Essays in Public Policy and Labour Economics

Abdullah Selim Öztek

University College London (UCL)

Thesis submitted in partial fulfilment of the degree of Doctor of Philosophy (PhD) in Economics

London

October 2019

Declaration

I, Abdullah Selim Öztek, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

London, April 2019

Abstract

This thesis comprises three chapters that provide discussions for labour income taxation and labour market effects of immigration and minimum wage.

Chapter 1 studies the optimal income taxation with a finite number of types. It is shown that Rawlsian social welfare and maximax social welfare functions constitute upper and lower bounds for the second best optimal marginal tax schedules. Therefore any marginal tax schedule with a higher tax rate than Rawlsian bound or with a lower tax rate than maximax bound would be inefficient. Moreover, it is shown that reasonable marginal tax schedules between these two benchmarks could be supported as a second-best tax schedule with appropriate social weights. These results are also valid when bunching is optimal. Additionally, some characterization for the total tax rates at the top and bottom of the income distribution are given.

Chapter 2 analyses the labour market effects of the Syrian refugees on Turkish natives. Our results suggest that there are no negative effects on native employment but there is a compositional change in the labour market. On the contrary, we provide evidence for positive effects on formal employment which is confirmed by the administrative data. When we analyse the changes in labour outcomes by gender, results are differentiated in a systematic way. For males, while there is an increase in formal employment, informal employment decreases. Results are the opposite for females. There is a reduction in formal employment but an increase in informal female employment. These results suggest that while refugees are substitutes for females in the formal market, they are complements to formal male workers.

Chapter 3 investigates wage and employment effects of the minimum wage in Turkey. Our analysis suggests that while formal wages are increasing with the minimum wage, there is no significant change in informal market wages. For the employment outcomes, we observe a significant increase in informal employment however there is no significant change in formal employment. The increased share of informal labour is mainly due to increased labour force participation. Since females

are paid less than males, the wage and employment effects are much stronger for women. Although minimum wage is set for a calendar month, we observe no changes in formal and informal working hours.

Impact Statement

In terms of the academic impact, all of the chapters in this thesis clarify our understanding of the important aspects of labour economics. Moreover, chapters include components that could improve policy implementations.

The discussion for income taxation generally focuses on efficiency and equity concerns. Chapter 1 draws attention to the possible inefficient structure of marginal taxation and characterizes the properties of an efficient marginal tax schedule. We show that whatever the redistribution desire of the government is, tax schedule cannot be efficient if it exceeds the boundaries we identify in this chapter. Since the setups are very similar, this idea is also extendable to the non-linear pricing literature in which a characterization could be given for the efficient price levels. Some countries[1] have inefficiently high marginal tax rates and our results provide refinements for such taxation schedules. We provide a novel technique that could support a reasonable tax schedule as a second-best marginal tax schedule. Therefore for a wide range of taxation schemes, the main issue would not be the efficiency concerns but redistributive desire. Moreover, the total tax burden levied on low and high-income earners could be inefficiently high or low. Chapter 1 gives efficiency bounds for total taxes at the top and bottom of the income distribution.

Today, Turkey is the top refugee-hosting country around the world. Since immigration creates political tension in the destination countries, the economic effects of the immigrants on the native populations are excessively studied. Chapter 2 studies the employment effect of Syrian refugees on Turkish natives. This is the first study that utilizes newly available quarterly Labour Force Surveys and immigrant data using alternative estimation techniques. Chapter 2 clarifies our understanding of the effect of the refugees as it presents the most precise results so far. The endogeneity is a common problem in immigration literature and we use a novel instrument to overcome this issue. Moreover, we point out a common methodological problem in

[1] See Lorenz and Sachs (2012) for Germany.

the literature about assessing the effect of refugees in Turkey. Our results suggest that even under huge refugee influx, the labour market outcomes of the natives are not adversely affected. However, we show that women in Turkey have disadvantages compared to men.

Turkey has minimum wage legislation for many years but there exist very few studies about the topic. For the countries with a considerable informal labour market, we propose a novel approach to study the effect of the minimum wage in Chapter 3. Studies do not differentiate the bite of the minimum wage for formal and informal workers and instead utilize a single overall measure for all workers. However, bite of the minimum wage for formal and informal markets have differentiated consequences on wages and employment.

Acknowledgements

First of all, I would like to express my sincere gratitude to my advisors Guy Laroque and Ian Preston. Without your knowledge, patience and motivation this research would not be completed. Your guidance always helped me with my PhD and I am forever thankful for all the efforts and time you have given me on this.

Besides my advisors, I would like to thank Attila Lindner, Konrad Mierendorff, Uta Schoenberg, Martin Weidner from UCL Economics department who guided me on my predicaments throughout my studies and taught me a lot on this journey. Their contributions not only helped with my thesis but also gave me insights on my future career as an academician. I really appreciate all your hard work.

I am thankful for all the discussions we had with all of my colleagues who I had the great pleasure of working and studying together but there are especially 4 of them who I would like to mention here: Gavin Kader, Peter Spittal, Riccardo D'Adamo, Barbara Boelmann. Thank you for all your support and feedback. I appreciate all your input in this study and I am thankful for your kindness and understanding.

I would like to extend my gratitude for the funding I have received from numerous sources, in particular, The Council of Higher Education in Turkey and the Economics department at UCL for the tuition fee waivers.

I owe a lifetime of gratitude to my parents, my brothers and sister. This dissertation would not have been possible without their warm love, continued patience, and endless support. My success is your success.

Last, but definitely not least, I would like to express my deepest gratitude to my wife, Meriç, for her love, devotion and patience. Meriç, I could not be able to finish my PhD without your support. Thank you for being with me and for your countless sacrifices. Finally, my cute little daughter, Zeynep Nihan, thank you for being my *"hüzün kovan kuşu"* during my PhD. Allow me the honour and privilege of dedicating this thesis to you.

Contents

List of Tables

List of Figures

Chapter 1

A Characterization for Marginal Income Tax Schedules

1.1 Introduction

Efficiency and equity are the most important criteria that economists consider while assessing the outcomes of tax policy. Efficiency is about how resources are allocated in the society and it is not related to any normative judgements. However, equity is highly involved with the norms of society as it is about the distribution of the resources. The problem arises from the fact that it is not possible to fully achieve these two goals at the same time. Due to this trade-off, characterizing the properties of an efficient tax schedule becomes an important issue.

Following Mirrlees (1971), a huge literature emerged in optimal income taxation literature using models with a continuum of types. On the other hand, Guesnerie and Seade (1982), Stiglitz (1982), and Weymark (1986, 1987) analyse the non-linear income tax problem with a finite number of types. These two modelling techniques use different assumptions and arguments which makes it difficult to understand the underlying common principles. However, Hellwig (2007) forms a new perspective by developing a unified approach to optimal income taxation. He shows that by using the same assumptions in continuum and finite models, the theory of optimal income taxation could be regarded as "monolith" meaning that they are mathematically equivalent. Moreover, Bastani (2013) uses the discrete model to derive marginal tax rates and shows that continuum and discrete models give similar numerical results when the number of types is sufficiently high.

In both of the modelling techniques, the structure of the tax schedule is identified by a complex relation of several components such as ability distribution, redistributive tastes of government and the labour supply responses to a change in tax schedule. Since it is quite a complicated problem, a general utility specification

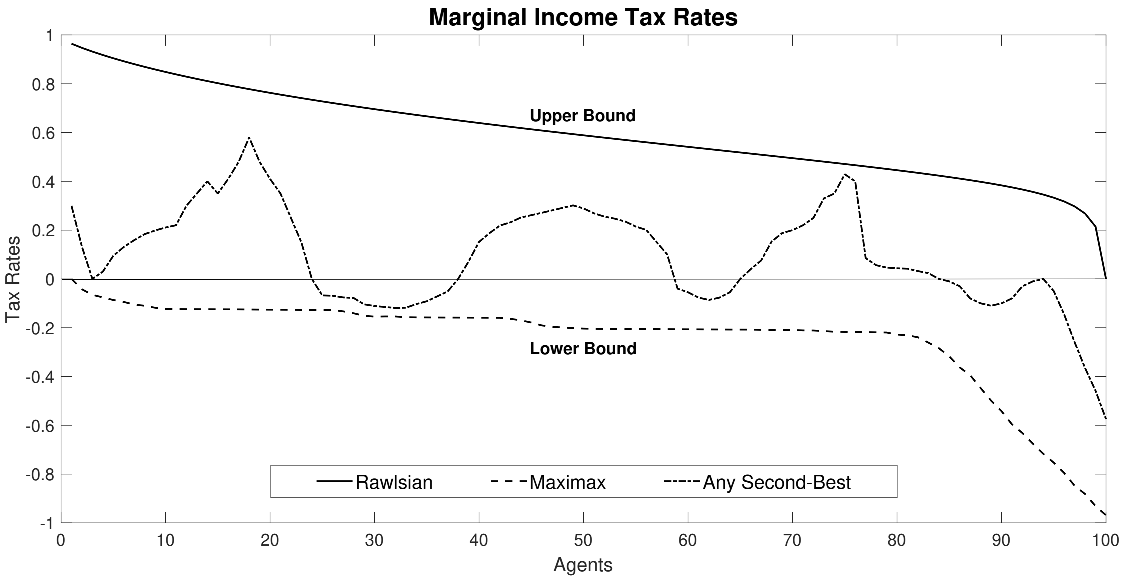

Figure 1.1: Marginal Income Tax Schedules

leads to very few analytical results[1], and many studies have to rely on the numerical simulations (Tuomala 1990).

In order to deal with the complexity of the problem, and to have clear-cut results several studies use quasi-linear utility specifications. Lollivier and Rochet (1983), Weymark (1986,1987), Ebert (1992) papers conduct the analysis by using a quasi-linear utility which is linear in labour as it provides a closed-form solution. However, this type of utility seems rather restrictive as it leads to a tax schedule that is independent of income level. Moreover, Blundell and MaCurdy (1999) shows that substitution effects have a higher impact on the labour supply than income effects, therefore instead of using a quasi-linear in labour utility, adapting a utility function which is linear in consumption seems more relevant to the general case.

In this study, we analyse the optimal income tax schedule with a finite number of types by using a quasi-linear in consumption utility. Under this setup, we give a characterization for the efficient marginal tax schedules which is summarized in Figure 1.1[2]. We show that when we have a Rawlsian social welfare function, the resulting marginal tax schedule constitutes an upper bound (or benchmark) for the

[1]Such as, zero marginal tax rate at the top (if the skill distribution is bounded) and bottom (if the lowest skill is positive and no-bunching at the bottom), also a non-negative tax schedule between 0 and 1. (Mirrlees (1971), Sadka (1976), Seade (1977)).

[2]For the numerical simulations in Figure 1.1, we employ the utility function $u(c,l) = c - \frac{l^{1+1/\varepsilon}}{1+1/\varepsilon}$. The second term is a standard form commonly used in the optimal income tax literature and we assume that utility is quasi-linear in consumption. Following Mirrlees(1971) and Tuomala(1990,2010) we use a log-normal skill distribution with parameters (μ, σ) = (-1, 0.39). Frisch elasticity of labour supply ε is set equal to 0.5. For the Rawlsian social welfare function, we set all other social weights to zero except the least able agent. Conversely, we maximize the utility of the highest able agent for Maximax social welfare function. Second-Best schedule in Figure 1.1 is derived from a random social weight distribution.

tax rates obtained by any weighted utilitarian social welfare function. There is a positive marginal tax rate along with the distribution except at the top as there is no distortion at the top hence we have zero marginal tax rate. In the weighted utilitarian social welfare function, social weights assigned by the government are generally aimed to redistribute from high-income earners to low-income earners, however other redistributive desires such as redistribution towards mean income or high-income earners are also possible. Since we allow for all social weight distributions, loosely speaking, one could say that the Rawlsian social welfare criterion gives an upper bound for all second-best marginal income tax schedules. Therefore any marginal tax schedule with a higher tax rate than Rawlsian bound would be inefficient. If the marginal tax rate is above this bound for any ability level, the government could reduce the tax rate and increase the tax revenue. Then redistributing this excess revenue would make the agents better-off. On the opposite, the maximax criterion that maximizes the utility of the highest able agent constitutes a lower bound for all second-best optimal tax schedules. In this case, there is no distortion at the bottom while there is a subsidy for other agents in the economy. Again it would be inefficient to set a lower marginal tax rate than this bound. So any efficient marginal tax schedule should be between these two benchmarks.

Moreover, we show that reasonable marginal tax schedules between these boundaries could be supported as a second-best efficient tax schedule via appropriate social weights.

Atkinson (1983) numerically shows that optimal linear tax rate is always higher under Rawlsian criterion than any other second-best case. A similar analysis is conducted by Saez (2001) for non-linear optimal taxation. Numerical simulations show that the Rawlsian criterion leads to higher marginal tax rates than the utilitarian social welfare function. In an optimal non-linear income tax model with extensive labour supply responses, Laroque (2005), and Choné and Laroque (2005) papers show that the Rawlsian social welfare criterion constitutes a benchmark for the tax schedules as well. Laroque (2005) shows that all utilitarian second best allocations are below the Laffer bound or the Rawlsian benchmark, and also proves that, under some mild conditions, any feasible allocation below Laffer bound corresponds to a second-best optimal allocation. The present study applies the same idea for marginal income tax schedules under intensive labour supply responses.

There is an ongoing discussion about the efficiency of marginal tax rates, especially for the top income earners. However, the effectiveness of the whole marginal tax schedule is not discussed very often. Bourguignon and Spadaro (2008) paper study the so-called “optimal inverse problem” which tries to recover the social welfare function (SWF) that would make the observed marginal tax rates optimal. They derive a necessary condition for the observed marginal tax rates that ensure the

SWF to be Paretian[3]. They interpret this Paretian condition as a test on the relative position of the tax schedules with respect to the “Laffer Bound”, defined as the revenue-maximizing tax system. They conclude that a tax system above the Laffer bound could only be optimal with non-Paretian social weights.

Lorenz and Sachs (2012) analyse the efficiency of the marginal tax rates in the phase-out region. They develop a similar test for marginal tax rates whether they are above the Laffer bound and thus second-best inefficient. The Laffer bound here is an extension of the Laffer argument to non-linear taxation, so the consideration is about whether the marginal tax rate at some specific income level is inefficiently high or not. They apply this test to Germany and find out that marginal tax rates are second best inefficient for the transfer phase-out region. The present study generalizes these kinds of tests to the entire distribution. Lorenz and Sachs (2012) use a quasi-linear in consumption utility. With this utility function maximizing the welfare by using Rawlsian social welfare function and maximizing the total tax revenue would generate exactly the same labour supply levels, since in the Rawlsian case government would collect the maximum possible revenue from other agents and give it to the least able individual as it only cares for the worst-off agent in the population. However, resulting allocations may not be the same due to different consumption levels. Since the marginal tax rates are independent of consumption in this utility specification, the resulting marginal tax rates will be the same.

To the best of our knowledge, Jacquet (2010) is the most relevant study for our study. By using a quasi-linear in consumption utility with an iso-elastic disutility of labour, Jacquet (2010) shows that a Rawlsian social welfare function always gives higher marginal tax rates than any second best redistributive utilitarian case. However, this result depends on the specific utility formulation and the redistribution desire of the government.

Moreover, by trusting the first order approach, Jacquet (2010) disregards the cases where bunching is optimal. The present paper shows that this result could be generalized to all labour supply functional forms, and to cases where bunching is optimal.

Due to the complexity of the problem, the characterization analysis is conducted under three separate parts.

First, we will analyse the Rawlsian case and show that Rawlsian is a benchmark for other social welfare functions where we have generally decreasing social weights ($GDSW$) for the agents. We show that under a Rawlsian SWF we have the highest downward distortion on labour supply which leads to the result that we have the highest marginal tax rate.

