment rates and hours worked per employed by married couples in European countries and in the US. Bick et al. emphasise that there have been secular increases in the labour supply of married women despite considerable variation across countries. Their model of joint household labour supply decisions accounts for 113% of the long-term changes in the hours worked by employed married women between 1983 and 2016.

Additionally, future research could analyse the behaviour of total hours worked in New Zealand in response to the COVID-19 shock. This analysis could elicit information regarding the business cycle properties of total hours worked in New Zealand. Culling and Robinson (2020) find that the intensive margin is an important factor in how firms adjust total hours worked during recessions and recoveries. Specifically, in recessions firms tend to decrease the hours worked by workers before letting them go, whereas in recoveries firms tend to increase the hours of existing workers before hiring new workers. It would be interesting to explore whether the intensive margin and extensive margin in New Zealand exhibit this behaviour in response to the economic slowdown triggered by COVID-19.

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Appendix

A.1 Proofs

A.1.1 Proposition 1

The current-valued Lagrangian is written as follows:

$$\mathcal{L} = \sum_{t=0}^{\infty} \beta^t \left\{\alpha log(C_t + \lambda G_t - \bar{C}) + (1-\alpha)\frac{(\bar{H}-H_t)^{1-\gamma}-1}{1-\gamma} + \mu_t\left[R_t K_t + (1-\tau_{l,t})w_t H_t + \Pi_t + T_t - (1+\tau_{c,t})C_t - I_t)\right]\right\}. \quad \text{(A1)}$$

Here μ_t is the Lagrangian multiplier attached to household's budget constraint in period t. Note that we are only interested in the first-order conditions for C_t and H_t, which are given below:

$$C_t: \beta^t \left[\frac{\alpha}{C_t+\lambda G_t-\bar{C}} - \mu_t(1+\tau_{c,t})\right] = 0. \quad \text{(A2)}$$

$$H_t: \beta^t\left[-(1-\alpha)(\bar{H}-H_t)^{-\gamma} + \mu_t(1-\tau_{l,t})w_t\right] = 0. \quad \text{(A3)}$$

Rearranging (A2) and (A3) we obtain:

$$\frac{\alpha}{C_t+\lambda G_t-\bar{C}} = \mu_t\left(1+\tau_{c,t}\right). \quad \text{(A4)}$$

$$(1-\alpha)(\bar{H}-H_t)^{-\gamma} = \mu_t w_t(1-\tau_{l,t}). \quad \text{(A5)}$$

(A4) states for each household, the marginal utility of consumption equals the marginal utility of wealth, corrected for the consumption tax rate. (A5) states at the margin each hour spent working for the firm should balance the benefit from doing so in terms of additional income generated, and the cost measured in terms of lower utility of leisure. Dividing (A4) by (A5) yields:

$$\frac{\alpha}{1-\alpha} \cdot \frac{(\bar{H}-H_t)^{\gamma}}{C_t+\lambda G_t-\bar{C}} = \left(\frac{1+\tau_{c,t}}{1-\tau_{l,t}}\right) \cdot \frac{1}{w_t}. \quad \text{(A6)}$$

Recall that the problem of the firm is a sequence of static profit maximising problems. The profit maximisation problem faced by each firm is written as follows:

$$\max_{\{K_t, H_t\}} A_t K_t^{\theta} H_t^{1-\theta} - w_t H_t - r_t K_t. \tag{A7}$$

In equilibrium, there are no profits, and each input is priced according to its marginal product:

$$\theta \frac{Y_t}{K_t} = r_t \tag{A8}$$

$$(1-\theta) \cdot \frac{Y_t}{H_t} = w_t \tag{A9}$$

Using (A9) in (A6) yields:

$$\frac{\alpha}{1-\alpha} \cdot \frac{(\bar{H}-H_t)^{\gamma}}{C_t+\lambda G_t-\bar{C}} = \left(\frac{1+\tau_{c,t}}{1-\tau_{l,t}}\right) \cdot \frac{H_t}{(1-\theta)Y_t} \tag{A10}$$

Rearranging (A10) yields:

$$\frac{H_t}{(\bar{H}-H_t)^{\gamma}} = \left(\frac{1-\tau_{l,t}}{1+\tau_{c,t}}\right) \cdot \frac{\alpha(1-\theta)}{(1-\alpha)} \cdot \frac{Y_t}{C_t+\lambda G_t-\bar{C}}. \tag{A11}$$

Recall we've defined the tax wedge as $1-\tau_t \equiv \frac{1-\tau_{l,t}}{1+\tau_{c,t}}$. Accordingly,

$$\frac{H_t}{(\bar{H}-H_t)^{\gamma}} = (1-\tau_t) \cdot \frac{\alpha(1-\theta)}{(1-\alpha)} \cdot \frac{Y_t}{C_t+\lambda G_t-\bar{C}}. \tag{A12}$$

This completes the proof.

