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Essays on Agricultural Seasonal Workers

By

Ze Zhang

DISSERTATION

Submitted in partial satisfaction of the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

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of the

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DAVIS

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Abstract

Seasonal labor is vital to the production and sustainability of modern agriculture. Fruits, vegetables, and other high-value horticultural products require intensive labor during short, critical windows for planting, thinning, and harvesting. Without an adequate and timely seasonal workforce, farmers may face significant yield losses, reduced product quality, and increased food loss. Beyond farm productivity, seasonal agricultural labor supports rural economies, sustains export industries, and contributes to food security. Some recent policy debates have been centered around the effectiveness of seasonal foreign workers in agriculture and their potential negative impact on the domestic workforce.

This dissertation, in a book-style format, analyzes the Recognised Seasonal Employer (RSE) scheme, a seasonal foreign worker program in horticulture implemented in New Zealand. This dissertation provides a comprehensive view of how this kind of visa program impacts the labor market and growers' decision to hire these seasonal workers. Using the administrative dataset, especially the tax, income and business data, this dissertation fills the gap of current literature in agricultural seasonal labor that is often constrained by data availability.

Chapter 1 introduces the dissertation. In Chapter 2, I introduce the contextual and policy background of the RSE scheme. Following, in Chapter 3, I use data from the Ministry of Business, Innovation, and Employment to demonstrate the insights that can be drawn from publicly available information.

In Chapter 4, I develop a graphical two-sector framework with two types of workers to conceptualize the labor market mechanisms that arise when an influx of seasonal workers enters one sector.

In Chapter 5, I use an administrative dataset from Statistics New Zealand and a shift-share instrumental variable (SSIV) approach to analyze the RSE scheme and its effects on the labor market outcomes of both domestic and foreign workers.

In Chapter 6, using the South Pacific Seasonal Cyclone, a labor-supply-side instrumental variable, I estimate that large growers are benefiting from hiring RSE workers. A 1% increase in the RSE workers' employment would lead to a 0.1% increase in large growers' revenue. However, the RSE workers do not benefit the smaller growers.

In Chapter 7, based on a hybrid CES–Translog framework, I estimate that domestic and foreign workers, i.e., both RSE and non-RSE, are jointly sustainable in horticultural production. Furthermore, RSE and non-RSE foreign workers are complementary in the production process.

This dissertation examines the economic impacts of the RSE program on the labor market and growers using linked administrative data from New Zealand and quasi-experimental methods. The findings show that the RSE program significantly affects labor market and grower performance, with impacts varying across workers and firms. While the RSE program supports sectoral economic activity, larger growers benefit but not the smaller ones, and wage and employment responses differ across labor markets. These findings reflect the differences in the distributional impact of such policy.

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Disclaimers

IDI Disclaimer

These results are not official statistics. They have been created for research purposes from the Integrated Data Infrastructure (IDI) which is carefully managed by Stats NZ. For more information about the IDI please visit:
https://www.stats.govt.nz/integrated-data/

LBD Disclaimer

These results are not official statistics. They have been created for research purposes from the Longitudinal Business Database (LBD) which is carefully managed by Stats NZ. For more information about the LBD please visit:
https://www.stats.govt.nz/integrated-data/

IRD Tax Data Disclaimer

The results are based in part on tax data supplied by Inland Revenue to Stats NZ under the Tax Administration Act 1994 for statistical purposes. Any discussion of data limitations or weaknesses is in the context of using the IDI for statistical purposes and is not related to the data's ability to support Inland Revenue's core operational requirements.

This dissertation is based on 202210 IDI refresh.

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Chapter 1: Introduction to the Dissertation

In the agricultural sectors of some developed countries, as domestic workers in rural areas find employment elsewhere, farm owners are unable to attract sufficient labor to perform essential tasks. Consequently, the sector increasingly relies on international workers. Programs such as the American H-2A visa facilitate the employment of temporary foreign agricultural laborers (Castillo, Martin, and Rutledge, 2022; U.S. Citizenship and Immigration Services, 2022).

Visa programs like H-2A are often viewed as demand-driven immigration programs. The demand-driven immigration program is not uncommon for the agriculture sector and follows a similar selection mechanism: the government often sets an annual quota for seasonal workers. Then, the employers sponsor these seasonal workers to grant valid visas to legally work in the receiving countries. The American H-2A program allows employers' agents who meet regulatory requirements to bring foreign nationals to the United States to fill temporary agricultural jobs. The Canadian Seasonal Agricultural Worker Program (SAWP) allows foreign agricultural workers to work in Canada temporarily. In Europe, France, Germany, Italy, Spain, and Sweden organize seasonal worker schemes to meet demand in the domestic labor market. Spain and Italy heavily rely on the foreign workforce in the agricultural sector, around 20%-25% of agricultural laborers are seasonal migrants (Augère-Granier, 2021).

By analyzing New Zealand's Recognised Seasonal Employer (RSE) scheme, a seasonal worker program that targets just the horticulture and viticulture industries, this dissertation aims to provide a comprehensive understanding of the various impacts of seasonal guest worker programs, including (i) the wage and employment impacts of seasonal foreign workers on domestic and existing foreign workers in the local labor market; (ii) the impact of RSE workers on

growers' revenue; (iii) given the availability of seasonal foreign workers, the complementarity or substitutability between domestic and foreign workers on the farm. Apart from Chapter 1, the introduction, this dissertation is divided into seven different chapters.

Following, I introduce the contextual and policy background of the RSE scheme. In Chapter 3, I use publicly available data to analyze the impact of the RSE workers on the annual earnings of domestic workers. The results show that it increases the annual earnings of female workers and employees in the accommodation and administrative sectors. However, as horticultural and viticultural production is seasonality-driven, using aggregate annual data does not capture the importance of seasonal labor market trends and their impacts on individual workers.

To motivate the empirical analysis in Chapter 5, Chapter 4 depicts a two-sector framework to graphically illustrate the impact of a sector-specific immigration program with a quota on the local labor market in rural areas. The model characterizes an economy that has an agricultural and a non-agricultural sector.

Chapter 5 uses a unique administrative longitudinal dataset from Statistics New Zealand (Stats NZ) to evaluate the RSE scheme on labor market outcomes of domestic and foreign workers. Besides the unique dataset, this study introduces a new identification strategy and extends the analysis to include the effects on employment, wages, and sectoral outcomes, providing a complete picture of the impact of seasonal workers on local labor market outcomes. Using a shift-share instrumental variable approach, this analysis provides three main findings.

First, contemporaneously, the influx of seasonal workers has no wage effects on domestic workers except for females and low-skilled ones. On the other hand, the influx has much more

prevalent effects on the employment of domestic workers. Females, middle-aged, Māori & Pacific, European, and low-skilled workers have positive and significant employment effects. Second, the inflow of seasonal workers has positive impacts on related industries. Accommodation & food service and administrative & support have the highest employment effects. Further, agriculture, forestry, and fishing have positive and significant effects on both the wage and employment of domestic workers. Third, results show that non-RSE foreign workers are disproportionately worse off when faced with an influx of foreign seasonal workers. The wage of non-RSE foreign workers decreases, but with no significant change in employment.

Chapter 6 investigates the impact of the RSE workers on grower's income. Leveraging a supply-side-instrument, results reveal that large growers gain reasonably: their revenue rises by approximately 1% when their workforce contains 0.1% more RSE workers. In contrast, small growers hiring RSE workers experience no revenue gain.

Chapter 7 further examines the complementarity and substitutability between domestic and foreign workers across different types of orchards, such as kiwifruit and apple. I first develop a model representing a typical production process for growers in the horticulture and viticulture industries. I then use confidential income tax data from Statistics New Zealand to estimate the elasticity of substitution among domestic workers, RSE workers, and non-RSE foreign workers. The results indicate that domestic workers and the two groups of foreign workers are somewhat substitutable in production, whereas RSE and non-RSE foreign workers are complementary. The dissertation concludes in Chapter 8.

This dissertation has three major contributions to the existing literature. The first is the exceptionally high-quality data that is available for this study. The longitudinal nature of the dataset covers the entire population receiving salary and wage within New Zealand. This allows

analysis of the various impacts of these seasonal workers on the workforce for different demographics and growers' incomes. In addition, unlike previous studies using annual data, this dataset records the monthly salary of the employees. This allows me to analyze the contemporaneous effects of the impact of the seasonal workers on the workforce with consideration of seasonality, which is crucial for horticulture and viticulture.

Second, this study also contributes to the existing literature on agricultural laborers. Apart from the data either not being available, or a substantial amount of foreign agricultural laborers are unauthorized immigrants who are absent from the official data, the previous studies have focused on the aggregate impact of agricultural workers on domestic workers' outcomes within confined geographic areas, either a single state or certain areas within a state. This study's level of analysis is the entire country of New Zealand. Further, the extension also includes the analysis of the impact of the seasonal laborers on other foreign-born workers, a topic that has lacked attention in the literature.

The third contribution to the literature is to bring evidence of the benefit of a skilled-based immigration program to the recipient country, especially for low-skilled workers, such as H-2A. The previous studies focused mostly on the high-skilled group, such as H-1B visa holders and skilled workers in European Union countries. The findings not only pertain to seasonal workers but also are useful for low-skilled immigrants in general.

This dissertation sits at the intersection of two streams of literature. The first stream emphasizes agricultural laborers. Studies focus on the stringent enforcement policies directly decreasing the number of foreign workers on farms. They show that the reduction of foreign seasonal workers decreases farms' profit, reduces production capacity, and increases operational expenses (e.g., Charlton and Kostandini, 2021; Luo and Kostandini, 2022). The decrease in foreign

workers has caused some local businesses to permanently leave the industry and also caused job losses for domestic workers (e.g., Clemens, Lewis, and Postel, 2018; East et al., 2022; Lee, Peri, and Yasenov, 2022; Shrestha and Kostandini, 2024). These studies use various empirical strategies to estimate the impact of immigration policies on different outcomes. Alternatively, another approach using the equilibrium displacement model estimates the upper bounds for the effects of interest (Rutledge and Mérel, 2023).

Beyond the context of agricultural labor, this dissertation also adds value to the analysis of the impact of skill-based immigration programs and low-skilled immigrants on domestic workers. For the former, the studies find that H-1B immigrants have a positive impact on the amount of US patenting and wages of college-educated domestic workers, especially for firms and cities highly dependent on foreign scientists (e.g., Kerr and Lincoln, 2010; Peri, Shih, and Sparber, 2015). For the latter, these studies lead to contrasting findings. One side argues that immigration reduced real wages paid to domestic workers without a high school degree (e.g., Borjas, 2003; Borjas and Katz, 2007). By contrast, other regional studies find minimal effects of low-skilled immigration on the real wages of less educated domestics (e.g., Card, 2001; 2007; Card and Lewis, 2007). Ottaviano and Peri (2006, 2008, 2012) argue that immigrants and domestics of similar education and experience possess unique skills that lead them to specialize in different tasks. I add new empirical evidence to this discussion.

Chapter 2: RSE Policy Background

The RSE work policy, which became operational in late 2007, allows for the temporary entry of international workers to work in the horticulture and viticulture industries. The RSE policy did not intend to solve the contemporaneous labor shortage because there is no absolute labor shortage in New Zealand. The essence and incentive of the RSE policy at the time of its establishment was to create a stable seasonal agriculture labor force for growers in the future (Ramasamy et al., 2008). Simultaneously, the Pacific Island Countries (PICs) put pressure on the New Zealand government to allow workers from PICs to have short-term access to New Zealand's labor markets.

The initial preference was given to five PICs, Kiribati, Samoa, Tonga, Tuvalu, and Vanuatu. Four other PICs have subsequently joined the scheme: Solomon Islands in 2010,[1] Papua New Guinea in 2013, Fiji in 2014, and Nauru in 2015.[2] While some Asian countries also participate in the RSE scheme, a residual from an earlier seasonal work policy that had been grandparented to the RSE, the focus of the RSE program and my analysis is on eight PICs because these countries are the sources of the RSE workers and impetus to establish the RSE program.

The first two growing seasons since the RSE program was established are the "trial period", allowing employers to be accredited: the grower needs to spend several thousand dollars to become an accredited employer and needs to pay a fee to maintain the accredited status. Second, employers must pay the RSE workers at or above the national minimum wage. Third, by regulation, RSE employers must provide accommodations, orientation programs, onsite safety training, medical support, and religious services to the employees (Immigration New Zealand, 2023). Further, New

[1] I classify the Solomon Islands as joining the program in 2007 because there are seasonal workers from the Solomon Islands starting 2007/08 despite the country having not signed the agreement at the outset.

[2] I exclude Nauru in the analysis, due to the small number of people who arrive each year.

Zealand's regulators ensure that RSE workers do not work illegally and stay longer than necessary in New Zealand. RSE employees can only obtain limited visas, which means they cannot work for other employers unless specified upfront and cannot renew their visas in New Zealand.

There is an administrative national quota made by the government on the maximum number of RSE workers that are allowed to work in New Zealand in any one year. The RSE quota is allocated to the growers or the firms rather than to the municipalities. During the trial period, accredited RSE employers and nearly accredited employers receive quota and permission to recruit RSE employees from a work-ready pool established by each PIC, i.e., pools of suitable citizens from which RSE employers could recruit. It was also anticipated that the employers would look to recruit from PICs and the distribution of seasonal work opportunities between PICs would be relatively equitable.

Three features of the RSE program create the validity of the empirical strategy in the Chapter 5, i.e., SSIV. First, the allocation process creates randomness at the outset of the selection of RSE workers for the employer because the growers do not know either the quality of workers or the attributes that they may or may not like for certain groups of RSE workers. Further, the RSE quota is allocated to the growers or the firms rather than tied to the municipalities. Indeed, from the point of view of the municipality, the numbers of RSE workers arriving was hardly anticipated during the initial growing seasons.

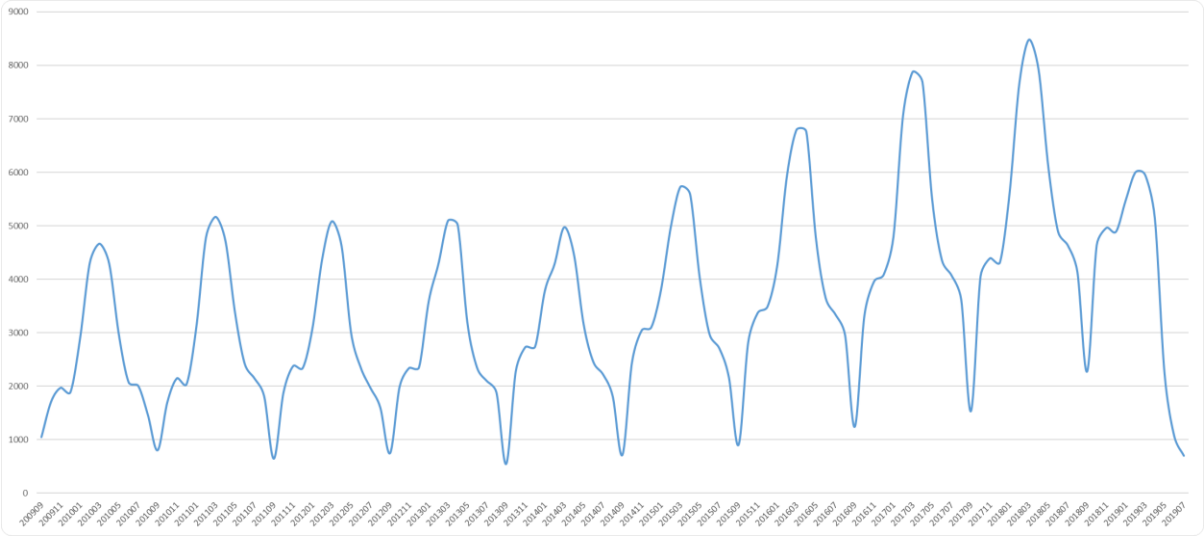
Second, while government sets a national quota, the distribution, and numbers of workers across PICs are not regulated by the policy. Therefore, over time, as employers have become familiar with workers from certain countries and have established relationships and networks with their RSE workers, direct recruitment has become more prevalent. Indeed, there are variations in

the inflow of RSE workers across different nationalities and municipalities. This give the instrument reasonable predictable power.

Third, the RSE policy does not bring influxes of workers equally in New Zealand. The municipalities without horticulture and viticulture do not have an influx of RSE workers. Horticulture and viticulture-dependent municipalities also have distinct flows of RSE workers: regions that grow apples and pears get influxes earlier in the season, from November and end around April and May; regions that grow cherries, plums, and apricots get RSE workers from December to February; kiwifruit dependent region gets influxes of RSE workers from March to June; the wineries and vineyards, however, need seasonal workers all year round. Figure 1 shows numbers of RSE workers who remained in New Zealand each month from PICs at the national level since September 2009. The number of RSE workers varies a lot depending on the month. The peak usually happens around January to March, and the lowest number of national RSE workers often appears during the winter months, i.e., July to September.

Previous policy papers have discussed the benefits of the RSE program. Studies have found that these workers have a steady learning curve after the first two years of experience. RSE workers also had noticeably higher productivity than domestics and working holiday visa workers (Bedford, 2013; Gibson and McKenzie, 2014a). Another study confirms that the RSE program benefits these workers because they can bring about 40% their earnings back to their own country (Gibson and McKenzie, 2014b). The prior studies focus on the outcomes of these RSE workers, e.g., remittances, but do not discuss the impact of the RSE on the local labor market by sector in New Zealand. This study not only fills these gaps in the context of New Zealand but also with relevance to other developed countries that implement similar programs.

Figure 1: Flow of the RSE Workers from PICs



Source: New Zealand's IDI database and author's calculations

Chapter 3: What Can We Learn from the Publicly Available Source?

1. Data Sources

Before analyzing the impact of RSE workers on the workforce using confidential data, I want to examine this topic using publicly available data. This chapter relies on four data sources: (i) New Zealand's Regional Economic Activity Webtool includes measures of the regional GDP, economic activities, and population;[3] (ii) New Zealand's migration data explorer contains visa applications and entry/exit information; (iii) The RSE employer survey reports have been conducted since the program started; and (iv) Statistics New Zealand's Inforshare databases. The data frequency is by year and usually are collected at the end of March or June.

This study focuses on two types of outcome variables: earnings and housing indicators. Appendix 3 shows some of the main outcomes of interest. Specifically, the earnings are defined as the median annual earnings (NZD) for individuals and households working in a specific sector or specific group in each city. There are a few missing variables for Kaikoura, a coastal municipality on the South Island. I estimated the missing variables by averaging the corresponding values from neighboring years. The pre-treatment variables are missing for the households and individuals. These are due to the data source coming from the Household Labour Force Survey (HLFS), rather than the Linked Employer-Employee Data (LEED).

The housing indicator is the mean weekly rent. Another concern from the agencies and governments is that the RSE workers would put pressure on the local housing market for domestic residents. Since 2019, a new rule has restricted the RSE workers living in a residential property

[3] These numbers are mainly from the Modelled Territorial Authority Gross Domestic Product constructed by the Ministry of Business, Innovation, and Employment.

unless the property was included in the agreement or bought before September 26th, 2019. Yet, the evidence is limited to whether the RSE workers cause the local rent to increase (Immigration New Zealand, 2023).

2. Empirical Strategy

Chapter 3 seeks to quantify the impact of changes in the number of RSE workers on various local earnings and housing market indicators described above. The study exploits variation across narrowly defined labor markets, i.e., cities or municipalities, within New Zealand. This reflects that the New Zealand labor market is highly localized, especially in small cities or rural areas (Nel, Connelly, and Stevenson, 2019). Furthermore, the RSE workers tend to only reside and spend their earnings within the municipalities or cities where they are located (Evalue Research, 2010).

Given the data and nature of the RSE program e.g., quota and the number of RSE workers entering New Zealand change almost every year, the empirical analysis emphasizes the short-run impacts rather than the long-run or dynamic impacts. We would expect that the wages across sectors do not fully arbitrage. Further, prior studies show that these seasonal workers spend about half of their incomes in the city (Gibson and McKenzie, 2014ab). The influx of seasonal workers increases the demand for goods in some if not all non-agriculture sectors. Therefore, we would expect some non-agriculture sectors to experience increases in earnings. Further, based on the data, Chapter 3 focuses on aggregate labor market outcomes for domestic workers by genders and industries.

Defining $\underset{\sim}{\mathbf{S}}(RSE_{c,t})$ as the ratio of RSE workers of the total domestic working age population, from 15 to 64 years old in city c in year t, the impact of the RSE program can be

estimated with a panel specification in equation (1). [4] The city-fixed effect is represented by ϕ_c, the year-fixed effect by η_t, the control variables by $X_{c,t}$, and the outcome variables by $Y_{c,t}$. The city-fixed effects control fixed and potentially unobserved differences between cities. The year-fixed effects capture temporal changes and trends in the outcome variable that are common to all cities.

$$Y_{c,t} = \phi_c + \eta_t + \beta * \mathbf{S}(RSE_{c,t}) + \theta X_{c,t} + \varepsilon_{c,t} \quad (1)$$

However, there are two issues with the main parameter of interest, β, in equation (1). First, the data on the number of RSE workers is unavailable at the city-year level due to data constraints. Second, even if this data existed, the model would likely return a biased estimate of the true parameter. For example, growers may decide to plant more crops and acquire more land in anticipation of the arrival of the RSE. This would increase the demand for seasonal workers and create a downward bias.

Due to these issues, following Card (2001), I employ a variation of the shift-share dependency-index approach. The shift-share method is one of the most widely used strategies in the immigration literature (e.g., Card, 2001; 2007; Goldsmith-Pinkham, Sorkin, and Swift, 2020). The shift-share approach addresses the endogeneity of immigration flows at the city level by exploiting exogenous variation in the national inflows of immigrants by country of origin, i.e., the "shift" or exogenous variation in the dependence of country-specific immigration across cities, i.e., the "share." In the context of RSE, I exploit the "share" as exogenous, rather than the "shift".

In equation (2), let $\mathbf{S}(RSE_{c,t})$ be the constructed ratio of RSE workers to the total domestic working age population, from 15 to 64 years old in city c in year t.

[4] For simplicity, I use the word "city" to refer to both municipality and city onward.

$$Y_{c,t} = \phi_c + \eta_t + \beta * \mathbf{S}(RSE_{c,t}) + \theta X_{c,t} + \varepsilon_{c,t} \quad (2)$$

The $\mathbf{S}(RSE_{c,t})$ is shown in equation (3).

$$\mathbf{S}(RSE_{c,t}) = \frac{RSE_c * RSE_t}{POP_{c,t}} \quad (3)$$

First, I identify the RSE-depend cities, RSE_c indexes city c's dependency on the RSE program, which represents the differential exposure to the program, i.e., the "share". Higher dependency rates imply that the cities depend more on the RSE workers. The cities that do not rely on RSE workers receive 0 for RSE_c. The RSE_t is the national inflow of RSE workers in year t, i.e., the "shift". The interaction gives the estimated RSE population in a city each year. $POP_{c,t}$ is the total domestic working age population of domestic workers, from 15 to 64 years old in city c in year t.

I now describe more closely the derivation of RSE_c in equation (4). First, I identify the cities that have industries that depend on RSE workers. These include mainly apple growing, kiwifruit growing, berry growing and grape growing areas. Second, using the share of horticulture in city GDP and total/aggregate city GDP in 2002, I get the GDP for horticulture and viticulture in these impacted cities, i.e., $GDP_{c,h,2002}$. Then, I sum these numbers as the denominator. Finally, I get the RSE_c for each city after the division. This implies the sum of these shares is equal to 1.

$$RSE_c = \frac{GDP_{c,h,2002}}{\sum_{i=1}^{c} GDP_{c,h,2002}} \quad (4)$$

I choose 2002 as the year for the calculation of the share of RSE workers for two reasons. First, it is the closest agricultural census before implementing the program. It is more accurate than

the earlier census, in which some growers changed crops between 1992 and 2002. Second, it occurred before the creation of the RSE policy. The industry leaders and the government initiated the conversation about the creation of the RSE in 2005 (Bailey, 2019). Growers did not know this conversation and policy ex-ante in 2002, so using 2002 data does not reflect the distribution of the RSE workers affected by the policy. The indexes of RSE_c are shown in the Appendix 4. For simplicity, the table only shows the cities that have strictly positive RSE_c. The RSE-independent cities which assign 0 RSE_c are omitted from the table. Table 1 shows the descriptive statistics for non-zero $\mathbf{S}(RSE_{c,t})$.