[3]A social welfare function is said to be Paretian if it assigns a positive social weight to each agent.

Second, we apply the same analysis to the maximax case and any SWF with generally increasing social weights ($GISW$). Similarly, we show that with $GISW$, the upward distortion for labour supply could not exceed the upward distortion in maximax case. Therefore the marginal tax schedule under maximax SWF would be a lower bound for social welfare functions with $GISW$. Since there is a downward distortion in $GDSW$ cases, this result trivially holds for those possibilities as they imply positive marginal tax rates.

Third, although the $GDSW$ and $GISW$ cases form a significant part of all second-best cases, in general, there are many other possible second-best tax schedules. For this reason, to cover all second-best cases, we analyse all the possible second best allocations and show that in any case, the downward distortion for labour supply could not be greater than the downward distortion in Rawlsian case, and on the opposite, the upward distortion could not exceed the upward distortion in maximax case. Therefore, while Rawlsian gives an upper bound for the marginal tax rates, maximax constitutes a lower bound.

We show that these results are also valid when the monotonicity constraint is binding which corresponds to bunching. Results under bunching slightly differ from the cases where pooling is not optimal.

We conduct the same three-stage analysis on the converse of the result. We show that reasonable non-negative marginal tax schedules under Rawlsian benchmark could be supported as a second-best marginal tax schedule by choosing the appropriate social weights. Also at the other extreme, any reasonable non-positive tax schedule could be supported as a second-best schedule. For the general case, we need a complicated algorithm to show that any reasonable marginal tax schedule below Rawlsian and above Maximax would overlap with a second-best tax schedule with the appropriate social weights.

For the total tax rates, Rawlsian SWF gives a lower bound for the lowest able agent and an upper bound for the most productive agent. Total tax under Rawlsian SWF and any second-best tax schedule cross only once which means Rawlsian SWF constitutes a lower bound for the lower part of the population, and an upper bound for the remaining part of the ability distribution. Under reasonable distributions for ability and social weights, this intersection occurs near the median agent which is in line with Brett and Weymark (2015) and needs to be investigated further. On the opposite extreme, maximax SWF gives a lower bound for the highest able agent total taxes and an upper bound for least able individual's taxes.

The study is organized as follows: Section 1.2 presents the model. Sections 1.3 and 1.4 derives the results for Rawlsian and maximax social welfare functions respectively. Section 1.5 analyses the general case for all social weight distributions, and section 1.6 deals with bunching cases. Section 1.7 shows that reasonable tax schedules between these two benchmarks could be supported as a second-best efficient tax schedule. Section 1.8 presents the results for total tax rates, and section 1.9 concludes. Some of the proofs are left to the Appendix A.

1.2 The Model

We study an optimal income taxation model with discrete ability types as in Guesnerie and Seade (1982), Stiglitz (1982) and Weymark (1986 and 1987). The only source for agent's heterogeneity is the labour productivity w, and in the economy, there are N productivity levels ranked in increasing order:

$$0 < w_1 < ... < w_N$$

The fraction of the population of ability w_i is π_i, with $\sum\limits_{i=1}^{N} \pi_i = 1$. It is convenient to define the cumulative distribution function as $F_i = \sum\limits_{j=1}^{i} \pi_j$, hence we have $F_N = \sum\limits_{i=1}^{N} \pi_i = 1$.

All agents have identical preferences over consumption c and labour supply l which are represented by a quasi-linear utility function $U : \mathbb{R} \times \mathbb{R}_+ \to \mathbb{R}$

$$U(c, l) = c - v(l)$$

where the function $v : \mathbb{R}_+ \to \mathbb{R}_+$ is assumed to be increasing and strictly convex with $v(0) = 0$, $\lim\limits_{l \to \infty} v'(l) \to \infty$ and $v'''(.) > 0$[4]. While agents derive utility from private consumption working generates disutility i.e. $U_c' = 1 > 0$ and $U_l' = -v'(l) < 0$.

The economy is competitive, with constant returns to scale technology; therefore agent i's gross wage rate is equal to his productivity w_i. Agent i with productivity level w_i, earns a gross income $y_i = w_i l_i$ and pays an income tax from his gross income y_i. The government knows the functional form of the utility function and the skill distribution. However, it cannot observe the productivity of the agent nor the labour supply of the agent. Therefore the government is restricted to set a non-linear tax $T(y)$ as a function of gross income y_i.

Agents choose their optimal consumption and labour choice in the market by maximizing their utility subject to their budget constraint;

[4]This assumption is used in the literature involving risk and uncertainty, and is called "prudence" by Kimball (1990) which leads to precautionary savings. In the present setup it corresponds to convex marginal disutility of labour which says as the labour supply gets larger, the increase in additional labour supply that becomes unattractive becomes larger (Simula (2010)). This assumption provides a unique optimum. Several other studies (e.g. Hellwig (2007)) prove existence and uniqueness of the solution with different but weaker set of assumptions.

$$\max_{c,l} c - v\left(l\right)$$

$$s.t.$$

$$c = wl - T\left(wl\right)$$

or equivalently if we substitute out l as $l = \frac{y}{w}$;

$$\max_{c,y} c - v\left(\frac{y}{w}\right)$$

$$s.t.$$

$$c = y - T\left(y\right)$$

The first order optimality condition of the agent's problem would be

$$1 - T^{'}\left(y\right) \equiv \Omega\left(c, y, w\right) = v^{'}\left(\frac{y}{w}\right)\frac{1}{w}$$

where $\Omega\left(c, y, w\right)$ is the marginal rate of substitution of agent w which is independent of consumption c. This formulation allows to express the marginal tax rate as $T^{'}\left(y\right) = 1 - \Omega\left(c, y, w\right)$.

The single crossing property $\frac{\partial\Omega(c,y,w)}{\partial w} < 0$ is satisfied for this specific utility form. This condition states that at any point in the (y, c) space with y and c on the horizontal and vertical axes, respectively, the indifference curve of a more productive agent is flatter than the indifference curve of a less productive agent and these curves cross only once. The intuition is, in order to produce an additional unit of output, a high productive agent does not have to work as hard as a less able agent and hence needs less compensation. The single crossing property ensures that a more able agent will end up with a higher consumption-income allocation, so that second best taxation could separate types and guarantees incentive-compatibility. It can also be exploited to rule out the global incentive comparisons, meaning that it suffices to take into account the incentive compatibility constraints that compare adjacent individuals.

An allocation for this economy is a pair of consumption level and output for individuals with different skill levels, $a = (c_i, y_i)_{i=1}^{N} \in \mathbb{R} \times \mathbb{R}_{+}$

An allocation is feasible if

$$\sum_{i=1}^{N} \pi_i c_i \leq \sum_{i=1}^{N} \pi_i y_i \tag{1.1}$$

so total consumption does not exceed total output or income.

And the allocation is incentive-compatible if

$$c_i - v\left(\frac{y_i}{w_i}\right) \geq c_j - v\left(\frac{y_j}{w_i}\right) \text{ for all } i \text{ and } j \quad (IC_{ij}) \tag{1.2}$$

so nobody has an incentive to lie about his type. Henceforth we say that an allocation is incentive feasible if it is feasible and incentive compatible.

An incentive compatibility constraint is called adjacent or local when $i = j \pm 1$, and called non-local (global) if $i \neq j \pm 1$. Since the government cannot observe the private productivity parameter, incentive compatibility should be taken into account for implementing any desired allocation.

The aim of the government is to maximize the total social welfare, defined by a weighted utilitarian welfare function $W(a) : \mathbb{R}^N \times \mathbb{R}^N_+ \to \mathbb{R}$

$$W(a) = \sum_{i=1}^{N} \pi_i \delta^i \left[c_i - v\left(\frac{y_i}{w_i}\right)\right] \tag{1.3}$$

where δ^i is the social weight of the type i agents. While the case $\delta^i = 1$ for all i gives the pure utilitarian social welfare function, the case $\delta^1 = 1$ and $\delta^i = 0$ for all $i \neq 1$ will generate the Rawlsian social welfare function where the government maximizes the utility of the lowest ability agents, whereas on the opposite extreme we have a maximax social welfare function when $\delta^N = 1$ and $\delta^i = 0$ for all $i \neq N$. We allow for all social weight distributions. Therefore redistribution does not necessarily take place from high able agents to low productive agents. Also, it is required that the function $W(.)$ be non-decreasing in each $U(c_i, l_i)$. Such welfare functions are called Paretian social welfare functions which ensure Pareto optimality of the solution. For later reference, it is practical to define the weighted cumulative social weight β_i that gives the summation of the social weight of the agents from agent 1 to agent i (i.e. $\beta_i = \sum\limits_{j=1}^{i} \pi_j \delta^j$), and also we can normalize $\beta_N = 1$ since the objective function is homogeneous of degree one in δ.

By the taxation principle of Hammond (1979) and Guesnerie (1995), setting a non-linear tax schedule is identical with choosing a specific consumption-income bundle for each agent which satisfies the incentive compatibility constraints. The optimal income tax problem is to choose an allocation $a = (c_i, y_i)_{i=1}^N$ to maximize

$$\sum_{i=1}^{N} \pi_i \delta^i \left[c_i - v\left(\frac{y_i}{w_i}\right)\right]$$

subject to feasibility condition (1.1) which must be binding at the optimum since the utility function is increasing in consumption, and incentive compatibility constraints (1.2). The Lagrangian for this problem is;

$$\mathcal{L} = \sum_{i=1}^{N} \pi_i \delta^i \left[c_i - v\left(\frac{y_i}{w_i}\right)\right] + \lambda \sum_{i=1}^{N} \pi_i \left[y_i - c_i\right] + \sum_{i=1}^{N} \sum_{\substack{j=1 \\ i \neq j}}^{N} \mu_{ij} \left[c_i - v\left(\frac{y_i}{w_i}\right) - c_j + v\left(\frac{y_j}{w_i}\right)\right]$$

where λ and μ_{ij} are non-negative multipliers. The maximization yields the following first-order conditions:

$$c_i : \pi_i \delta^i - \lambda \pi_i + \sum_{\substack{j=1 \\ i \neq j}}^{N} \mu_{ij} - \sum_{\substack{j=1 \\ i \neq j}}^{N} \mu_{ji} = 0$$

$$y_i : \pi_i \delta^i v' \left(\frac{y_i}{w_i} \right) \frac{1}{w_i} - \lambda \pi_i + \sum_{\substack{j=1 \\ i \neq j}}^{N} \mu_{ij} v' \left(\frac{y_i}{w_i} \right) \frac{1}{w_i} - \sum_{\substack{j=1 \\ i \neq j}}^{N} \mu_{ji} v' \left(\frac{y_i}{w_j} \right) \frac{1}{w_j} = 0$$

and complementary slackness conditions:

$$\lambda \sum_{i=1}^{N} \pi_i \left[y_i - c_i \right] = 0$$

$$\mu_{ij} \left[c_i - v \left(\frac{y_i}{w_i} \right) - c_j + v \left(\frac{y_j}{w_i} \right) \right] = 0 \text{ for all } i \text{ and } j.$$

However, this problem is complicated due to the number $(N(N-1))$ of the incentive compatibility constraints. It turns out that it is possible to relax the problem by reducing the number of incentive compatibility constraints with the following Lemmas.

Lemma 1. *For any incentive feasible allocation we have:* $y_i \geq y_{i-1}$ *and* $c_i \geq c_{i-1}$ *for all* $i \geq 2$*. Moreover we have* $c_i = c_{i-1}$ *if and only if* $y_i = y_{i-1}$*.*

Proof. See Appendix A. □

Lemma 1 implies that two different types either differ in both income and consumption and they are monotonically increasing with ability, or have the same bundle, in which case they are said to be bunched. In order to reduce the number of IC constraints, the following Lemma shows that only local incentive compatibility constraints matter, therefore the focus could be solely on the local incentive compatibility.

Lemma 2. *A local incentive compatible allocation is incentive compatible.*

Proof. See Appendix A. □

First, two local downward IC for adjacent agents i and $i-1$ ($IC_{i,i-1}$ and $IC_{i-1,i-2}$) imply the global downward IC between agents i and $i-2$ ($IC_{i,i-2}$). Second, two local upward IC constraints for agents i and $i+1$ imply the global upward IC between agents i and $i+2$. One can also show that $IC_{i,i-1}$, $IC_{i-1,i-2}$ and $IC_{i-2,i-3}$ imply $IC_{i,i-3}$, and etc. By starting from $i = N$ and proceeding inductively, it is possible to show that local downward incentive compatibility constraints imply all of the global downward incentive compatibility constraints. A similar argument applies to reverse direction that local upward incentive compatibility constraints imply all global upward incentive compatibility constraints. This feature is referred as the "transitivity property", which states that if the local IC constraints are satisfied then the allocation would be incentive compatible.

Then it is possible to set up the maximization problem by only using local IC constraints;

$$c_i - v\left(\frac{y_i}{w_i}\right) \geq c_{i-1} - v\left(\frac{y_{i-1}}{w_i}\right) \text{ for all } i \ (IC_{i,i-1})$$

$$c_i - v\left(\frac{y_i}{w_i}\right) \geq c_{i+1} - v\left(\frac{y_{i+1}}{w_i}\right) \text{ for all } i \ (IC_{i,i+1})$$

Hence, we have reduced the number of the necessary and sufficient IC constraints from $N(N-1)$ to $2(N-1)$, and the Lagrangian becomes;

$$\mathcal{L} = \sum_{i=1}^{N} \pi_i \delta^i \left[c_i - v\left(\frac{y_i}{w_i}\right)\right] + \lambda \sum_{i=1}^{N} \pi_i \left[y_i - c_i\right] + \sum_{i=2}^{N} \mu_{i,i-1} \left[c_i - v\left(\frac{y_i}{w_i}\right) - c_{i-1} + v\left(\frac{y_{i-1}}{w_i}\right)\right]$$

$$+ \sum_{i=1}^{N-1} \mu_{i,i+1} \left[c_i - v\left(\frac{y_i}{w_i}\right) - c_{i+1} + v\left(\frac{y_{i+1}}{w_i}\right)\right]$$

with $\mu_{1,0} = \mu_{0,1} = \mu_{N+1,N} = \mu_{N,N+1} = 0$. The first order conditions are:

$$c_i : \pi_i \delta^i - \lambda \pi_i + \mu_{i,i-1} - \mu_{i+1,i} - \mu_{i-1,i} + \mu_{i,i+1} = 0$$

$$y_i : \pi_i \delta^i v'\left(\tfrac{y_i}{w_i}\right) \tfrac{1}{w_i} - \lambda \pi_i + \mu_{i,i-1} v'\left(\tfrac{y_i}{w_i}\right) \tfrac{1}{w_i} - \mu_{i+1,i} v'\left(\tfrac{y_i}{w_{i+1}}\right) \tfrac{1}{w_{i+1}}$$
$$- \mu_{i-1,i} v'\left(\tfrac{y_i}{w_{i-1}}\right) \tfrac{1}{w_{i-1}} + \mu_{i,i+1} v'\left(\tfrac{y_i}{w_i}\right) \tfrac{1}{w_i} = 0$$

By defining $\Psi_i = \mu_{i,i-1} - \mu_{i-1,i}$ for $i = 2, ..., N$ and setting $\Psi_1 = 0$, the first order conditions for consumption become;

$$\pi_i \delta^i - \lambda \pi_i + \Psi_i - \Psi_{i+1} = 0 \text{ for all } i$$

Summing up these conditions yield $\lambda = 1$. By starting with the condition for agent one, it is possible to solve for all Ψ_i and multipliers μ_i. For all i, we have;

$$\Psi_i = \beta_{i-1} - F_{i-1}$$

and the IC constraint multipliers μ's are given by;

$$\mu_{i,i-1} = \max(0, \Psi_i) \quad \mu_{i-1,i} = -\min(0, \Psi_i)$$

then; if $\Psi_i > 0$, downward $IC_{i,i-1}$ is binding,

if $\Psi_i < 0$, upward $IC_{i-1,i}$ is binding,

and if $\Psi_i = 0$, none of $IC_{i,i-1}$ and $IC_{i-1,i}$ are binding.