A.1.2 Lemma 1

Setting $\gamma = 1$ in Equation (A12) we have:

$$\frac{H_t}{(\bar{H}-H_t)} = (1-\tau_t) \cdot \frac{\alpha(1-\theta)}{(1-\alpha)} \frac{Y_t}{C_t+\lambda G_t-\bar{C}}.$$

$$H_t = (\bar{H} - H_t) \cdot (1 - \tau_t) \cdot \frac{\alpha(1-\theta)}{(1-\alpha)} \frac{Y_t}{C_t + \lambda G_t - \bar{C}}.$$

$$H_t = \bar{H} \cdot (1 - \tau_t) \cdot \frac{\alpha(1-\theta)}{(1-\alpha)} \frac{Y_t}{C_t + \lambda G_t - \bar{C}} - H_t \cdot (1 - \tau_t) \cdot \frac{\alpha(1-\theta)}{(1-\alpha)} \frac{Y_t}{C_t + \lambda G_t - \bar{C}}.$$

$$H_t + H_t \cdot (1 - \tau_t) \cdot \frac{\alpha(1-\theta)}{(1-\alpha)} \frac{Y_t}{C_t + \lambda G_t - \bar{C}} = (1 - \tau_t) \cdot \bar{H} \cdot \frac{\alpha(1-\theta)}{(1-\alpha)} \frac{Y_t}{C_t + \lambda G_t - \bar{C}}.$$

$$H_t \left(1 + (1 - \tau_t) \cdot \frac{\alpha(1-\theta)}{(1-\alpha)} \frac{Y_t}{C_t + \lambda G_t - \bar{C}}\right) = (1 - \tau_t) \cdot \bar{H} \cdot \frac{\alpha(1-\theta)}{(1-\alpha)} \frac{Y_t}{C_t + \lambda G_t - \bar{C}}.$$

$$H_t = \frac{(1-\tau_t)}{1 + (1-\tau_t) \frac{\alpha(1-\theta)}{(1-\alpha)} \frac{Y_t}{C_t + \lambda G_t - \bar{C}}} \cdot \bar{H} \cdot \frac{\alpha(1-\theta)}{(1-\alpha)} \frac{Y_t}{C_t + \lambda G_t - \bar{C}}.$$

$$H_t = \frac{(1-\tau_t)\alpha(1-\theta)\bar{H}Y_t}{(1-\alpha)(C_t + \lambda G_t - \bar{C}) + (1-\tau_t)\alpha(1-\theta)Y_t}. \tag{A13}$$

This completes the proof.

A.2 Alternative approaches to compute $\tau_{c,t}$

Carey and Rabesona (2002) criticise the method Mendoza et al. (1994) use to compute $\tau_{c,t}$. They argue that additional indirect taxes should be incorporated when calculating $\tau_{c,t}$. These indirect taxes include taxes on profits of fiscal monopolies (5122), customs and import duties (5123), taxes on specific services (5126), other taxes on specific goods and services (5128), and taxes on the use of goods and performance activities (5200) except motor vehicle charges paid by others (5212). Additionally, Carey and Rabesona state that the consumption tax base should be expressed in gross terms (i.e., including indirect taxes). The formula Carey and Rabesona proposes to compute $\tau_{c,t}$ is $\tau_{c,t}^{CR} = \frac{5110+5121+5122+5123+5126+5128+5200-5212}{C+G-GW}$.

Additionally, McDaniel (2007) offers an alternative method to compute $\tau_{c,t}$. McDaniel's method utilises the taxes on production and imports (*TPI*). *TPI* includes any tax revenue collected from consumption and investment expenditures and is comprised of general taxes on goods and services, excise taxes, import duties, and property taxes. McDaniel computes a version of *TPI*, namely $\widetilde{TPI}$, which represents tax revenues collected exclusively from consumption and investment expenditures. $\widetilde{TPI}$ is computed by ignoring the share of TPI that represents property taxes paid by entities other than households.[33] McDaniel identifies that some of the taxes included in $\widetilde{TPI}$ are only levied on consumption expenditures, whereas other taxes included in $\widetilde{TPI}$ are levied on both consumption and investment expenditures.[34]

Consequently, McDaniel attempts to allocate $\widetilde{TPI}$ between consumption and investment expenditures. To achieve this, she assumes that the tax revenue earnt from taxes levied on both consumption and investment expenditures are split between consumption and investment tax revenue according to the share of consumption and investment in private expenditures. After identifying the taxes in $\widetilde{TPI}$ that are levied strictly on consumption expenditures, McDaniel calculates their share of $\widetilde{TPI}$ (which is denoted as λ) in five-year intervals between 1965 and 2000. McDaniel uses the average λ to compute TPI_c, which represents the tax revenues collected strictly from consumption expenditures.[35] In order to compute the consumption tax, McDaniel divides TPI_c by the taxable consumption expenditures ($C - TPI_c$): $\tau_{c,t}^{M} = \frac{TPI_c}{C - TPI_c}$.