Table 1: Descriptive Statistics for Constructed RSE Share

Variable	Observation	Mean	Std. dev	Min	Max
RSE Share	84	0.047	0.022	0.012	0.110

Notes: The numbers are based on the equations and calculations in (3) and (4).

When the different exposure levels determine the different treatments to the policy, the β coefficient in Equation (2) is an estimate of the weighted average causal response (ACR) of the arrival of RSE workers on the outcome variables in cities that receive RSE workers, i.e., ACR across RSE_c, where RSE_c is multivalued or discrete. The difference-in-differences with multi-values treatments require a stronger parallel trend assumption than the standard difference-in-differences design that I describe shortly (Callaway, Goodman-Bacon, and Sant'Anna, 2025).

In a setting where pre-period data are available, the credibility of this empirical strategy can be tested by using pre-trend variables (Goldsmith-Pinkham, Sorkin, and Swift, 2020).[5] Thus, the necessary assumptions for casually identifying the coefficients β in equation (2) are: (i)

[5]In a setting where pre-period data is unavailable, researchers need other forms of argument to get the validity of shift-share strategy (Goldsmith-Pinkham, Sorkin, and Swift 2020).

Allocations of RSE workers in RSE-dependent cities were not determined by potential outcome variables, e.g., sector earnings and rent. (ii) There are heterogeneous impacts across cities and regions due to fixed dependence and exposure. (iii) Parallel trend: without the policy, the RSE-dependent and RSE-independent cities follow the same trends over time in the treatment years. (iv) Stronger parallel trend: the average change in outcomes over time from being exposed to the policy is independent of the level of exposure actually experienced, for all possible levels of exposure to the policy.[6] (v) It should not have any effect on that city's outcome variables in other periods, i.e., no spillover across space and time.

The major threats to the identification are violating the parallel trend assumption and being affected by spillovers. First, violating the parallel trend assumption implies that without the policy, the average outcomes for the treated and control would not have experienced the same variation over time during the treatment years. One example is that if the median earnings between the treated and control groups do not move in parallel before the policy intervention, this may indicate that in the absence of the RSE program, the RSE-dependent and RSE-independent cities have different trends over time in the treatment years.

One would expect that receiving RSE workers is independent of pre-intervention outcome trends. In Appendices 5 and 6, I include the results of a series of tests where the pre-trend data are available from 2000 to 2007.[7] I test whether RSE-dependent cities and RSE-independent cities follow parallel trends of the outcome variables and other related variables, i.e., annual earnings, rent, annual labor force participation rate, and annual unemployment rate, before the policy intervention. The tests include city-fixed effects, year-fixed effects, log population, log GDP per

[6] The detailed discussions of assumptions could refer to difference-in-differences with a continuous treatment (Callaway, Goodman-Bacon, and Sant'Anna, 2025).
[7] Data on household, individual, male, and female earnings is not available for the pre-treatment period.

capita, and City-Year trend as control variables. While Appendix 5 visualizes the diagnostic graphs for this method, Appendix 6 shows the test results. From the tests and graphs, I cannot reject the null hypothesis of parallel trends in the pre-intervention years, suggesting the general validity of the empirical strategy.

Another threat to the identification strategy is if the cross-city migration in response to the arrival of RSE workers is large, i.e., large spillover effects, the β in equation (2) would be biased, and the direction of bias is unclear. For instance, suppose that the β estimate in equation (2) is positive and there are spillover effects on control and other treated units. If there are positive spillovers, the β estimate would be attenuated towards zero. On the other hand, if the spillover effects are negative, the estimate would increase in magnitude. However, according to Stats NZ, cross-city migration is only at a rate of 6 per 100 population per year which is tiny compared to the population. Further, the migration rate is much smaller for cities in rural areas (Stats NZ, 2018a).

3. Results

(a) City Level Impact: Table 2 panel (a) shows the impact of the influx of RSE workers on the domestic workers' earnings by city. The outcome variables include the median annual household income, median annual income for individuals (both genders), median annual income for males, and median annual income for females. The table presents only the estimates of the coefficient of interest, β, in equation (2). The control variables in the main specification include various city-level controls at the annual level: log population, log GDP per capita, unemployment rate, labor force participation rate. Each entry in the table is an estimate from a different regression using the different sector variables listed as entries in the corresponding rows.

Table 2: Impact of the Influx of RSE Workers on the Domestic Workers' Earnings and Rent

(a) By City	
Household	0.408
	(0.447)
Individual, both Genders	0.612**
	(0.250)
Male	0.194
	(0.265)
Female	0.746***
	(0.288)
(b) By City-Sector	
Accommodation	1.133
	(0.692)
Agriculture	-0.270
	(0.837)
Construction	0.221
	(0.300)
Education	-0.224
	(0.450)
Health Service	0.499
	(0.346)
Manufacture	0.221
	(0.392)
Public Service	0.437
	(0.377)
Retail Service	1.002***
	(0.369)
Transportation	0.852*
	(0.495)
Wholesale	-0.517
	(0.474)
(c) Rent	
Week Rent	126.5059
	(142.9526)

Notes: The regressions are in log-level forms, except for the one in panel (c). Each entry of the table is the coefficient on the explanatory variable of interest in equation (2) using data between 2008 and 2019, with 780 observations. The dependent variables (left column) have the same regression specification. Standard errors are in parenthesis. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

To accurately interpret the coefficients, it's necessary to exponentially transform the estimates due to the log-level nature of the data. The results indicate that the influx of RSE workers has an insignificant impact on household earnings and male earnings. However, a 1% increase in the ratio of RSE workers to the total domestic working-age population leads to a 1.1% increase in annual median earnings for females and a 0.84% increase for individuals (across both genders) in the affected cities. These findings reflect aggregate labor market outcomes, suggesting the average expected impacts on domestic workers. The results also reveal that males and females are not perfect substitutes in the labor market, potentially due to differences in the occupations they hold. To provide a more tangible understanding of these estimates, based on the descriptive statistics in Table 1, RSE-dependent cities see an average increase in median annual earnings of 5.17% for females and 3.95% for individuals (both genders). The most impacted city shows median annual earnings increase of 12.1% for females and 9.24% for individuals (both genders). These results show that the RSE workers contribute to the local economy significantly.

(b) City- Sector Level Impact: Panel (b) shows the impact of the influx of RSE workers on the domestic workers' annual earnings by different sectors with the same set of control variables. The results show that the influx of the RSE increases the earnings in retail service and transportation. A 1% increase the ratio of RSE workers of the total domestic working age population increases the median annual earnings of these two sectors by 1.72% and 1.34% respectively.

Compared to the sectors which have significant coefficients, the result for all other sectors is the earnings do not change. There are two reasons why this can happen. First, workers within a city are not perfect substitutes. There are barriers preventing labor from moving across sectors at least in the short-run. In the long-run, when workers can perfectly arbitrage the earning opportunity, we would expect the impact on earnings to equalize across sectors. Second, the seasonal workers

only purchase goods and services in several sectors. By contrast, these workers do not purchase goods from other sectors, so the remaining sectors do not face an increase in demand for goods and services, i.e., no change in earnings. For example, these RSE workers hardly purchase manufacturing products or participate in roles related to manufacturing, so we do not expect the efficiency of manufacturing to increase or decrease. Furthermore, the relatively high response numbers for transportation and retail services imply the strong demand from the RSE workers.

(c) Rent: RSE employers may build accommodation on-site or purchase residential properties to provide the essential residential needs of the RSE workers. One is worried that if the RSE employers purchase residential houses, it will put upward pressure on the housing market. Panel (c) shows that while the coefficient is positive, the weekly rent for residential housing remains insignificant after the influx of RSE workers. This implies the RSE workers do not influence the local housing market in terms of residential rent, which indicates the successful management of pastoral care.[8]

In this chapter, using the aggregate data from publicly available data sources, I find that the influx of seasonal agriculture laborers causes increases in earnings for some groups of domestic workers, e.g., females, retail, and transportation, but the earnings in other groups remain unaffected. This makes sense because most of the sectors do not relate to agricultural production or consumption required by these RSE workers. Indeed, the results do not show any worse earning

[8] Under the regulations of Immigration New Zealand, the growers and farmers must provide pastoral care. This includes but is not limited to providing suitable accommodation, transportation to and from the worksite(s), and giving opportunities for recreation and religious observance, etc. (Immigration New Zealand, 2023).

effect for domestic workers. Further, these RSE workers do not have any impact on rent of the local housing market.

While publicly available data provides valuable descriptive insights into seasonal labor programs, they are insufficient for answering more detailed causal and distributional questions about labor market impacts and growers' responses. Aggregate statistics lack the detail needed to distinguish among domestic, the RSE, and non-RSE foreign workers, to track individuals over time, or to link workers to specific firms and industries. As a result, key outcomes, such as wage changes, employment responses, and firm-level differences, cannot be credibly identified using public data. The following chapters use administrative data from Statistics New Zealand to address these limitations.

Chapter 4: Motivating Framework

To motivate Chapter 5, I propose a two-sector framework to graphically illustrate the impact of a sector-specific immigration program with a quota on the local labor market in rural areas. The model characterizes an economy that has an agriculture and a non-agriculture sector. I first list the assumptions that underpin the model. Then, I show the impact of these seasonal workers on the low-skilled labor market. I illustrate a general case where the quota does not bind for these low-skilled foreign seasonal workers. Following, I discuss the cases in which the quota binds in the short run. Further, I present the impact of these seasonal workers on the high-skilled labor market. Last, I discuss the factors that influence wages and employment for both high-and low-skilled workers.

1. Assumptions

The economy has two cities 1 and 2. City 1 produces a combination of a tradable agricultural good and a non-agriculture good consumed locally by both domestic and foreign workers. City 2 has only the non-agriculture sector, which is used as a counterfactual in Chapter 5.

Second, the labor market localizes at the city level, which implies the model prohibits the cross-city migration of laborers. This assumption matches the rural study in New Zealand, where small towns' labor markets are highly localized and isolated (Nel, Connelly, and Stevenson, 2019). This assumption is a valid and appropriate choice for the analysis given the location-specific nature, i.e., rural areas and small towns, of the RSE program in New Zealand.[9]

[9] The effects are different for rural and metropolitan areas. For large cities, especially in the US, the additional effects come from the spatial economics linkages between locations across space. Additional people and businesses are drawn

Third, firms need both high-skilled and low-skilled workers to produce agricultural and non-agriculture goods. Firms in the non-agricultural sector can only hire domestic workers for both high-and low-skilled jobs. By contrast, firms in the agriculture sector can employ either domestic or foreign laborers for low-skilled jobs but only hire domestics for high-skilled jobs. Put another way, the low-skilled labor force has domestic workers employed in both agriculture and non-agriculture and foreign workers employed in agriculture.

Fourth, domestic workers, regardless of skills, can move freely across sectors in the long-run, but foreign workers must work in agriculture. In the short-run, however, there are frictions that prevent domestic workers from moving seamlessly across different sectors, such as acquiring the necessary skills and trainings for different occupations.

Fifth, the government announces a seasonal workers program that persistently allows foreign low-skilled workers who are willing to work at lower wages than domestic workers. Further, there is an administrative quota on the maximum number of foreign low-skilled workers entering the country in any given year. This program brings a shock to City 1's low-skilled labor market, but City 2 remains unaffected.

Lastly, local labor supply curves are upward-sloping for both high- and low-skilled workers. The labor movement in and out of the sector within a city shifts the labor supply curve. The local labor demand curves are downward sloping for both high- and low-skilled workers.

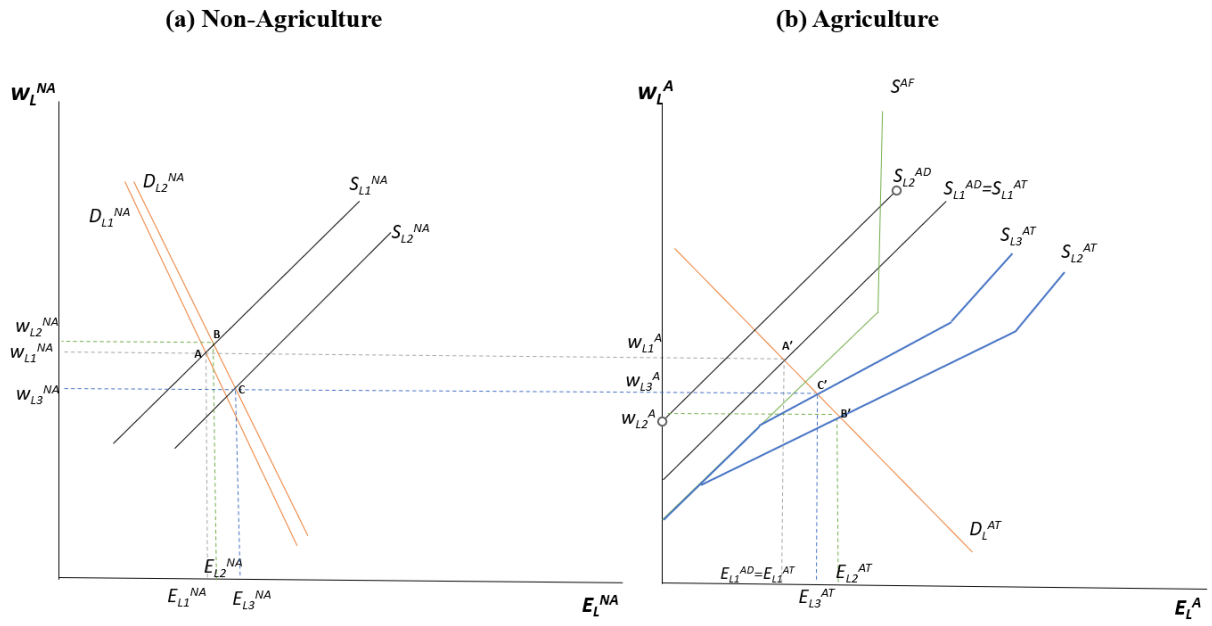
to these metropolitan areas by the amenities and opportunities (e.g., Allen and Arkolakis, 2023). Examples are the Bay Area for IT hub and the Greater Boston Area for pharmaceutical companies.

2. Labor Market for Low-Skilled Workers

(i) General Setting: The labor market for low-skilled workers is shown in Figure 2. Panel (a) shows the market for low-skilled in the non-agriculture. Panel (b) depicts the low-skilled labor market for agriculture. Before any policy intervention, the total demand for low-skilled workers in agriculture is D_L^{AT}. The total labor demand for low-skilled workers in agriculture is exogenously determined and unchanged, such as, the available land and soil quality for certain crops. The total supply is S_{LI}^{AT} which equals S_{LI}^{AD}. The superscript T represents the total labor supply, and D represents the labor supply of the domestic labor force. Before policy intervention, the total low-skilled labor force only has the domestic labor force. The demand and supply for low-skilled workers in non-agriculture are D_{LI}^{NA} and S_{LI}^{NA}, respectively. Both low-skilled labor markets offer the same wages in equilibrium, i.e., w_{LI}^{NA} equals w_{LI}^{A}, at points **A** and **A'**.

The government implements a program that allows seasonal foreign low-skilled workers to work legally in agriculture. This policy attracts foreign low-skilled workers who are willing to work at lower wages than domestic workers until the annual cap is reached. The annual cap is exogenously made by the government. In panel (b), this policy brings a new labor supply curve for foreign laborers, denoted as S^{AF}. The vertical segment of this labor supply curve reflects the program that has an annual cap or quota. Now, the total labor supply for low-skilled workers in agriculture is curve, S_{L2}^{AT}, which is the horizontal summation of both domestic and foreign labor supply. The new short-run equilibrium is at point **B'**, with wage w_{L2}^{A} and employment E_{L2}^{AT}. In panel (a), the influx of foreign workers increases the demand for goods in non-agriculture, which leads to an increase in demand for low-skilled workers in this sector. This shifts the demand from D_{LI}^{NA} to D_{L2}^{NA}, at new short-run equilibrium **B**, with wage w_{L2}^{NA} and employment E_{L2}^{NA}.

Figure 2: Impact of the Influx of Low-Skilled Workers on Low-Skilled Labor Market When Quota Does Not Bind



In the short-run, the wage $w_{L2}{}^{A}$ is lower than the wage $w_{L2}{}^{NA}$. In the long-run, this triggers domestic low-skilled workers to move out from agriculture and join the non-agricultural sector. In panel (b), the domestic labor supply in agriculture shifts from $S_{LI}{}^{AD}$ to $S_{L2}{}^{AD}$. This also shifts the total low-skilled labor supply in agriculture from $S_{L2}{}^{AT}$ to $S_{L3}{}^{AT}$: fewer domestic low-skilled workers are in agriculture. In panel (a), as more domestic workers enter from agriculture, the domestic labor supply in non-agriculture shifts from $S_{LI}{}^{NA}$ to $S_{L2}{}^{NA}$. Both sectors now have the same wage, i.e., $w_{L3}{}^{NA}$ equals $w_{L3}{}^{A}$, with long-run equilibriums at **C** and **C'**, respectively. In this example, the net employment increases in both sectors, but the wage decreases in both sectors after the influx of foreign seasonal workers. However, wages can increase for both sectors if there is a sufficient increase in demand for low-skilled workers in non-agriculture. [10]

[10] The agricultural product is a tradable good which mostly for export. Thus, by assumption, the demand for agricultural goods and workers in the agricultural sector does not increase after the influx of the RSE workers.

(ii) Quota Binds: Despite the quota rarely binding for growers in New Zealand, there were two instances when growers faced binding constraints (Immigration New Zealand, 2023). In 2008/2009, there was a sudden increase in labor demand in the middle of the harvest season in the Bay of Plenty. Due to the short notice, growers were unable to find oversea workers. There were insufficient foreign low-skilled workers in town (Evalue Research, 2010). Similarly, during the Covid-19 Border Closure, many RSE workers could not travel to New Zealand. As the foreign low-skilled labor supply was restricted, this created a binding constraint. In both cases, growers hired domestic workers instead and offered them higher wages (Coltman, 2021). If the quota is binding in the long-run, wages in the agricultural sector will be higher than those in the non-agricultural sector. As a result, wages will not equalize across the two sectors.

3. Labor Market for High-Skilled Workers

The labor market for high-skilled workers is shown in Figure 3. Panel (a) shows the market for high-skilled in non-agriculture. Panel (b) depicts the high-skilled labor market in agriculture. Before any policy, the total demand for high-skilled workers in agriculture is D_{HI}^{A} and the total supply is S_{HI}^{A}. The demand and supply for high-skilled workers in non-agriculture are D_{HI}^{NA} and S_{HI}^{NA}, respectively. Both high-skilled labor markets offer the same wages in equilibrium, i.e., w_{HI}^{NA} equals w_{HI}^{A}, at points **A** and **A'**.

In the short-run, the seasonal worker program attracts foreign low-skilled workers in agriculture. The shift in demand for high-skilled workers in agriculture depends on two factors embedded in the production function, but which dominates is ambiguous. The first is the elasticity of input substitution between high- and low-skilled workers in agriculture. As low-skilled workers become cheaper, growers may substitute the low-skilled laborers for high-skilled ones to some

extent, unless the production function is fixed proportion (Leontief). This shifts high-skilled labor demand to the left. The second is the complementarity between the high- and low-skilled workers: an influx of low-skilled workers may make the marginal productivity of high-skilled workers greater in agriculture. This shifts high-skilled labor demand to the right.

Figure 3: Impact of the Influx of Low-Skilled Workers on High-Skilled Labor Market

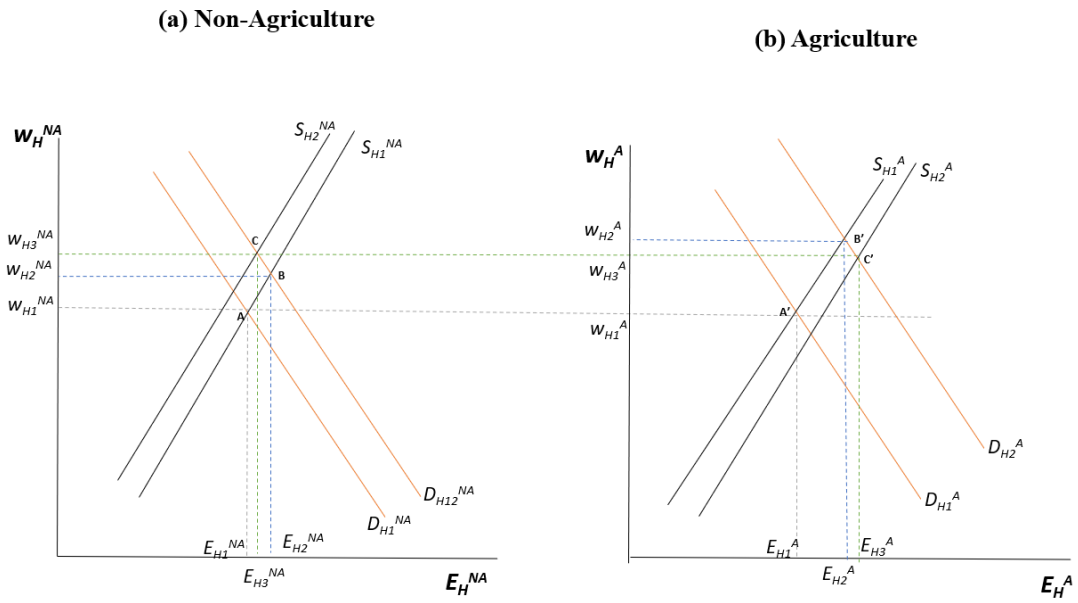


Figure 3 shows a case when the influx of low-skilled foreign workers leads to an increase in demand for high-skilled workers in agriculture, i.e., $D_{HI}{}^A$ shifts to $D_{H2}{}^A$ at new short-run equilibrium **B'**, with wage $w_{H2}{}^A$ and employment $E_{H2}{}^A$ in panel (b). In this example, the complementarity dominates the substitution effect. By contrast, if the elasticity of substitution between high- and low-skilled workers is high enough to dominate their complementary nature in production, the demand for high-skilled workers in agriculture shifts left. In panel (a), the influx of foreign workers increases the demand for service in non-agriculture, which leads to an increase

in demand for high-skilled workers in this sector. This shifts the demand from D_{H1}^{NA} to D_{H2}^{NA}, at new short-run equilibrium **B**, with wage w_{H2}^{NA} and employment E_{H2}^{NA}.

In this example, agriculture has higher wages than non-agriculture for high-skilled workers. Thus, in the long-run, this triggers domestic high-skilled workers to move out from non-agriculture and join agriculture. In panel (b), the high-skilled labor supply in agriculture shifts from S_{H1}^{A} to S_{H2}^{A}, as more high-skilled workers enter agriculture. In panel (a), as more workers leave, the high-skilled labor supply in non-agriculture shifts from S_{H1}^{NA} to S_{H2}^{NA}. Both sectors now have the same wage, i.e., w_{H3}^{NA} equals w_{H3}^{A}, with long-run equilibriums at **C** and **C'**, respectively. The net employment and wages will increase in both sectors for high-skilled workers. However, if agriculture has lower wages, high-skilled workers will move out of agriculture and join non-agriculture. Further, the net employment and wages may decrease in both sectors for high-skilled workers if there is a sufficient decrease in demand for high-skilled workers in agriculture and an insufficient increase in demand for high-skilled workers in non-agriculture in the long-run. This movement and direction depend on factors that I discuss in the implications.

4. Implications

The seasonal worker program increases net total employment for low-skilled workers in both sectors. However, the net impacts on the wages of the low-skilled workers and both employment and wages of high-skilled workers are ambiguous and depend on four elements. First, the magnitude of the impacts depends on how quickly domestic workers can arbitrage the opportunity in wage differentials to reach long-run outcomes. In the short-run, workers may fail to realize the arbitrage opportunity of wages across the sectors, i.e., **B** and **B'** in Figures 2 and 3. The final

equalized wages and employment, i.e., at **C** and **C',** depicts the long-run equilibrium. The quicker workers can arbitrage opportunities, the fewer wage differentials across sectors.

The second source comes from two factors embedded in the production function, but the net effect is ambiguous depending on which dominates. The first is the elasticity of input substitution between high- and low-skilled workers.[11] In the short-run, as low-skilled workers become cheaper in agriculture, growers may substitute the low-skilled laborers for high-skilled ones to some extent, unless the production function is fixed proportion , e.g., Leontief. This shifts high-skilled labor demand to the left in agriculture. The long-run adjustment is not obvious and depends on other sources that I mentioned above and below. For instance, if low-skilled workers become relatively expensive, firms and growers substitute the high-skilled workers for low-skilled laborers in both sectors. This shifts high-skilled labor demand to the right in the long-run adjustment and vice versa if low-skilled workers are cheaper. Second, an influx of low-skilled workers may make the marginal productivity of high-skilled workers greater in agriculture. This shifts high-skilled labor demand to the right.