Hence, once we have the distribution of social weights δ and the population share parameter π, we can find which of the IC constraints are binding in the equilibrium.

The following matrix shows all the IC constraints in the very general problem, however as we showed in Lemma 2 the local IC constraints highlighted in the matrix are sufficient to have an incentive compatible solution. Hence corresponding multipliers for other IC constraints are zero.

$$\begin{bmatrix} \boldsymbol{IC_{1,2}} & \boldsymbol{IC_{2,1}} & IC_{3,1} & IC_{4,1} & IC_{5,1} & IC_{6,1} & \dots & IC_{N,1} \\ IC_{1,3} & \boldsymbol{IC_{2,3}} & \boldsymbol{IC_{3,2}} & IC_{4,2} & IC_{5,2} & IC_{6,2} & \dots & IC_{N,2} \\ IC_{1,4} & IC_{2,4} & \boldsymbol{IC_{3,4}} & \boldsymbol{IC_{4,3}} & IC_{5,3} & IC_{6,3} & \dots & IC_{N,3} \\ IC_{1,5} & IC_{2,5} & IC_{3,5} & \boldsymbol{IC_{4,5}} & \boldsymbol{IC_{5,4}} & IC_{6,4} & \dots & IC_{N,4} \\ IC_{1,6} & IC_{2,6} & IC_{3,6} & IC_{4,6} & \boldsymbol{IC_{5,6}} & \boldsymbol{IC_{6,5}} & \dots & IC_{N,5} \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ IC_{1,N} & IC_{2,N} & IC_{3,N} & IC_{4,N} & IC_{5,N} & \dots & \boldsymbol{IC_{N-1,N}} & \boldsymbol{IC_{N,N-1}} \end{bmatrix}$$

In the following part of the study, we analyse the optimal tax schedule under no bunching, however in a later section, we will consider the cases where bunching is optimal. In the no-bunching case, the following Lemma has to hold which is identical with the non-binding monotonicity constraints.

Lemma 3. *If there is no bunching at most one of the $IC_{i,i+1}$ and $IC_{i+1,i}$ binds.*

Proof. See Appendix A. □

This is known as the "asymmetry property" in the literature (Homburg (2002)). If a downward IC constraint is binding then the corresponding upward IC constraint will be slack when the higher able agent has strictly more income *i.e.* no-bunching.

For agent i (where $i \neq 1, N$), there are four relevant IC constraints: $IC_{i-1,i}$, $IC_{i,i-1}$, $IC_{i,i+1}$, $IC_{i+1,i}$. If there is no bunching then we know that only one of ($IC_{i-1,i}$, $IC_{i,i-1}$) and ($IC_{i,i+1}$, $IC_{i+1,i}$) could be binding. Also if $IC_{i,i-1}$ and $IC_{i,i+1}$ bind at the same time, agent i will be undistorted. As noted above which of these constraints are binding at the equilibrium is identified by the magnitudes of β_{i-1}, β_i, F_{i-1}, and F_i. Table 1.1 gives these regions and binding IC constraints under each region. There will be nine possible cases for each agent.

Table 1.1: Binding IC Constraints by Model Parameters

Ψ_i/Ψ_{i+1}	$\beta_i > F_i$	$\beta_i < F_i$	$\beta_i = F_i$
$\beta_{i-1} > F_{i-1}$	$IC_{i,i-1} - IC_{i+1,i}$	$IC_{i,i-1} - IC_{i,i+1}$	$IC_{i,i-1}$
$\beta_{i-1} < F_{i-1}$	$IC_{i-1,i} - IC_{i+1,i}$	$IC_{i-1,i} - IC_{i,i+1}$	$IC_{i-1,i}$
$\beta_{i-1} = F_{i-1}$	$IC_{i+1,i}$	$IC_{i,i+1}$	–

Boadway et al. (2002) analyses the optimal income taxation with three ability levels. As they allow for all social weight distributions, there will be four different scenarios for binding IC constraints. By calling regimes these cases they characterize the optimal tax schedule and they also derive the conditions that make some specific IC constraints binding. Here the nine possible cases for each agent is just a generalization of this idea to a N-type model. There is a similar discussion in Stantcheva (2014) where she derives the conditions that make the downward local or upward local constraints binding. The optimality condition for agent i is as follows:

$$v'\left(\frac{y_i}{w_i}\right)\frac{1}{w_i} = 1 - \frac{\mu_{i+1,i}}{[\pi_i\delta^i + \mu_{i,i+1} + \mu_{i,i-1}]}\left[1 - v'\left(\frac{y_i}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]$$

$$-\frac{\mu_{i-1,i}}{[\pi_i\delta^i + \mu_{i,i+1} + \mu_{i,i-1}]}\left[1 - v'\left(\frac{y_i}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]$$

For ease of presentation, it would be better to briefly discuss the possible cases here, which would also make it easier to follow up the subsequent sections. From Table 1.1 we have the following nine possibilities for each agent i.

1-) If $\beta_{i-1} > F_{i-1}$ and $\beta_i > F_i$ then $IC_{i,i-1}$ and $IC_{i+1,i}$ bind. This is the usual case when the government has a redistributive desire from high income earners to low income earners (generally decreasing social weights). Only local downward incentive compatibility constraints are binding in the equilibrium and Rawlsian SWF is a special form of this case. Optimality condition:
$v'\left(\frac{y_i}{w_i}\right)\frac{1}{w_i} = 1 - \frac{\mu_{i+1,i}}{\pi_i\delta^i+\mu_{i,i-1}}\left[1 - v'\left(\frac{y_i}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]$ where the distortion depends on agent $i+1$.

2-) If$\beta_{i-1} > F_{i-1}$ and $\beta_i < F_i$ then $IC_{i,i-1}$ and $IC_{i,i+1}$ bind. Optimality condition:
$v'\left(\frac{y_i}{w_i}\right)\frac{1}{w_i} = 1$. There is no distortion.

3-) If $\beta_{i-1} > F_{i-1}$ and$\beta_i = F_i$ then only $IC_{i,i-1}$ binds. Optimality condition:
$v'\left(\frac{y_i}{w_i}\right)\frac{1}{w_i} = 1$. There is no distortion.

4-) If $\beta_{i-1} < F_{i-1}$ and $\beta_i > F_i$ then $IC_{i-1,i}$ and $IC_{i+1,i}$ binds. Optimality condition:
$v'\left(\frac{y_i}{w_i}\right)\frac{1}{w_i} = 1 - \frac{\mu_{i-1,i}}{\pi_i\delta^i}\left[1 - v'\left(\frac{y_i}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right] - \frac{\mu_{i+1,i}}{\pi_i\delta^i}\left[1 - v'\left(\frac{y_i}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]$ where the distortion depends on agents $i-1$ and $i+1$.

5-) If $\beta_{i-1} < F_{i-1}$ and $\beta_i < F_i$ then $IC_{i-1,i}$ and $IC_{i,i+1}$ bind. Here we have binding local upward IC constraints which is the case when we have a maximax SWF or generally increasing social weights . Optimality condition:
$v'\left(\frac{y_i}{w_i}\right)\frac{1}{w_i} = 1 - \frac{\mu_{i-1,i}}{\pi_i\delta^i+\mu_{i,i+1}}\left[1 - v'\left(\frac{y_i}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]$ where the distortion depends on agent $i-1$.

6-) If $\beta_{i-1} < F_{i-1}$ and $\beta_i = F_i$ then only $IC_{i-1,i}$ binds. Optimality condition:

$v'\left(\frac{y_i}{w_i}\right)\frac{1}{w_i} = 1 - \frac{\mu_{i-1,i}}{\pi_i \delta^i}\left[1 - v'\left(\frac{y_i}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]$ where the distortion depends on agent $i-1$.

7-) If $\beta_{i-1} = F_{i-1}$ and $\beta_i > F_i$ then only $IC_{i+1,i}$ binds. Optimality condition:

$v'\left(\frac{y_i}{w_i}\right)\frac{1}{w_i} = 1 - \frac{\mu_{i+1,i}}{\pi_i \delta^i}\left[1 - v'\left(\frac{y_i}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]$ where the distortion depends on agent $i+1$.

8-) If $\beta_{i-1} = F_{i-1}$ and $\beta_i < F_i$ then only $IC_{i,i+1}$ binds. Optimality condition:

$v'\left(\frac{y_i}{w_i}\right)\frac{1}{w_i} = 1$. There is no distortion.

9-) If $\beta_{i-1} = F_{i-1}$ and $\beta_i = F_i$ then there is no binding IC constraints. Optimality condition:

$v'\left(\frac{y_i}{w_i}\right)\frac{1}{w_i} = 1$. There is no distortion.

Under no bunching case there are three possibilities for the lowest able agent.

1-) If $\beta_1 > F_1$ then only IC_{21} binds.

$v'\left(\frac{y_1}{w_1}\right)\frac{1}{w_1} = 1 - \frac{\mu_{21}}{\pi_1 \delta^1}\left[1 - v'\left(\frac{y_1}{w_2}\right)\frac{1}{w_2}\right]$ where the distortion depends on agent 2. Since IC_{21} is binding agent 2 can be either downward distorted or undistorted. So even the agent 2 is undistorted, agent 1 will be distorted downwards.

2-) If $\beta_1 < F_1$ then only IC_{12} binds. $v'\left(\frac{y_1}{w_1}\right)\frac{1}{w_1} = 1$ there is no distortion.

3-) If $\beta_1 = F_1$ then there is no binding IC constraints, so no distortion.

Similarly, there are three possibilities for the highest able agent.

1-) If $\beta_{N-1} > F_{N-1}$ then only $IC_{N,N-1}$ binds.

$v'\left(\frac{y_N}{w_N}\right)\frac{1}{w_N} = 1$. There is no distortion.

2-) If $\beta_{N-1} < F_{N-1}$ then only $IC_{N-1,N}$ binds.

$v'\left(\frac{y_N}{w_N}\right)\frac{1}{w_N} = 1 - \frac{\mu_{N-1,N}}{\pi_N \delta^N}\left[1 - v'\left(\frac{y_N}{w_{N-1}}\right)\frac{1}{w_{N-1}}\right]$ where the distortion depends on agent $N-1$. Since $IC_{N-1,N}$ is binding agent $N-1$ can be either upward distorted or undistorted. So even the agent $N-1$ is undistorted, agent N will be distorted upwards.

3-) If $\beta_{N-1} = F_{N-1}$ then there is no binding IC constraints, hence no distortion.

Since the population share parameter π is given for the economy, the only parameter that identifies the binding IC constraints is the social weight parameter δ. Hence depending on the redistribution taste of the government, the optimal solution will be characterized by these 9 possible cases for each agent. In the following two sections, first, we will analyse the Rawlsian case and show that Rawlsian is a benchmark for other social welfare functions where we have generally decreasing social weights ($GDSW$) for the agents. Second, we will show that maximax SWF is a benchmark for all other SWF with generally increasing social weights ($GISW$). Finally, we aim to show that all other possible solutions are between these two benchmarks.

1.3 The Rawlsian Benchmark

Most of the studies in the literature deal with the cases where the government has a redistributive desire from high-income earners to low-income earners (or from high able agents to low able agents). As it is a more interesting example we first analyse the Rawlsian social welfare function and any social welfare criterion with generally decreasing social weights, which is a special form of case 1 in our formulation. When the government has a redistributive desire from high able to low able (i.e. a decreasing social weight δ^i with the ability), Weymark (1986,1987), Hellwig (2007) and many other papers show that the allocation is a simple monotonic chain to the left, which means only the downward IC constraints are relevant and binding, therefore it is possible to relax the problem. In this environment, Rawlsian SWF yields the maximum downward distortion for the agent's labour supply except for the top agent (no distortion at the top). Since the marginal tax rate is independent of consumption, this downward distortion leads to the result that marginal tax rates are positive and always higher in the Rawlsian case. This result trivially holds when we compare the Rawlsian case and any other social welfare criterion with an increasing social weight pattern, because in that case except for the lowest able agent, there exists an upward distortion leading marginal tax rates to be negative.

Questions may arise about the existence and uniqueness of a solution for this kind of problem. Because $v(.)$ is strictly convex and $v^{'''}(.) > 0$, the objective function is concave over the set $\mathbb{R}_+$. Therefore these first order conditions are both necessary and sufficient for an optimum[5]. The existence and uniqueness for this problem are discussed in several papers. Simula (2010) and Brett and Weymark (2015) mention that existence and uniqueness could be provided by using the same assumptions as we have here, however Hellwig (2010) paper shows that existence could be possible even with a weaker set of assumptions.

If we have a decreasing social weight distribution we know that only the downward IC constraints $IC_{i,i-1}$ and $IC_{i+1,i}$ are binding, and the optimality condition is:

$$v^{'}\left(\frac{y_i}{w_i}\right)\frac{1}{w_i} = 1 - \frac{\mu_{i+1,i}}{\pi_i\delta^i + \mu_{i,i-1}}\left[1 - v^{'}\left(\frac{y_i}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]$$

[5]Second order condition would be; $\mu_{i+1,i}v^{''}\left(\frac{y_i}{w_{i+1}}\right)\frac{1}{w_{i+1}^2} - \left[\pi_i\delta^i + \mu_{i,i-1}\right]v^{''}\left(\frac{y_i}{w_i}\right)\frac{1}{w_i^2} < 0$ which is satisfied as we have $v^{'''} > 0$ and $\mu_{i+1,i} = [\beta_i - F_i] < \pi_i\delta^i + \mu_{i,i-1} = [\beta_i - F_{i-1}]$

where $\mu_{i,i-1} = \beta_{i-1} - F_{i-1}$.

A sufficient condition for $\mu_{i,i-1} > 0$ is a decreasing social weight distribution (i.e. $\delta^i > \delta^j$ if $i < j$) as with these social weights β_{i-1} is always greater than F_{i-1}. Moreover for some social weight distributions, those are not always decreasing (increasing or constant for some weights), it is possible to fulfil the $\mu_{i,i-1} > 0$ condition[6]. This is also pointed out in Weymark (1987) as the social weights should not increase too rapidly with ability. Therefore a generally decreasing pattern is enough to have binding local downward IC constraints.

It is practical to rewrite the optimality conditions in the following form;

$$v'\left(l_i^{GD}\right)\frac{1}{w_i} = 1 - \frac{\beta_i - F_i}{\beta_i - F_{i-1}}\left[1 - v'\left(\frac{w_i l_i^{GD}}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]$$

where the superscript GD stands for "generally decreasing" social weights, and the Rawlsian optimality condition can be found by setting all $\delta^i = 0$ for $i \neq 1$;

$$v'\left(l_i^{R}\right)\frac{1}{w_i} = 1 - \frac{1 - F_i}{1 - F_{i-1}}\left[1 - v'\left(\frac{w_i l_i^{R}}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]$$

where the superscript R stands for Rawlsian SWF.