Figure A1 displays the $\tau_{c,t}$ series for New Zealand using the method of Mendoza et al. (1994) and Carey and Rabesona (2002) between 1972 and 2019, and the method of McDaniel (2007) between 1998 and 2018.[36] There is a close agreement between the $\tau_{c,t}$ series computed following Mendoza et al. ($\tau_{c,t}^{MRT}$) and Carey and Rabesona ($\tau_{c,t}^{CR}$) for New Zealand. The correlation between the $\tau_{c,t}^{MRT}$ series and the $\tau_{c,t}^{CR}$ series is 0.996. The $\tau_{c,t}^{CR}$ series exceeds the $\tau_{c,t}^{MRT}$ series by only 16.50% on average between 1972 and 1986. However, the $\tau_{c,t}^{MRT}$ series exceeds the $\tau_{c,t}^{CR}$ series by only 1.37% on average between 1987 and 2019. In contrast, the $\tau_{c,t}$ series computed for New Zealand following the methodology of McDaniel ($\tau_{c,t}^{M}$) exceeds the $\tau_{c,t}^{MRT}$ and $\tau_{c,t}^{CR}$ series in level terms between 1998 and 2018. This is demonstrated through the sample average for New Zealand's $\tau_{c,t}^{M}$ series being 20.23% between 1998 and 2018 while the

[33] $\widetilde{TPI}$ includes property taxes paid by households, general taxes on goods and services, excise taxes, customs and import duties, taxes on specific services, and taxes on the use of goods to perform activities.

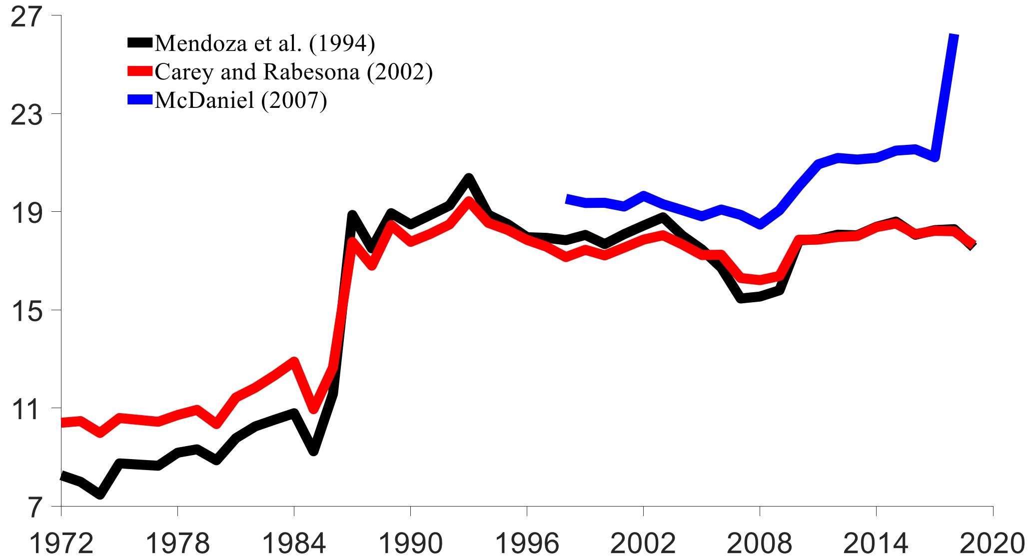
[34] The taxes in $\widetilde{TPI}$ that are only levied on consumption expenditures include property taxes paid by households, excise taxes, and taxes on specific services. The taxes in $\widetilde{TPI}$ that are levied on both consumption and investment expenditures include general taxes on goods and services, customs and import duties, and taxes on the use of goods to perform activities.

[35] TPI_c represents the part of $\widetilde{TPI} - Sub$ that can be attributed to consumption, where *Sub* is the amount by which consumption and investment expenditures are subsidized. The formula McDaniel uses to compute TPI_c is $TPI_c = \left(\lambda + (1-\lambda)(C/(C+I))\right)\left(\widetilde{TPI} - Sub\right)$.

[36] Data for $\tau_{c,t}^{M}$ is obtained from Cara McDaniel's webpage: https://www.caramcdaniel.com/research

sample average for New Zealand's $\tau_{c,t}^{MRT}$ series and $\tau_{c,t}^{CR}$ series are 17.68% and 17.59% over this time period, respectively.

Figure A1. Average effective tax rates on consumption (%), New Zealand, 1972-2019



Source: OECD.Stat and Statistics New Zealand, December 2021.

Despite the differences in levels each of the consumption tax series display fairly similar fluctuations until 2017. For instance, the $\tau_{c,t}^{M}$ series has a correlation of 0.57 with the $\tau_{c,t}^{MRT}$ series and a correlation of 0.79 with the $\tau_{c,t}^{CR}$ series between 1998 and 2017. However, the $\tau_{c,t}^{M}$ increases dramatically from 21.22% in 2017 to 26.24% in 2018, while $\tau_{c,t}^{MRT}$ and $\tau_{c,t}^{CR}$ experience modest decreases over this time.[37] Consequently, between 1998 and 2018 the correlation between the series $\tau_{c,t}^{M}$ and $\tau_{c,t}^{MRT}$ decreases to 0.45 and the correlation between the series $\tau_{c,t}^{M}$ and $\tau_{c,t}^{MRT}$ series decreases to 0.63.