Third, the magnitude of the impacts depends on the size of the program or the magnitude of the influx of low-skilled workers. Increasing the annual quota allows the growers to request more foreign laborers: the higher the quota or the larger the inflow, the lower the wage for the low-skilled domestic workers. By contrast, the scenario can be different for high-skilled workers depending on which factor dominates the production function that I mention above.

[11] Mathematically, $S_{HL}=\frac{\partial \ln (E_H/E_L)}{\partial \ln (w_L/w_H)}$, H represents high-skilled workers, L represents low-skilled workers.

The fourth element is the magnitude of demand shift in the non-agriculture sector, i.e., the demand for local goods in non-agriculture from these seasonal workers. If the seasonal workers spend a large portion of their earnings in the cities, the influx of seasonal migrants increases the demand for goods in non-agriculture. This leads to an increase in demand for both high- and low-skilled workers which also increases their wages and employment, and vice versa if the seasonal workers remit most of their earnings back to their home countries.

In conclusion, the magnitude and direction of the net effects on wages and employment for domestic workers are unclear based on the economic theory. Further, this model is not limited to a two-sector and two-types of workers framework. It can be generalized into other multiple sectors, nationalities and skills. Thus, an empirical analysis is needed to investigate the outcomes.

Chapter 5: Seasonal Workers' Effect on Labor Market Outcomes: Analysis with Monthly Longitudinal Data

1. Introduction

Chapter 5, using a unique longitudinal dataset in New Zealand, analyzes a seasonal worker program that targets just the horticulture and viticulture industries, New Zealand's Recognised Seasonal Employer (RSE) scheme, on labor market outcomes of domestic and foreign workers. Besides the unique dataset, this study introduces a new identification approach and extends the analysis to include the effects on employment, wages, and sectoral outcomes, providing a complete picture of the impact of seasonal workers on local labor market outcomes. It provides a new lens into a classic question in the economics literature and is currently at the center of the political debate as the labor forces and rural economy in some developed countries are shrinking: what is the impact of industry or skill -specific immigrants on wages and employment of domestic workers as well as foreign workers?

Using a shift-share instrumental variable approach, this study has three main findings. First, contemporaneously, the influx of seasonal workers has mild wage effects on domestic females and low-skilled workers, but other groups are not affected. On the other hand, the influx has much more prevalent effects on the employment of domestic workers. Females, Middle-aged, Māori & Pacific, European, and low-skilled workers have positive and significant employment effects. Second, the inflow of seasonal workers has positive impacts on related industries. Accommodation & food service and administrative & support have the highest employment effects. Further, agriculture, forestry, and fishing have positive and significant effects on both wages and employment among domestic workers. Third, results show that foreign workers are

disproportionately worse off. The wages of foreign workers decrease, but there is no significant change in employment.

This study has three major contributions to the existing literature. The first is the exceptionally high-quality data that is available for this study. The longitudinal nature of the dataset covers the entire population receiving salary and wage within New Zealand. This allows analysis of the various impacts of these seasonal workers on the workforce for different demographics. In addition, unlike previous studies using annual-level data, this dataset records the monthly salary of the employees. This allows me to analyze the contemporaneous effects of the impact of the seasonal workers on the workforce with consideration of seasonality which is crucial for agricultural production.[12]

Second, this study also contributes to the existing literature on agricultural laborers. Apart from the data either not being available, or a substantial amount of foreign agricultural laborers are unauthorized immigrants who are absent from the official data, the previous studies have focused on the aggregate impact of agricultural workers on domestic workers' outcomes within confined geographic areas, either a single state or certain areas within a state. This study focuses on the individual outcomes, and the level of analysis is on the entire country of New Zealand. Further, the extension also includes the analysis of the impact of the seasonal laborers on other foreign-born workers, a topic that has lacked attention in the literature.

The third contribution is to bring evidence of the benefit of a skilled-based immigration program to the recipient country, especially for low-skilled workers. The previous studies focused mostly on the high-skilled group, such as H-1B visa holders and skilled workers in EU countries.

[12] Examples are agriculture in most countries in the temperate climate.

The findings not only pertain to seasonal workers but also are useful for low-skilled immigrants in general.

This chapter sits at the intersection of four streams of literature. The first stream emphasizes agricultural laborers. Studies focus on the stringent enforcement policies directly decreasing the number of foreign workers on farms. They show that the reduction of foreign seasonal workers decreases farms' profit, reduces production capacity, and increases operational expenses (e.g., Charlton and Kostandini, 2021; Luo and Kostandini, 2022). The decrease in foreign workers has caused some local businesses to permanently leave the industry and also job losses for the domestic workers (e.g., Clemens, Lewis, and Postel, 2018; East et al., 2022; Lee, Peri, and Yasenov, 2022). These studies use various empirical strategies to estimate the impact of immigration policies on different outcomes. Alternatively, another approach using the equilibrium displacement model estimates the upper bounds for the effects of interest (Rutledge and Mérel, 2023).

The second stream is the analysis of the impact of skill-based immigration programs. The most renowned skill-based immigration program is the H-1B from the US. The H-1B visa program allows companies to hire high-skilled foreign workers. By using various shift-share strategies, the studies find that H-1B immigrants have a positive impact on the amount of US patenting and wages of college-educated domestic workers, especially for firms and cities highly dependent on foreign scientists (e.g., Kerr and Lincoln, 2010; Peri, Shih, and Sparber, 2015).

Third, this study relates to a rich set of literature that analyzes the impact of low-skilled immigrants on domestic workers. These studies lead to contrasting findings. One side argues that immigration reduced real wages paid to domestic workers without a high school degree by a considerable amount (e.g., Borjas, 2003; Borjas and Katz, 2007). By contrast, other regional studies find minimal effects of low-skilled immigration on the real wages of less educated

domestics (e.g., Card, 2001; 2007; Card and Lewis, 2007). Ottaviano and Peri (2006, 2008, 2012) argue that immigrants and domestics of similar education and experience possess unique skills that lead them to specialize in different tasks.

Last, this chapter is also relevant to a couple of case studies using individual longitudinal data to follow the impact of immigration on domestic individual outcomes, rather than on aggregate labor market outcomes. One study using annual longitudinal data from Denmark shows that an increase in the supply of refugee-country immigrants, who are predominantly low-skilled, pushes less educated domestic workers to work in less-manual-intensive occupations. Overall, these refugee-country immigrants have positive effects on wages, employment, and occupational mobility for domestic low-skilled workers (Foged and Peri, 2016). By contrast, a study using data from Germany shows that immigrants lead to a moderate decline in wages and a sharp decline in employment for domestic workers. While young workers experience the largest wage effect, older workers have the highest employment response (Dustmann, Schönberg, and Stuhler, 2017)

The rest of this chapter is organized as follows. Section 2 presents the data, and summary statistics. Section 3 presents identification strategy and the SSIV estimates for contemporaneous analysis. Section 4 shows the main results of this study. Section 5 concludes Chapter 5.

2. Data and Descriptive Statistics

The data in this chapter come from the administrative database managed by Statistics New Zealand (Stats NZ), i.e., Integrated Data Infrastructure (IDI) and Longitudinal Business Database (LBD). Statistics New Zealand refreshes the IDI and LBD dataset every three to four months and keeps the October refresh for three years and the rest for 18 months. At the time of this study, I used the 202210 refresh.

As the data are not publicly available, I describe them in detail. The first data source comes from the Employer Monthly Schedule (EMS). It records the employees' paycheck information and links the permanent enterprise identifier to a unique individual identifier. Stats NZ assigns a unique ID to everyone in the dataset. For this study, I only include the individuals who receive wage and salary payments from the employers. I exclude entries that receive stock benefits, pension, dividend payments, etc.

The raw EMS table faces a challenge in that employers have different payroll dates for their employees. Some send weekly paychecks, but others pay either bi-weekly or monthly. To solve this, I use Richard Fabling's table which aggregates the payroll to monthly level for each employer-employee pair (Fabling and Maré, 2015). Thus, each month, researchers only observe one salary & wage entry for each employer-employee combination. If an individual has two or more jobs in a month, people can observe two or more entries in the table. I aggregate them into one entry based on the latest wage & salary entry. This table also has other individual information, i.e., age, gender, number of jobs they hold in the month, full-time equivalent status (FTE), industry of the firm, and skills index of the employees.

Hours and wages are usually unknown to Stats NZ. To transform the monthly salary to wage and employment, i.e., hours of work per month, I use the following steps: (i) FTE measures are used to approximate the hours worked by employees for each employer in each month, assuming one FTE is equivalent to 40 hours per week and that each month comprises 4.35 weeks.[13] (ii) Monthly salary number is divided by hours to get the approximated hourly wage rate for each employee.[14] (iii) The natural logs for hours (employment) and wages are used in the empirical analysis. Let me emphasize that the wage and employment measures in this study are FTE

[13] Hours=FTE*40*4.35
[14] Wage=Monthly Salary/Hours

measures to make the best proximity to the wage and employment information of the employees from the data. Another drawback of these measures is that they lack overtime information for employees. This is mainly because New Zealand has not yet had universal legislation for overtime rates.

While the previous literature uses obtaining a college degree or some college education classified as high-skilled and obtaining a high-school diploma or below as low-skilled, this method is not suitable for New Zealand. First, time-variant educational information for employees is generally missing in Stats New Zealand's database, and only available in the census 2013 and 2018. This does not reflect the actual educational attainment of the employees. For instance, a person may obtain a college degree between two censuses, but in the data, this person only has a high school diploma or less. This issue is especially prevalent among young adults.

Second, using with or without a college education to measure the skills of a worker in New Zealand is misleading. New Zealand workers hold more vocational education and training (VET) qualifications than the OECD average, and employees can succeed in the job market without a college degree. These VETs often include several months to a year job specific training which ensures workers have the necessary skills. Thus, using college education as a benchmark to classify the skill level of New Zealand employees tends to downgrade their skill level (OECD, 2023).

Therefore, I use an index approach to classified worker's skill level. The skills index is based on a constructed measure to solve the issues above (Maré et al., 2017).[15] I denote employees are high-skilled if their skill index is in the top quartile of the municipality in each year-month.

[15] They measure individual workers' skill index using results from a two-way effect model. Each worker gets a pair of time-varying and time-invariant components that represent the observed and unobserved skills, respectively. Then, the two components sum up to the individual's skill index. This skill index captures both time-varying skills, such as training via jobs, and time-invariant skills, such as the individual's characteristics.

Similarly, the low-skilled employees are in the bottom quartile of the spectrum. The skill level of the employees is classified at the municipality level rather than at the national level. This reflects the "closed" nature of New Zealand's labor market condition in each municipality.

The second source of data comes from the Administrative Population Census (APC), a census-like dataset that has time-variant and invariant information that integrates different sources of information into one manageable dataset. The advantage of this over the census is the information is up to date because Stats NZ updates the table multiple times a year. I extract the number of children for females, ethnicity, and birth country from the APC. I use the birth country to identify the domestic (New Zealand-born) workers. This measure can identify the numbers of domestic workers, without the problem of individuals having multiple nationalities or people immigrating to New Zealand and obtaining citizenship later in their life.

The third source of data is the address notification, which records individuals' residential address information, i.e., the municipality they live in. Like APC, the address notification integrates different sources of information into one manageable dataset. To make this dataset consistent throughout my analysis, I use the address replacement date rather than the notification date as the indication of people moving from one place to the other.[16] Further, few individuals move more than once a month. I use the first record in each month to indicate the address information. People who reside in the same municipality are in the same labor market.

The fourth source of data comes from the Migration Spell, which records the entry and exit information of RSE workers. To make the data suitable for the analysis, I remove all the records for workers who stayed in New Zealand for less than 14 days. This manipulation excludes approximately 3,000 from 100,000 entries. Many of them only stay in New Zealand for 7 days or

[16] Some people notify the authority earlier or later about the change of address, the actual move date can be different from the date of notification.

less, because they may have health reasons not suitable for the tasks in horticulture. These short-stay workers do not have a significant presence in the labor market. Indeed, Immigration New Zealand (INZ) requires the RSE workers to work at least 30 hours a week. Therefore, the short-stay individuals are not valid RSE workers under INZ's classification. This study focuses on the RSE workers entering New Zealand between 2009-09-01 and 2019-08-31. Some RSE workers work for different employers within one growing season, as the INZ refers to this policy as a "variation of conditions". In the Migration Spell, a worker with a variation of conditions has two or more entries. I combine these into one entry, making each only one record in one growing season. Although RSE workers come from twenty different countries, my analysis is restricted to eight policy-targeted Pacific Island Countries, Fiji, Kiribati, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu, and Vanuatu.

Fifth, the municipalities are the geographic units to approximate local labor markets. This study excludes four urban areas, Auckland, Wellington City, Christchurch City, and Dunedin City, because these have non-rural and/or non-agricultural populations and are not good comparisons to the less urbanized RSE-dependent municipalities. Further, Auckland aggregated all its local municipalities into the Greater Auckland in 2012, which causes inconsistency across samples. Each municipality has its closed labor market. This assumption is appropriate for New Zealand because according to Stats NZ, cross-city migration is only at a rate of 6 per 100 population per year. The migration rate is much smaller for cities in rural areas (Stats NZ, 2018a).

Last, some restrictions are added to the whole dataset to fit my analysis. (i) Keeping workers with age 15 or above and 65 or below, and separating age into five different groups: 15-25, 26-35, 36-45, 46-55, and 56 to 65; (ii) Dropping observations that declared they have five and more jobs in a month. This is likely to be an error; (iii) Grouping ethnicity into three groups:

European, Māori-Pacific, and Other; (iv) Following Australian and New Zealand Standard Industrial Classification (ANZSIC), New Zealand firms belong to one of the nineteen industries (Australian Bureau of Statistics, 2022); (v) Using a random sample of 10% of the population in the empirical analysis, due to computational constraints. Summary statistics of the controls and the dependent variables used in the empirical analysis are provided in Table 3. The table shows summary statistics for the sample of domestic workers used in the regressions. About 8.6% of the observations over the period were related to jobs in agriculture, forestry, and fishery, which shows the relative importance of agriculture in New Zealand's municipalities. In addition to agriculture, forestry, and fishery, the empirical analysis also focuses on four other industries (in bold and italic) closely related to the demand for RSE workers or horticulture and viticulture, such as hospitality, warehousing, and transportation.

Further, the share of RSE Workers as employment is relatively low if calculated as a whole country. However, the share of RSE workers as employment is not tiny for these horticulture and viticulture-dependent municipalities. Table 4 shows the top seven municipalities that received the most RSE workers. On average, the RSE workers represent 1.7 to 4.1% of the workforce. However, these numbers are not static throughout the months. During the harvest season, typically from December to May, municipalities get the greatest number of RSE workers, ranging from 4% to 7.7%. During the winter, by contrast, these numbers drop dramatically from 0% to 0.3%.

Table 3: Summary Statistics for Domestic Workers

A. Variables	Observation	Mean	Standard Deviation
Age	8,401,395	40.098	13.931
Number of Jobs	8,401,395	1.060	0.261
Number of Children	4,169,100	1.331	1.418
Male	8,401,395	0.504	0.500
Share RSE Workers as Employment	8,401,395	0.004	0.011
Wage (NZD$ per Hour)	8,401,395	27.019	55.606
Employment (Hours of Work Per Month)	8,401,395	141.979	53.864

B. Share of Observations in Different Industries	Observation	Shares of Total Employment
Agriculture, Forestry and Fishery	***719,460***	***0.086***
Mining	44,283	0.005
Manufacturing	1,083,723	0.129
Utility	77,712	0.009
Construction	670,419	0.080
Wholesale Trade	347,856	0.042
Retail Trade	***884,772***	***0.106***
Accommodation and Food Service	***489,744***	***0.058***
Transport, Postal and Warehousing	***359,130***	***0.043***
Information Media and Telecommunications	71,742	0.009
Financial and Insurance	177,504	0.021
Rental Hiring and Real Estate Service	103,800	0.012
Professional, Scientific and Technical	410,001	0.049
Administrative and Support	***276,690***	***0.033***
Public Administration and Safety	564,561	0.067
Education and Training	774,897	0.093
Health Care and Social Assistance	888,657	0.106
Arts and Recreation	139,206	0.017
Other	290,994	0.035

Note: The empirical analysis and descriptive statistics are based on a 10% random sample of domestic workers due to facility limitations at the data lab. Panel A in Table 3 shows the descriptive statistics for 10% random samples. Shares of total employment are calculated on the full sample to avoid measurement error.

Table 4: Statistics for Municipalities that Received the Most RSE Workers

Municipalities	Observation	Mean	Min	Max
Hasting	286,869	0.037	0.001	0.077
Central Otago	77,685	0.041	0.000	0.074
Western Bay of Plenty	147,576	0.024	0.002	0.063
Opotiki	29,595	0.019	0.000	0.055
Marlborough	173,091	0.029	0.003	0.054
Tasman	181,422	0.016	0.001	0.044
Central Hawke's Bay	51,852	0.017	0.000	0.040

Note: Mean, min, and max represent the share of RSE workers in total employment in each municipality. These statistics are calculated on the full sample to avoid measurement error.

3. Empirical Strategy

In this section, I introduce the empirical strategy used to estimate the impact of the influx of RSE workers on the contemporaneous labor market outcome of the domestic and foreign workers. The outcome variable is $Y_{i,c,y,m}$, for individual i, in municipality c, in year y, and month t in equation (5). Defining $S_{c,y,m}$ as the share of all RSE workers of the total employment in municipality c, in year y, and month m, the impact of the RSE program on workers can be estimated with an OLS panel specification in equation (5). The municipality-fixed effect is represented by ϕ_c, the individual fixed effect by $\gamma_{i,}$ the year-fixed effect by η_y, the month-fixed effect by δ_m, and the sets of time-varying control variables for individuals are $X_{i,y,m}$.

$$Y_{i,c,y,m} = \gamma_i + \phi_c + \eta_y + \delta_m + \beta * S_{c,y,m} + \theta X_{i,y,m} + \varepsilon_{i,c,y,m} \quad (5)$$

The municipality-fixed effects control for time-invariant and potentially unobserved differences between municipalities. The year-fixed effects capture temporal changes in the outcome variable that are common to all municipalities, such as national economic conditions, inflation, and minimum wage change. The month-fixed effects capture the seasonality of the labor market cycle, which is important to agriculture production. The individual sets of time-varying control variables include age, age squared, number of employees in the firm to capture the size of

the firm, number of jobs, and number of children for female employees. The analysis focuses on the number of children for female employees, as it is one of the most critical determinants of their wages. In contrast, the number of children in the family has minimal impact on the salaries and wages of male workers (Statistics NZ and Ministry for Women, 2017). The dependent variables are log hourly wage and log hours of work per month, for individual i, in municipality c, in year y, and month m. To account for the correlation of errors across individuals and time within the municipality, the standard errors are clustered at the municipality level. Although this happens less frequently, for individuals who move across different municipalities, the level of the cluster is the municipality where they most spent time from 09/2009 to 08/2019.

For equation (5) to identify a causal effect, I must assume that, in the absence of influxes of seasonal workers, the trends of the wages and hours of work would have been similar in municipalities with different levels of seasonal workers, i.e., the distribution of the RSE workers across municipalities and over time is uncorrelated with the error term.

Despite including rich sets of fixed effects and control variables, this assumption might not hold in practice. The coefficients in equation (5) still risk producing biased estimates, and the direction of the bias is unclear. For example, an increase in world demand for a particular horticulture and viticulture product, e.g., wine or kiwifruit of New Zealand would increase the labor demand for both seasonal foreign workers and domestic workers in certain municipalities. Thus, the estimates produced by equation (5) are upward biased. On the other hand, a downward bias may result from situations where firms employ seasonal workers to overcome a declining ability to attract domestic workers to the specific aspects of the municipalities, e.g., due to a lack of amenities.

In light of the allocation of the RSE policy and the continuous inflows of the seasonal laborers, I construct an instrument based on the initial distribution of the RSE workers during the trial period, i.e., the 2008/09 growing season, but also leveraging the large and varying seasonal workers inflows from 2009 to 2019, where an increasing number of RSE workers arrive to New Zealand each growing season due the prior success of the RSE program. Based on the construction of the policy described in Chapter 2, I view the initial distribution, i.e., the "share" as exogenous (Goldsmith-Pinkham, Sorkin, and Swift, 2020). This method is widely used in the migration literature (e.g., Card, 2001; Peri, Shih, and Sparber, 2015; Foged and Peri, 2016).

I choose the 2008/09 growing season instead of the 2007/08 growing seasons as the determinant of the initial distribution, i.e., the "share" for two reasons. First, substantial numbers of growers were not RSE accredited by the government in 2007/08. Using this does not represent the subsequent RSE distribution for the program. Second, at the outset, PICs were not aware of the RSE program, and the RSE workers from some countries arrived much later during 2007/08 compared to the following seasons.

Let $F_{j,y,m}$ denote the total RSE workers who enter and stay in New Zealand from one of the eight countries j (Kiribati, Samoa, Tonga, Tuvalu, Vanuatu, Solomon Islands, Papua New Guinea, and Fiji) working in New Zealand in year y, and month m. For each country j, based on the allocation, let $s_{j,e,m}$ indicate the share of RSE workers from country j that worked in firm e and month m during the 2008/09 growing season. Mathematically, this is equation (6).[17]

$$s_{j,e,m} = \frac{\text{RSE workers from country j,worked in firm e,during month m in 2008/09}}{\text{RSE workers from country j,worked in New Zealand,during month m in 2008/09}} \quad (6)$$

[17] For Papua New Guinea and Fiji, I use 2013/14 and 2014/15 respectively due to these two countries joining the program later than the others. This implies $\sum_e s_{j,e,m} = 1$.

Then, $s_{j,e,m}$ can further be decomposed into $s_{j,e,c,m}$ such that $s_{j,e,m} = \sum_c s_{j,e,c,m}$ and c represents municipality. This represents the share of RSE workers from country j that worked in firm e, municipality c, and month m during the 2008/09 growing season. Mathematically, this is equation (7).

$$s_{j,e,c,m} = \frac{\text{RSE workers from country j,worked in firm e,municipality c,during month m in 2008/09}}{\text{RSE workers from country j,worked in New Zealand,during month m in 2008/09}} \quad (7)$$

To get the share of RSE workers from country j that worked, in municipality c, month m during 2008/09, I sum up to the municipality level, i.e., $s_{j,c,m} = \sum_e s_{j,e,c,m}$ for each PIC j. This is equation (8).[18]

$$s_{j,c,m} = \frac{\text{RSE workers from country j,worked in municipality c,during month m in 2008/09}}{\text{RSE workers from country j,worked in New Zealand,during month m in 2008/09}} \quad (8)$$

As mentioned in Chapter 2, after the 2008/09 growing season, the firms tended to recruit directly from the workers that they were familiar with, and the work-ready pools were no longer in use for most of the PICs. Therefore, from September 2009, the imputed RSE workers from PIC-sending country j, in municipality c in year y, and month m is as follows: $\hat{F}_{j,c,y,m} = s_{j,c,m} \times F_{j,y,m}$. This imputed RSE population is constructed as a function of the shares $s_{j,c,m}$, which were completely determined by the initial distribution of the RSE policy, and the total seasonal population from each country j from 09/2009 to 08/2019, which was in large part driven by variation of the RSE workers inflow in the following years.

Then, I aggregate across these PICs to get the total RSE population from these PICs. I standardize it by the total domestic worker employment, by distinct headcount of employees in municipality c in 2008/09, month m, i.e., $P_{c,2008/09,m}$. Therefore, the imputed RSE share is

$$\hat{S}_{c,y,m} = (\sum_j \hat{F}_{j,c,y,m}) / P_{c,2008/09,m} \quad (9)$$

[18] This implies $\sum_c s_{j,c,m} = 1$.

This variable is used as the instrument for the share of all RSE workers of the total employment in municipality c, in year y, and month m in equation (5).

Two characteristics of this instrument need to be specified. First, while $S_{c,y,m}$ is the share of all RSE workers of the total employment, the instrument is based on eight PICs that are the main source of the RSE workers, e.g., over 85% in recent years. Second, the denominator of the instrument is based on the number of domestic workers' employment rather than the total employment, which gives another degree of exogeneity.