Since the optimal allocation is a simple monotonic chain to the left, the tax schedule is not differentiable, however it is possible to use the differentiability of the utility function to define implicit marginal tax rates as;

$$T_i'\left(y_i\right) = 1 - v'\left(\frac{l_i}{w_i}\right)$$

then optimal tax rates for $GDSW$ case will be as follows:

$T_N'\left(y_N^{GD}\right) = 0$ and

$T_i'\left(y_i^{GD}\right) = \frac{\beta_i - F_i}{\beta_i - F_{i-1}}\left[1 - v'\left(\frac{w_i l_i^{GD}}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]$

and Rawlsian marginal tax rates are;

$T_N'\left(y_N^{R}\right) = 0$ and

$T_i'\left(y_i^{R}\right) = \frac{1 - F_i}{1 - F_{i-1}}\left[1 - v'\left(\frac{w_i l_i^{R}}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]$

We know that both in the Rawlsian and $GDSW$ cases only downward IC constraints are binding. Therefore while there is no distortion at the top (zero marginal tax), it is optimal to impose a distortion on agent i to prevent agent $i+1$ from mimicking agent i by reducing his or her labour supply. For the rest of the population, there are two parts in the tax function. When we compare the first terms we can say that $\frac{1-F_i}{1-F_{i-1}}$ term is always greater than the $\frac{\beta_i - F_i}{\beta_i - F_{i-1}}$ term.

[6]Consider the following example; suppose we have 4 types, and $\pi_i = 0.25$ for all agents. A social weight distribution such as $\delta = [2, 0.8, 1, 0.2]$ is not decreasing in ability but the Lagrange multipliers for downward IC constraints are still positive.

$T_i^{'}\left(y_i^{GD}\right)$ and $T_i^{'}\left(y_i^{R}\right)$ tax rates are for the agent i, however the income levels are different in these tax functions due to the different labour supplies l_i^{GD} and l_i^{R}. In a discrete model, it may not be possible to compare the tax rates for the same income levels, but it could be possible to make this comparison with a continuum of agents. In order to compare these two tax rates, one also needs to know the labour supply of the agent i under each social welfare function. If the Rawlsian labour supply is more downward distorted than any decreasing social weights, we can conclude that marginal tax schedule under Rawlsian is always greater than second best marginal tax schedules where there is a decreasing social weight distribution. Hence, a marginal tax schedule $T_i^{'}(y_i^{R})$ under Rawlsian SWF would be an upper bound for the possible marginal tax rates for the agent i. If the labour supply of the agent i increases with any social weight δ^j, we conclude that $l_i^{GD} \geq l_i^{R}$.

Using a quasi-linear utility specification which is linear in labour, Weymark (1987) conducts a comparative statics for the welfare weights. A corresponding comparative analysis is done by Simula (2010) by using a utility function that is linear in consumption. Simula (2010) analyses the effects of increasing agent i's social weight δ^i while reducing the other agents social weights proportionately. In the absence of any normalization for the social weights, this is equivalent to increasing δ^i while holding the other social weights constant.

According to Simula (2010) when there is an increase in the social weight of agent i with all other social weights δ^j $i \neq j$ scaled down proportionately, there will be no change in the gross income y_N of the highest able agent. However, agents who have a lower ability level than agent i will have a higher gross income which means there will be a lower marginal tax rate for these agents. On the other hand, agent i's and more able agents' income levels will decrease and the marginal tax rates will increase. This analysis compares two different second best $GDSW$ income tax schedules. However our concern in this study is to compare the tax rates under Rawlsian and any second best tax schedule. So we need to check the effect of decreasing social weight of the least able agent while increasing the social weight of any agent.

Corresponding results for Theorem 2 in Weymark (1987) and Proposition 9 in Simula (2010) are as follows. When there is a change from Rawlsian to any $GDSW$ second-best we can investigate the situation as an increase in δ^j $j \neq 1$ with a decrease in δ^1. Otherwise comparison would be between any two second best cases. One can conclude that if δ^j increases, for the agents $i < j$ labour supply and income level will increase so there will be a lower tax for these agents. However for the agents $i \geq j$ there will be no change in labour supply and so in the income. Then the result is similar to Simula (2010) however in this case, if there is an increase in the δ^j agents $i \geq j$ labour supply and income will not be affected by this change. Under

$GDSW$, one could say that agents with a higher ability than agent j are in the same case as they are under the Rawlsian criterion. Theorem 2 in Weymark (1987) could be interpreted as the counterpart of this result with quasi-linear in labour utility. It is possible to adapt this theorem by analysing the effects of an increase in agent j's social weight δ^j with a corresponding decrease in δ^1. The result is the same but instead of labour, his paper compares the consumption levels. So while the agents $i < j$ would have a higher consumption, the consumption level for agents $i \geq j$ would not change. The following proposition shows that labour supply and income levels are weakly smaller under Rawlsian SWF than any utilitarian case with decreasing social weights.

Proposition 1. *For all i, $l_i^{GD} \geq l_i^R$ or equivalently $y_i^{GD} \geq y_i^R$.*

Proof. We need to show that if we switch from Rawlsian to any $GDSW$ utilitarian case labour supply of the agent i increases. From the optimality condition we have;
$v'(l_i)\frac{1}{w_i} = 1 - \frac{\beta_i - F_i}{\beta_i - F_{i-1}}\left[1 - v'\left(\frac{w_i l_i}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]$

For agent i if any δ^j with $j \leq i$ increases, the term $\frac{\beta_i - F_i}{\beta_i - F_{i-1}}$ will be the same for both Rawlsian and $GDSW$ cases, because the increase in δ^j means a corresponding decrease in δ^1. Therefore the cumulative weight β_i will be the same in both cases since it contains the δ^j term. Then labour supply levels will be the same in this case. However if any δ^j with $j > i$ increases then the corresponding term will be lower in the $GDSW$ case. Here β_i does not contain the social weight δ^j hence β_i will be lower under $GDSW$ utilitarian case. From the optimality conditions we have;

$$\frac{\beta_i - F_i}{\beta_i - F_{i-1}} = \frac{\left[1 - v'\left(l_i^{GD}\right)\frac{1}{w_i}\right]}{\left[1 - v'\left(\frac{w_i l_i^{GD}}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} \text{ and } \frac{1 - F_i}{1 - F_{i-1}} = \frac{\left[1 - v'\left(l_i^{R}\right)\frac{1}{w_i}\right]}{\left[1 - v'\left(\frac{w_i l_i^{R}}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}$$

since $\frac{1-F_i}{1-F_{i-1}} > \frac{\beta_i - F_i}{\beta_i - F_{i-1}}$ we have

$$\frac{\left[1 - v'\left(l_i^{R}\right)\frac{1}{w_i}\right]}{\left[1 - v'\left(\frac{w_i l_i^{R}}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} > \frac{\left[1 - v'\left(l_i^{GD}\right)\frac{1}{w_i}\right]}{\left[1 - v'\left(\frac{w_i l_i^{GD}}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}$$

Note that the function $f(y) = \frac{\left[1 - v'\left(\frac{y}{w_i}\right)\frac{1}{w_i}\right]}{\left[1 - v'\left(\frac{y}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}$ is decreasing in y (or l) since the numerator of its derivative;
$v''\left(\frac{y}{w_{i+1}}\right)\frac{1}{w_{i+1}^2}\left[1 - v'\left(\frac{y}{w_i}\right)\frac{1}{w_i}\right] - v''\left(\frac{y}{w_i}\right)\frac{1}{w_i^2}\left[1 - v'\left(\frac{y}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]$ is negative by convexity of $v'(.)$.

Hence, the inequality implies that $l_i^{GD} > l_i^R$ (or $y_i^{GD} > y_i^R$). □

Consequently, if a higher ability agent's social weight increases then the agent i labour supply increases, and there is no impact of an increase in social weight of a lower able agent.

With a Rawlsian SWF, the government collects the maximal amount of money from all agents, and transfers this money to the least well-off agent in the society. Intuitively, to increase the amount collected government will increase the marginal tax rates which creates a downward distortion for the labour supply. Since there is a positive social weight for other agents in the *GDSW* case, in order to increase the total welfare government should let the people work more and consume more than in the Rawlsian case. Hence, the labour supply level in Rawlsian SWF would be lower than any *GDSW* utilitarian criterion. After analysing the labour supply of agent i under two different social welfare functions, it is possible to compare the marginal tax rates under these two different cases.

Proposition 2. *For all i, $T_i^{'}(y_i^R) \geq T_i^{'}(y_i^{GD})$.*

Proof. *GDSW* case marginal tax function for agent i: $T_i^{'}(y_i^{GD}) = \frac{\beta_i - F_i}{\beta_i - F_{i-1}}\left[1 - v'\left(\frac{w_i l_i^{GD}}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]$

Rawlsian marginal tax function for agent i: $T_i^{'}(y_i^R) = \frac{1-F_i}{1-F_{i-1}}\left[1 - v'\left(\frac{w_i l_i^R}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]$

In Proposition 1 we showed that if there is an increase in δ^j for agents $j \leq i$, there will be no change in labour supply levels and $\beta_i = 1$. Hence, the marginal tax rate of the agent i is not affected by a change in social weight of himself or a lower able agent. However if δ^j for $j > i$ increases β_i will be lower than 1 and again from Proposition 1 we have $l_i^U \geq l_i^R$. Note that the function $f(y) = \left[1 - v'\left(\frac{y}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]$ is decreasing in y (or l) since its derivative $-v''\left(\frac{y}{w_{i+1}}\right)\frac{1}{w_{i+1}^2}$ is negative. So the marginal tax rate for agent i will be higher in the Rawlsian case. □

Hence, the Rawlsian case where $\delta^i = 0$ for $i \neq 1$ constitutes an upper bound for any *GDSW* optimal marginal tax rates for agent i.

The inequality $\frac{1-F_i}{1-F_{i-1}} \geq \frac{\beta_i - F_i}{\beta_i - F_{i-1}}$ depends on the assumption that cumulative social weight $\beta_i \leq 1$. If we have the reverse then at least one of the social weights has to be negative (since we have $\beta_N = \sum_{j=1}^{N} \pi_j \delta^j = 1$), which means we do not have a Paretian SWF. Marginal tax rates above the Rawlsian might be achieved by a non-Paretian SWF. Hence, Rawlsian marginal tax rates constitute an efficiency bound. Above this bound we could not have a Pareto efficient tax schedule. This condition also says that if we have a Paretian SWF then the resulting marginal tax schedule has to be below the Rawlsian bound. However below Rawlsian some marginal tax schedules could still be inefficient due to the inefficient structure of the tax schedule itself. We will further discuss these issues in section 1.7.

There is a positive tax for all agents in the discrete ability setup, however Seade (1977) shows that the optimal tax rate at the bottom should be zero if there is no bunching at the bottom. This difference is due to the continuum setup he uses. In a continuum model, the mass of the worst-off agents is zero in the utilitarian objective. Therefore it is not possible to increase the social welfare by taxing these agents and redistributing the excess revenue. However, with a Rawlsian SWF, there will be a positive tax for the worst of agent even if we have a continuous ability distribution, as these agents are the only mass in the social welfare function. In a discrete model there is a positive mass of worst-off agents both in the Rawlsian and the utilitarian SWF. Therefore there would be equity gains from a positive marginal tax in either cases.

One of the general results in optimal income taxation is the zero marginal tax for the top agent (Sadka 1976, Seade 1977), as increasing the tax rate for the highest able agent will distort his labour supply without providing any additional revenue. However this result is only valid under a bounded ability distribution assumption since in an unbounded distribution there will always be a higher income earner than any income level. Since we have a finite setup, the zero marginal tax at the top result is valid for both Rawlsian and redistributive utilitarian social welfare functions.

The preceding analysis applies to cases where we have a proper redistribution from high income earners to low income earners. However for some distribution of social weights, upward IC constraints could be binding. Since the marginal tax rate is decreasing in income for the same agent, if there is an upward distortion it necessarily means a lower (negative) marginal tax rate for the agent. Hence, in an economy where all the agents are distorted upwards, the marginal tax schedule will always be below the Rawlsian tax schedule. The next section deals with the maximax benchmark and compare marginal tax rates with the social welfare functions where we have an increasing social weight distribution.

1.4 The Maximax Benchmark

On the opposite extreme, the maximax social welfare function gives a lower bound for the marginal tax schedule as the largest upward distortion occurs under this kind of social welfare function. When all upward IC constraints are binding one can say that all of the agents are distorted upwards. In this case an upward distortion is imposed on agent i to prevent agent $i-1$ pretending to be a high able individual. In the following, we only consider the second best cases with generally increasing social weights ($GISW$) and compare them to the results for maximax SWF.

In the maximax and $GISW$ cases we know that only upward IC constraints $IC_{i-1,i}$ and $IC_{i,i+1}$ are binding, and the optimality condition is:

$$v'\left(\frac{y_i}{w_i}\right)\frac{1}{w_i}=1-\frac{\mu_{i-1,i}}{\pi_i\delta^i+\mu_{i,i+1}}\left[1-v'\left(\frac{y_i}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]$$

where $\mu_{i,i+1}=F_i-\beta_i$.

So with increasing social weights where $\delta^i>\delta^j$ if $i>j$, F_i increases faster than β_i and multiplier $\mu_{i,i+1}$ will be positive. These multipliers could also be positive for some social weight distributions those are not entirely increasing (generally increasing social weights).

Brett and Weymark (2015) analyse the optimal tax rates identified by majority voting. In this setup while the lowest able agent proposes the Rawlsian tax schedule, the top agent votes for the maximax case. For the maximax case, second order conditions for an optimum could be problematic and they refer to this problem as "ill-behaved". However it is possible to have an optimum by imposing restrictions on the parameters[7].

By plugging the multipliers the first order condition could be written as;

$$v'\left(l_i^{GI}\right)\frac{1}{w_i}=1-\frac{F_{i-1}-\beta_{i-1}}{F_i-\beta_{i-1}}\left[1-v'\left(\frac{w_il_i^{GI}}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]$$

where superscript GI stands for "generally increasing" social weights. Maximax optimality condition could be found by setting all $\delta^i=0$ for $i\neq N$.

$$v'\left(l_i^{M}\right)\frac{1}{w_i}=1-\frac{F_{i-1}}{F_i}\left[1-v'\left(\frac{w_il_i^{M}}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]$$

where superscript M states for Maximax SWF.

And the corresponding marginal tax functions;

$T_1'\left(y_1^{GI}\right)=0$ and

$T_i'\left(y_i^{GI}\right)=\frac{F_{i-1}-\beta_{i-1}}{F_i-\beta_{i-1}}\left[1-v'\left(\frac{w_il_i^{GI}}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]$

and the tax rates for maximax case are;

$T_1'(y_1^M)=0$ and

$T_i'(y_i^M)=\frac{F_{i-1}}{F_i}\left[1-v'\left(\frac{w_il_i^{M}}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]$

For both of these SWF while there is no distortion at the bottom, there is an upward distortion for all other agents. Again there are two parts in the tax function of the agents. When we compare the first terms we can say that $\frac{F_{i-1}}{F_i}$ is always

[7] Second order condition would be;
$\mu_{i-1,i}v''\left(\frac{y_i}{w_{i-1}}\right)\frac{1}{w_{i-1}^2}-[\pi_i\delta^i+\mu_{i,i+1}]v''\left(\frac{y_i}{w_i}\right)\frac{1}{w_i^2}<0$ This would hold if
$\frac{F_{i-1}-\beta_{i-1}}{F_i-\beta_{i-1}}<\frac{v''\left(\frac{y_i}{w_i}\right)\frac{1}{w_i^2}}{v''\left(\frac{y_i}{w_{i-1}}\right)\frac{1}{w_{i-1}^2}}$. As discussed in Brett and Weymark (2015), this condition is harder to hold for the upper end of the ability distribution since the difference in adjacent agents abilities is higher, and more likely to hold at the bottom of the distribution. With a smooth small increment in ability, this condition could hold. Instead of making strong assumptions, we focus on the cases where we have an optimum.

greater than or equal to $\frac{F_{i-1}-\beta_{i-1}}{F_i-\beta_{i-1}}$. Also since there is an upward distortion, the second terms are both negative. Therefore, we can say that if the labour supply of the agent is more upward distorted in maximax, then maximax SWF gives lower tax rates than any $GISW$ marginal tax schedule. The analysis is very similar to the Rawlsian and $GDSW$ cases.