The method of McDaniel generates a larger increase in $\tau_{c,t}$ for New Zealand between 1998 and 2018 than the methods of Mendoza et al. and Carey and Rabesona. Specifically, $\tau_{c,t}^{M}$ increases in New Zealand from 19.53% in 1998 to 26.24% in 2018, an increase of 6.71 percentage points. In comparison, the methods of Mendoza et al. and Carey and Rabesona generate increases in $\tau_{c,t}$ of only 0.45 and 1.05 percentage points for New Zealand between 1998 and 2018, respectively. Furthermore, the method of Mendoza et al. generates a larger increase in $\tau_{c,t}$ for

[37] The unusual observation for New Zealand's $\tau_{c,t}^{M}$ in 2018 may occur because McDaniel uses national accounts data for New Zealand in this year that does not represent the actual data. Specifically, the forecasted national accounts data used by McDaniel in 2018 may have been inaccurate.

New Zealand between 1972 and 2019 compared to Carey and Rabesona. $\tau_{c,t}^{MRT}$ increases in New Zealand from 8.27% in 1972 to 17.54% in 2019, an increase of 9.28 percentage points. In comparison, $\tau_{c,t}^{MRT}$ increases in New Zealand from 10.40% in 1972 to 17.63% in 2019, an increase of 7.23 percentage points.

A.3 Alternative approaches to compute $\tau_{l,t}$

Similar to the method of Mendoza et al. (1994), Carey and Rabesona (2002) compute $\tau_{h,t}$ prior to computing $\tau_{l,t}$. Carey and Rabesona make various adjustments to the Mendoza et al. method when computing $\tau_{h,t}$. For example, Carey and Rabesona reallocate some of the tax revenue data in order to make estimates of $\tau_{h,t}$ more realistic. Specifically, business tax revenues are removed from household tax revenues and allocated to capital tax revenues. Also, instead of ignoring tax revenues on income, profits, and capital gains that had not been allocated to households or companies (1300) like Mendoza et al., Carey and Rabesona allocate this tax revenue between households and companies according to what seems most appropriate. Additionally, Carey and Rabesona allow for the possibility that households are able to deduct social security contributions from their taxable income. This is achieved by computing two versions of $\tau_{h,t}$; a version where social security contributions are not deductible and a version where social security contributions are deductible. The version of $\tau_{h,t}$ where social security contributions are not deductible is computed in the same manner as Mendoza et al., which is given by $\tau_{h,t}^{CR} = \tau_{h,t}^{MRT} = \frac{1100}{OSPUE+PEI+W}$. The version of $\tau_{h,t}$ where social security contributions are deductible is given by $\tau_{h,t}^{CR} = \frac{1100}{OSPUE+PEI+W-2100-2300-2400}$.

Moreover, Carey and Rabesona also make adjustments to the Mendoza et al. methodology when computing $\tau_{l,t}$. Specifically, Carey and Rabesona allocate social security contributions of the self-employed (2300) to capital tax revenues instead of labour tax revenues.[38] Also, instead of allocating unallocated social security contributions (2400) exclusively to labour tax revenue, Carey and Rabesona allocate 2400 between labour tax revenues and capital tax revenues.[39] Additionally, Carey and Rabesona make an adjustment to the labour income base.

[38] Carey and Rabesona make this adjustment because as self-employed income is treated as capital income in the Mendoza et al. methodology.

[39] Carey and Rabesona make this adjustment because the tax revenue 2400 is paid out of both labour and capital incomes. Carey and Rabesona note that incorporating these changes requires disaggregating total social security

The adjustment involves adding private employers contributions to pension funds and payroll taxes to the labour income base by replacing the denominator of $\tau_{l,t}$ with compensation of employees (WSSS) plus taxes on payroll and workforce (3000).[40]

The version of $\tau_{l,t}$ where social security contributions are not deductible is calculated as $\tau_{l,t}^{CR} = \frac{\tau_{h,t} \cdot W+2100+2200+\alpha \cdot 2400+3000}{WSSS+3000}$, where $\alpha = \frac{W}{OSPUE+PEI+W}$ is the share of labour income in household income. The version of $\tau_{l,t}$ where social security contributions are deductible is calculated as $\tau_{l,t}^{CR} = \frac{\tau_{h,t} \cdot (W-2100-\alpha \cdot 2400)+2100+2200+\alpha \cdot 2400+3000}{WSSS+3000}$, where $\alpha = \frac{W-2100}{OSPUE+PEI+W-2100-2300}$ is the share of labour income in household income.

McDaniel (2007) computes $\tau_{l,t}$ by dividing tax revenues from labour income by aggregate labour income. The tax revenues from labour income that McDaniel considers include tax revenue from household income (*HHT*) and tax revenue from social security taxes (*SS*). McDaniel finds the household income tax rate by applying $\tau^{inc} = \frac{HHT}{GDP-(TPI-Sub)}$, where the denominator denotes household income. McDaniel notes that the household income tax represents taxes on total income. Since household income is comprised of both labour income and capital income this means that only a portion of the taxes on household income are taxes on labour income. Consequently, after finding τ^{inc} McDaniel performs adjustments to find the total household income tax paid specifically on labour income.[41] McDaniel finds the household income tax revenue earnt specifically from labour income by applying $HHT_L = \tau^{inc} \cdot (1-\theta)(GDP-(TPI-Sub))$. Here $(1-\theta)$ denotes the share of income attributed to labour. In order to calculate $\tau_{l,t}$, McDaniel divides the sum of HHT_L and *SS* by the share of aggregate income attributed to labour: $\tau_{l,t}^{M} = \frac{SS+HHT_L}{(1-\theta)(GDP-(TPI-Sub))}$.