For this instrument to be valid, it needs to pass the power and validity tests, i.e., relevance and exclusion restrictions. I first test the correlation between the SSIV and the share of all RSE workers in total employment. The correlation is 0.6284, indicating a strong positive relationship between the IV and the variables of interest. Next, in Table 5, for each set of IV regressions, I report the first-stage coefficients, the first-stage F statistics, and the Kleibergen-Paap statistic. Kleibergen-Paap statistic is a robust version of the Cragg–Donald minimum eigenvalue statistic, which provides an overall test of weak instruments and is used often when the study has heteroskedasticity and clustered standard errors. There is no specific cutoff for rejection, but the general rule of thumb is 10. These results show that the SSIV has reasonable powers.

Second, it is important to test that the share of the SSIV is not driven by a correlation with domestic workers labor market outcomes during pre-2009/10, which may persist and affect wages and employment after 2009/10. In other words, the initial distribution of the RSE workers does not correlate with the domestic workers' wage and employment outcomes before 2009/10.

Table 5: First-Stage statistics

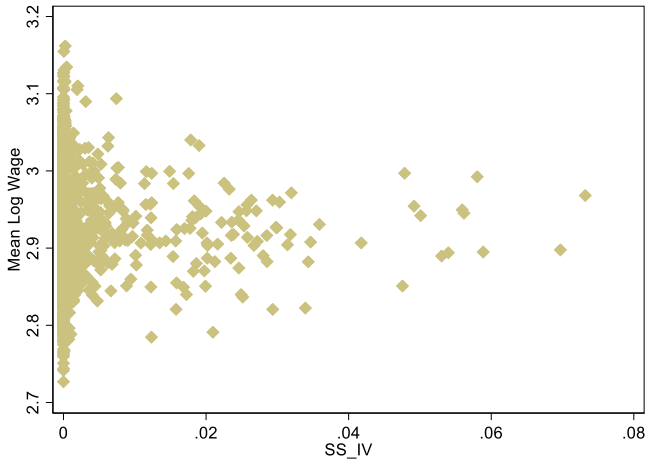
	First Stage Coef.	First-Stage S.E.	F-Stats	Kleibergen-Paap Statistic
Panel A: DOMESTIC WORKERS				
All Workers	0.133***	(0.000)	19388.072	12.58086
Male Workers	0.131***	(0.000)	10287.359	12.62958
Female Workers	0.136***	(0.000)	9038.044	12.50383
15-25	0.134***	(0.001)	4064.974	12.61658
26-35	0.134***	(0.001)	3515.346	13.50516
36-45	0.138***	(0.001)	3399.544	11.48316
46-55	0.136***	(0.000)	3665.214	11.86565
56-65	0.140***	(0.001)	2550.774	13.09293
Other Ethnicity	0.131***	(0.001)	984.458	10.3235
Māori & Pacific	0.137***	(0.000)	4533.213	11.01323
European	0.133***	(0.000)	13971.411	12.7397
Low Skilled	0.135***	(0.000)	3958.970	11.61119
High Skilled	0.134***	(0.000)	4738.080	12.46656
Agriculture, Forestry and Fishery	0.119***	(0.001)	2509.366	16.92068
Retail Trade	0.139***	(0.001)	1621.584	13.00529
Accommodation and Food Service	0.131***	(0.001)	926.627	12.60309
Transport, Postal and Warehousing	0.123***	(0.001)	755.990	12.2107
Administrative and Support	0.142***	(0.002)	432.525	8.247971
Panel B: FOREIGN WORKERS				
All Workers	0.136***	(0.000)	4923.612	11.20733
Male Workers	0.141***	(0.001)	2764.994	11.13174
Female Workers	0.129***	(0.001)	2185.742	11.34178
15-25	0.145***	(0.001)	1012.301	12.09114
26-35	0.135***	(0.001)	1308.886	11.44806
36-45	0.140***	(0.001)	870.826	10.75869
46-55	0.134***	(0.001)	847.638	8.85307
56-65	0.132***	(0.001)	491.418	11.29081
Low Skilled	0.135***	(0.001)	1125.698	10.5802
High Skilled	0.135***	(0.001)	1211.137	11.67749

Note: Robust standard errors are reported in parentheses. * p<0.10, ** p<0.05, *** p<0.01

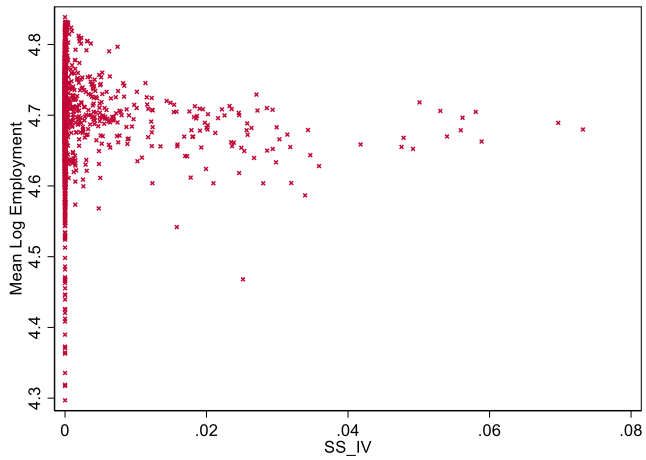
To check these correlations, using month-municipal level data from September 2007 to August 2009, I conduct two sets of tests. First, I plot these values in two panels of Figure 4. In panel (a), I show the correlation of the SSIV by using the pre-September 2009 national RSE workers inflow (horizontal axis) with the (log of) hourly wage (vertical axis). The wage is the mean wage of domestic employees at the municipal level, every month from the period I mentioned above. Similarly, in panel (b), I show the correlation of the constructed Share (horizontal axis) with the (log of) monthly employment (vertical axis).

Figure 4: Plot of Pre-trend Outcomes vs Shift-Share IV

(a)



(b)



Both panels of Figure 4 show visually, the absence of significant relationships, suggesting that the constructed "shares" are not correlated with wages and employment of domestic workers before the full establishment of the RSE policy. Indeed, these correlations are -0.0227 and -0.0643 respectively. This evidence is shown more analytically in Table 6, where I report the OLS estimates of regressions of the outcomes on the share. The outcomes for columns (1) to (3) are log of mean wage of domestic employees at the municipal level for every month, while for columns (4) to (6) they are log of mean monthly hours of employment of domestic employees at the municipal level. Columns (1) and (4) are the naïve basic regressions as comparisons to the other

columns, whereas Columns (2), (3), (5), and (6) add more controls. The overall results show insignificant relationships between the Share and outcomes before 2009/10. In conclusion, the constructed SSIV exhibits reasonable power and passes validity tests as it is uncorrelated with pre-intervention trends.

Table 6: OLS Estimates of the Effect of Share on Pre-trends Outcomes

	Wage	Wage	Wage	Employment	Employment	Employment
Share	-0.220	0.093	-0.175	-0.632**	0.194	0.110
	(0.249)	(0.230)	(0.188)	(0.252)	(0.185)	(0.182)
Constant	2.929***	3.613***	2.905***	4.697***	-4.947***	-5.228***
	(0.002)	(0.909)	(0.738)	(0.002)	(0.733)	(0.713)
R-squared	0.000	0.192	0.470	0.003	0.490	0.520
N	1,512	1,512	1,512	1,512	1,512	1,512
Demographics Control	No	Yes	Yes	No	Yes	Yes
Month FE	No	No	Yes	No	No	Yes

Note: The demographic controls include age and ethnic-group variables. Robust standard errors are reported in parentheses. * p<0.10, ** p<0.05, *** p<0.01

4. Results

A. Domestic Workers

I now turn to the main results. Table 7 shows the estimates of the contemporaneous effect on wages for domestic workers. Column (2) shows the IV estimates of the coefficient β in equation (5) using the instrument constructed in equation (9) by different demographics and industries. Column (1) shows the OLS estimates for comparison. The dependent variables in Table 7 are the (log) hourly wage. Panels A to E show the results for pooled estimates, different age groups, different ethnicities, skill groups, and different industries respectively. For panel E, although New Zealand has more industries than shown in the tables, these five industries are either directly or indirectly affected by the policy: agriculture, forestry, and fishery is directly affected by the policy. The other four are affected by the demand for goods and services from the RSE workers, such as transport and hospitality.

Table 7: Contemporaneous Effect on Wage for Domestic Workers

	(1)	(2)	(3)
Panel A: Pooled	OLS	SSIV	Observations
All Workers	0.130***	-0.059	8,401,395
	(0.046)	(0.123)	
Male Workers	0.218***	0.126	4,232,295
	(0.056)	(0.171)	
Female Workers	0.035	-0.276**	4,169,100
	(0.051)	(0.120)	
Panel B: Age			
15-25	0.191**	-0.146	1,736,346
	(0.083)	(0.222)	
25-35	0.098	-0.186	1,539,606
	(0.087)	(0.216)	
35-45	0.127**	-0.281	1,792,566
	(0.062)	(0.220)	
45-55	0.147***	-0.045	1,932,687
	(0.049)	(0.170)	
55-65	0.194**	0.235	1,396,989
	(0.075)	(0.169)	
Panel C: Ethnicity			
Other Ethnicity	0.041	-0.047	464,178
	(0.069)	(0.477)	
Māori and Pacific	0.175**	-0.087	2,055,321
	(0.075)	(0.202)	
European	0.118***	-0.057	5,881,893
	(0.044)	(0.142)	
Panel D: Skill-Level			
Low Skilled	0.096**	-0.268*	2,056,824
	(0.045)	(0.150)	
High Skilled	0.015	-0.086	2,137,980
	(0.074)	(0.207)	
Panel E: Industries			
Agriculture, Forestry and Fishery	0.408**	0.411*	719,460
	(0.161)	(0.212)	
Retail Trade	0.049	0.033	884,772
	(0.060)	(0.175)	
Accommodation and Food Service	0.096	-0.428	489,744
	(0.060)	(0.277)	
Transport, Postal and Warehousing	0.097	0.347	359,130
	(0.145)	(0.339)	
Administrative and Support	0.250***	-0.038	276,690
	(0.074)	(0.299)	

Note: Each entry of the table is the coefficient on the explanatory variable of interest in equation (5). Column (1) uses OLS, and column (2) uses the instrument constructed in equation (9) with samples of employed domestic workers between 2009 and 2019. Observation counts are rounded to the nearest multiple of three in accordance with Statistics New Zealand's confidentiality requirements. Standard errors in parentheses are clustered by municipality. * $p<0.10$, ** $p<0.05$, *** $p<0.01$

Table 8: Contemporaneous Effect on Employment for Domestic Workers

	（1）	（2）	（3）
Panel A: Pooled	OLS	SSIV	Observations
All Workers	0.274***	0.477***	8,401,395
	(0.062)	(0.144)	
Male Workers	0.172*	0.194	4,232,295
	(0.091)	(0.155)	
Female Workers	0.383***	0.777***	4,169,100
	(0.125)	(0.284)	
Panel B: Age			
15-25	0.528***	0.825*	1,736,346
	(0.140)	(0.469)	
25-35	0.174	0.280	1,539,606
	(0.113)	(0.289)	
35-45	0.324***	0.408**	1,792,566
	(0.089)	(0.202)	
45-55	0.154	-0.201	1,932,687
	(0.106)	(0.284)	
55-65	0.125	0.111	1,396,989
	(0.139)	(0.224)	
Panel C: Ethnicity			
Other Ethnicity	0.393**	0.832	464,178
	(0.172)	(0.694)	
Māori and Pacific	0.605***	0.675***	2,055,321
	(0.089)	(0.237)	
European	0.143**	0.385**	5,881,893
	(0.071)	(0.164)	
Panel D: Skill-Level			
Low Skilled	0.760***	1.616***	2,056,824
	(0.188)	(0.514)	
High Skilled	0.004	-0.137	2,137,980
	(0.032)	(0.114)	
Panel E: Industries			
Agriculture, Forestry and Fishery	1.341***	1.006**	719,460
	(0.240)	(0.488)	
Retail Trade	0.311*	0.396	884,772
	(0.170)	(0.471)	
Accommodation and Food Service	0.376	2.017**	489,744
	(0.396)	(0.912)	
Transport, Postal and Warehousing	0.267*	0.900**	359,130
	(0.147)	(0.421)	
Administrative and Support	1.506***	1.646***	276,690
	(0.343)	(0.557)	

Note: Each entry of the table is the coefficient on the explanatory variable of interest in equation (5). Column (1) uses OLS, and column (2) uses the instrument constructed in equation (9) with samples of employed domestic workers between 2009 and 2019. Observation counts are rounded to the nearest multiple of three in accordance with Statistics New Zealand's confidentiality requirements. Standard errors in parentheses are clustered by municipality. * p<0.10, ** p<0.05, *** p<0.01

I now turn to the main results. Table 7 shows the estimates of the contemporaneous effect on wages for domestic workers. Column (2) shows the IV estimates of the coefficient β in equation (5) using the instrument constructed in equation (9) by different demographics and industries. Column (1) shows the OLS estimates for comparison. The dependent variables in Table 7 are the (log) hourly wage. Panels A to E show the results for pooled estimates, different age groups, different ethnicities, skill groups, and different industries respectively. For panel E, although New Zealand has more industries than shown in the tables, these five industries are either directly or indirectly affected by the policy: agriculture, forestry, and fishery is directly affected by the policy. The other four are affected by the demand for goods and services from the RSE workers, such as transport and hospitality. The results in Table 7 show that OLS estimates for wage effect have upward biases. For the wage effects, the influx of RSE workers only has slightly negative and significant impacts on female workers and low-skilled employees as well as a positive and significant impact on workers in agriculture, forestry, and fishery.

The dependent variables in Table 8 are employment, i.e., (log) work hours per month. The results show that the OLS estimates for employment effect have downward biases. Further, in Table 8, the influx of RSE workers has much more widespread effects on the employment of domestic workers. Panel A shows the influx of RSE workers has positive and significant employment effects on all workers (pooled) and female workers. Female workers have the larger effect. In panel B, the estimates show positive and significant effects for the youngest and the middle age group, while the youngest has greater effects. In panel C, both Māori & Pacific and European workers have positive and significant employment effects. Despite census statistics showing that the Māori & Pacific group works more as laborers than the other groups, I find no evidence that RSE workers displace Māori & Pacific workers (Stats NZ, 2018b). In panel D, the

estimates show a positive and significant employment effect on low-skilled domestic workers. Last, in panel E, the results show that the influx of RSE workers have positive and significant impacts on all but retail trade.

The regressions are log-level forms, so the estimates need to be exponentially transformed before interpretation. To interpret, for instance, a 1% increase in the share of RSE workers to total employment would lead to a 0.51% increase in wage and a 1.73% increase in employment for workers in agriculture, forestry and fishery. To make the example more concrete, Hasting, Hawke's Bay is one of the municipalities that receives a large inflow of RSE workers. The main crops are apples and wine grapes. During the harvest months, RSE workers account for about 7.7% of the municipality's total employment. By contrast, during the winter months, RSE workers account for less than 0.1% of their total employment. Then, a 7.6% increase in the share of RSE workers to the total employment would lead to a 3.88% increase in wages and an 13.15% increase in employment for workers in agriculture, forestry and fishery. If a worker in agriculture, forestry and fishery works 30 hours a week and earns an hourly wage of NZD 20, a 7.6% influx of the RSE workers corresponds to a wage increase of NZD 0.776 and an increase of 3.95 hours of employment comparing months with and without the RSE influx.

Finally, Appendices 7 and 8 provide estimation results for the control variables in these estimations. They show that in addition to the share of RSE workers, age and number of jobs an employee has are also important determinants of the wage and employment of domestic workers. However, the size of the firm does not have a significant influence on either wage or employment.

Overall, contemporaneously, the labor market experiences insignificant wage impacts and positive and significant employment impacts for most groups, while there are considerable heterogeneity across groups. More specifically, I observe positive and significant effects for both

wage and employment on domestic workers employed in agriculture, forestry, and fishery. One possible explanation is that domestic and RSE workers perform different and complementary tasks, which has been documented in the previous literature (e.g., Peri and Sparber, 2009; Foged and Peri, 2016). Another explanation is that an influx of seasonal foreign workers may make the marginal productivity of domestic workers greater in agriculture (Gibson and McKenzie, 2014b). The marginal productivity increases of domestic workers may result from either an increase in the number of seasonal workers (RSE workers) or higher productivity among RSE workers than the other alternatives.

Second, as the previous study shows, seasonal foreign workers spend 40% or more of their earnings in the municipalities, and the influx of seasonal migrants increases the demand for goods & services (Gibson and McKenzie, 2014b). Therefore, among other industries, accommodation & food service and administrative & support have the highest responsiveness in employment to the influx of RSE workers. This may be because RSE workers demand more service from these industries while they are at present.

Further, the influx of RSE workers decreases wages slightly for female and low-skilled domestic workers, while their monthly employment increases dramatically. Similarly, accommodation and food services industry exhibits a weakly significant negative effect on wages at the 15% significance level, while the estimated effect on employment is positive and statistically significant. As noted above, the influx of RSE workers shifts the domestic labor demand curve to the right by increasing labor productivity and stimulating demand for goods and services. Simultaneously, the domestic labor supply curve for some domestic workers may also shift to the right as higher labor force participation expands the supply of domestic workers, especially young female workers.

Indeed, at the national level, the labor force participation for females increased 4.8% from 2008 to 2019, while males increased only 1.9%. The majority of these increases for females came from two young age groups who mostly have lower skills than the older age groups, increasing 8.5% for age 20-24 and 6.8% for 25-34, while males from the same age groups only increased 4.3% and 2.1%, respectively (OECD, 2019).

Table 9: Average Quarter Labor Force Participation Rate (LFPR) for Female

Quarter	BP-Female	GH-Female	TNMW-Female	NZ-Female
Q1	61.70%	62.49%	63.16%	63.91%
Q2	61.41%	61.48%	62.91%	63.30%
Q3	60.77%	61.52%	62.70%	63.04%
Q4	60.91%	61.85%	62.94%	63.66%

Note: The labor force participation rate (%) is from the quarterly household labour force survey administered by Statistics New Zealand. Each survey has around 15,000 respondents. The abirritations are stand for BP-Bay of Plenty, GH-Gisborne/Hawke's Bay, Tasman/Nelson/Marlborough/West Coast (TNMW) are the top regions for horticulture production in New Zealand.

At the regional level, as shown in Appendix 9, the general trends from 2008 to 2019 show that the horticulture production regions have slightly higher increases in female labor participation than the national average. Table 9 shows the average female's quarterly labor force participation rate (LFPR) for several horticultural regions and the national average. Unfortunately, the LFPR is calculated at more aggregate levels, e.g., regional and quarterly, rather than at the municipality and monthly levels, which are the levels of analysis in this chapter. Bay of Plenty, Hawke's Bay, Tasman and Marlborough are the top regions for horticulture production in New Zealand. Nevertheless, a general pattern is observed from the LFPR. Q1, when the RSE workers are abundant, the LFPR is the highest, whereas when the RSE workers are the lowest, i.e., in Q3, the LFPR is the lowest. The difference in LFPR between Q1 and Q3 in horticulture production regions is slightly higher than that of the national average, especially for Bay of Plenty and Hawke's Bay. However, the difference between Tasman and Marlborough is not as large as the national average.

One reason for this is that the LFPRs for these two municipalities are included within all regions on the north and west of the South Island. West Coast and Nelson are non-horticultural regions.

As the specification controls for city, annual and monthly effects, one explanation is that the influx of RSE workers increases the labor force participation of domestic female workers, by creating additional complementary or less physically demanding employment opportunities. More females enter the labor market or become willing to work at prevailing wages. Then, the labor supply curve for domestic women shifts outward.

Fourth, the wage and employment effects do not equalize, which may be explained by the fact that domestic workers within a municipality are not perfect substitutes across some industries and demographic groups. There are barriers preventing labor from moving freely because jobs require unique skills specific to their industries and occupations. Last, the high-skilled group does not have significant wage or employment impact, implying that the influx of the RSE workers does not affect the high-skilled labor market.

B. Foreign Workers

Part A discusses the contemporaneous impacts of the RSE workers on the wage and employment of the domestic workers. Part B extends the analysis to investigate the impact of the RSE workers on the non-RSE foreign workers. Some studies have found that immigrants have more entrepreneurship than domestics (e.g., Anelli et al., 2023). By contrast, immigrants experience significant immigrant-domestic earning gaps and that jeopardizes their labor market outcomes (Ingwersen and Thomsen, 2021; Dostie et al., 2023;). However, few studies have discussed the impact of immigrants on other immigrant groups, especially since the skills and tasks they perform are substitutable.

Three points need to be clarified for the analysis of foreign workers. First, foreign workers are defined as individuals who are born abroad, which includes those who later obtained New Zealand citizenship. Second, I exclude industry-level analysis because the sample size is small at the municipal-industry level for foreign-born workers. Last, I follow the same empirical specification as the equations (5) and (9).

Table 10: Contemporaneous Effect on Wage for Foreign Workers

	（1）	（2）	（3）
Panel A: Pooled	OLS	SSIV	Observations
All Workers	-0.231***	-0.912***	2,272,623
	(0.076)	(0.259)	
Male Workers	-0.316**	-0.982***	1,185,627
	(0.121)	(0.343)	
Female Workers	-0.148***	-0.904***	1,086,996
	(0.037)	(0.338)	
Panel B: Age			
15-25	-0.152	-0.846***	372,246
	(0.105)	(0.293)	
25-35	-0.364*	-0.913***	579,696
	(0.190)	(0.291)	
35-45	-0.370***	-1.160***	511,023
	(0.136)	(0.356)	
45-55	-0.242***	-1.039***	497,280
	(0.070)	(0.383)	
55-65	0.132	-0.240	310,989
	(0.093)	(0.321)	
Panel C: Skill-Level			
Low Skilled	-0.099	-0.495*	551,508
	(0.075)	(0.282)	
High Skilled	-0.079	-0.272	576,000
	(0.138)	(0.307)	

Note: Each entry of the table is the coefficient on the explanatory variable of interest in equation (5). Column (1) uses OLS, and column (2) uses the instrument constructed in equation (9) with samples of employed domestic workers between 2009 and 2019. Observation counts are rounded to the nearest multiple of three in accordance with Statistics New Zealand's confidentiality requirements. Standard errors in parentheses are clustered by municipality. * p<0.10, ** p<0.05, *** p<0.01

Table 10 shows the estimates of the contemporaneous effect on wages for foreign workers. Column (2) shows the IV estimates of the coefficient β in equation (5) using the instrument

constructed in equation (9) by different demographics. Column (1) shows the OLS estimates for comparison. Most foreign workers experience negative and significant wage effects except the oldest and high-skilled groups. By contrast, in Table 7, the wage effects for domestic workers are mostly insignificant. Even when the wage effect is negative and significant, the magnitude is much smaller for the domestics. These results in Tables 7 and 10 indicate the domestic and foreign workers are not perfect substitutes.

Table 11: Contemporaneous Effect on Employment for Foreign Workers

	（1）	（2）	（3）
Panel A: Pooled	OLS	SSIV	Observations
All Workers	1.020***	0.312	2,272,623
	(0.141)	(0.453)	
Male Workers	1.013***	0.317	1,185,627
	(0.116)	(0.503)	
Female Workers	1.070***	0.401	1,086,996
	(0.239)	(0.575)	
Panel B: Age			
15-25	1.218***	-0.156	372,246
	(0.315)	(0.887)	
25-35	1.734***	0.590	579,696
	(0.195)	(0.602)	
35-45	1.330***	0.755	511,023
	(0.257)	(0.530)	
45-55	0.489***	0.731**	497,280
	(0.114)	(0.347)	
55-65	0.172	0.153	310,989
	(0.258)	(0.466)	
Panel C: Skill-Level			
Low Skilled	0.913***	0.568	551,508
	(0.277)	(0.630)	
High Skilled	0.412***	0.269	576,000
	(0.063)	(0.287)	

Note: Each entry of the table is the coefficient on the explanatory variable of interest in equation (5). Column (1) uses OLS, and column (2) uses the instrument constructed in equation (9) with samples of employed domestic workers between 2009 and 2019. Observation counts are rounded to the nearest multiple of three in accordance with Statistics New Zealand's confidentiality requirements. Standard errors in parentheses are clustered by municipality. * p<0.10, ** p<0.05, *** p<0.01

In Table 11, OLS estimates on employment mostly show upward biases except for some age groups. These results show that foreign workers have positive but insignificant employment effects, except in the second-oldest age group. These intriguing results suggest that non-RSE foreign-born workers are disproportionately worse off than domestic workers following an influx of RSE workers. There are two possible explanations.