Proposition 3. *For all i, $l_i^M \geq l_i^{GI}$ or equivalently $y_i^M \geq y_i^{GI}$.*

Proof. We need to show that if we switch from Maximax to any $GISW$, the labour supply of agent i decreases. From the optimality condition we have;

$$v'\left(l_i^{GI}\right)\frac{1}{w_i} = 1 - \frac{F_{i-1}-\beta_{i-1}}{F_i-\beta_{i-1}}\left[1 - v'\left(\frac{w_i l_i^{GI}}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]$$

Since under maximax we have only δ^N this condition will be as follows;

$$v'\left(l_i^{M}\right)\frac{1}{w_i} = 1 - \frac{F_{i-1}}{F_i}\left[1 - v'\left(\frac{w_i l_i^{M}}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]$$

Suppose there is an increase in δ^j where $j \geq i$, β_{i-1} will be zero. The optimality conditions would be exactly the same and there is no change in the labour supply. Now suppose δ^j increases where $j < i$, then β_{i-1} will be positive, and we have;

$$\frac{F_{i-1}}{F_i} > \frac{F_{i-1}-\beta_{i-1}}{F_i-\beta_{i-1}} \text{ which implies } \frac{\left[1-v'\left(l_i^M\right)\frac{1}{w_i}\right]}{\left[1-v'\left(\frac{w_i l_i^M}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]} > \frac{\left[1-v'\left(l_i^{GI}\right)\frac{1}{w_i}\right]}{\left[1-v'\left(\frac{w_i l_i^{GI}}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]}$$

Note that the function $f(y) = \frac{\left[1-v'\left(\frac{y}{w_i}\right)\frac{1}{w_i}\right]}{\left[1-v'\left(\frac{y}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]}$ is increasing in y (or l) since the numerator of its derivative

$$v''\left(\frac{y}{w_{i-1}}\right)\frac{1}{w_{i-1}^2}\left[1 - v'\left(\frac{y}{w_i}\right)\frac{1}{w_i}\right] - v''\left(\frac{y}{w_i}\right)\frac{1}{w_i^2}\left[1 - v'\left(\frac{y}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]$$

is positive by convexity of $v'(.)$. Otherwise, the second order condition would be violated as SOC implies;

$$\frac{v''\left(\frac{y_i}{w_i}\right)\frac{1}{w_i^2}}{v''\left(\frac{y_i}{w_{i-1}}\right)\frac{1}{w_{i-1}^2}} > \frac{F_{i-1}-\beta_{i-1}}{F_i-\beta_{i-1}} = \frac{\left[1-v'\left(\frac{y_i}{w_i}\right)\frac{1}{w_i}\right]}{\left[1-v'\left(\frac{y_i}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]}$$

Hence, the inequality implies that $l_i^M > l_i^{GI}$ (or $y_i^M > y_i^{GI}$). □

We know that the marginal tax rate for agent i decreases with the upward distortion. Since we have a higher income level under maximax for everybody, we have a lower marginal tax rate. Similar with the corresponding proposition for $GDSW$ case, under maximax criterion marginal tax rates are always lower than in any $GISW$. So while Rawlsian is an upper bound for the second-best optimal marginal tax rates, maximax constitutes a lower bound for the tax rates.

Proposition 4. *For all i, $T_i'(y_i^{GI}) \geq T_i'(y_i^M)$.*

Proof. See Appendix A. □

1.5 General Case

So far, we have shown that under generally decreasing social weights we have the Rawlsian benchmark. For the opposite case when we have generally increasing social weight distribution maximax is a lower bound and since these tax rates are negative they will always be below the Rawlsian marginal tax rates.

We previously assumed that social weights were generally decreasing or increasing with the ability. In this part, we will show that Rawlsian and Maximax SWF constitute benchmarks when there is no restriction on the distribution of social weights. It is possible that for some social weight distributions while some agents are distorted downwards, some agents could be distorted upwards. We may have different binding IC constraints and as we showed above there will be 9 different cases for each agent in the economy.

In cases 2,3,8, and 9 we have the first best so agents would be undistorted. Since we have a zero marginal tax in first best, Rawlsian marginal tax rates would be higher than these cases as we have a positive marginal tax for the agents. And, maximax marginal tax rates would be less than the first best as we have negative marginal tax rates (subsidies). The other 5 cases should be discussed separately.

Case 1 is the case we analysed above while discussing the Rawlsian benchmark. In Proposition 1 we showed that Rawlsian SWF leads to the highest downward distortion for the agents. In Proposition 2 we proved that Rawlsian gives the highest possible marginal tax rates when we have generally decreasing social weights. Clearly, since the maximax SWF gives a negative tax rate for all agents, it constitutes a lower bound for case 1.

We analysed case 5 when we discussed the maximax benchmark. While maximax constitutes a lower bound for the generally increasing social weights, the Rawlsian marginal tax schedule is an upper bound as in Rawlsian we have positive marginal tax rates whereas in case 5 we have negative rates for the agents.

Then cases 4,6, and 7 should be further investigated. Here, we will only discuss the possible magnitudes of the distortions. However, a formal proof will be provided in the following proposition with considering the changing IC constraint multipliers.

In case 6 we only have $IC_{i-1,i}$ binding. The optimality condition is;
$v'\left(\frac{y_i}{w_i}\right)\frac{1}{w_i} = 1 - \frac{\mu_{i-1,i}}{\pi_i \delta^i}\left[1 - v'\left(\frac{y_i}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]$ where the direction of the distortion depends on agent $i-1$. Agent $i-1$ is undistorted if we have case 2 ($IC_{i-1,i-2}; IC_{i-1,i}$) or case 8 ($IC_{i-1,i}$). Otherwise if we have case 5 ($IC_{i-2,i-1}; IC_{i-1,i}$) agent $i-1$ is distorted upwards. So in any case agent i would be distorted upwards and this upward distortion could not be larger than the maximax case.

In case 7 only $IC_{i+1,i}$ binds. Optimality condition is;
$v'\left(\frac{y_i}{w_i}\right)\frac{1}{w_i} = 1 - \frac{\mu_{i+1,i}}{\pi_i \delta^i}\left[1 - v'\left(\frac{y_i}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]$ where the direction of the distortion

depends on agent $i+1$. Agent $i+1$ is undistorted if we have case 2 ($IC_{i+1,i}; IC_{i+1,i+2}$) or case 3 ($IC_{i+1,i}$). Otherwise if we have case 1 ($IC_{i+1,i}; IC_{i+2,i+1}$) agent $i+1$ is distorted downwards. So in any case agent i would be distorted downward and this downward distortion could not be larger than Rawlsian case.

In case 4, $IC_{i-1,i}$ and $IC_{i+1,i}$ constraints are binding and optimality condition is; $v'\left(\frac{y_i}{w_i}\right)\frac{1}{w_i} = 1 - \frac{\mu_{i-1,i}}{\pi_i\delta^i}\left[1 - v'\left(\frac{y_i}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right] - \frac{\mu_{i+1,i}}{\pi_i\delta^i}\left[1 - v'\left(\frac{y_i}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]$ where the distortion depends on agents $i-1$ and $i+1$. As we showed in case 6, from agent $i-1$ we know for sure that there is an upward distortion effect for agent i. On the other side, in case 7 we showed that there will be a downward distortion effect from agent $i+1$. Direction of the final distortion is ambiguous but the idea is if we have a downward distortion effect it cannot exceed Rawlsian case and if we have a upward distortion it should be lower than the upward distortion under maximax SWF.

Consequently, suppose we have Rawlsian SWF with $\delta = [1, 0, 0, ..., 0]$, and we increase some δ^j which leads to a corresponding decrease in δ^1. After this increase if we still have a generally decreasing social weight distribution, as we have showed above, there will be no change for the agents where $i \geq j$. However, the labour supply of the agents below agent j will increase. If the increase in δ^j leads to a generally increasing social weight distribution, then this change will have an upward effect for all agents, and the labour supply levels will be higher than in the Rawlsian case.

For agent i, lower ability has an upward effect, and higher ability has a downward effect. If lower able agents' labour supply is distorted upwards, this leads to a higher upward distortion for agent i. On the other hand, any upward distortion for higher able agents means a lower downward effect on agent i. So in either case, when we move away from Rawls, there is an upward effect on agent i. This situation leads to the result that under Rawls we always have a higher marginal tax rate. On the other hand, upward distortion could not be greater than the maximax SWF which leads to the result that marginal tax rate is the lowest in maximax case. The example above analyses only the sign of the distortions. However, when we change the social weights, the multipliers for the IC constraints would change. In the proof for Proposition 5, we consider this change and prove the result.

Proposition 5. *For all i, $l_i^M \geq l_i \geq l_i^R$ or equivalently $y_i^M \geq y_i \geq y_i^R$.*

Proof. See Appendix A. □

Proposition 6. *For all i, $T_i'(y_i^R) \geq T_i'(y_i) \geq T_i'(y_i^M)$.*

Proof. Follows as Proposition 2. □

Hence, Rawlsian and maximax SWF appear to be the two extreme cases. Any second best Pareto efficient marginal tax schedule should be between these two benchmarks. Under this setup one could rationalize the negative marginal tax rates that are not possible under usual Mirrleesian setup. In order to have a negative tax rate, social weights should be increasing totally as in $GISW$ or partly increasing. For example, if we have a inverse-U shape for the social weight distribution where government gives the highest value to middle income earners, there will be negative rates for these agents.

The preceding sections assume that the monotonicity condition is satisfied, however in some cases it may not be the case and we could have pooling equilibria. The next section deals with the cases where bunching is optimal.

1.6 Optimal Allocation and Bunching

Bunching occurs when the income and consumption levels of two different agents are equal to each other. Similar with Boadway et al.(2002), we allow for all social weight distributions, hence both downward and upward IC constraints could be binding in the equilibrium. Lemma 3 shows that under no bunching at most one of the $IC_{i,i+1}$ and $IC_{i+1,i}$ binds. However, agents i and $i+1$ receive the same income-consumption bundle (i.e. bunching) if both constraints bind at the same time. It is convenient to analyse bunching under two different cases. First, there could be bunching due to violation of the non-negativity constraint for income level. This is called the $y = 0$ bunching, and only occurs at the bottom of the income distribution. Second, agents with different ability levels could be bunched along the income distribution which is due to the violation of the monotonicity.

Once we have a binding non-negativity condition, it is not possible to analyse the problem with first order conditions. In that case we have inequalities for the first order conditions and it is not possible to compare the magnitudes of the marginal tax rates. Therefore we will focus on the bunching that occurs at the interior of the ability distribution.

It is important to note that we need to have the same bunching sets under different social welfare considerations. Otherwise it is not possible to show the result without assuming specific distributions for social weights δ and for agent shares π.

For the sake of notational convenience we will focus on the bunching case of agent i and $i+1$. However it is possible to generalize the result for the cases where more than two agents are bunched. When agents i and $i+1$ are bunched it means that $IC_{i,i+1}$ and $IC_{i+1,i}$ are binding at the same time. The first order conditions for the other agents are exactly the same as for no-bunching. Denote y_b the income level of bunched agents, then first-order conditions for agents i and $i+1$ are:

$$(i)\colon\ v'\left(\frac{y_b}{w_i}\right)\frac{1}{w_i}\left[\pi_i\delta^i+\mu_{i,i-1}+\mu_{i,i+1}\right]-\mu_{i+1,i}v'\left(\frac{y_b}{w_{i+1}}\right)\frac{1}{w_{i+1}}-\mu_{i-1,i}v'\left(\frac{y_b}{w_{i-1}}\right)\frac{1}{w_{i-1}}$$
$$=\pi_i\delta^i-\mu_{i-1,i}+\mu_{i,i-1}+\mu_{i,i+1}-\mu_{i+1,i}$$
$$(i{+}1)\colon\ v'\left(\frac{y_b}{w_{i+1}}\right)\frac{1}{w_{i+1}}\left[\pi_{i+1}\delta^{i+1}+\mu_{i+1,i}+\mu_{i+1,i+2}\right]-\mu_{i,i+1}v'\left(\frac{y_b}{w_i}\right)\frac{1}{w_i}-\mu_{i+2,i+1}v'\left(\frac{y_b}{w_{i+2}}\right)\frac{1}{w_{i+2}}$$
$$=\pi_{i+1}\delta^{i+1}-\mu_{i,i+1}+\mu_{i+1,i}+\mu_{i+1,i+2}-\mu_{i+2,i+1}$$

by adding these conditions we have

$$\left[1-v'\left(\frac{y_b}{w_i}\right)\frac{1}{w_i}\right]=\frac{\mu_{i-1,i}}{\pi_i\delta^i+\mu_{i,i-1}}\left[1-v'\left(\frac{y_b}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]-\frac{\pi_{i+1}\delta^{i+1}+\mu_{i+1,i+2}}{\pi_i\delta^i+\mu_{i,i-1}}\left[1-v'\left(\frac{y_b}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]$$
$$+\frac{\mu_{i+2,i+1}}{\pi_i\delta^i+\mu_{i,i-1}}\left[1-v'\left(\frac{y_b}{w_{i+2}}\right)\frac{1}{w_{i+2}}\right]$$

By following similar steps as above, first we will analyse the Rawlsian and generally decreasing social weights cases. Second we will show that Maximax is a benchmark for all generally increasing social weights. Finally, we will show that it is possible to generalize this result for all other possible cases.

If we have generally decreasing social weights, we need to check whether labour supply or income level is higher in the Rawlsian case.

Proposition 7. *For all i those are bunched, $l_b^{GD}\geq l_b^R$ or equivalently $y_b^{GD}\geq y_b^R$.*

Proof. We need to show that if we switch from Rawlsian to any $GDSW$ case labour supply of the agent i increases. From the optimality condition we have;

$$\left[1-v'\left(\frac{y_b^{GD}}{w_i}\right)\frac{1}{w_i}\right]=\frac{\mu_{i+2,i+1}}{\pi_i\delta^i+\mu_{i,i-1}}\left[1-v'\left(\frac{y_b^{GD}}{w_{i+2}}\right)\frac{1}{w_{i+2}}\right]-\frac{\pi_{i+1}\delta^{i+1}}{\pi_i\delta^i+\mu_{i,i-1}}\left[1-v'\left(\frac{y_b^{GD}}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]$$

where $\mu_{i,i-1}=\beta_{i-1}-F_{i-1}$

By plugging $\mu_{i,i-1}$ we have;

$$\left[1-v'\left(\frac{y_b^{GD}}{w_i}\right)\frac{1}{w_i}\right]=\frac{\beta_{i+1}-F_{i+1}}{\beta_i-F_{i-1}}\left[1-v'\left(\frac{y_b^{GD}}{w_{i+2}}\right)\frac{1}{w_{i+2}}\right]-\frac{\pi_{i+1}\delta^{i+1}}{\beta_i-F_{i-1}}\left[1-v'\left(\frac{y_b^{GD}}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]$$

In Rawlsian case we have $\delta^i=0$ except agent 1:

$$\left[1-v'\left(\frac{y_b^R}{w_i}\right)\frac{1}{w_i}\right]=\frac{1-F_{i+1}}{1-F_{i-1}}\left[1-v'\left(\frac{y_b^R}{w_{i+2}}\right)\frac{1}{w_{i+2}}\right]$$

First, suppose any δ^j where $j\leq i$ increases. Second term on the right hand side of the first equation is zero. For the first term, β_{i+1} will be equal to one, since it contains δ^j, and any increase in δ^j means a decrease in δ^1. Hence the conditions are exactly the same as for the labour supply levels.