Figure A2 displays the $\tau_{l,t}$ series for New Zealand using the method of Mendoza et al. (1994) and Carey and Rabesona (2002) between 1986 and 2018, and the method of McDaniel (2007)

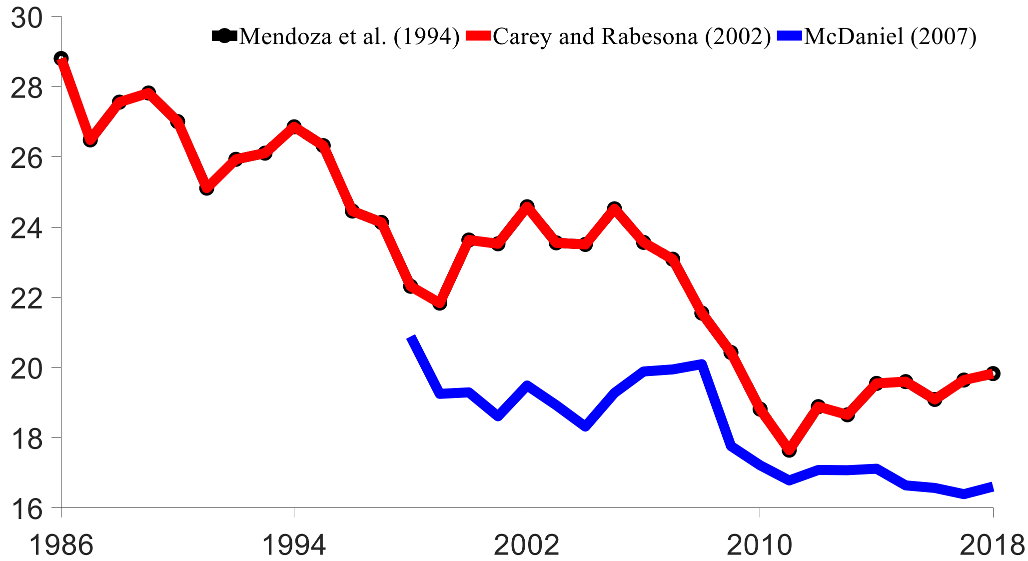
contributions so that employees (2100) and employers' (2200) contributions as well as labour's share (denoted α) of the tax revenue 2400 can be allocated to labour tax revenues.

[40] Carey and Rabesona make this adjustment because WSSS and 3000 are elements of wage compensation.

[41] An assumption that McDaniel makes when performing these adjustments is that the tax rate on household labour income is equal to the tax rate on household capital income.

between 1998 and 2018.[42] The figure displays that the $\tau_{l,t}$ series computed for New Zealand using the methodologies of Mendoza et al. $(\tau_{l,t}^{MRT})$ and Carey and Rabesona $(\tau_{l,t}^{CR})$ are identical between 1986 and 2018. This is because the tax revenues 2000, 2100, 2200, 2300, 2400, and 3000 are zero for New Zealand between 1970 and 2019. The $\tau_{l,t}$ series computed following the method of McDaniel for New Zealand $(\tau_{l,t}^{MRT})$ is lower in level terms compared to the $\tau_{l,t}^{MRT}$ and $\tau_{l,t}^{CR}$ series between 1998 and 2018. This is demonstrated through the sample average for New Zealand's $\tau_{l,t}^{M}$ series being 18.25% between 1998 and 2018, whereas the sample average for New Zealand's $\tau_{l,t}^{MRT}$ series and $\tau_{l,t}^{CR}$ series are both 21.32% over this period.

Figure A2. Average effective tax rates on labour (%), New Zealand, 1986-2018



Source: OECD.Stat, United Nations, and Cara McDaniel's research webpage, January 2022.

Despite the level differences between the series, the $\tau_{l,t}^{M}$ series displays similar fluctuations to the $\tau_{l,t}^{MRT}$ and $\tau_{l,t}^{CR}$ series. For instance, the $\tau_{l,t}^{M}$ series has a correlation of 0.80 with the $\tau_{l,t}^{MRT}$ and $\tau_{l,t}^{CR}$ series between 1998 and 2019. The method of McDaniel generates a larger decrease in $\tau_{l,t}$ for New Zealand between 1998 and 2018 than the methods of Mendoza et al. and Carey and Rabesona. Specifically, $\tau_{l,t}^{M}$ decreases from 20.88% in 1998 to 16.61% in 2018, a decrease

[42] Only one $\tau_{l,t}^{CR}$ series is displayed for New Zealand. This is because each of the $\tau_{l,t}^{CR}$ series computed for New Zealand (where social security contributions are deductible and not deductible, respectively) are identical. This arises because the tax revenues 2100, 2200, 2300, 2400, and 3000 are zero for New Zealand between 1970 and 2019. Additionally, this implies that each of the $\tau_{h,t}$ series computed following the methodology of Mendoza et al. (1994) and Carey and Rabesona (2002) are identical between 1986 and 2018.

of 4.27 percentage points. In comparison, $\tau_{l,t}$ decreases by 2.49 percentage points between 1998 and 2018 when following the methods of Mendoza et al. and Carey and Rabesona. Moreover, when following the methods of Mendoza et al. and Carey and Rabesona $\tau_{l,t}$ decreases from 28.80% in 1986 to 19.83% in 2018, a decrease of 8.98 percentage points.