The magnitude of the wage effects for males is slightly larger than the females. The coefficients do not equalize across the demographic groups, implying foreign workers within a municipality are not fungible. However, the differences in coefficients are less pronounced compared to those for domestic workers, indicating a higher substitutability among foreign workers. Further, it is easily understood that the youngest two groups get negative wage effects because most of them are WHV holders who face direct competition from the RSE workers. Yet, this does not explain why the older age groups get negative and significant wage effects because they are too old to obtain WHV. Indeed, the two middle age groups are affected the most.

One possible explanation is that restrictions on visa programs reduced other migrants' wages. One recent study using a wage-posting model and New Zealand's data from 2008 to 2022 finds that migrants, even without visa restrictions, who largely work with other migrants with visa restrictions, typically have their wages reduced by over 20% compared to other groups such as domestic workers. However, these migrants' employment is non-decreasing (Townsend and Allan, 2025). This is exactly the case for non-RSE foreign workers who work closely with RSE workers in the same municipality, as RSE workers are heavily regulated and have tight visa restrictions.

Further, suppose domestic and foreign workers belong to distinct labor groups and, from employers' perspective, these groups are more complementary in the skills and tasks they perform than workers within each group (e.g., Peri and Sparber 2009; Ottaviano and Peri 2012). An influx

of RSE workers increases the labor supply available to foreign workers, placing downward pressure on their wages. In contrast, because domestic and foreign workers are complements in production, the increased availability of foreign seasonal labor raises the demand for domestic workers, shifting the domestic labor demand curve outward.

5. Conclusion and Policy Implications

In Chapter 5, I use detailed longitudinal data and an exogenous increase in the supply of seasonal workers in horticulture and viticulture from PICs to identify the effect of these seasonal workers on the labor market outcomes of domestic and foreign workers in New Zealand. The exceptional quality of the monthly income data implies high reliability.

The SSIV approach exploits exogenous variation in the initial allocation of the RSE shares at the municipal level driven by the design of the RSE policy. I show that changes in the constructed instruments are uncorrelated with pre-intervention outcomes. This provides supporting evidence for the exclusion restriction of the instrument. Subsequent flows of seasonal laborers added significant variation to this exogenously determined policy, and I use it to estimate its effects on labor market outcomes.

The evidence from this study shows that the wage and employment effects of influx of the seasonal workers immigration are heterogeneous across demographics and industries. Contemporaneously, the influx of seasonal workers has no or minimal wage effects on domestic workers, but the influx has much more widespread significant effects on their employment. Last, results show that foreign workers are disproportionately worse off and experience significant displacement when faced with an influx of foreign seasonal workers.

These results provide some insights for policymakers. First, well-established skilled-based immigration programs, even the low-skilled ones, are beneficial to domestic workers in related

industries. Policymakers may consider amending the current immigration policy to encourage skills- and industry-based migration. Similarly, a skills-based training program for migrants may also benefit the local labor market and domestic workers. Second, in the 2024 presidential election in the US, polls show some Hispanic voters are shifting toward Republican candidates. Apart from other determinants, one possible explanation from this study is that the recent flow of unauthorized migrants primarily jeopardizes the job prospects of Hispanic voters, which causes them to favor a more stringent immigration policy.

Chapter 6: Impact of the RSE Workers on Growers' Revenue

1. Introduction

Using grower-level data from Statistics New Zealand, this chapter of the dissertation contributes to the literature on the impact of foreign agricultural workers on the farms' revenue. Analyzing the impact of foreign seasonal workers on farms' revenue or other variables of interest faces one major obstacle in that the labor input on farms is usually unobserved in the data, and these seasonal workforces are mostly undocumented workers. Another challenge is that the farm-level data are not readily available.

Several studies have attempted to analyze the impact of changes in foreign labor supply on production, revenue, and/or profit for the farm. Implementing equilibrium displacement model and data from California, the top horticulture & viticulture producing state in the US, a study found that a 10% decrease in the farm labor supply causes at most a 4.2% reduction in production in the top 10 fruit and vegetable producing counties in California (Rutledge and Mérel, 2023). In California, a study estimates that one additional immigrant worker contributes to an increase of $23,457 in vegetable production (Devadoss and Luckstead, 2008). Using the Danish administrative data, a study found that an increase of 10% in immigrant workers in the farm leads to a 0.8% revenue increase (Malchow-Møller et al., 2013).

In the United States, stringent immigration policy also caused a reduction in the total number of farm workers and the total acres of farmland operated (Luo, Kostandini, and Jordan, 2022). American farms' crop choices and labor use also change due to the decrease in the availability of foreign labor (Kostandini, Mykerezi, and Escalante, 2014). In the US dairy industry,

implementing labor-saving technology was insufficient to offset the decrease in the supply of labor entirely due to the more stringent immigration policy (Charlton and Kostandini, 2021).

The results show that the RSE program benefits large growers by increasing revenue. However, small growers are not able to generate additional income when recruiting RSE workers. This chapter proceeds as follows. Section 2 provides industry background and data. Section 3 introduces the empirics and identification assumptions. Section 4 presents the results and discussions of the policy. Section 5 concludes the chapter.

2. Industry Background and Data

The analysis focuses on five sub-industries in the perennial fruit and tree nut growing industry that hire RSE workers: grape, kiwifruit, berry fruit, apple and pear, and stone fruit. The classification is under the Australian and New Zealand Standard Industrial Classification (ANZSIC) 2006. Under this classification, berry fruit includes boysenberries, raspberries, strawberries, blackberries, blueberries, and currants; stone fruit includes apricots, cherries, nectarines, peaches, and plums. Further, while RSE workers can participate in off-farm work, such as in packhouses, this chapter focuses solely on their impact on growers. Packhouses are less interesting to study than growers because they are dominated by a few large employers.

The data in this paper come from the administrative database managed by Statistics New Zealand. The main database used in this paper is New Zealand's Longitudinal Business Database (LBD). The LBD contains de-identified data about businesses, which comes from a range of government agencies and Stats NZ surveys. Each firm within the database is assigned a unique identifier, and it may only change when the firm exits, changes ownership, or sells to another firm. While the plant-level data is also available for some firms, most firms do not have their plant data in the LBD. To make it consistent, I use the firm, more specifically, the grower, as the level of

observation for this study. I use grower to specify these horticulture and viticulture firms for the rest of this chapter.

The main data source comes from the corporate tax return (IR 10), the financial statements summary required for most companies to file tax returns in New Zealand, i.e., growers in this case. It records the sales, purchases, number of employees, and gross salary paid to its employees. Sales, purchases and gross salary paid to its employees are proxies for revenues or income, capital costs, and labor costs. To make each growing season comparable, I calculated sales, purchases to the real term based on the New Zealand Dollar (NZD) in 2008 by using Reserve New Zealand's inflation calculator.

Growers can file a tax return monthly, bi-annually, and annually, so I aggregate them into annual format for consistency. In New Zealand, the fiscal year is either from July to June of next year or April to March of next year depending on the industry. However, this is not suitable for most horticulture and viticulture growers. Thus, I use the growing year, i.e., September to August of the next year, for this paper. Further, using annual data can alleviate the potential noise of using the monthly data, such as accounts receivable. Another benefit of aggregating into yearly income is that it removes the seasonal nature of the revenue received by viticulture and horticulture growers: growers usually received most of their revenue during the harvest period, but relatively little in other months.

Similar to the antecedent research, this analysis only uses the revenue rather than the profit of the grower, because of the data limitation (e.g., Devadoss and Luckstead, 2008; Malchow-Møller et al., 2013; Rutledge and Mérel, 2023). While the LBD contains the purchase or capital cost of each grower, the measurement of land or capital inputs is lacking in the system. Further, from the LBD alone, we cannot observe the accounting method to calculate the depreciation of

equipment. Different methods usually lead to drastically different expense figures, making expenses across growers incomparable.

Another source of data comes from the Migration Spell, which records the entry and exit information of RSE workers. To make the data suitable for the analysis, I removed all the records for workers who stayed in New Zealand for less than 14 days. However, unlike in Chapter 5, I include all RSE workers regardless of their nationalities. Thus, the RSE workers not only include workers from the PICs but also include workers from other countries, such as Vietnam and Indonesia.

Other crucial information included in the data is the full-time equivalent (FTE) employee count for each grower. By combining immigration and business output tables provided by Richard Fabiling, I calculate the FTE measure for both RSE workers and total workers for each grower in each growing year (Fabling and Maré, 2015). I estimate the RSE ratio as the proportion of RSE workers' FTE to total workers' FTE. FTE is a more accurate measure of labor input than headcount, because it accounts for hours worked.

The size of the grower is also a crucial deciding factor in agricultural production: One would expect small and large growers to operate differently. Thus, it is appropriate to analyze the outcome of the arrival of seasonal workers differently by the size of growers. However, the acreage for each grower is not directly observed from the data. Yet, I can use employee numbers at peak during the harvest season to estimate the size of the growers. Following the convention of Statistics NZ, growers with 50 or more employees are classified as large.

Table 12 reports the average, median, 75th, and 90th percentiles of the number of employees at peak for different sub-industries. Becoming an RSE-accredited employer or hiring RSE workers from a labor cooperative is an endogenous decision for a grower unobserved by an

outside party. This chapter only focuses on growers that hire RSE workers, i.e., the RSE ratio is positive. Thus, the analysis implies an intensive margin for hiring RSE workers rather than an extensive margin.

Table 12: Descriptive Statistics for Number of Employees at Peak

	Average	Median	75%	90%	Observations
Grape	23	15	31	50	102
Kiwifruit	45	23	44	94	216
Berry	242	126	222	736	66
Apple and Pear	100	65	114	160	480
Stone Fruit	104	77	152	242	81

Source: Statistics New Zealand's IDI and LBD. Observation counts are rounded to the nearest multiple of three in accordance with Statistics New Zealand's confidentiality requirements.

3. Empirical Strategy

I estimate the impact of employment share of RSE workers on grow's revenue using the following equation:

$$Y_i = \beta * \log(RSE_i) + \theta X_i + \phi_s + \varepsilon_i \quad (10)$$

The outcome variable is the (log) revenue for growers. RSE_i is the RSE ratio described in the data section. X_i are the control variables at the grower-level, including (log) expenses, (log) salary paid to the employees, FTE for non-RSE Pacific Islanders (FTE for Pasifika), and (log) number of employees at the peak. To make variables comparable across different observations, revenue, expenses, and salary paid to the employees are in real terms, deflating to NZD in 2008.

ϕ_s is the crop fixed effects, including grape, kiwifruit, berry fruit, apple and pear, and stone fruit, which controls for unobserved time-invariant variation for specific industries, such as outbreaks of disease that only harm one crop. However, including time fixed effects will absorb meaningful variations, i.e., an annual level supply side instrument. Similarly, while it is tempting

to include grower fixed effects for each grower using the firm identifier, it has one drawback. The identifier in Stats NZ's LBD does not consider merger & acquisition or change of ownership activities. For instance, if two growers decide to merge in year t, the identifiers of these two growers may be permanently deleted or only keep one of them in the LBD from t+1. In either case, the grower's identifier is inconsistent, providing inefficient estimates. Further, the specification does not include the regional fixed effects. As shown in Appendix 1, New Zealand only has half a dozen horticulture regions; the regional fixed effects are highly correlated with the crop fixed effects, and these are redundant and create multicollinearity in estimation.

ε_i is the error term. Robust standard errors account for heteroskedasticity but assume independent observations. This is problematic since growers may experience common shocks, such as economic or temperature shocks, which lead to either positive or negative correlations. To address this, I cluster the standard errors by year. There are 12 clusters, which is above the minimal threshold proposed by recent theory and simulation (Gafarov and Ura, 2026). Because clustering is by year, each cluster generally has a balanced sample, ranging from small to large growers. As a comparison, I report both the robust and cluster standard errors in the following analysis.

The major threat to the identification is the potential endogeneity concerns. While the LBD covers all growers that recruit the RSE workers, and implementing crop fixed effects limits the possibility of measurement errors or sample selection bias, the endogeneity comes from omitted variable bias and reverse causality, which both can cause the direction of the bias to be unclear. Omitted variable bias arises when factors that affect both revenue and the RSE ratio, such as managerial decisions or macroeconomic factors, are omitted. The reserve causality problem arises when the grower's revenue affects the RSE ratio. For example, more successful growers may want to hire more RSE workers, implying β in (10) overstates the causal effect of RSE workers and

creates an upward bias. By contrast, if growers hire RSE workers due to the difficulty in finding suitable seasonal workers, β will lead to a downward bias. To address the above identification challenges and draw causal inferences, I employ an instrumental variable approach.

Since the RSE ratio is a labor demand parameter, an ideal instrument variable needs to come from the labor supply side. The instrument I use in this chapter is the total damage due to South Pacific tropical cyclones in United States Dollars (USD). There are a couple of advantages of using total cyclone damage as an instrument variable, especially satisfying exclusion restrictions. First, it is a random shock that affects the labor supply decision of the RSE workers. If RSE workers' home country experienced a severe cyclone season, which caused their earnings to decrease back home, RSE workers would supply more labor input to compensate for losses that occurred in their home country. Indeed, the South Pacific tropical cyclone season is concurrent with the horticulture and viticulture harvest season in New Zealand. Second, the South Pacific tropical cyclone mostly impacted the PICs, and left New Zealand unaffected from 2007 to 2019. Third, the total cyclone damage differs from year to year, which creates enough variation for the instrument. Table 13 shows the total cyclone damage in USD (Billion) from 2007/08 to 2018/19.

Table 13: Total Cyclone Damage for Pacific Island Countries under the RSE program

Year	Total Loss (USD Billion)	Year	Total Loss (USD Billion)
2007-2008	0.046	2013-2014	0.048
2008-2009	0.065	2014-2015	0.692
2009-2010	0.163	2015-2016	1.410
2010-2011	0.025	2016-2017	0.0477
2011-2012	0.017	2017-2018	0.0377
2012-2013	0.313	2018-2019	0.05

Source: Fiji Meteorological Service and Wikipedia

The IV strategy identifies the causal effect of the RSE ratio on the grower's revenue under the following assumptions: (1) Relevance: the instrument is strongly correlated with the RSE ratio.

The first-stage regression and the weak instrument tests show it is a suitable instrument. (2) Exogeneity: the instrument affects the grower's revenue only through its impact on the RSE ratio and is uncorrelated with unobserved determinants of the grower's revenue. This assumption is valid because cyclone damages during the study period did not affect New Zealand's major horticulture and viticulture regions and only affected the RSE workers' inputs; (3) Monotonicity implies that the total cyclone damage either positively or negatively influences the RSE ratio for all growers, but not both; and (4) No productivity or other spillover effects across growers. This is a valid assumption because growers' productivity and decisions are generally independent.

4. Results and Discussions

Table 14: Summary Statistics for Growers

	Mean	SD	Median	10 %	90 %
Total Salary	1,157,243	2,342,558	572,425	54,081	2,351,130
Revenue	3,995,203	6,675,237	1,941,740	226,059	8,406,401
Non-Salary Expense	2,518,198	4,670,211	1,156,082	123,222	5,150,244
N of Employees	90.27	161.87	48.00	11.00	169.00
FTE for Pasifika	84.32	200.34	24.26	0.00	206.81
RSE Ratio	0.1707	0.1714	0.1123	0.0097	0.4169
Annual Inflation Rate	1.07%	0.06%	1.08%	1.00%	1.18%

Note: Data is from Statistics New Zealand's IDI and LBD, except the RSE ratio and annual inflation rate. The number of observations is 936 which is rounded based on the Statistics New Zealand's confidentiality policy. The total salary, revenue and expense are in nominal term New Zealand Dollars.

I now turn to the main results of the chapter. Table 16 shows the estimation result for the instrumental variables; as a comparison, the OLS estimates are shown in Table 15. The dependent variable, log revenue, along with two explanatory variables, log expense and log total salary paid, are in real terms (NZD 2008). The first stage coefficients show positive and significant

relationships between the instrument variable, which generally is considered that the instrument variable is trustworthy (Angrist and Kolesár 2024). In addition, the Cragg-Donald statistics are higher than the critical value of 16.38 for the pooled and large growers.

Table 15: OLS Estimates for the Impacts of the RSE Workers on Growers' Revenue

	(1)	(2)	(3)	(4)	(5)	(6)
	Pooled	Large	Small	Pooled	Large	Small
Log RSE Ratio	0.0009	0.0036	-0.0147	0.0009	0.0036	-0.0147
	(0.0083)	(0.0093)	(0.0178)	(0.0071)	(0.0093)	(0.0106)
Log N of Employees	-0.0974**	-0.1157*	-0.2117**	-0.0974***	-0.1157	-0.2117***
	(0.0449)	(0.0642)	(0.0891)	(0.0284)	(0.0667)	(0.0468)
Log Non-Salary Expense	0.5321***	0.5978***	0.4846***	0.5321***	0.5978***	0.4846***
	(0.0393)	(0.0450)	(0.0570)	(0.0486)	(0.0485)	(0.0621)
FTE for Pacifica	-0.001*	-0.001	0.009	-0.001***	-0.001	0.009
	(0.001)	(0.001)	(0.009)	(0.0002)	(0.001)	(0.007)
Log Total Salary	0.5016***	0.4289***	0.5487***	0.5016***	0.4289***	0.5487***
	(0.0618)	(0.0534)	(0.0972)	(0.0583)	(0.0434)	(0.0764)
Kiwifruit	0.2490***	0.2867***	0.2582**	0.2490**	0.2867***	0.2582*
	(0.0957)	(0.0908)	(0.1091)	(0.1028)	(0.0711)	(0.1178)
Berry	0.1443	0.1775*	-0.0415	0.1443	0.1775*	-0.0415
	(0.1089)	(0.1075)	(0.1679)	(0.1169)	(0.0939)	(0.1744)
Apple and Pear	0.1039	0.0949	0.1522	0.1039	0.0949	0.1522
	(0.0921)	(0.0828)	(0.1221)	(0.0942)	(0.0666)	(0.1170)
Stone Fruit	0.1285	0.1346	0.1568	0.1285	0.1346	0.1568
	(0.1188)	(0.1088)	(0.1652)	(0.0888)	(0.1137)	(0.1117)
Constant	0.7318**	0.9017**	1.0157**	0.7318***	0.9017**	1.0157***
	(0.3283)	(0.3809)	(0.4260)	(0.2216)	(0.3243)	(0.2262)
R-squared	0.9213	0.9171	0.8438	0.9213	0.9171	0.8438
N	936	456	480	936	456	480
Standard Errors	Robust	Robust	Robust	Clustered	Clustered	Clustered

Note: Each column of the table is the coefficient on the explanatory variable of interest in equation (10) using the OLS. Observation counts are rounded to the nearest multiple of three in accordance with Statistics New Zealand's confidentiality requirements. Standard errors are in parentheses. The revenue, expense, and total salary are measured in real term (2008 NZD). The FTE Pacifica is measured in 10s for calculation. * p<0.10, ** p<0.05, *** p<0.01

Table 16: IV Estimates for the Impacts of the RSE Workers on Growers' Revenue

	(1) Pooled	(2) Large	(3) Small	(4) Pooled	(5) Large	(6) Small
Log RSE Ratio	0.0642*	0.0967**	0.0454	0.0642**	0.0967***	0.0454
	(0.0364)	(0.0388)	(0.1231)	(0.0266)	(0.0292)	(0.0682)
Log N of Employees	-0.0800*	-0.0293	-0.2049**	-0.0800**	-0.0293	-0.2049***
	(0.0455)	(0.0648)	(0.0887)	(0.0352)	(0.0561)	(0.0528)
Log Non-Salay Expense	0.5444***	0.6092***	0.4921***	0.5444***	0.6092***	0.4921***
	(0.0396)	(0.0452)	(0.0579)	(0.0499)	(0.0442)	(0.0620)
FTE for Pacifica	-0.003***	-0.003**	-0.008	-0.003***	-0.003**	-0.008
	(0.001)	(0.001)	(0.034)	(0.001)	(0.001)	(0.023)
Log Total Salary	0.4988***	0.3741***	0.5738***	0.4988***	0.3741***	0.5738***
	(0.0615)	(0.0524)	(0.1085)	(0.0641)	(0.0430)	(0.0816)
Kiwifruit	0.2117**	0.0900	0.2390**	0.2117**	0.0900	0.2390**
	(0.0983)	(0.1264)	(0.1140)	(0.1069)	(0.0735)	(0.1159)
Berry	0.1253	-0.0433	0.0017	0.1253	-0.0433	0.0017
	(0.1096)	(0.1435)	(0.1876)	(0.1287)	(0.1313)	(0.1747)
Apple and Pear	0.0160	-0.1909	0.1234	0.0160	-0.1909	0.1234
	(0.1042)	(0.1532)	(0.1313)	(0.1152)	(0.1311)	(0.1240)
Stone Fruit	0.0868	-0.1254	0.1532	0.0868	-0.1254	0.1532
	(0.1206)	(0.1500)	(0.1642)	(0.0870)	(0.1152)	(0.1112)
Constant	0.7589**	1.6054***	0.7900	0.7589***	1.6054***	0.7900***
	(0.3271)	(0.4604)	(0.6047)	(0.2321)	(0.3507)	(0.3011)
R-squared	0.9181	0.8969	0.8414	0.9181	0.8969	0.8414
N	936	456	480	936	456	480
Standard Errors	Robust	Robust	Robust	Clustered	Clustered	Clustered
First-Stage	0.7467***	0.7207***	0.4956**	0.7467**	0.7207***	0.4956***
	0.1275	0.1564	0.2077	0.3229	0.2851	0.1872
Cragg-Donald Wald F statistic	32.292	18.52	6.69	32.29	18.52	6.69
Stock-Yogo weak F test critical values	16.38	16.38	16.38	16.38	16.38	16.38

Note: Each column of the table is the coefficient on the explanatory variable of interest in equation (10) using IV. Observation counts are rounded to the nearest multiple of three in accordance with Statistics New Zealand's confidentiality requirements. Standard errors are in parentheses. The revenue, expense, and total salary are measured in real term (2008 NZD). The FTE Pacifica is measured in 10s for calculation.* p<0.10, ** p<0.05, *** p<0.01

Comparing Tables 14 and 15, the results suggest that the OLS estimates are downward-biased. The columns (1) to (3) in the two tables report robust standard errors, and columns (4) to

(6) report clustered standard errors. Compare Table 16 column (1) to (3) and column (4) to (6); the cluster standard errors are smaller than the robust standard errors. With the model correctly identified, one explanation is that the samples within the same year are negatively correlated. While this may be counterintuitive, one potential reason is that the weather shock to different crops is not identical within the same growing season. This is mainly due to the ideal growing and harvest conditions are heterogenous across different crops, e.g., rainy weather in December and January is considered good for apples but negatively impacts yield on peaches.

The main variable of interest is the RSE Ratio. From Table 16, column (4), the coefficient of the pooled estimate is about 0.064, implying that hiring more RSE workers benefits the RSE employers overall. From columns (5) and (6), the estimates reveal that the large growers especially benefit from the program. Yet, for smaller growers, the estimate implies no significant relationship.

Since the regression is in the double-log form, for the pooled estimate, a 1% increase in the RSE worker ratio leads to a revenue increase of about 0.064%. The estimate in column (5) indicates that for large growers, a 1% increase in the RSE worker ratio would lead to a roughly 0.1% increase in large growers' revenue. For instance, if a hypothetical large grower's revenue is 10 million, an additional 1% increase in the RSE worker ratio would lead to a $10,000 increase in its revenue. Given that the price of apple and pear is around $1 to $2 per kilogram at the farm gate, $10,000 is equivalent to an additional 5,000 to 10,000 kilograms or 5 to 10 metric tons of fruit being harvested.

An increase in the RSE worker ratio may occur through two channels. First, growers may hire additional RSE workers. This is the more straightforward approach, but it can be costly. Moreover, hiring new RSE workers during the harvest season may be unrealistic, since labor contracts are typically arranged prior to the season, unless the growers can recruit the RSE workers from labor cooperatives. The second channel is through existing RSE workers supplying additional

hours of labor, such as staying longer in New Zealand, which effectively increases the RSE FTE employment and raises the RSE ratio. Further, RSE workers tend to increase their working hours following a cyclone to compensate for the economic losses in their home countries: a behavior that underpins the logic of using cyclone exposure as an instrumental variable.

This program disproportionately benefits large growers, not the smaller ones. One possible explanation is that larger growers can manage their workers more efficiently. This interpretation is consistent with the estimates in this study, which show that an increase in the number of employees reduces revenue among small growers, while having no statistically significant effect on revenue among large growers. Further, another explanation is that the large growers operate under economies of scale, while we cannot interpret the coefficients of the (log) total salary causally. Comparing columns (5) and (6) in Table 16, the coefficient for small growers is 0.57, but it is 0.37 for large growers. The difference is roughly 55%, implying a cost-saving advantage for large growers.