Second, suppose we increase δ^j where $j>i+1$. Again the second term is zero, however in this case both β_{i+1} and β_i terms will reduce. By manipulating the terms we have;

$$\frac{\left[1-v'\left(\frac{y_b^{GD}}{w_{i+2}}\right)\frac{1}{w_{i+2}}\right]}{\left[1-v'\left(\frac{y_b^{GD}}{w_i}\right)\frac{1}{w_i}\right]}=\frac{\beta_i-F_{i-1}}{\beta_{i+1}-F_{i+1}}=\frac{\pi_1\delta^1-F_{i-1}}{\pi_1\delta^1-F_{i+1}}>\frac{1-F_{i-1}}{1-F_{i+1}}=\frac{\left[1-v'\left(\frac{y_b^R}{w_{i+2}}\right)\frac{1}{w_{i+2}}\right]}{\left[1-v'\left(\frac{y_b^R}{w_i}\right)\frac{1}{w_i}\right]}$$

by convexity of $v(.)$ function we have $y_b^{GD}>y_b^R$.

In the third case the difference between bunching and no-bunching appears. In no-bunching when we increase δ^{i+1} it does not have any effect on agent $i+1$. However in bunching, because it has an effect on agent i, it will change the income level of the agent $i+1$ as well. So suppose δ^j where $j = i+1$ increases, by manipulating the optimality condition we have;

$$\frac{\left[1-v'\left(\frac{y_b^{GD}}{w_{i+2}}\right)\frac{1}{w_{i+2}}\right]}{\left[1-v'\left(\frac{y_b^{GD}}{w_i}\right)\frac{1}{w_i}\right]} = \frac{\beta_i - F_{i-1}}{\beta_{i+1}-F_{i+1}} + \frac{\pi_{i+1}\delta^{i+1}}{\beta_{i+1}-F_{i+1}}\frac{\left[1-v'\left(\frac{y_b^{GD}}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}{\left[1-v'\left(\frac{y_b^{GD}}{w_i}\right)\frac{1}{w_i}\right]} > \frac{1-F_{i-1}}{1-F_{i+1}} = \frac{\left[1-v'\left(\frac{y_b^{R}}{w_{i+2}}\right)\frac{1}{w_{i+2}}\right]}{\left[1-v'\left(\frac{y_b^{R}}{w_i}\right)\frac{1}{w_i}\right]}$$

Since $\frac{\left[1-v'\left(\frac{y_b^{GD}}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}{\left[1-v'\left(\frac{y_b^{GD}}{w_i}\right)\frac{1}{w_i}\right]}$ term on the left hand side is greater than 1, we have the strict inequality which implies $y_b^{GD} > y_b^R$. □

Consequently; suppose the agents 3 and 4 bunched, then if δ^3 increases there will be no change for these agents. However when δ^4 increases both of the agents 3 and 4's labour supply levels and income levels will increase. This could be generalized to the cases where more than two agents are bunched. If the social weight of the first agent in the bunched group increases, there will be no change in the labour supply of the bunched group. However an increase in the social weight of the second or above agents affects the labour supply of all bunched agents.

After analysing the labour supply of agent i under two different social welfare functions, it is possible to compare the marginal tax rates under two different cases.

Proposition 8. *For all i, $T_i'(y_i^R) \geq T_i'(y_i^{GD})$.*

Proof. Follows as Proposition 2. □

A similar analysis could be conducted for Maximax SWF and any generally increasing social weights case.

Proposition 9. *For all i that are bunched, $l_b^M \geq l_b^{GI}$ or equivalently $y_b^M \geq y_b^{GI}$.*

Proof. Again suppose the agents i and $i+1$ are bunched at the optimum. First order optimality conditions for the other agents are exactly the same as with the no-bunching case however condition for agent i and $i+1$ are as follows;

$$\left[1-v'\left(\frac{y_b^{GI}}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right] = \frac{\mu_{i-1,i}}{\pi_{i+1}\delta^{i+1}+\mu_{i+1,i+2}}\left[1-v'\left(\frac{y_b^{GI}}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right] - \frac{\pi_i\delta^i}{\pi_{i+1}\delta^{i+1}+\mu_{i+1,i+2}}\left[1-v'\left(\frac{y_b^{GI}}{w_i}\right)\frac{1}{w_i}\right]$$

by plugging $\mu_{i-1,i} = F_{i-1} - \beta_{i-1}$ we have;

$$\left[1-v'\left(\frac{y_b^{GI}}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right] = \frac{F_{i-1}-\beta_{i-1}}{F_{i+1}-\beta_i}\left[1-v'\left(\frac{y_b^{GI}}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right] - \frac{\pi_i\delta^i}{F_{i+1}-\beta_i}\left[1-v'\left(\frac{y_b^{GI}}{w_i}\right)\frac{1}{w_i}\right]$$

The condition for Maximax case:

$$\left[1-v'\left(\frac{y_b^{M}}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right] = \frac{F_{i-1}}{F_{i+1}}\left[1-v'\left(\frac{y_b^{M}}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]$$

First, suppose δ^j where $j \geq i+1$ increases, since we have $\beta_{i-1} = \beta_i = 0$ the conditions are exactly the same as with the income levels.

Second, suppose δ^j where $j < i$ increases, then both β_{i-1} and β_i will increase and we have;

$$\frac{\left[1-v'\left(\frac{y_b^{GI}}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]}{\left[1-v'\left(\frac{y_b^{GI}}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} = \frac{F_{i+1}-\beta_i}{F_{i-1}-\beta_{i-1}} > \frac{F_{i+1}}{F_{i-1}} = \frac{\left[1-v'\left(\frac{y_b^{M}}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]}{\left[1-v'\left(\frac{y_b^{M}}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}$$

which implies that $y_b^M > y_b^{GI}$.

Third, again this is the difference from no-bunching. If δ^j where $j = i$ increases, in the no-bunching case we know that agents who have a higher ability level will have a lower labour supply level compared to maximax case. However when we have bunching, because δ^i affects agent $i+1$, it also affects agent i. We can manipulate the conditions as;

$$\frac{\left[1-v'\left(\frac{y_b^{GI}}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]}{\left[1-v'\left(\frac{y_b^{GI}}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} = \frac{F_{i+1}-\beta_i}{F_{i-1}-\beta_{i-1}} + \frac{\pi_i\delta^i}{F_{i-1}-\beta_{i-1}}\frac{\left[1-v'\left(\frac{y_b^{GI}}{w_{i}}\right)\frac{1}{w_{i}}\right]}{\left[1-v'\left(\frac{y_b^{GI}}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} > \frac{F_{i+1}}{F_{i-1}} = \frac{\left[1-v'\left(\frac{y_b^{M}}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]}{\left[1-v'\left(\frac{y_b^{M}}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}$$

The $\frac{\left[1-v'\left(\frac{y_b^{GI}}{w_{i}}\right)\frac{1}{w_{i}}\right]}{\left[1-v'\left(\frac{y_b^{GI}}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}$ term on the left hand side is always greater than one which leads to the strict inequality implying $y_b^M > y_b^{GI}$ again in this case. □

For the other social weight distributions, we can conduct the same analysis. However in this case the possible binding constraints for the agents are different than the separating equilibrium case. We left this analysis to the Appendix A, however, in words, when we have a bunching between agent i and $i+1$ we have nine possible binding constraints, and under any of these possibilities, labour supply or income level cannot be lower than Rawlsian level and cannot exceed maximax labour supply level.

Proposition 10. *For all i those are bunched, $l_b^M \geq l_b \geq l_b^R$ or equivalently $y_b^M \geq y_b \geq y_b^R$.*

Proof. See Appendix A. □

Proposition 11. *For all b, $T_b'(y_b^R) \geq T_b'(y_b) \geq T_b'(y_b^M)$.*

Proof. Follows as Proposition 2. □

The following section deals with the reverse of the relation. We try to characterize the efficient marginal tax schedules between Rawlsian and maximax benchmarks. We show that "reasonable" tax schedules could be supported as a second best efficient tax schedule with appropriate social weights.

1.7 Converse of the Relation

The preceding analysis aims to show that any second best marginal tax schedule lies below the Rawlsian SWF marginal rates and above the maximax SWF marginal rates. In this section, we will show that any reasonable marginal tax schedule between these two benchmarks can be supported as a second best optimal tax schedule by an appropriate distribution of social weights δ. Therefore we need to solve the optimal inverse problem. In the standard approach, by using a specific social welfare function and given population parameters optimal tax problem solves the marginal income tax schedule. However, here we seek for the social weights (or SWF) that are consistent with the actual marginal tax schedules. Bourguignon and Spadaro (2008) solves the inverse problem in a continuum model with a utility form that is linear in consumption and iso-elastic with respect to labour supply. The intuition is similar for discrete and continuum models. Once we observe the marginal tax schedule we could solve for the labour supply levels. The rest is just finding the appropriate social weights that make the labour supply levels second best efficient. Bourguignon and Spadaro (2008) is an empirical study as they infer the actual marginal tax schedule from income, tax and benefit data. Here our aim is to characterize the marginal tax schedules that could be supported as efficient tax schedules.

We will start with the usual redistributive (redistribute towards poor) marginal tax schedules. Given any non-negative marginal tax schedule $T_i^{'}(Y_i) < T_i^{'}(Y_i^R)$ for all i, one can find the allocation (l_i, c_i) for all i and the corresponding social weights δ^i as follow. From the agent market condition we know that $[1 - T_i^{'}(y_i)] = \frac{v^{'}(l_i)}{w_i}$. So for each agent labour supply level is $l_i = \frac{y_i}{w_i} = v^{'-1}[w_i[1 - T_i^{'}(y_i)]]$. Once we solve for labour supply levels, we can find the consumption from the incentive compatibility constraints and feasibility constraint. For each agent the consumption will be;

$$c_i = \left\{ \sum_{j=1}^{N} \pi_j y_j + \sum_{a=1}^{i-1} \pi_a \sum_{b=a}^{i-1} [R_{b+1}] - \sum_{a=i+1}^{N} \pi_a \sum_{b=i+1}^{a} [R_b] \right\}$$

where $R_i = v(\frac{y_i}{w_i}) - v(\frac{y_{i-1}}{w_i})$

This consumption function is the corresponding function in Weymark (1986, 1987) where he uses a quasi-linear in labour utility and derives the corresponding income function. Also this is the same term that appears in Simula (2010) when he studied optimal income taxation with a quasi-linear in consumption utility[8]. Both of

[8] The corresponding consumption functions as in Weymark (1986, 1987) and Simula (2010) are as follows:

$$c_1 = \left\{ \sum_{j=1}^{N} \pi_j y_j + \sum \left[\sum_{a=j+1}^{N} \pi_a \right] \left[v\left(\frac{w_j l_j}{w_{j+1}}\right) - v\left(\frac{w_{j+1} l_{j+1}}{w_{j+1}}\right) \right] \right\}$$

$$c_i = c_1 + \sum_{j=1}^{i-1} \left[v\left(\frac{w_{j+1} l_{j+1}}{w_{j+1}}\right) - v\left(\frac{w_j l_j}{w_{j+1}}\right) \right]$$

these studies analyse the redistributive case and they solve a two step maximization problem which gives the same analytical results as we study here. The following proposition concludes the argument.

Proposition 12. *Any reasonable non-negative marginal tax schedule $T_i^{'}(y_i)$ is second best efficient with appropriate social weights.*

Proof. We solve for the social weights δ^i that lead to the marginal tax schedule $T_i^{'}(y_i)$. From the optimality condition of government problem we have $n-1$ equations $v^{'}\left(\frac{y_i}{w_i}\right)\frac{1}{w_i} = 1 - \frac{\beta_i - F_i}{\beta_i - F_{i-1}}\left[1 - v^{'}\left(\frac{y_i}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]$ for all $i \neq N$, and we also have the normalization $\sum_{i=1}^{N}\pi_i\delta^i = 1$. Since we have n equations and n unknowns we can solve for all δ^i as below:

$$\delta^i = \frac{\left[1-v^{'}\left(\frac{y_i}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}{\left[v^{'}\left(\frac{y_i}{w_i}\right)\frac{1}{w_i}-v^{'}\left(\frac{y_i}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} - \frac{\pi_{i-1}}{\pi_i}\left\{\frac{\left[1-v^{'}\left(\frac{y_{i-1}}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]}{\left[v^{'}\left(\frac{y_{i-1}}{w_{i-1}}\right)\frac{1}{w_{i-1}}-v^{'}\left(\frac{y_{i-1}}{w_i}\right)\frac{1}{w_i}\right]}\right\} \text{ for all } i \neq N.$$

and $\delta^N = \frac{1-\sum_{i=1}^{N-1}\delta^i\pi_i}{\pi_N}$

Plugging the marginal tax terms is left to the Appendix A. □

There should be a discussion for "reasonable marginal tax" schedules. It is important to note that this inversion procedure is inconsistent if the actual (or chosen) marginal tax schedule is not a solution to a problem that maximizes a social welfare function with respect to the budget constraint and IC constraints. Hence theory itself imposes restrictions on the chosen marginal tax rates. As an example if we have a marginal tax schedule which is positive for the first agent, negative for the second agent and positive for the third agent and follows like this, it is hard to find the social weights that support this tax schedule as a second best tax schedule. Even it is hard to believe that the government has such a strange redistribution desire, mathematically we could not disregard those possibilities, however it is not possible to characterize these cases. Therefore we have to restrict our attention to the "reasonable" marginal tax schedules.

First, any efficient tax schedule should satisfy the incentive compatibility constraints which also means that existing income levels should be strictly (if no bunching) monotonic. This will put conditions on the maximum and the minimum values for all marginal tax rates. From the market condition of the agent we know that $y_i = v^{'^{-1}}[w_i[1 - T_i^{'}(y_i)]]w_i$ holds for all agents in an efficient solution. So IC constraints imply that;

$$v^{'^{-1}}[w_{i+1}[1 - T_{i+1}^{'}(y_{i+1})]]w_{i+1} > v^{'^{-1}}[w_i[1 - T_i^{'}(y_i)]]w_i$$

which restricts the maximum and minimum values for marginal tax rates of agents i and $i+1$. Rewriting the inequality gives;

$$T_i^{'}(y_i) > 1 - v^{'}\left\{v^{'^{-1}}[w_{i+1}(1 - T_{i+1}^{'}(y_{i+1}))]\frac{w_{i+1}}{w_i}\right\}\frac{1}{w_i}$$

and

$$T'_{i+1}(y_{i+1}) < 1 - v' \left\{ v'^{-1}[w_i(1 - T'_i(y_i))] \frac{w_i}{w_{i+1}} \right\} \frac{1}{w_{i+1}}$$

So given the ability distribution, $T'_{i+1}(y_{i+1})$ sets the minimum value for $T'_i(y_i)$, while $T'_i(y_i)$ sets the maximum of $T'_{i+1}(y_{i+1})$. If the actual or desired tax schedule does not satisfy these conditions, it is not possible to reach that marginal tax schedule with usual optimal income tax problem.

The second restriction is the Paretian condition. In order to have a Pareto efficient tax schedule we should have a Paretian social welfare function which says that each agent in the economy should have a non-negative social welfare weight. This will restrict the choice for marginal tax schedules. In order to have non-negative social weights the following condition has to be satisfied;

$$\frac{1-\Omega_i}{1-T'_i(y_i)-\Omega_i} \geq \frac{\pi_{i-1}}{\pi_i}\left[\frac{T'_{i-1}(y_{i-1})}{1-T'_{i-1}(y_{i-1})-\Omega_{i-1}}\right]$$

where

$$\Omega_i = v'[v'^{-1}[w_i(1 - T'_i(y_i))] \frac{w_i}{w_{i+1}}] \frac{1}{w_{i+1}}.$$ [9]

Therefore once we have the ability distribution, population share and marginal tax rate for T'_{i-1}, the condition gives the minimum value for the T'_i, similarly on the other side T'_i sets the maximum marginal tax rate for T'_{i-1}.