A.4 Model exercise using alternative approaches to compute the tax wedge

A.4.1 Tax wedge and model hours relationship

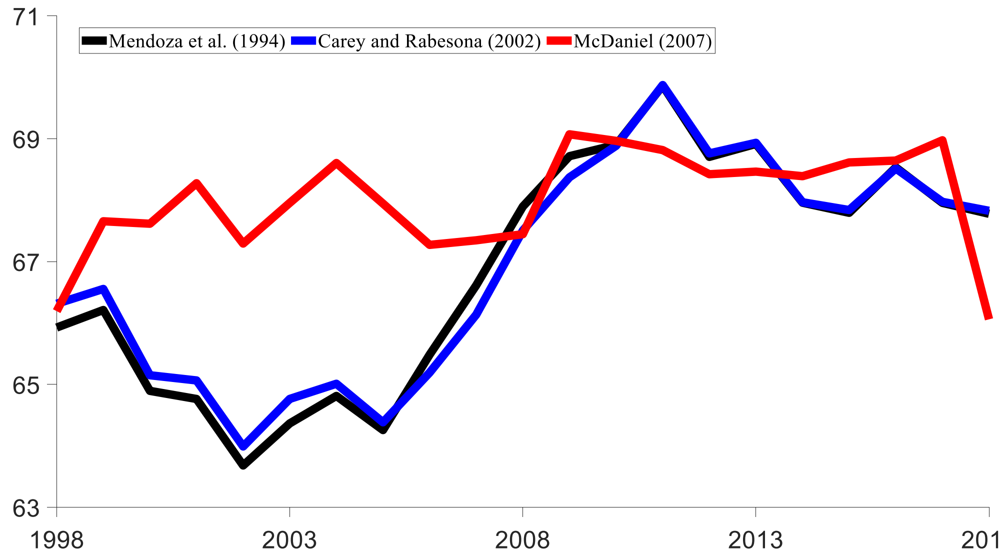
Using Lemma 1, the first order partial derivative of H_t can be evaluated with respect to the tax wedge as follows. I define $R_t \equiv \frac{\alpha(1-\theta)}{(1-\alpha)} \cdot \frac{Y_t}{C_t+\lambda G_t-\bar{C}}$. Now, I can write $H_t = \frac{(1-\tau_t)}{1+(1-\tau_t)\cdot R_t} \cdot \bar{H} \cdot R_t$. Then, $\frac{\partial H_t}{\partial(1-\tau_t)} = \frac{(1+(1-\tau_t)\cdot R_t)\cdot 1-(1-\tau_t)\cdot R_t}{(1+(1-\tau_t)\cdot R_t)^2} = \frac{1+(1-\tau_t)\cdot R_t-(1-\tau_t)\cdot R_t}{(1+(1-\tau_t)\cdot R_t)^2} = \frac{1}{(1+(1-\tau_t)\cdot R_t)^2} > 0$. This implies that an increase in the tax wedge leads to an increase in total hours worked. The positive sign of $\frac{\partial H_t}{\partial(1-\tau_t)}$ indicates that a positive relationship exists between the magnitudes of the tax wedge series and the model hours series. More precisely, when a tax wedge series is incorporated in the model that exceeds other available tax wedge series in level terms, the model hours series computed by the model will be comparably higher, ceteris paribus. This analytical prediction is empirically assessed below for New Zealand.

A.4.2 Model exercise for New Zealand

A.4.2.1 Tax wedge series

Figure A3 displays the tax wedge series for New Zealand between 1998 and 2018. The tax wedge series have been computed following the methods of Mendoza et al. (1994), Carey and Rabesona (2002), and McDaniel (2007).

Figure A3. Tax wedge series for New Zealand (%), 1998-2018



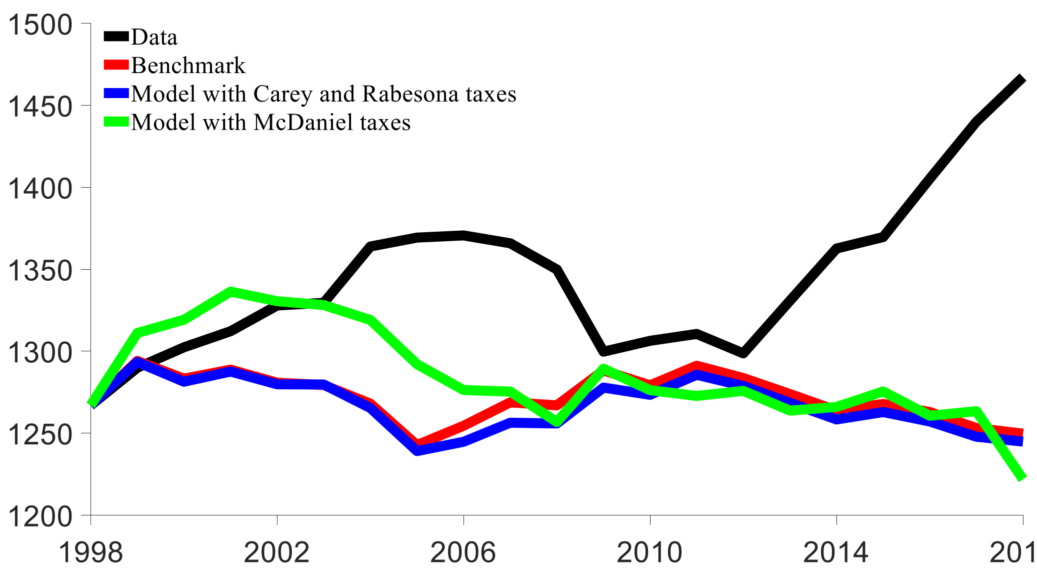
Source: OECD.Stat, Statistics New Zealand, and Cara McDaniel's research webpage, January 2022.