5. Conclusion

This chapter uses the South Pacific Cyclone as a supply-side instrumental variable to estimate the impact of growers' revenue on hiring RSE workers. The results in Chapter 6 of the dissertation reveal the effectiveness of the RSE program, especially for the large growers. There is some controversy about a potential reform of the RSE program being mostly beneficial to large growers, putting smaller growers at a disadvantage in accessing RSE workers (B2B News, 2026). The results imply that the large growers are the ones who can use seasonal foreign workers more effectively than the smaller growers. In fact, hiring RSE workers does not increase revenue for the smaller growers.

Chapter 7: Can One Hand Replace Another? On Farm Labor Substitutability in Horticulture

1. Introduction and Background

This chapter estimates the short-run or within-season elasticity of substitution among three types of orchard workers—domestic workers, RSE workers, and non-RSE foreign workers, as well as the own-price labor demand elasticities for each type of worker. Many medium and large growers employ all three groups. Although these workers may perform similar tasks in orchards, they differ in terms of their skills and availability.

Domestic workers are available within the local community throughout the year. RSE workers are specifically trained to perform horticultural and viticultural tasks, such as fruit picking, pruning, and orchard maintenance. However, they are typically present in New Zealand for only seven to nine months, with most arriving in spring and departing in late autumn. By contrast, non-RSE foreign workers are more flexible. Most are holders of a Working Holiday Visa (WHV), allowing them to remain in New Zealand for 12 to 36 months, depending on their nationality. From RSE employers survey and several studies, while WHV workers have noticeably lower productivity than the RSE workers, WHV workers are readily available during the winter and early spring, when RSE workers have not yet arrived (e.g., Bedford, 2013; Gibson and McKenzie, 2014a; Research New Zealand, 2019).

Another important difference among the three types of workers is the flexibility and the non-farm job availability to them. The RSE workers are the least flexible, because their visas are tied to performing horticulture tasks and often pertain to a specific orchard or entity. While most WHV holders can work in almost any job, they can only work for one employer for up to 3 months.

The domestic workers are the most flexible. They can work for any employer at any length of time with no obligation, subject to clauses that have been written in the contract.

Finally, the cost of hiring these workers varies. To hire RSE workers, growers must become RSE accredited employers or recruit RSE workers from accredited third parties, which involves payment for RSE accreditation, sharing about half of the transportation costs for the workers coming to New Zealand, insurance and accommodation costs. While hiring domestic workers does not incur expenses like the RSE workers, employers may need to pay pension, additional levies and other benefits that are written in the contract for the domestic employees. The WHV holders are the cheapest to hire, because they have already paid the visa application fee up-front by the visa holders. Further, some WHV holders may be paid lower wages in exchange for a place to stay during employment.

Labor demand elasticity varies depending on the industry, location, data and time-spectrum of the study. Study finds that the elasticity of labor demand is close to −1 at the industry-city level and −0.3 at the city level (e.g., Beaudry et al., 2018). In agriculture, an earlier study finds the short-run labor demand elasticity is -0.1 and in the long-run is -0.5 (Griliches, 1959). Later studies find that the labor demand elasticities range from -0.02 to -1.63 with an average elasticity of -0.73 (e.g., Espey and Thilmany, 2000). However, some studies suggest that the hired farm labor demand tends to be elastic over time, ranging from -1.38 to -2.08 in the short-run, and -3.14 to -11.45 in the long-run (e.g., Devadoss and Luckstead, 2008). At a more aggregate level, one study investigates the substitutability among U.S. citizens, authorized immigrants, and unauthorized immigrant farmworkers. Using a nested CES model and survey data from the US, the authors find that substitutability among the three groups is small (Wei et al., 2019).

Utilizing grower-level data from New Zealand, Chapter 7 addresses the question of short run substitutability between domestic and foreign labor in orchard production. This dataset from New Zealand is unique in the following ways. First, it clearly records the before-tax revenue and salary expense data for each grower. Second, accompanying the immigration data, this dataset clearly records the labor inputs used by growers that employ both domestic and foreign workforce. To my best knowledge, this study is the first to use tax records and labor input data to analyze substitutability among different types of farm laborers.

The results indicate that domestic workers and the two groups of foreign workers are somewhat substitutable in production, whereas RSE and non-RSE foreign workers are complementary. This chapter proceeds as follows. Section 2 illustrates a theoretical model for a labor-intensive crop in horticulture. Section 3 provides the information regarding the data. Section 4 provides and interprets the results. Section 5 concludes the study and provides direction for future research.

2. Model

In this section, I present a framework that depicts the short-run behavior of fruit growers in New Zealand. Before introducing the framework, several points should be noted. First, in the context of horticulture, I assume that all growers use labor (L) alongside a composite input (M). The composite input includes other non-labor input in the short run, such as capital, energy, and materials. Both labor and composite inputs are variable inputs. Second, this model employs a CES-Translog hybrid production function. The hybrid or generalized Translog function has been built on a few seminal works. A few influential articles develop a generalized parametric cost function that nests several flexible functional forms, including the Translog, generalized Leontief, and other standard specifications, within a unified framework (Berndt and Khaled, 1979; Pollak et al., 1984).

The framework in this paper is a simpler version of the seminal models that fits well into horticultural production.

Hypothetical growers use a mix of composite input (M) and labor inputs (L) (Labor type 1, 2, 3) to produce homogenous products, such as apples or kiwifruit. Growers can recruit a mix of three types of workers. For simplicity, I denote them as labor type 1, 2, and 3. In the context of New Zealand, these are domestic, RSE and non-RSE foreign workers. Fruit growers exhibit a CES and Translog hybrid production function. Further, growers are homogenous in productivity. For each grower, the exact production function is shown in equation (11):

$$Q = F(M, L|\delta, \rho, A) = A[\delta * L^{\rho} + (1-\delta) * M^{\rho}]^{\frac{1}{\rho}} \quad (11)$$

The relationship between labor L and the composite M is under a CES function; L is the Translog function of labor inputs L_1, L_2, L_3; M is the composite input; δ is the share parameter which is bounded between 0 and 1 under the CES; ρ determines the elasticity of substitution between L and M under the CES; σ=1/(1-ρ) is the elasticity of substitution between L and M; A is a constant efficiency parameter. This is a generalized model, which can be transformed into special cases such as Cobb-Douglas, perfect substitute and Leontief depending on a chosen ρ and σ. This is a simpler version of the seminal model that fits well into horticultural production (e.g., Berndt and Khaled, 1979).

For simplicity, I assume constant returns to scale of the inputs. The cost minimization involves two steps. The first is to calculate the optimal aggregate labor input L using the Translog function. The cost minimization for producing a given level of L, using three types of labor inputs with wages w_1, w_2, and w_3, is in equation (12).

$$\ln C_L(w_1, w_2, w_3, L) = \alpha_0 + \sum_{i=1}^{3} \alpha_i * \ln(\mathrm{w_i}) + (\tfrac{1}{2}) \sum_{i=1}^{3} \sum_{j=1}^{3} \gamma_{ij} * \ln(\mathrm{w_i}) * \ln(\mathrm{w_j}) + \ln(L) \quad (12)$$

With restrictions:

(a) Symmetry: $\gamma_{ij} = \gamma_{ji}$ for i,j=1, 2, 3

(b) Homogeneity in price: $\sum_i \alpha_i = 1, \sum_j \gamma_{ij} = 0$

Equation (12) is a function of wage and the level of aggregate labor input. After exponentiating and rearranging the term, the aggregate Translog function for labor inputs is given by equation (13). P_L is the wage price index that is only affected by the wages.

$$C_L(w_1, w_2, w_3, L) = P_L(w_1, w_2, w_3) * L \quad (13)$$

Where $\ln P_L(w_1, w_2, w_3) = \alpha_0 + \sum_{i=1}^{3} \alpha_i * \ln(\mathrm{w_i}) + (\frac{1}{2}) \sum_{i=1}^{3} \sum_{j=1}^{3} \gamma_{ij} * \ln(\mathrm{w_i}) * \ln(\mathrm{w_j})$

The second step is to substitute the wage price index P_L into the CES total cost function. Let r be the rental cost of M and σ be the elasticity of substitution between L and M. The total cost function is in equation (14):

$$C(P_L, r, Q) = Q * [\delta^\sigma * P_L^{(1-\sigma)} + (1-\delta)^\sigma * r^{(1-\sigma)}]^{\frac{1}{1-\sigma}} \quad (14)$$

Using Shephard's Lemma and the total cost function, we get the share of M, the share of labor Translog function, and each labor inputs.

$$S_M = (1-\delta)^\sigma * r^{(1-\sigma)} / [\delta^\sigma * P_L^{(1-\sigma)} + (1-\delta)^\sigma * r^{(1-\sigma)}] \quad (15)$$

$$S_L = \delta^\sigma * P_L^{(1-\sigma)} / [\delta^\sigma * P_L^{(1-\sigma)} + (1-\delta)^\sigma * r^{(1-\sigma)}] \quad (16)$$

$$S_i|L = \frac{w_i * L_i}{P_L * L} = \alpha_i + \sum_{j=1}^{3} \gamma_{ij} * \ln(\mathrm{w_j}) \text{ where i,j=1, 2, 3 (17)}$$

Given a level of labor share L, $S_i|L$ is the conditional share of each labor input. $S_i|L$ in (17) is the key component to derive the Allen Elasticity of Substitution (AES) in equation (18). One key feature of this method is that the conditional share of labor input is independent of the level of the composite input, which is very convenient in the estimation process. The parameters of interest are the AES of three labor inputs as shown in equation (18). The AES is a composite of the conditional share of individual labor input and a parameter from the Translog function.

$$(AES_{ij}) = (\gamma_{ij} + S_i|L \cdot S_j|L)/(S_i|L \cdot S_j|L) \quad \text{for } i,j = 1,2,3 \quad (18)$$

3. Data

The data used in this chapter have been described in Chapter 6. In addition, to better understand labor substitutability among domestic, RSE, and non-RSE foreign workers, the analysis is restricted to growers that hire all three groups. It contains 90% of the sample described in Chapter 6. This implies that we rule out a few observations that only hire either RSE or non-RSE foreign workers. Table 17 summarizes the statistics on the number of employees at peak season for growers who hire all three types of workers.

Table 17: Descriptive Statistics for Number of Employees at Peak

	Average	Median	75 Percentile	90 Percentile	Observations
Grape	23	15	31	50	70
Kiwifruit	45	23	44	94	198
Berry	242	126	222	736	63
Apple and Pear	100	65	114	160	470
Stone Fruit	104	77	152	242	75

Source: Statistics New Zealand's IDI and LBD. Observation counts are rounded to the nearest multiple of three in accordance with Statistics New Zealand's confidentiality requirements.

The before-tax salary paid to employees is directly observed in Statistics New Zealand's Employer Monthly Schedule (EMS). Then, I separate employees into three distinct groups, i.e., domestics, RSE and non-RSE foreign. Hours and wages are usually unknown to Statistics New Zealand. To transform the salary to wage and employment, for each group, I follow the method in the previous chapter.

Finally, I make some small adjustments to the data. (i) To make the wage rate comparable across different years, using the inflation rate published by the Reserve Bank of New Zealand, I recalculate the wage rate using the 2008 real term. (ii) I removed three duplicate entries in the

dataset, which is likely caused by data entry errors in the system. (iii) I remove a few entries that have negative salary or employment information. This rarely happens in the data, but when one firm merged or is acquired by the other, this process sometimes leads to absurd values. However, due to confidentiality of the data, researchers are unable to know the exact number of employees and salaries after the merger or acquisition.

4. Methodology and Results

I use the Seemingly Unrelated Regression (SUR) to estimate the conditional share of three labor inputs in equation (17). The SUR is appropriate in this context because growers are likely to make recruitment decisions simultaneously for all three labor inputs. Therefore, the labor input shares in equation (17) are likely to be contemporaneously correlated. In addition, the SUR framework facilitates the imposition of linear homogeneity in input prices and symmetry restrictions implied by economic theory. The use of SUR to estimate Translog cost systems is well established in the literature (e.g., Binswanger, 1974; Berndt and Khaled, 1979; Ray, 1982).

In each equation, the dependent variable is the conditional cost share of a labor input, defined as the ratio of the wage bill for a particular labor group to the total wage bill for all employees. The explanatory variables include the log of the real wage for each labor group. As the cost shares sum to one, one of the three equations is omitted during estimation to avoid perfect multicollinearity. In addition to imposing the homogeneity in prices and symmetry constraints, the model includes the log real sales as a proxy for the variable inputs. The estimation gives γ_{ij} and conditional share evaluated at the mean for three labor inputs. Then, I use the above information and equation (18) to calculate each AES.

Table 18 reports the AES for three labor inputs, i.e., s_{ii} and s_{ij}. The diagonal presents s_{ii}, and the off-diagonal presents s_{ij}. The exact derivation can be found in the previous literature (e.g.,

Binswanger, 1974; Glass and McKillop, 1990). The own price labor demand elasticities (e_{ii}) and cross-price elasticities (e_{ij}) of the labor demand are given by $e_{ii} = s_{ii}S_i$ and $e_{ij} = s_{ij}S_j$. Both S_i and S_j are the conditional cost share for one of labor group, evaluated at the mean.

Table 18: Allen Elasticity of Substitutions

Prices / Quantalities	Domestic Worker	non-RSE Foreign Worker	RSE Worker
Domestic Worker	-0.744***		
	(0.256)		
non-RSE Foreign Worker	0.421**	-0.214*	
	(0.197)	(0.123)	
RSE Worker	0.730*	-0.465**	-0.603***
	(0.378)	(0.189)	(0.236)

Source: Statistics New Zealand IDI Dataset. The elasticity calculation is based on 876 observations from 2008/2009 to 2018/2019. Standard errors are in parentheses. The revenue, expense, and total salary are measured in real term (2008 NZD). The FTE Pacifica is measured in 10s for calculation.* p<0.10, ** p<0.05, *** p<0.01.

Several noteworthy points arise. First, all own AES are negative, satisfying the concavity conditions of the cost function. The magnitudes vary among the three types of laborers, showing heterogeneity in the cost function's curvature concerning wages. These differences suggest that employers are more price sensitive when it comes to domestic and RSE workers than to non-RSE foreign workers, with employer demand for domestic workers being the most price sensitive. This implies growers seek outside options when domestic workers are more expensive to hire, such as an annual minimum wage change that primarily targets domestic workers.These estimates of the labor demand elasticity fall within the range of previous studies, though they are more on the inelastic side (e.g., Griliches, 1959; Espey and Thilmany, 2000; Devadoss and Luckstead, 2008). This may mainly be due to the rigid timing requirements for horticulture production, such as the need to pick fruit just before ripening. Another reason is that the study is focused on estimating the short-run or within season elasticity, e.g., labor demand in one growing season.

The AES between two groups of foreign and domestic workers are positive, implying that the foreign and domestic workers are somewhat substitutes but not perfect substitutes. The negative AES between RSE and non-RSE workers implies that the two groups of foreign workers are complementary. This may be due to three different reasons. First, the RSE and non-RSE workers perform different tasks in production. For instance, RSE workers are trained to perform horticultural tasks, e.g., harvesting fruit using ladders. By contrast, non-RSE foreign workers are focused on transporting fruits from the orchard to the packhouse.

Further, the growers hire both RSE and non-RSE foreign workers based on different needs in production. The number of RSE workers is calculated before the harvest season, reflecting the rough estimation of how many workers are needed based on the production of the previous season. Yet, growers hire non-RSE foreign workers, especially WHV, on short notice, reflecting the need to complement or supplement tasks that RSE workers are unable to fulfil.

Third, the RSE workers are constrained by the visa condition, i.e., the maximum length of stay is 9 months, and most of the RSE workers can only stay 7 months. By contrast, most WHV holders can stay in New Zealand for 12 months, with some exceptions that can stay 24 or 36 months, e.g., British or Canadian Citizens. This gives the WHV holders the opportunity to participate in on-orchard jobs when the RSE workers are not present, especially during the winter months.

5. Conclusion

The results imply that either RSE or non-RSE foreigner workers are substitutable with domestic workers in the orchard. This may lead to the domestic workers participating in jobs outside horticulture or leaving the workforce and claiming unemployment benefits during a time when competition from foreign workers is fierce. However, the evidence of these two claims is limited.

One future research direction is to track the domestic workers who previously worked or currently work in horticulture and analyze their responses to the arrival of foreign workers in agriculture.

This study only focuses on orchards that hire both RSE and non-RSE foreign workers, which often are large growers that have the resources to hire RSE workers. Yet, small or family-run growers are often unable to afford or unwilling to recruit RSE workers. Therefore, they mostly hire foreign workers from WHV holders. With the possibility of getting the data, another future research direction is to analyze the labor substitutability between WHV and domestic workers for these small or family-run growers.

Chapter 8: Conclusion

This dissertation, analyzing New Zealand's Recognised Seasonal Employer (RSE) scheme, provides a comprehensive understanding of the impacts of agricultural seasonal guest worker programs on labor markets and growers. This dissertation provides five main findings.

First, contemporaneously, the influx of seasonal workers has no wage effects on domestic workers except for females and low-skilled ones. On the other hand, the influx has much more prevalent effects on the employment of domestic workers. Females, middle-aged, Māori & Pacific, European, and low-skilled workers have positive and significant employment effects. Second, the inflow of seasonal workers has positive impacts on related industries. Accommodation & food service and administrative & support have the highest employment effects. Further, agriculture, forestry, and fishing have positive and significant effects on both the wage and employment of domestic workers. Third, results show that non-RSE foreign workers are disproportionately worse off when faced with an influx of foreign seasonal workers. The wage of non-RSE foreign workers decreases, but with no significant change in employment. Fourth, among the growers that hire RSE workers, the large growers gain reasonably: their revenue rises by approximately 1% when their workforce contains 0.1% more RSE workers. In contrast, small growers hiring RSE workers experience no revenue gain. Last, the domestic workers and the two groups of foreign workers are somewhat substitutable in production, whereas RSE and non-RSE foreign workers are complementary.

This dissertation has three major contributions to the existing literature. The first is the exceptionally high-quality data that is available for this study. The longitudinal nature of the dataset covers the entire population receiving salary and wage within New Zealand. This allows

analysis of the various impacts of these seasonal workers on the workforce for different demographics and grower's income. In addition, unlike previous studies using annual data, this dataset records the monthly salary of the employees. This allows me to analyze the contemporaneous effects of the impact of the seasonal workers on the workforce with consideration of seasonality, which is crucial for horticulture and viticulture.

Second, this study also contributes to the existing literature on agricultural laborers. Apart from the data either not being available, or a substantial amount of foreign agricultural laborers are unauthorized immigrants who are absent from the official data, the previous studies have focused on the aggregate impact of agricultural workers on domestic workers' outcomes within confined geographic areas, either a single state or certain areas within a state. This study's level of analysis is the entire country of New Zealand. Further, the extension also includes the analysis of the impact of the seasonal laborers on other foreign-born workers, a topic that has lacked attention in the literature.

The third contribution to the literature is to bring evidence of the benefit of a skilled-based immigration program to the recipient country, especially for low-skilled workers, such as H-2A. The previous studies focused mostly on the high-skilled group, such as H-1B visa holders and skilled workers in European Union countries. The findings not only pertain to seasonal workers but also are useful for low-skilled immigrants in general.

Finally, this dissertation contributes to policy discussions on seasonal foreign worker programs in developed countries, such as the H-2A program in the United States. The findings suggest that seasonal foreign worker programs can increase employment opportunities for domestic workers in related industries. Consequently, policymakers may consider gradually increasing program quotas or caps. The results also indicate that large growers benefit more from

the program than smaller growers. Accordingly, policymakers could consider allocating additional quota or cap increases to larger growers, where the economic benefits appear to be greatest.

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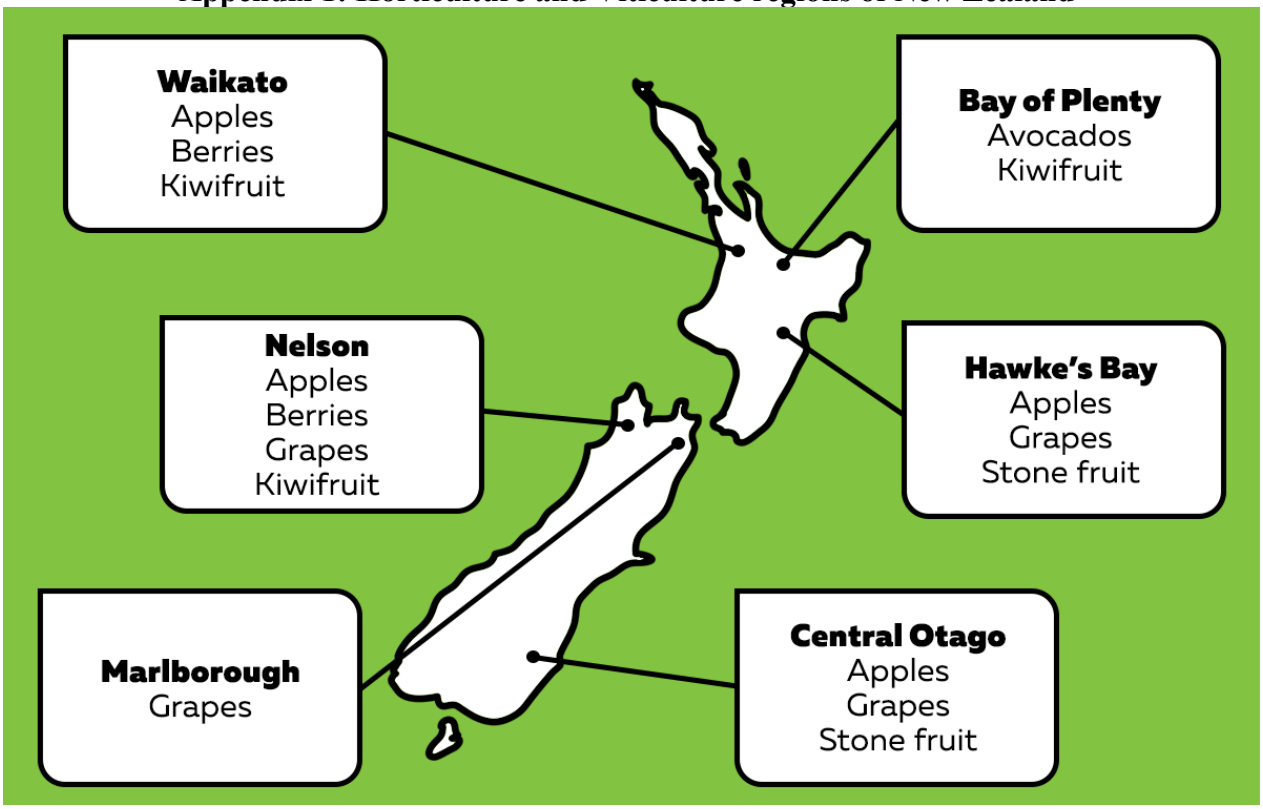
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Appendices

Appendix 1: Horticulture and Viticulture regions of New Zealand



Source: PickNZ, Frech Fact

Appendix 2: RSE workers enter New Zealand by category, year, and nationality

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
N of RSE enter	4,486	6,821	6,216	7,091	7,009	7,456	7,855	8,483	9,278	10,437	11,078	12,581
Samoa	647	1,228	1,021	1,219	1,162	1,137	1,169	1,238	1,454	1,690	1,878	2,315
Tonga	805	1,355	1,142	1,411	1,398	1,573	1,538	1,563	1,687	1,822	1,899	2,037
Tuvalu	99	49	54	51	88	56	71	70	64	80	80	92
Vanuatu	1,698	2,342	2,137	2,352	2,412	2,829	3,070	3,435	3,726	4,171	4,445	5,130
Papua New Guinea	-	-	-	6	6	31	58	96	68	121	124	172
Kiribati	69	38	48	149	142	138	127	136	162	189	231	263
Fiji	-	-	-	-	-	-	-	30	92	355	359	444
Nauru	-	-	-	-	-	-	-	20	20	17	14	19
Solomon Islands	238	311	256	252	407	423	491	511	590	593	643	696
RSE State	3,556	5,323	4,658	5,440	5,615	6,187	6,524	7,099	7,863	9,038	9,673	11,168
As % of RSE State	79.3%	78.0%	74.9%	76.7%	80.1%	83.0%	83.1%	83.7%	84.7%	86.6%	87.3%	88.8%
Thailand	195	684	727	827	658	565	588	624	637	634	629	628
Philippines	80	76	75	74	74	68	68	67	67	66	67	66
Malaysia	364	374	406	375	317	273	308	333	335	321	329	335
Indonesia	249	271	271	304	299	303	305	313	321	323	325	326
India	41	77	25	40	15	25	28	27	35	35	35	35
Taiwan	-	12	54	31	31	34	34	20	20	20	20	23
Non RSE	929	1,494	1,558	1,651	1,394	1,268	1,331	1,384	1,415	1,399	1,405	1,413

Note: The cells in red are the RSE-participating countries and the percentage of seasonal laborers that come from these participating countries. The number of laborers coming from the RSE participating countries has increased dramatically over time. By contrast, the number of non-RSE countries has stagnated. For the 2018/2019 growing season, 88.8% of RSE workers come from RSE-participating countries. Citizens from other countries may not participate in this program unless the workers have previous working relationships with the employers. Most RSE workers can work in New Zealand for a maximum of 7 months during an 11-month period, except for citizens of Tuvalu or Kiribati, who may be granted 9-month visas. RSE employers must pay for half of the return airfare between New Zealand and the worker's country of residence to ensure that employees return to their home country at the end of their contracts. If certain conditions are met, workers can return to New Zealand for the next season (Immigration New Zealand, 2023).