For the preceding analysis we assume that all downward IC constraints are binding. Indeed this is the case when all agents labour supplies are distorted downward while the top agent is undistorted. Since we know the ability distribution, we could find the first best labour supply of the each agent by $l_i = v'^{-1}[w_i]$, and could check whether the downward IC constraints are binding by comparing the labour supply in the first best and the labour supply level implied by the actual marginal tax schedule. If all agents are distorted downward then we could apply the preceding analysis. Marginal tax schedule should satisfy these two conditions, if not we could not support the existing tax schedule as a second best efficient tax schedule with a generally decreasing social weights. Therefore, the second condition also shows that whether it is possible to achieve the actual tax schedule by only binding downward IC constraints.

For the opposite case, if all of the agents (except the lowest) are distorted up-

[9] By using optimality condition we could derive;

$$v'\left(\frac{y_i}{w_{i+1}}\right)\frac{1}{w_{i+1}} = v' \left\{ [v'^{-1}[w_i(1 - T'_i(y_i))]] \frac{w_i}{w_{i+1}} \right\} \frac{1}{w_{i+1}}$$

and

$$v'\left(\frac{y_{i-1}}{w_i}\right)\frac{1}{w_i} = v' \left\{ [v'^{-1}[w_{i-1}(1 - T'_{i-1}(y_{i-1}))]] \frac{w_{i-1}}{w_i} \right\} \frac{1}{w_i}$$

By plugging these conditions to the equation for social weight δ^i, we have a condition for the relation of social weight δ^i with the marginal tax rates T'_i and T'_{i-1}.

$$\delta^i = \frac{\left[1-v'\left\{\left[v'^{-1}\left[w_i(1-T'_i(y_i))\right]\right]\frac{w_i}{w_{i+1}}\right\}\frac{1}{w_{i+1}}\right]}{\left[1-T'_i(y_i)-v'\left\{\left[v'^{-1}\left[w_i(1-T'_i(y_i))\right]\right]\frac{w_i}{w_{i+1}}\right\}\frac{1}{w_{i+1}}\right]} - \frac{\pi_{i-1}}{\pi_i}\left\{\frac{T'_{i-1}(y_{i-1})}{\left[1-T'_{i-1}(y_{i-1})-v'\left\{\left[v'^{-1}\left[w_{i-1}(1-T'_{i-1}(y_{i-1}))\right]\right]\frac{w_{i-1}}{w_i}\right\}\frac{1}{w_i}\right]}\right\}$$

wards, then we know that all upward IC constraints are binding. We could apply the same analysis for non-redistributive second best schedules and maximax, and find the appropriate social weight distribution in a similar way with redistributive case. The corresponding consumption function would be;

$$c_i = \left\{ \sum_{j=1}^{N} \pi_j y_j + \sum_{a=1}^{i-1} \pi_a \sum_{b=a}^{i-1} [S_{b+1}] - \sum_{a=i+1}^{N} \pi_a \sum_{b=i+1}^{a} [S_b] \right\}$$

where $S_i = v\left(\frac{y_i}{w_{i-1}}\right) - v\left(\frac{y_{i-1}}{w_{i-1}}\right)$ and we can solve for all δ^i from optimality conditions

$$v^{'}\left(\frac{y_i}{w_i}\right)\frac{1}{w_i} = 1 - \frac{F_{i-1} - \beta_{i-1}}{F_i - \beta_{i-1}}\left[1 - v^{'}\left(\frac{y_i}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right] \text{ for all } i \neq 1.$$

and the normalization rule. These conditions yield the following equations for social weights;

$$\delta^i = \frac{\left[1 - v'\left(\frac{y_i}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]}{\left[v'\left(\frac{y_i}{w_i}\right)\frac{1}{w_i} - v'\left(\frac{y_i}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]} - \frac{\pi_{i+1}}{\pi_i}\left\{\frac{\left[1 - v'\left(\frac{y_{i+1}}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}{\left[v'\left(\frac{y_{i+1}}{w_{i+1}}\right)\frac{1}{w_{i+1}} - v'\left(\frac{y_{i+1}}{w_i}\right)\frac{1}{w_i}\right]}\right\} \text{ for all } i \neq N.$$

and

$$\delta^N = \frac{1 - \sum_{i=1}^{N-1} \delta^i \pi_i}{\pi_N}$$

The preceding two analysis are very robust and easy to implement. However, there are still marginal tax schedules between Rawlsian and Maximax that could not be covered by these two cases. In order to cover the other tax schedules between Rawlsian and maximax, we follow the following procedure. Table 1.2 shows the possible nine cases for each agent and the sign of the distortions for a 6 type example.

Table 1.2: Possible Binding IC Constraints and Sign of Distortions

Cases	***Distortion***	***Agent* 1**	***Agent* 2**	***Agent* 3**	***Agent* 4**	***Agent* 5**	***Agent* 6**
1	Downward	$IC_{2,1}$	$IC_{2,1}, IC_{3,2}$	$IC_{3,2}, IC_{4,3}$	$IC_{4,3}, IC_{5,4}$	$IC_{5,4}, IC_{6,5}$	–
7	Downward	–	$IC_{3,2}$	$IC_{4,3}$	$IC_{5,4}$	$IC_{6,5}$	–
5	Upward	–	$IC_{1,2}, IC_{2,3}$	$IC_{2,3}, IC_{3,4}$	$IC_{3,4}, IC_{4,5}$	$IC_{4,5}, IC_{5,6}$	$IC_{5,6}$
6	Upward	–	$IC_{1,2}$	$IC_{2,3}$	$IC_{3,4}$	$IC_{4,5}$	–
4	Ambiguous	–	$IC_{1,2}, IC_{3,2}$	$IC_{2,3}, IC_{4,3}$	$IC_{3,4}, IC_{5,4}$	$IC_{4,5}, IC_{6,5}$	–
2	Undistorted	$IC_{1,2}$	$IC_{2,1}, IC_{2,3}$	$IC_{3,2}, IC_{3,4}$	$IC_{4,3}, IC_{4,5}$	$IC_{5,4}, IC_{5,6}$	$IC_{6,5}$
3	Undistorted	–	$IC_{2,1}$	$IC_{3,2}$	$IC_{4,3}$	$IC_{5,4}$	–
8	Undistorted	–	$IC_{2,3}$	$IC_{3,4}$	$IC_{4,5}$	$IC_{5,6}$	–
9	Undistorted	$None$	$None$	$None$	$None$	$None$	$None$

As we mention above, when we pick a reasonable tax schedule between Rawlsian and Maximax, it is always possible to find the efficient labour supply levels from these tax rates as we have $l_i = v^{'^{-1}}[w_i[1 - T_i^{'}(y_i)]]$. Also we know the agents' labour supply level at the first-best case. After the comparison of these two labour supply levels, we could find the possible binding constraints for each agent. The rest is just finding the consistent binding IC constraints set. Once we found which IC constraints are binding we could solve for the consumption levels. Then we could find the social weight distribution that leads to the selected marginal tax schedule. This inversion procedure works if we do not cover cases where more than one agent have a zero marginal tax rate. Otherwise there will be less equations than the unknowns. For those cases the social weights could be solved with an optimization procedure subject to the first order conditions, inequalities for cumulative weighted social weights β and cumulative population share F. In a continuum setup since the IC constraint is just a differential equation, optimal inverse problem is easy to solve. However for the discrete setup, in order to solve the problem we need to find which IC constraints are binding in the optimum.

As long as the chosen marginal tax schedule (or actual tax schedule) satisfies the two efficiency condition stated above (monotonicity and Paretian), this inversion algorithm is applicable.

The next section considers the total taxes under different social welfare considerations.

1.8 Total Taxes

Rawlsian and Maximax social welfare functions constitute benchmarks for the total tax of the lowest and highest able individuals. Total tax paid for each agent is equal to the difference between his income and consumption;

$$T_i(y_i) = y_i - c_i = w_i l_i - c_i$$

For the redistributive cases we showed that consumption of agent i would be;

$$c_i = \left\{ \sum_{j=1}^{N} \pi_j y_j + \sum_{a=1}^{i-1} \pi_a \sum_{b=a}^{i-1} [R_{b+1}] - \sum_{a=i+1}^{N} \pi_a \sum_{b=i+1}^{a} [R_b] \right\}$$

where $R_i = v\left(\frac{w_i l_i}{w_i}\right) - v\left(\frac{w_{i-1} l_{i-1}}{w_i}\right)$

Total Tax at the top:

$T_N(y_N) = w_N l_N - c_N = w_N l_N - \left\{ \sum_{j=1}^{N} \pi_j y_j + \sum_{a=1}^{N-1} \pi_a \sum_{b=a}^{N-1} [R_{b+1}] \right\}$

and

$\frac{\partial T_N(y_N)}{\partial \delta^k} = w_N \frac{\partial l_N}{\partial \delta^k} - \left\{ \sum_{j=1}^{k-1} \pi_j w_j \frac{\partial l_j}{\partial \delta^k} + \sum_{a=1}^{k-1} \pi_a \sum_{b=a}^{k-1} \left[\frac{\partial R_{b+1}}{\partial \delta^k}\right] \right\} < 0$ for all k.

Which means if we increase any social weight in the population this leads to a reduction in the total tax of the highest able agent. So whatever the total tax for the other agents, we can say that Rawlsian total tax level is an upper bound for all second best allocations. Total Tax at the bottom:

$$T_1(y_1) = w_1 l_1 - c_1 = w_1 l_1 - \left\{ \sum_{j=1}^{N} \pi_j y_j - \sum_{a=2}^{N} \pi_a \sum_{b=2}^{a} [R_b] \right\}$$

and

$$\frac{\partial T_1(y_1)}{\partial \delta^k} = w_1 (\frac{\partial l_1}{\partial \delta^k}) - \left\{ \sum_{j=1}^{k-1} \pi_j w_j \frac{\partial l_j}{\partial \delta^k} - \sum_{a=2}^{N} \pi_a \sum_{b=2}^{a} \left[\frac{\partial R_b}{\partial \delta^k} \right] \right\} > 0 \text{ for all } k.$$

Then for the lowest able agent, Rawlsian total tax is a lower bound for the second best optimal tax rates. On the other hand maximax gives an lower bound for the top agent and an upper bound for the lowest able agent.

In maximax case we have the following total tax for the top agent;

$$T_N(y_N) = w_N l_N - \left\{ \sum_{j=1}^{N} \pi_j w_j \frac{\partial l_j}{\partial \delta^k} + \sum_{a=1}^{N-1} \pi_a \sum_{b=a}^{N-1} \left[\frac{\partial S_{b+1}}{\partial \delta^k} \right] \right\}$$

and

$$\frac{\partial T_N(y_N)}{\partial \delta^k} = w_N \frac{\partial l_N}{\partial \delta^k} - \left\{ \sum_{j=1}^{k-1} \pi_j w_j \frac{\partial l_j}{\partial \delta^k} + \sum_{a=1}^{k-1} \pi_a \sum_{b=a}^{k-1} \left[\frac{\partial R_{b+1}}{\partial \delta^k} \right] \right\} > 0 \text{ for all } k.$$

and for the lowest agent;

$$T_1(y_1) = w_1 l_1 - c_1 = w_1 l_1 - \left\{ \sum_{j=1}^{N} \pi_j w_j l_j - \sum_{a=2}^{N} \pi_a \sum_{b=2}^{a} [S_b] \right\}$$

and

$$\frac{\partial T_1(y_1)}{\partial \delta^k} = w_1 \frac{\partial l_1}{\partial \delta^k} - \left\{ \sum_{j=1}^{k-1} \pi_j w_j \frac{\partial l_j}{\partial \delta^k} - \sum_{a=2}^{N} \pi_a \sum_{b=2}^{a} \left[\frac{\partial S_b}{\partial \delta^k} \right] \right\} < 0 \text{ for all } k.$$

The following proposition summarizes these results:

Proposition 13. *For the highest able agent we have:* $T_N(y_N^M) \leq T_N(y_N) \leq T_N(y_N^R)$
For the lowest able agent we have: $T_1(y_1^R) \leq T_1(y_1) \leq T_1(y_1^M)$

The Rawlsian marginal tax schedule, any second best marginal tax schedule and maximax marginal tax schedule cross only once. So there is a critical point in the population below which the Rawlsian tax rate constitutes a lower bound and gives an upper bound above the threshold. It is the reverse for the maximax case, so Maximax constitutes an upper bound below the threshold ability level and gives a lower bound above the threshold. This threshold is identified by a complicated relation of social weight distribution δ, ability distribution w, and the share π of each ability in the distribution. One last point, with reasonable social weight distributions and population shares, numerical simulations show that Rawlsian and maximax SWF total tax rates are intersecting near median agent. This result is somehow similar with the optimal tax schedules those are identified by majority voting when the median voter theorem holds (Brett and Weymark (2015)).

1.9 Conclusion

In a discrete type setup assuming a quasi-linear in consumption utility, the present paper shows that Rawlsian social welfare and maximax social welfare functions constitute upper and lower bounds for the second best optimal marginal tax schedules. Also reasonable marginal tax schedules between these two benchmarks can be supported as a second best tax schedule with appropriate social weights. These results are also valid when the monotonicity constraint binds. Finally, we give some characterization for the total tax rates at the top and bottom of the income distribution.

The analysis for general setup is straightforward but a more unified approach would be better to present the results. The algorithm for finding the binding IC constraints is very robust for redistributive cases. Therefore it is possible to support any reasonable redistributive marginal tax schedule as a second best marginal tax schedule.

Under quasi-linear in consumption utility, marginal tax rates are independent of consumption. Hence social planner could change the consumption levels to satisfy constraints without any effect on the marginal rates. However, under the presence of income effect, marginal tax rates are affected by consumption. Our results in this study do not hold for the very general utility function. However, a set of weaker assumptions may be imposed to a more general utility function which would be a further contribution to the present study.

The optimal income taxation and non-linear pricing have identical setups with minor differences. We believe that the idea in this study can be extended to non-linear pricing to give a characterization for the efficient price levels.

Chapter 2

Labour Market Effect of the Refugees on Turkish Natives

2.1 Introduction

The Arab Spring, beginning with the protests in Tunisia in late 2010, spread to Syria on March 2011 and created a catastrophic damage in the country. Peaceful series of anti-government protests evolved to an armed conflict and hence a civil war. Due to the civil war many Syrians displaced within the country and a significant portion of the Syrians immigrated to many different regions around the world. However, most of them settled in the region countries; Turkey, Lebanon, Jordan, Iraq and Egypt. According to the United Nations (UNHCR) 5.5 million Syrians have fled to the neighbouring countries and Turkey hosted 3.5 million refugees at the end of 2017 which makes Turkey the top refugee-hosting country around the world.

The Turkish government has constructed refugee camps right after the first arrival of Syrians, and until the second half of 2013, Syrian refugees were generally located in the refugee camps. However as the number got larger, many Syrians who first settled in South-eastern Turkey afterwards spread all over the country.

At the beginning of the crisis both Turks and Syrians believed that the situation was temporary and would be resolved in the near future. As the Turkish government was building refugee camps to provide housing, the Turkish society was helping the refugees via various charities. However, as the Syrian crisis turned out to be insoluble and as the number of refugees reached extreme levels, the society started to discuss the possible effects of the refugees both economically and sociologically. Hence the refugee crisis created a literature about the economic effect of the refugees on the native population.