Figure A3 displays that the tax wedge series for New Zealand computed following McDaniel exceeds the other tax wedge series in level terms between 1999 and 2007. The tax wedge series in New Zealand computed following Carey and Rabesona and Mendoza et al. are very similar over this period. This is highlighted through the averages for New Zealand's tax wedge series computed following McDaniel, Carey and Rabesona, and Mendoza et al. being 67.62%, 65.26%, and 65.10% between 1998 and 2007, respectively. However, in 2008 the tax wedge series for New Zealand converge. Despite differing fluctuations after 2008 the magnitudes of the alternative tax wedge series remain fairly similar. For instance, the sample averages for New Zealand's tax wedge series computed following McDaniel, Carey and Rabesona, and Mendoza et al. are 68.35%, 68.40%, and 68.46% between 2008 and 2018, respectively. Therefore, based off our analytical prediction we expect that model hours for New Zealand will be higher in level terms between 1999 and 2007 when the tax wedge is computed following McDaniel compared to when the tax wedge is computed following Carey and Rabesona or Mendoza et al. However, we expect that the magnitude of each model hours series for New Zealand will be comparable from 2008 onwards.

A.4.2.2 Model exercise

Figure A4 compares model hours and the actual data on total hours worked in New Zealand between 1998 and 2018. The benchmark model incorporates a tax wedge series that is computed following Mendoza et al. whereas the two additional calibrations incorporate tax wedge series that are computed following McDaniel and Carey and Rabesona, respectively. Consistent with the analytical prediction, model hours for New Zealand are higher in level terms between 1999 and 2007 when the tax wedge is computed following McDaniel compared to when the tax wedge is computed following Carey and Rabesona or Mendoza et al. For instance, the sample averages for New Zealand's model hours series between 1999 and 2007 when the tax wedge is computed following McDaniel, Carey and Rabesona, and Mendoza et al. are 1310, 1270, and 1273, respectively. Additionally, the prediction that the magnitude of each model hours series for New Zealand will be comparable from 2008 onwards appears to hold. The sample averages for New Zealand's model hours series between 2008 and 2018 when the tax wedge is computed following McDaniel, Carey and Rabesona, and Mendoza et al. are 1266, 1265, and 1271, respectively.

Figure A4. Alternative model hours versus data, New Zealand, 1998-2018



Source: OECD.Stat, Statistics New Zealand, and Cara McDaniel's webpage, January 2022.

A.5 Data challenges and solutions for New Zealand

Initially the $\tau_{c,t}$ series for New Zealand (more specifically, the $\tau_{c,t}^{MRT}$ and $\tau_{c,t}^{CR}$ series) extended between 1986 and 2019. These series could not be extended to include earlier data because data on the 'compensation of employees paid by government, percentage of GDP' (hereafter COEPBG) is only available from 1986 onwards on OECD.Stat. We contacted Statistics New Zealand and requested data on the COEPBG in New Zealand before 1986. Statistics New Zealand guided me to their discontinued National Accounts series which is available on Statistics New Zealand's Infoshare website. From this source we were able to access data on the COEPBG in New Zealand between 1972 and 2020 across three separate series. The first series extends between 1972-1978, the second series extends between 1978-1996, and the third series extends between 1987-2020.

Aside from being one year ahead of the OECD.Stat data on the COEPBG, the third data series accessed via Statistics New Zealand matches the OECD.Stat data. This provides reassurance that the third data series on the COEPBG accessed via Statistics New Zealand is accurate. However, data on the COEPBG that overlaps between the second and third series (that were accessed via Statistics New Zealand) between 1987 and 1996 does not match. Since we determined earlier that the third series on the COEPBG is valid, this observation suggests the second series accessed on the COEPBG may be inaccurate. Also, data on the COEPBG that overlaps between the first and second series match in 1978. Therefore, by association to the second series, this suggests that the first series may also be inaccurate. Thus, the COEPBG data accessed via Statistics New Zealand appears accurate between 1987 and 2020 but inaccurate between 1972 and 1986.