Appendix 3: Summary Statistics for Main Outcome Variables

	Period	N	Mean	SD	Min	Max
Annual Earning Accommodation	2000-2007	520	11,809	1,571	7,930	19,420
	2008-2019	780	16,818	2,935	10,220	30,420
Annual Earning Agriculture	2000-2007	520	19,924	4,453	7,970	34,230
	2008-2019	780	28,014	7,621	7,420	48,000
Annual Earning Construction	2000-2007	520	30,768	3,582	21,160	40,280
	2008-2019	780	43,552	5,816	30,120	61,310
Annual Earning Education	2000-2007	520	29,705	3,841	17,120	40,270
	2008-2019	780	39,820	5,263	23,910	54,370
Annual Earning Health Service	2000-2007	520	24,234	3,884	14,100	37,680
	2008-2019	780	36,084	5,531	20,160	55,650
Annual Earning Manufacture	2000-2007	520	31,707	5,865	22,450	67,740
	2008-2019	780	43,240	6,959	29,000	74,080
Annual Earning Public Service	2000-2007	520	37,838	4,652	24,240	55,290
	2008-2019	780	53,755	6,842	30,510	78,310
Annual Earning Rental Service	2000-2007	520	18,560	1,880	12,310	23,190
	2008-2019	780	27,256	3,500	19,450	36,680
Annual Earning Transportation	2000-2007	520	31,281	4,208	20,620	44,110
	2008-2019	780	45,237	7,136	27,240	65,330
Annual Earning Wholesale	2000-2007	520	31,281	4,228	20,620	44,110
	2008-2019	780	45,237	6,277	27,240	65,330
Mean Week Rent	2000-2007	520	169	46	88	329
	2008-2019	780	267	69	137	586

Notes: All Earning Entries and Mean Week Rent are in New Zealand Dollars (NZD). The Numbers are rounded to the nearest dollar.

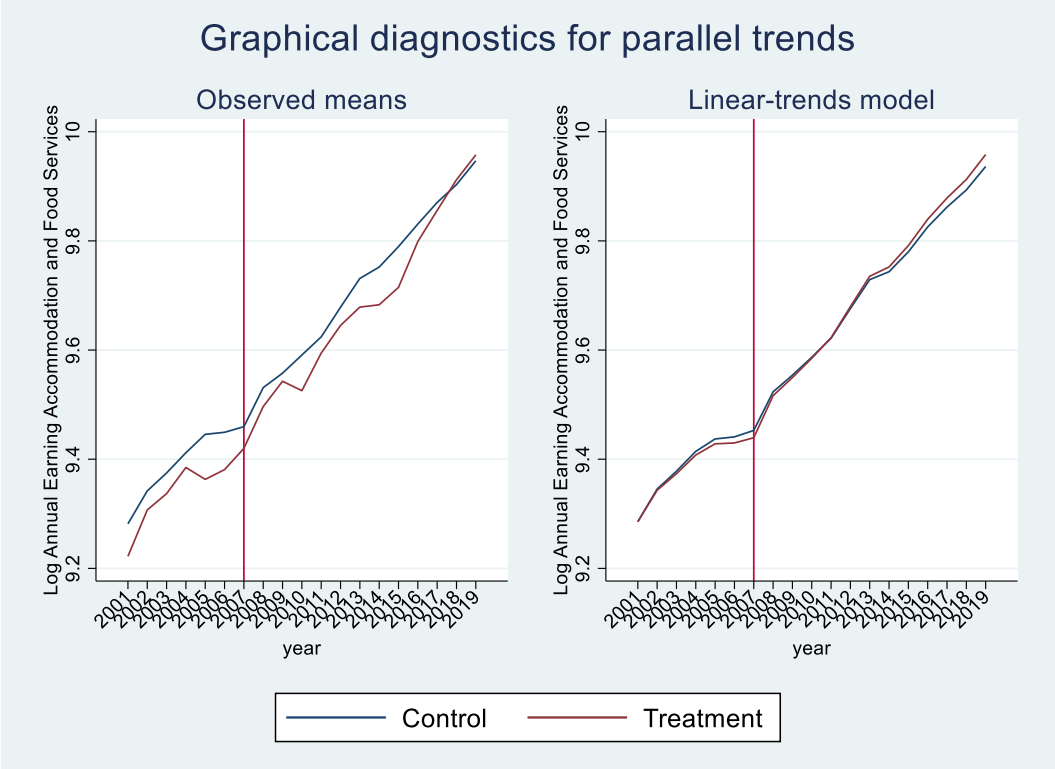
Appendix 4: Most Dependent Cities on the RSE Program

year	Municipality	Horticulture Region GDP Million Dollar (NZD)	RSE SHARE
2002	Hastings	187.9	0.291
2002	Western Bay of Plenty	143.7	0.222
2002	Tasman	100.9	0.156
2002	Central Otago	76.6	0.119
2002	Marlborough	68.1	0.105
2002	Gisborne	51.1	0.079
2002	Opotiki	18.0	0.028
2002	TOTAL RSE INDUSTRY	646.3	1

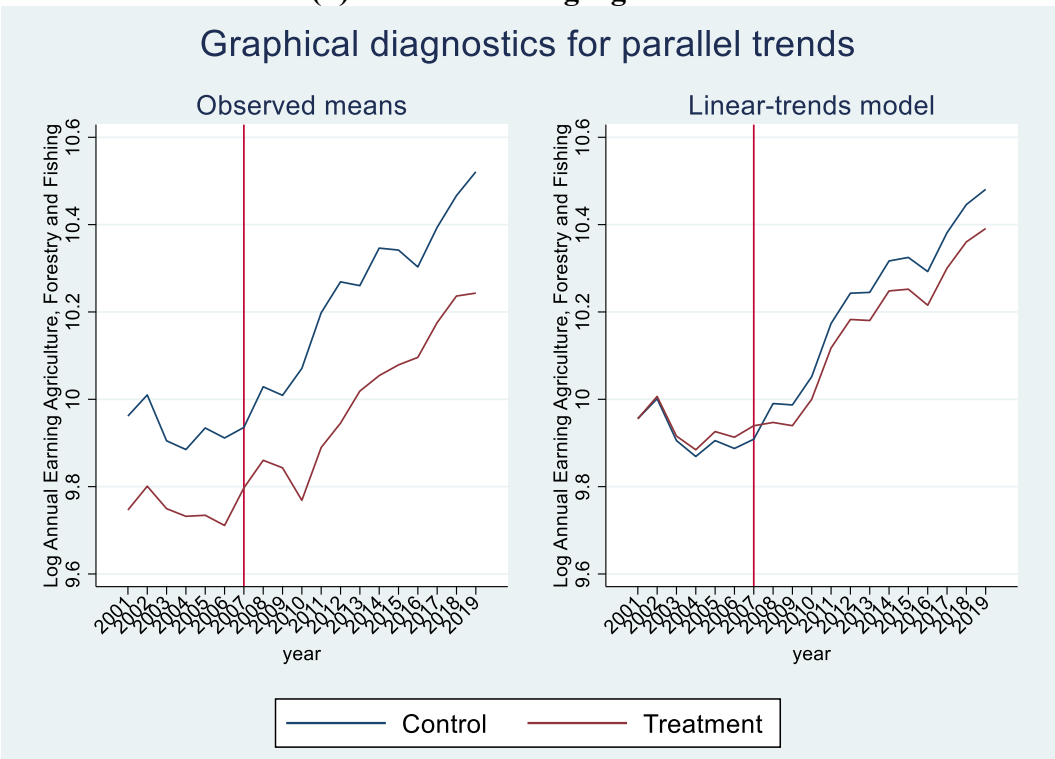
Source: Fresh Fact, MBIE, Author Construction

Appendix 5: Graphs of Parallel Trend Tests

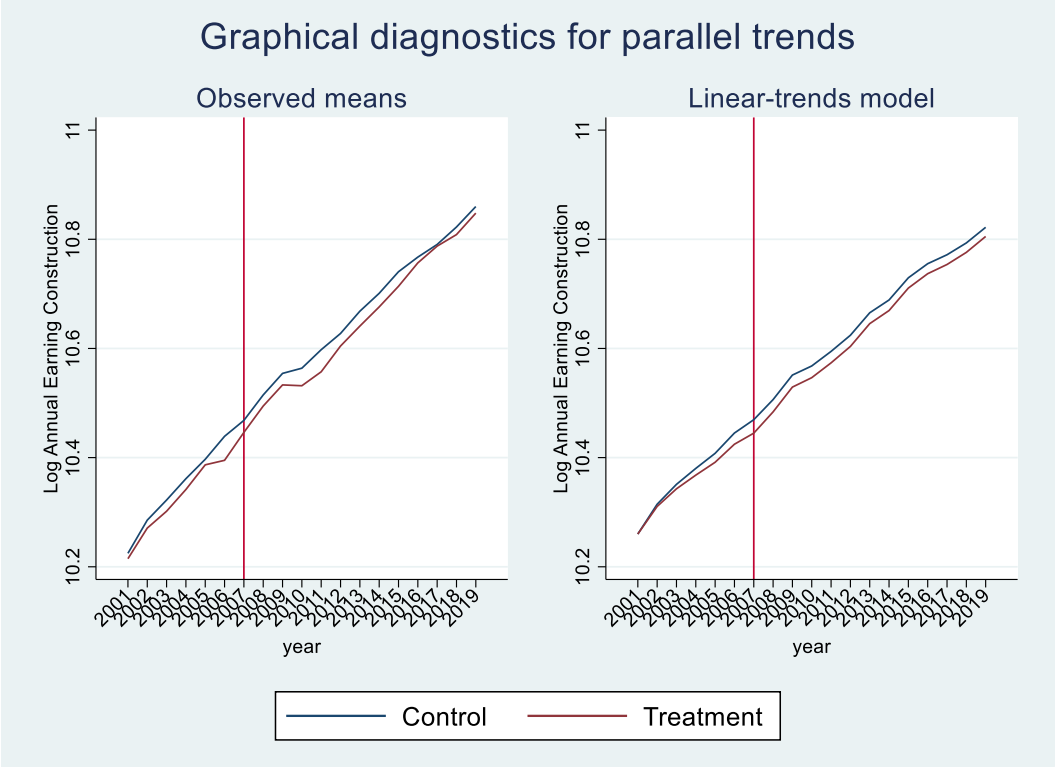
(a) Annual Earning Accommodation



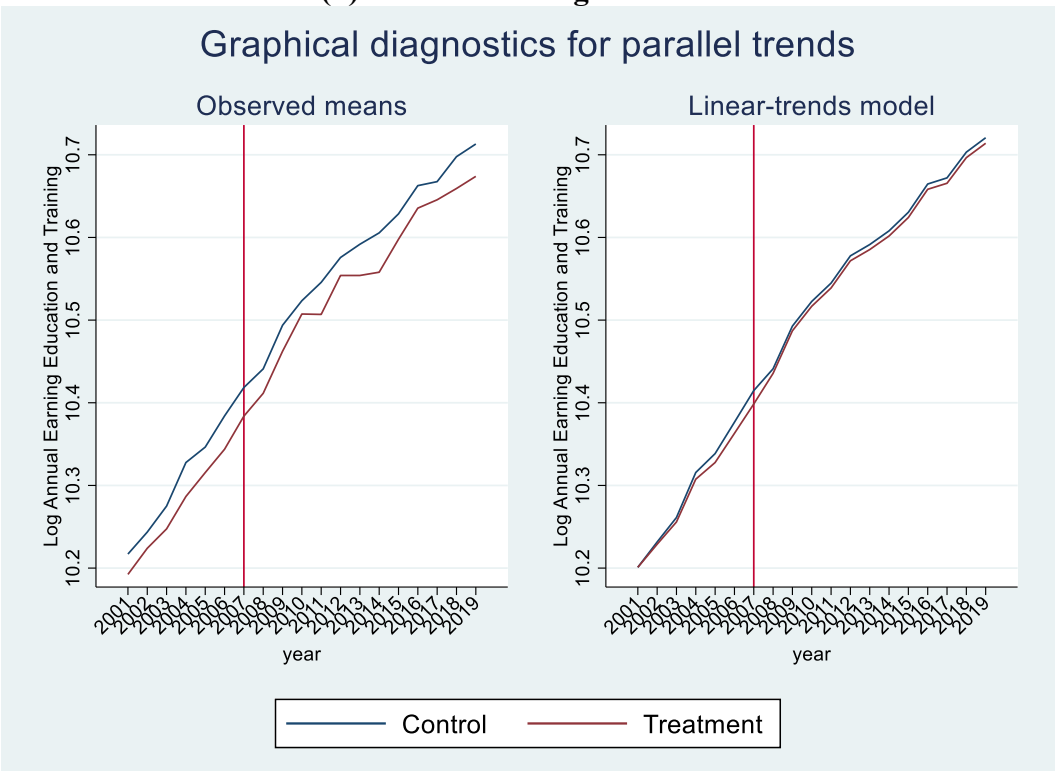
(b) Annual Earning Agriculture



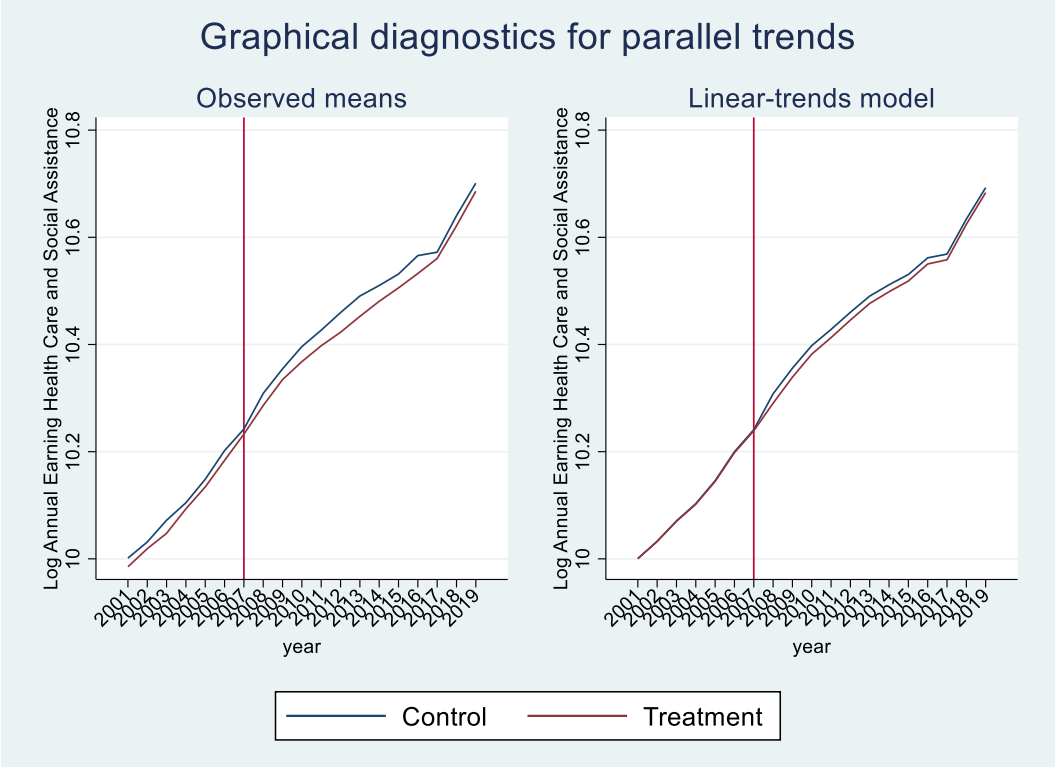
(c) Annual Earning Construction



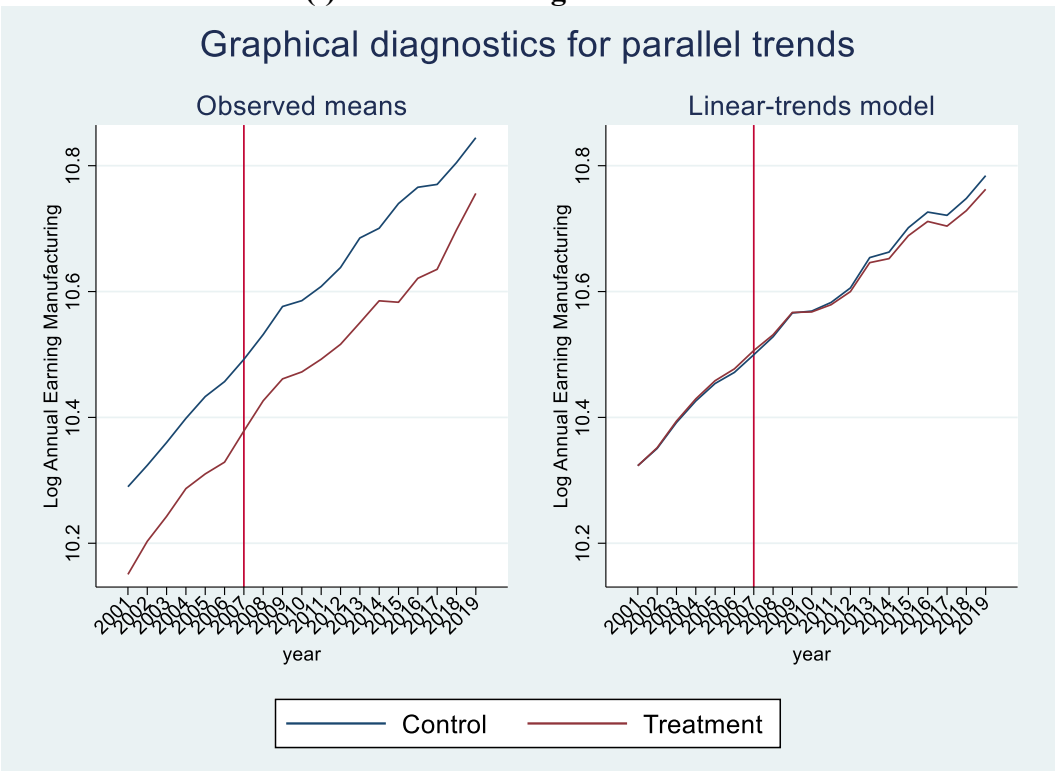
(d) Annual Earning Education



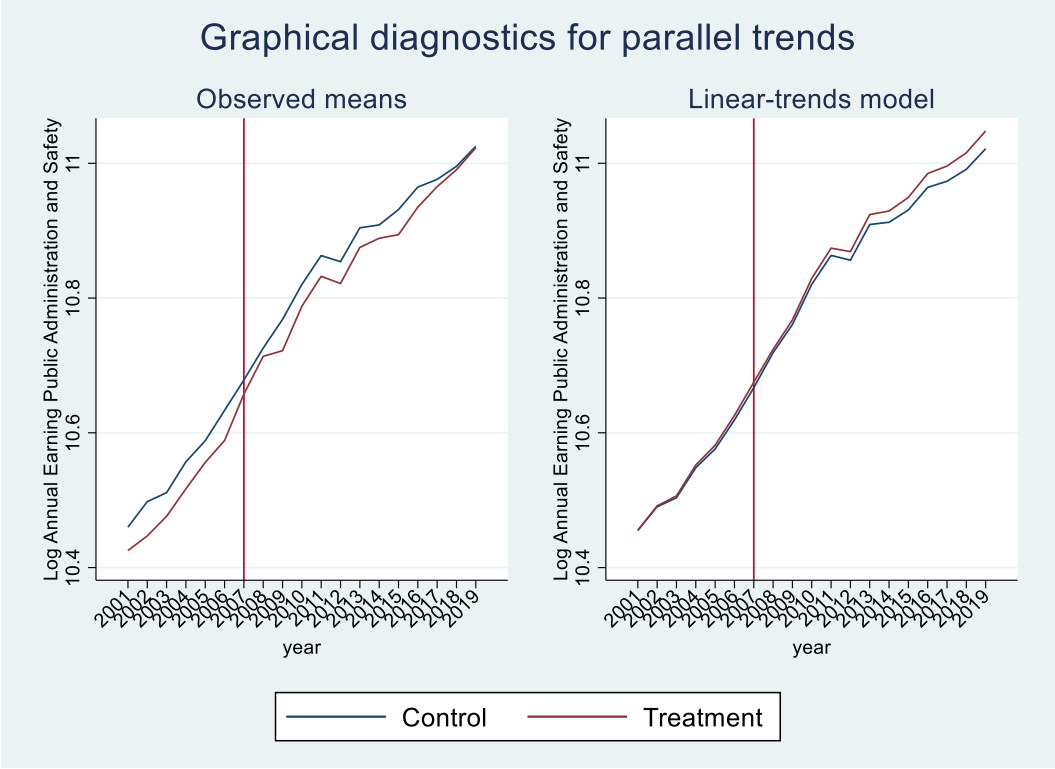
(e) Annual Earning Health Service



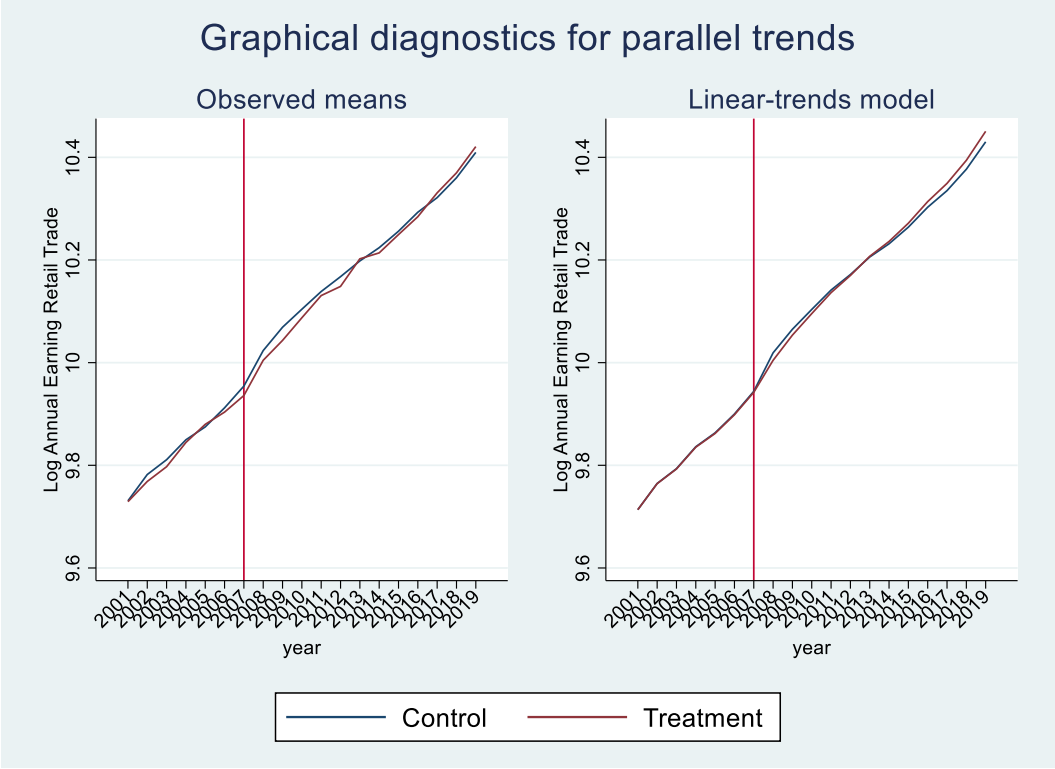
(f) Annual Earning Manufacture



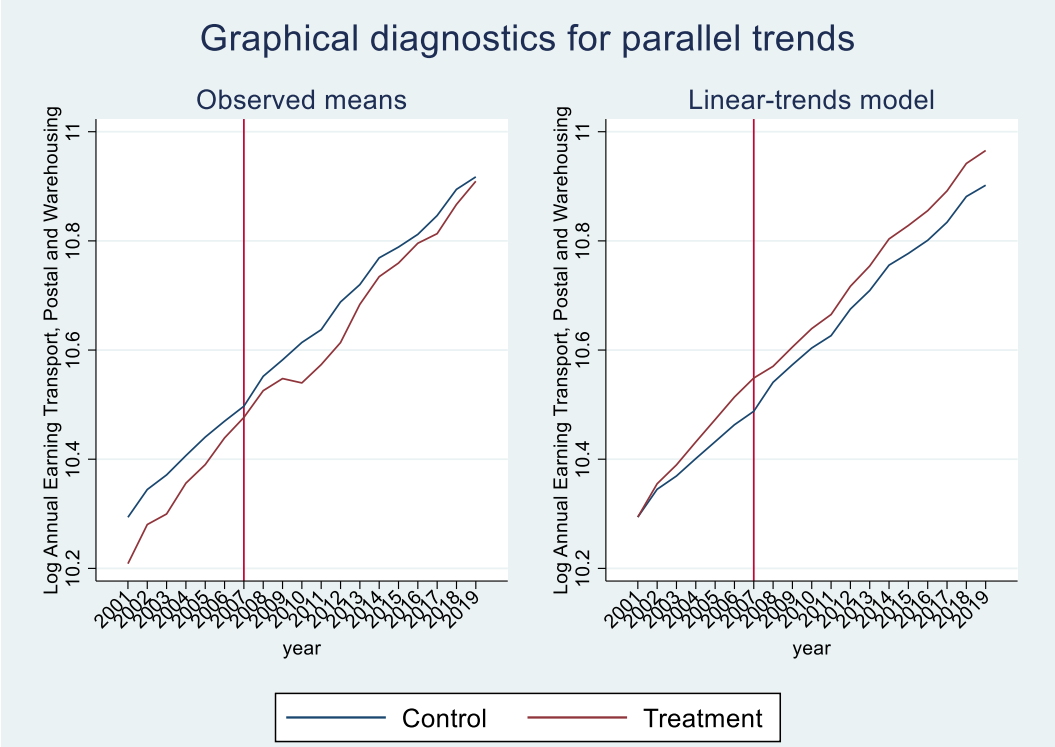
(g) Annual Earning Public Service



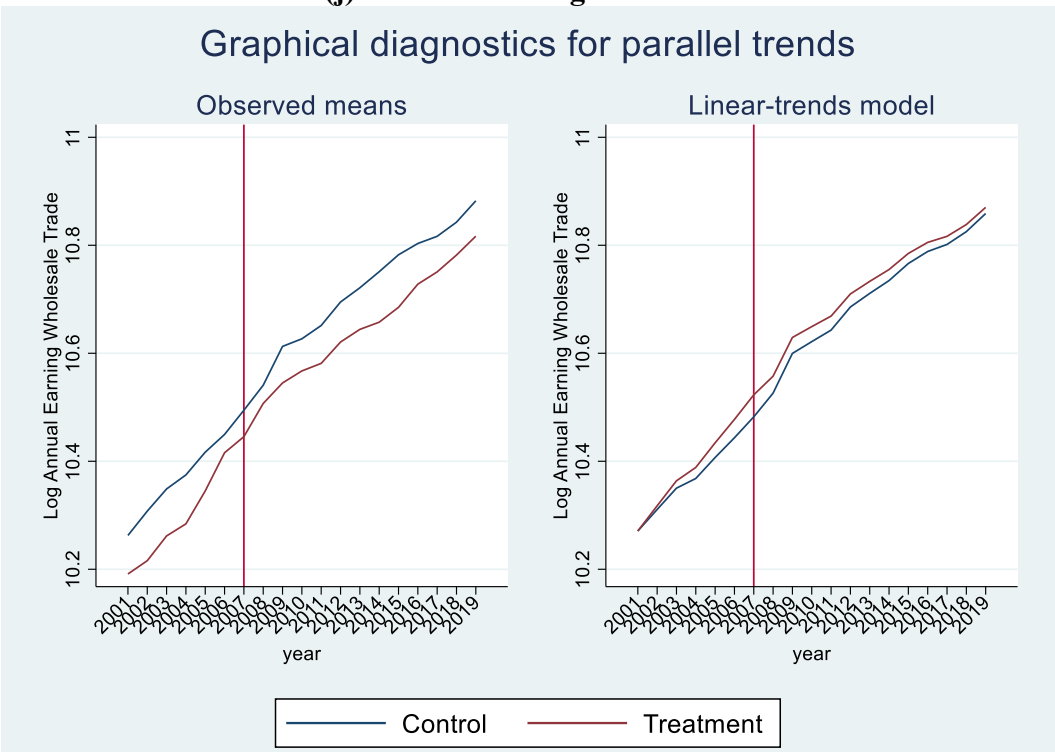
(h) Annual Earning Retail Trade



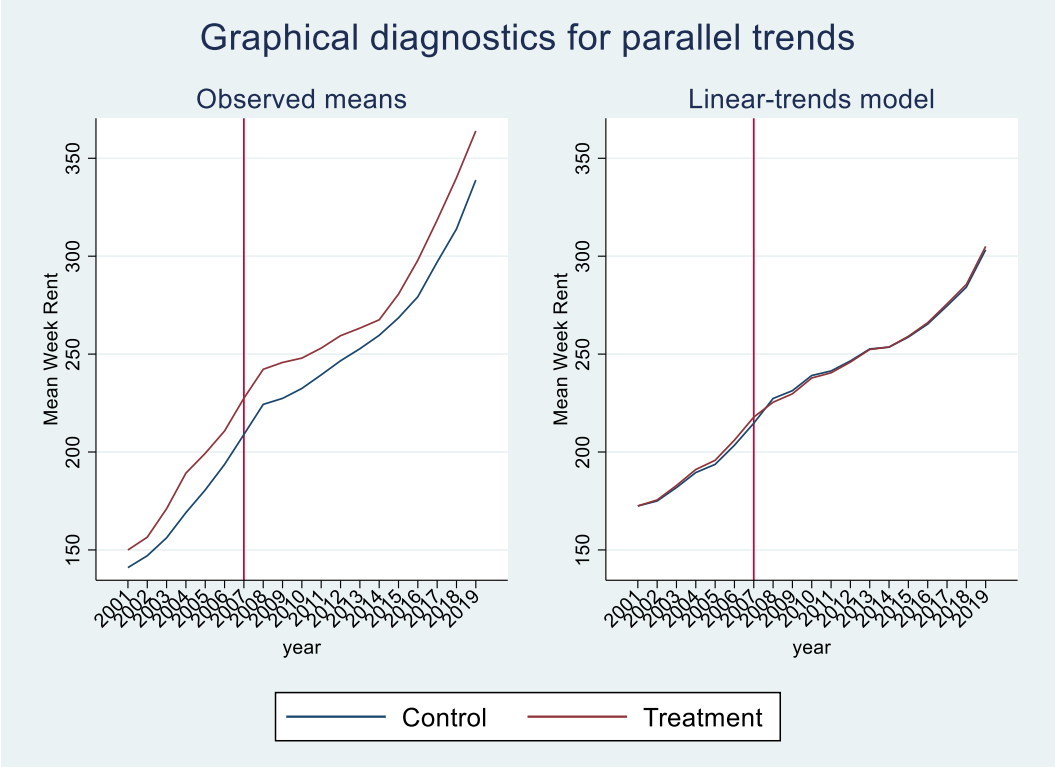
(i) Annual Earning Transportation



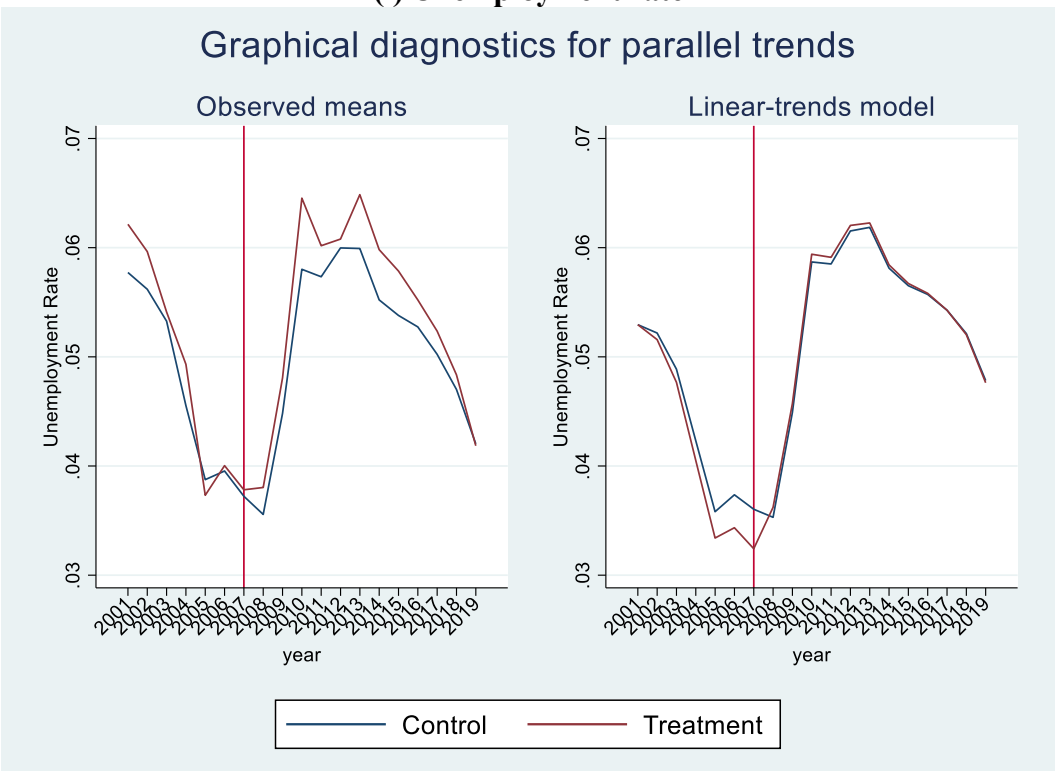
(j) Annual Earning Wholesale



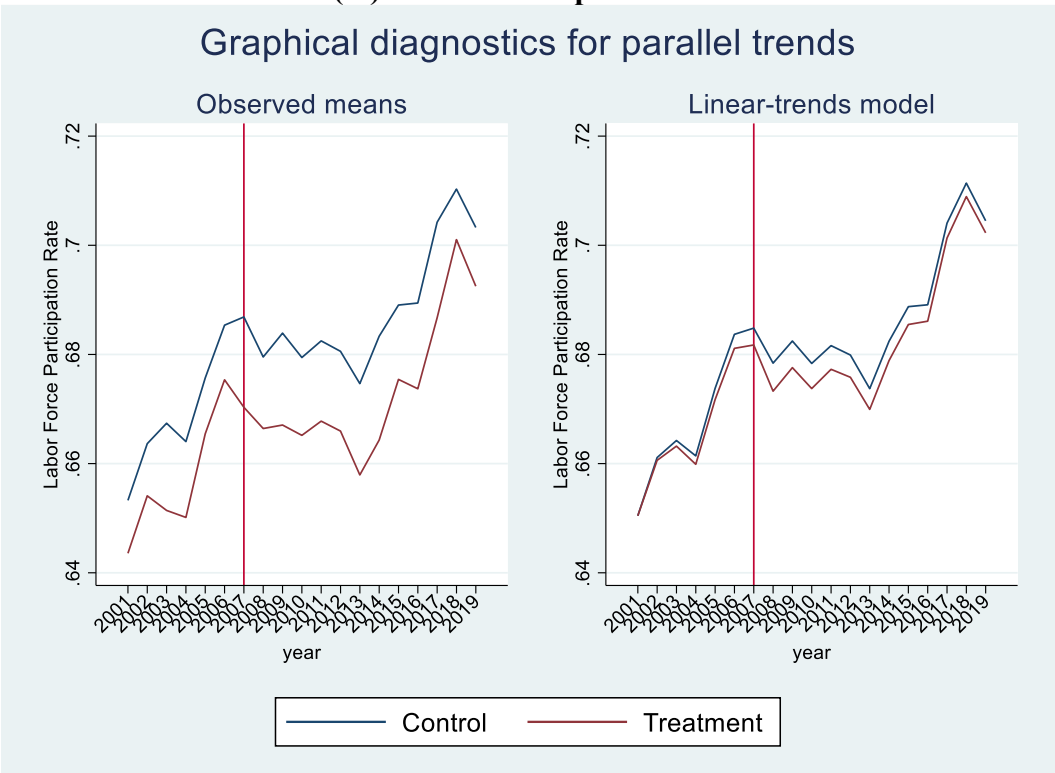
(k) Mean Week Rent



(l) Unemployment rate



(m) Labor Participation rate



Appendix 6: Results of Parallel Trend Tests

	Parallel-trends test[19]
Annual Earning Accommodation	0.19
	(0.66)
Annual Earning Agriculture	0.45
	(0.51)
Annual Earning Construction	0.81
	(0.37)
Annual Earning Education	0.98
	(0.33)
Annual Earning Health Service	0.01
	(0.90)
Annual Earning Manufacture	0.05
	(0.82)
Annual Earning Public Service	0.10
	(0.75)
Annual Earning Retail Service	0.01
	(0.91)
Annual Earning Transportation	2.41
	(0.13)
Annual Earning Wholesale	1.97
	(0.17)
Mean Week Rent	0.14
	(0.71)
Unemployment Rate	0.29
	(0.59)
Participation Rate	0.23
	(0.63)

Notes: Both F-Stats and P-Value are reported. The test result is for Parallel-trends tests. P-Values are in parentheses.
* Indicates a potential violation of the parallel trend assumption.

[19] The equation for linear trend model is $Y_{c,t} = \phi_c + \eta_t + \theta X_{c,t} + \delta D_{c,t} + w_i d_{t,0} t \kappa_1 + w_i d_{t,1} t \kappa_2 + \varepsilon_{c,t}$; the city-fixed effect is represented by ϕ_c, the year-fixed effect by η_t, the control variables by $X_{c,t}$, $D_{c,t}$ is a binary variable 1 if treated, and 0 if control; compared to a difference in difference equation, the additional terms consist of two 3-way interactions between $d_{t,0}$, w_i, and t, and $d_{t,1}$, w_i, and t; $d_{t,0} = 1(d_t = 0)$ is a variable indicates pretreatment periods; $d_{t,1} = 1(d_t = 1)$ indicates treatment periods; w_i variable that is 1 if ever treated, and 0 if never treated; the coefficient κ_1 captures the differences in slopes between treatment group and control group in pretreatment periods, i.e., 2000 to 2007 while κ_2 captures the differences in slopes in treatment periods, i.e., 2008 to 2019; if κ_1 is 0, the linear trends in the outcome are parallel during pretreatment periods.

Appendix 7: Additional Controls for the Contemporaneous Effect on Wages of Domestic Workers

	Age	Age Square	Number of Jobs	Size of Firm
All Workers	0.047***	-0.001***	0.070***	0.000***
Male Workers	0.058***	-0.001***	0.098***	0.000***
Female Workers	0.034***	-0.000***	0.053***	0.000***
15-25	-0.002	0.000	0.039***	0.000***
25-35	0.035***	-0.001***	0.100***	0.000***
35-45	0.010**	-0.000**	0.097***	0.000***
45-55	0.058***	-0.001***	0.103***	0.000***
55-65	0.078***	-0.001***	0.089***	0.000***
Other Ethnicity	0.049***	-0.001***	0.070***	0.000***
Māori and Pacific	0.036***	-0.000***	0.064***	0.000***
European	0.052***	-0.001***	0.073***	0.000***
Low Skilled	0.015***	-0.000***	0.036***	0.000***
High Skilled	0.066***	-0.001***	0.165***	0.000***
Agriculture, Forestry and Fishery	0.054***	-0.001***	-1.093***	0.000***
Retail Trade	0.029***	-0.000***	0.153***	0.000
Accommodation and Food Service	0.020***	-0.000***	0.093***	0.000***
Transport, Postal and Warehousing	0.048***	-0.001***	0.177***	0.000***
Administrative and Support	0.027***	-0.000***	0.108***	-0.000*

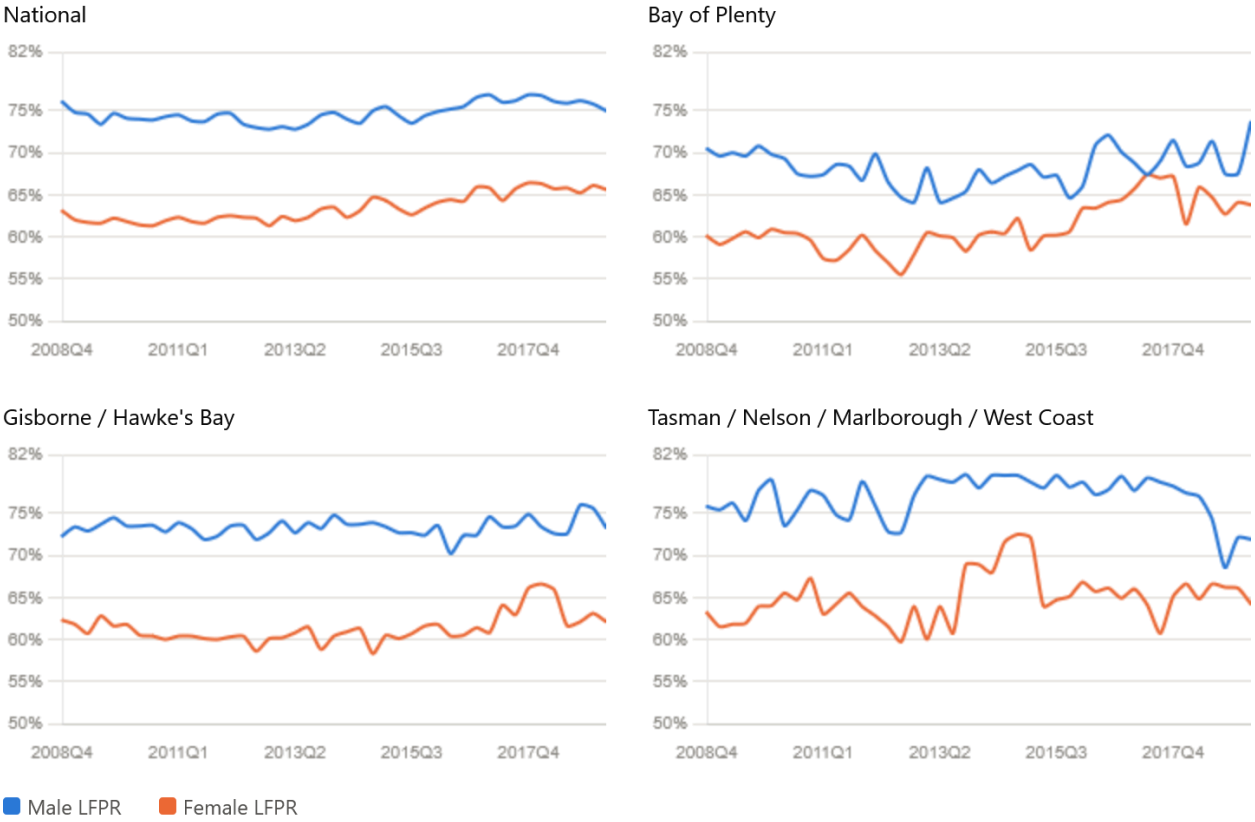
Note: Each entry of the table is the control in equation (5) using the instrument constructed in equation (9) and sample of employed domestic workers between 2009 and 2019. Observation counts are rounded to the nearest multiple of three in accordance with Statistics NZ's confidentiality requirements. Standard errors in parentheses are clustered by municipality. * p<0.10, ** p<0.05, *** p<0.01

Appendix 8: Additional Controls for the Contemporaneous Effect on Employment of Domestic Workers

	Age	Age Square	Number of Jobs	Size of Firm
All Workers	0.087***	-0.001***	-1.396***	0.000***
Male Workers	0.079***	-0.001***	-1.478***	0.000***
Female Workers	0.096***	-0.001***	-1.341***	0.000***
15-25	0.955***	-0.024***	-1.306***	0.000***
25-35	-0.059***	0.001***	-1.476***	0.000***
35-45	-0.039***	0.000***	-1.448***	0.000***
45-55	0.023**	-0.000**	-1.443***	0.000***
55-65	0.229***	-0.002***	-1.375***	0.000***
Other Ethnicity	0.096***	-0.001***	-1.414***	0.000***
Māori and Pacific	0.076***	-0.001***	-1.372***	0.000***
European	0.091***	-0.001***	-1.404***	0.000***
Low Skilled	0.149***	-0.002***	-1.158***	0.000***
High Skilled	0.010***	-0.000***	-1.716***	0.000
Agriculture, Forestry and Fishery	0.054***	-0.001***	-1.093***	0.000***
Retail Trade	0.074***	-0.001***	-1.183***	-0.000**
Accommodation and Food Service	0.077***	-0.001***	-1.108***	0.000***
Transport, Postal and Warehousing	0.032***	-0.000***	-1.301***	0.000**
Administrative and Support	0.058***	-0.001***	-1.182***	-0.000

Note: Each entry of the table is the control in equation (5) using the instrument constructed in equation (9) and sample of employed domestic workers between 2009 and 2019. Observation counts are rounded to the nearest multiple of three in accordance with Statistics NZ's confidentiality requirements. Standard errors in parentheses are clustered by municipality. * p<0.10, ** p<0.05, *** p<0.01

Appendix 9: Quarterly Labor Force Participation Rate (LFPR)



Note: The labor force participation rate is from the quarterly household labour force survey administered by Statistics New Zealand. Each survey has around 15,000 respondents. Bay of Plenty, Hawke's Bay, Tasman and Marlborough are the top regions for horticulture production in New Zealand. Unfortunately, monthly, municipality-level surveys that cover more of the population are not available.

Appendix 10: Additional Controls for the Contemporaneous Effect on Wages of Foreign Workers

	Age	Age Square	Number of Jobs	Size of Firm
All Workers	0.052***	-0.001***	0.074***	0.000***
Male Workers	0.061***	-0.001***	0.098***	0.000***
Female Workers	0.040***	-0.000***	0.055***	0.000***
15-25	-0.063***	0.001***	0.039***	0.000***
25-35	0.071***	-0.001***	0.077***	0.000***
35-45	0.037***	-0.000***	0.115***	0.000***
45-55	0.064***	-0.001***	0.108***	0.000***
55-65	0.104***	-0.001***	0.095***	0.000**
Low Skilled	0.015***	-0.000***	0.033***	0.000***
High Skilled	0.076***	-0.001***	0.165***	0.000**

Note: Each entry of the table is the control in equation (5) using the instrument constructed in equation (9) and sample of employed domestic workers between 2009 and 2019. Observation counts are rounded to the nearest multiple of three in accordance with Statistics NZ's confidentiality requirements. Standard errors in parentheses are clustered by municipality. * $p<0.10$, ** $p<0.05$, *** $p<0.01$

Appendix 11: Additional Controls for the Contemporaneous Effect on Employment of Foreign Workers

	Age	Age Square	Number of Jobs	Size of Firm
All Workers	0.078***	-0.001***	-1.362***	0.000***
Male Workers	0.075***	-0.001***	-1.409***	0.000***
Female Workers	0.081***	-0.001***	-1.322***	0.000***
15-25	0.711***	-0.017***	-1.225***	0.000***
25-35	0.027	-0.000	-1.400***	0.000***
35-45	-0.062**	0.001**	-1.448***	0.000**
45-55	0.023	-0.000	-1.417***	0.000***
55-65	0.212***	-0.002***	-1.376***	0.000*
Low Skilled	0.125***	-0.002***	-1.183***	0.000***
High Skilled	0.009***	-0.000***	-1.675***	-0.000

Note: Each entry of the table is the control in equation (5) using the instrument constructed in equation (9) and sample of employed domestic workers between 2009 and 2019. Observation counts are rounded to the nearest multiple of three in accordance with Statistics NZ's confidentiality requirements. Standard errors in parentheses are clustered by municipality. * p<0.10, ** p<0.05, *** p<0.01