Our solution to this data problem was the following: using the first and second series on the COEPBG accessed via Statistics New Zealand we computed the growth rates in the COEPBG between each year. This provided us with growth rates on the COEPBG each year between 1972 and 1996. To generate data on the COEPBG between 1972 and 1986 we backed out the data using these growth rates and the levels data on the COEPBG between 1987 and 2020 (accessed via Statistics New Zealand). For example, when computing the data for the COEPBG in 1986 we carried out the following computation: $COEPBG_{1986} = \frac{COEPBG_{1987}}{(1+g_{1987})}$, where g_{1987} is the growth rate of COEPBG between 1986 and 1987. Following this, in order to calculate the data for COE_{1985} we carried out the computation: $COEPBG_{1985} = \frac{COEPBG_{1986}}{(1+g_{1986})}$, where g_{1986} is the growth rate of COEPBG between 1985 and 1986. Repeating this computation enabled me to generate data on the COEPBG for New Zealand between 1972 and 1986. We combined this data with the levels data on the COEPBG between 1987 and 2020 accessed via Statistics New Zealand, which meant we had data on the COEPBG for New Zealand between 1972 and 2020. Using this extended series on the COEPBG for New Zealand we were able to extend the $\tau_{c,t}^{MRT}$ series and $\tau_{c,t}^{CR}$ series for New Zealand between 1972 and 2019.

The data on the COEPBG from Statistics New Zealand is one year ahead of the data on COEPBG from OECD.Stat. This arises due to a 'calendar year versus fiscal year' issue. A calendar year always runs from January 1 to December 31, whereas a fiscal year can start and end at any point during the year as long as it comprises a full 12 months. The data from the OECD National Accounts is based on a calendar year.[43] In contrast, National Accounts data on New Zealand provided by Statistics New Zealand refers to the fiscal year starting in April 1 and ending March 31.[44]

Personal communication with Statistics New Zealand personnel confirmed that the OECD uses different timing to Statistics New Zealand. This time inconsistency problem that exists between Statistics New Zealand's data and OECD.Stat's data affects New Zealand's tax data and National Accounts data. To eliminate the time inconsistency problem for New Zealand we follow the practice of using the same data source for each series. Specifically, we use OECD and UN data when computing the consumption and labour tax series. We only use data from Statistics New Zealand to extend the consumption tax and labour tax series. By eliminating the time inconsistency problem for New Zealand this enables us to perform cross-country comparisons in a meaningful way.

Initially the $\tau_{h,t}$ and $\tau_{l,t}$ series for New Zealand (more specifically, the $\tau_{h,t}^{MRT}$ series, $\tau_{h,t}^{CR}$ series, $\tau_{l,t}^{MRT}$ series, and the $\tau_{l,t}^{CR}$ series) are extended between 1998 and 2019 and were computed using tax data and national income data from OECD.Stat. These series could not be extended to include earlier data because data on the consumption of fixed capital is only available between

[43] The OECD explains that unless specified, data from the OECD National Accounts are based on calendar years: https://www.oecd-ilibrary.org/sites/gov_glance-2017-5-en/index.html?itemId=/content/component/gov_glance-2017-5-en

[44] National accounts data on New Zealand provided by Statistics New Zealand refers to a fiscal year: https://www.stats.govt.nz/information-releases/national-accounts-income-and-expenditure-year-ended-march-2021

1998 and 2019 from OECD.Stat. Consequently, this meant that data on the variable *OSPUE* was only available after 1998. We were able to access additional data on the consumption of fixed capital for New Zealand via the United Nations (UN) National Accounts Database.[45]

The UN has data on the consumption of fixed capital for New Zealand across three separate sectors; Households and non-profit institutions serving households (HH_NPISH, 1998-2018), Households (HH, 1986-2018), and Non-profit institutions serving households (NPISH, 1998-2018). In comparison, OECD.Stat only provides data on the consumption of fixed capital for New Zealand in the HH_NPISH sector. When comparing the UN National Accounts data on the consumption of fixed capital across the HH and NPISH sectors we identified that the proportion by which the HH sector data exceeds the NPISH sector data is fairly constant over time. Between 1998 and 2018 the HH sector data fluctuates between being 9.32 and 11.95 times higher than the NPISH sector data. On average, the HH data is 10.75 times higher than the NPISH data between 1998 and 2018. We use this average in order to approximate the data on the consumption of fixed capital in the NPISH sector in New Zealand between 1986 and 1998.

Specifically, we approximate this data by dividing the UN National Accounts data on the consumption of fixed capital in the HH sector between 1986 and 1997 by 10.75. This produces a series for the consumption of fixed capital in the NPISH sector between 1986 and 1998 that maintains the proportional relationship observed between the consumption of fixed capital data in the HH sector and NPISH sector on average between 1998 and 2018. To complete the series on the consumption of fixed capital in the NPISH sector we merged the approximated data between 1986 and 1997 with the consumption of fixed capital data in the NPISH sector from the OECD.Stat source (which is available between 1998 and 2019). Finally, to produce a series on the consumption of fixed capital in the HH_NPISH sector for New Zealand, we added the consumption of fixed capital data in the HH sector and the consumption of fixed capital data in the NPISH sector each year between 1986 and 2019. After extending the data on the consumption of fixed capital for New Zealand data we were able to compute earlier data for the variable OSPUE beginning in 1986. This enabled to produce data for the New Zealand tax series $\tau_{h,t}^{MRT}$, $\tau_{h,t}^{CR}$, $\tau_{l,t}^{MRT}$ and $\tau_{l,t}^{CR}$ between 1986 and 2018.

[45] United Nations National Accounts Database: https://unstats.un.org/unsd/nationalaccount/sdmxdata/