Effect of the immigrants on the native population has been a hot topic in the economics literature. Especially the refugee waves in the last decade lead many researchers to this important topic. Theoretically, as a result of immigration the canonical model predicts a decline in the wages and employment of the natives, especially for the affected groups (Altonji and Card(1991), Borjas(2013), Dustmann et al.(2016)). Refugees would shift labour supply outward but lead to a shift in labour demand as well. Combination of these shifts might create an excess supply (at least in the short-run) that leads to a reduction in the wages and employment of the natives. This potentially negative effect is expected to be higher for the natives with characteristics similar to that of the refugees. However empirical studies present conflicting results for the immigration and there is an ongoing discussion about the topic (Card(2009), Borjas and Monras(2016)). Early literature ((Altonji and Card(1991), Hunt (1992)) finds no or negligible negative effects on the natives which is assumed to be a result of weak substitutability between natives and refugees. However several studies report adverse effects of the immigrants on the native employment outcomes (Borjas et al..(1996), Borjas (2003)). There exist several other channels through which immigrants could affect the labour outcomes of the natives. Incoming refugees could change the capital allocation as it changes the marginal return of capital, also they could bring their capital to the destination country. They can also affect the internal migration patterns of the natives. Moreover since they increase the consumption base there are several demand side effects.

Several studies in the literature utilize quasi-experimental design by using the refugee influx as a natural experiment (Card (1990), Hunt(1992), Dustmann et al. (2017)). These studies generally employ Difference-in-Differences (DiD) analysis and use instruments to account for the possible endogeneity problems. They exploit the regional variation of the immigrants to analyse the labour market effects of the immigrants.[1]

This study aims to analyse the effects of the huge refugee wave on the labour market outcomes of the native Turkish people. We examine the changes in the native wages and employment status. Our results suggest that there are no negative effects on native employment as a whole but there is a compositional change in the labour market. On the contrary, we provide evidence for positive effects on employment especially for formal employment which is also verified by the administrative data. When we analyse the changes in market outcomes by gender, results are differentiated in a systematic way. For males, while there is an increase in formal employment, we observe a reduction in the informal employment. However the result is opposite for females. There is a reduction in formal employment but an increase in informal female employment. Borjas and Monras (2016) provides evidence for negative employment effects on competing natives. Our results are in line with the finding of

[1]See Dustmann et al. (2016) for a literature review.

their studies. The canonical model predicts possible positive effects for those whose skills are different from that of the refugees. Our results suggest that high skilled natives are not affected by the refugee influx. The positive and negative effects are more visible on low skilled agents and effects are differentiated by gender. It turns out that refugees crowd out female workers from the formal labour market to the informal labour market.

The present study improves the discussion about the labour market effects of immigrants on several aspects.

Our study utilizes a new quarterly Labour Force Survey (LFS) and mainly focuses on the labour market effects of the Syrian influx. Unlike the other studies about Turkey, instead of relying only on Difference-in-Differences (DiD) approach, we extend the analysis and try to verify the existing results. Failure of the common trend assumption makes DiD analysis invalid and according to our analysis it is hard to assume common trends for any selected treatment and control regions (Aksu et al.(2018)). Even if we assume that it holds at least for the short-run (one or two years), since refugee numbers were not too high and because refugees were mainly staying in the camps, it is hard to have a clear estimate for the effects on labour market outcomes. We employ usual fixed effects (OLS) and fixed effects with instrumental variable (2SLS). To check the validity of the linear model we employ non-linear form of the fixed effects model like Logit and IV-Probit. Therefore this study does not face the problems arising from common-trend assumption, the timing of the treatment or selection of treatment and control regions.

All of the existing studies are using yearly LFS, whereas our study utilizes quarterly LFS. Quarterly data let us control for the region specific seasonal effects. Sectors like agriculture, construction and tourism show seasonal patterns and with yearly LFS it is not possible to control for the seasonal effects. Once we consider the agriculture based economy in the Syrian border cities this seasonality issue becomes a critical point. We exploit the variation in the ratio of refugees within and across the regions over time to identify the effects of refugees. Since we take seasonal effects into consideration, our study presents more precise results for the effect of the Syrians.

Another problem in using yearly data is about defining the regional intensity of the refugees. Existing studies use the annual LFS and therefore the variation in the parameter of interest (such as refugee-native ratio) is very limited as they have yearly averages for each region. However, for many regions there are significant differences in these ratios along the year. In this study, we also utilize a new quarterly data for the number of the Syrians in each city of Turkey from beginning of the crisis to the end of 2017. Hence we can utilize the quarterly variation in the refugee ratio within and across the regions.

All of the existing studies have a common methodological problem. They assume that all Syrians stay in Turkey under the "Temporary Protection" status. However there is a significant Syrian population with a residence permit. Moreover, due to Syrian conflict and its spread to some regions in Iraq, Turkey faced an Iraqi refugee influx as well and this Iraqi population constitutes the largest share in residence permit holders. Turkey also receives refugees from Afghanistan and Turkic countries in Middle Asia. By using a new data for residence permit holders we check the effect of overall immigration instead of just focusing on the Syrian refugees.

As the location choice of the immigrants could be affected by the economic performance of the regions, we employ an instrumental variable approach to account for endogeneity problem. We utilize a novel instrument that includes three pieces. We use the camp populations and bilateral travel distance between cities in Turkey and Syrian provinces as instruments for Syrian refugees. For the other immigrants we use a past settlement instrument where we use the 2000 immigrant city allocation for the years 2012-2017.

To check how representative the LFS data is, we compare the results from LFS data with the administrative data. The Social Security Institution of Turkey shares monthly registered workers in the system, hence we could get the number of the formal workers for each city. We show that our estimations with LFS are consistent with the results from the administrative data.

The paper proceeds as follows. Section 2.2 summaries the studies dealing with the Turkey refugee crisis. Section 2.3 provides background on the Syrian refugees in Turkey and descriptive statistics. Section 2.4 contains a brief theoretical discussion. We describe our data sources in Section 2.5. Section 2.6 outlines our empirical strategy and Section 2.7 presents the results. We have additional analysis and robustness checks in Sections 2.8 and 2.9. Finally Section 2.10 concludes.

2.2 Review of Related Studies

The literature about the effect of immigration on the host countries is mainly focused on developed countries as the living standards make them attractive for many immigrants. However, for the forced immigrants (refugees) UNHCR (2016,2018) report that more than 80% of the refugees are hosted by developing countries. Compared to these high ratios, studies on the developing world are still very limited. Structural differences between economies of developed and developing countries could lead to differentiated consequences of immigration. High informality in the labour market turns out as a distinctive feature of the developing economies. This feature is expected to create possible job opportunities for undocumented immigrants or refugees without a work permit. Then, it seems reasonable to expect a higher competition for informal jobs and a negative effect on the informal native workers. UWT (2009) report shows that for developed countries like the UK, Belgium and Italy, undocumented immigrants have contributed to the deepening the informal economy. For Spain, Bosh and Farre (2013) investigates the relationship between immigration and the size of the informal economy and their results exhibit a significant positive relation. Bohn and Owens (2012) applies a similar analysis to the US and they find evidence that immigration is associated with informal employment especially for the construction industry.

Several studies, especially for developed countries, define informality as unregistered business including firms and self-employed agents which is referred to the extensive margin. The present study focuses on the change in intensive margin which refers to the decision of "firms that are formally registered to hire their workers with a formal contract or not" (Ulyssea (2018)). In Turkey, it is very likely to encounter formal and informal workers in the same working environment. Therefore we believe that our study sheds light on the labour market effect of immigrants under the presence of high informality.

Empirical findings for developing countries with a high informality generally suggest small negative effects, especially for the informal native workers. Maystadt and Verwimp (2014) studies the labour market effect of refugees from Rwanda and Burundi on Tanzanian native workers. They report small negative employment effects on agricultural workers. Similarly, for Colombia, Calderon-Mejia and Ibanez (2016) suggests that forced immigrants have adverse effects on the wages and employment outcomes of unskilled workers. However, for Jordan, Fallah et al. (2019) studied the Syrian refugee influx and they find that Jordanians living in areas with a high concentration of refugees have had no worse labour market outcomes than Jordanians with less exposure to the refugee influx. Moreover, they observe a slight transition from informal employment to formal employment for the native population which might be due to the complementary of the skills.

For Turkey, the discussion so far is mainly focused on the effects of refugees on native labour market outcomes and prices. There is only a handful of studies that analyse the possible effects of the Syrian refugees. The existing studies present conflicting results even though they use the same data sources. We briefly summarize and discuss the literature related to our study.

Ceritoglu et al. (2017) estimate the impact of Syrian refugees on the labour market outcomes of natives using a difference-in-differences (DiD) strategy and showed that the employment of natives is significantly affected by the immigrants. Their study utilizes the Labour Force Survey (LFS) for 2010-2013 and defines the treatment regions as the most refugee hosting 5 NUTS-2 border regions and compare them with the neighbouring 4 regions without a significant refugee mass. They found negligible effect on wages but significant negative impacts on employment outcomes especially for the informal labour market. Their study does not allow NUTS-2 region correlation of the errors leading to small standard errors. However once we cluster the standard errors at region level, their results became non-significant. Additionally their selection of control regions plays a crucial role in their results. By using different treatment and control regions we show that one should be more careful while choosing the control regions. Moreover, common trend assumption does not hold for some of the dependent variables as we relax this assumption by controlling for time-trends, results change significantly (Aksu et al. (2018)).

Akgündüz et al.(2015) applies a similar DiD analysis where they define the top 6 refugee hosting regions as treatment group and use the other NUTS-2 regions as their control group. As Ceritoglu et al.(2017) the selection of the control group is problematic since the common trend assumption is violated for these groups. They utilize aggregate employment statistics of TURKSTAT and find no effects on the native employment outcomes.

By aggregating LFS data over NUTS-2 regions from 2004 to 2015, Cengiz and Tekguc (2018) analyse the labour market outcomes of the native population. As in the other studies, they employ a DiD analysis with a binary treatment variable and to overcome the endogeneity problem and the differentiated regional trends they use the Generalized Synthetic Control methods. They use 3 border regions as their treatment group and compare these regions with their control group made of 16 NUTS-2 regions. In an alternative specification they use 2015 refugee city allocation and create ratios of refugees for post-treatment years 2012-2015. They use this intensity parameter for their OLS estimation. They found no negative effect on the employment but a positive effect on formal employment from which they put forward the complementarity of migrants and native born workers. Moreover their study shows the positive effect of immigrants on the residential building construction and new business creation. They conclude that demand side and capital inflow to the refugee hosting regions absorb the potential negative effect of the labour supply shock.

Del Carpio and Wagner (2016) employs a DiD instrumental variable approach where they use the travel distance from each Syrian governorates to the most populous city in each Turkish NUTS-2 region as their instrument. They compare year 2011 with 2014 by using the ratio of the refugees as their intensity parameter. According to their DiD-OLS and DiD-IV estimations, there is a positive effect on formal male employment but a net displacement effect for the females and low educated agents in informal employment. Due to the limited number of time periods their study cluster the standard errors at region-year level which might lead to underestimate the standard errors. They report a positive significant wage effect of the refugees which might be over-estimated as they also mentioned.

Loayza et al.(2018) estimates a structural model by using micro data from Turkey with focusing on the informality dimension of the discussion. Their study suggests that Syrian refugees lead to an increase in informality among low skill workers but generates a reduction in informality for high skill workers.

Finally a recent study Aksu et al. (2018) estimates the labour market effects of the Syrian refugees. Similar with the other studies they employ a DiD-IV method with a continuous impact parameter. They use yearly averages of refugee to native population ratio in their OLS estimates and instrument this variable with bilateral distance between Turkey regions and Syrian provinces. They report no effects on wages for men and women. However they found adverse effects on female employment and informal employment where there is one-to-one replacement in employment for native men in informal sector. On the other side their study shows a positive effect on formal employment.

Consequently, the existing literature suggests no employment effect on one side and one-to-one employment loss on the other side. Therefore, we believe that the present paper brings all the results together and clarifies our understanding about the effect of the refugees. In total, there is no significant negative employment effect of the refugees. However for males, while formal employment increases, there is a reduction in informal employment. Our results suggest the opposite for the females. While there is a negative effect on formal female employment, informal employment of the females increases with the immigrants. Our results are partially consistent with the existing studies but the differentiated effect by gender is only present in our study. We partly contribute to the literature on gender differences in employment. While there is no negative effect on total male and female employment, we observe a significant compositional change in the labour market. It turns out that females are better substitutes for immigrants and this causes a transition from the formal market to the informal market.

2.3 Background Information

Right after the Syrian crisis, Turkey started to receive refugees. Figure 2.1 shows the number of Syrians over time. By the end of 2011 in total 9,500 Syrians were living in Turkey. This number gradually increased during 2012 and had reached 170,000 at the end of the year. Almost all of the Syrians were still staying in the camps in 2012. As the number of the Syrians reached 300,000 by mid 2013, camps were no longer capable of hosting the all refugees and immigrants mainly settled down in South-Eastern Turkey. In the following years they dispersed around the country. At the end of 2013 the total number increased to 560,000. By the end of

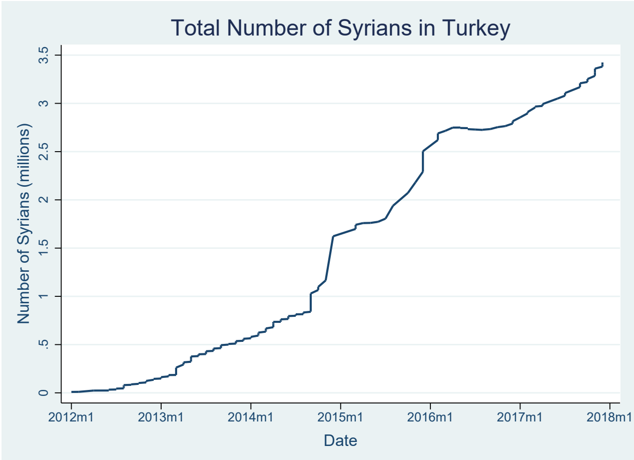

Figure 2.1: Total Number of Syrians

2014 there were 1.5 million Syrians in Turkey and the number of refugees increased to 2.5 million, 3 million and 3.5 million in 2015, 2016 and 2017, respectively.

In the beginning of the crisis, the Syrian refugees were mainly living in the camps constructed in border cities. By the end of 2017 there were 21 refugee camps in 10 border region cities with 230,000 inhabitants. During the years after 2012, many refugees moved to other cities around Turkey, but still in 2017, compared to other regions the refugee to native population ratio was very high in the border region. The ratio is around 80% for border city Kilis, and it is around 20% for the neighbouring cities.

Officially most of the Syrian refugees are registered under "Temporary Protection" and they do not hold work permits. However a very limited number of Syrians get work permits. At the end of 2016, there were 13,000 Syrians with work permit and at the end of 2017 this number reached 21,000. Compared to the huge number of refugees, work permits holders constitute 0.5% of the whole immigrant population. On the other hand, there is a significant Syrian population living with a "Residence Permit". Moreover since the Syria crisis spread to Iraq, Turkey received a significant number of immigrants from Iraq as well. According to the Ministry of Interior Directorate General for Migration Management (DGM) database, as of the end of 2017 there were 600,000 residence permit holders in Turkey and around 25% of them are from Syria and Iraq. With the global immigrant wave, Turkey became a transition point of refugees and received immigrants from Afghanistan and Turkic countries in middle Asia. Thus, other 25% of the total residence permit holders are from Afghanistan, Uzbekistan, Turkmenistan and Azerbaijan. Among the residence permit holders the share of the work permit holders is around 10%, therefore as Syrians under temporary protection, the main employment option is to work in the informal sector. Turkey has a considerable informal labour market which is on average 35% of the whole labour market. For some sectors like agriculture this ratio is around

80%. This structure of the Turkish labour market might lead to a substitution from natives to the cheaper labour force of the refugees.

Syrian immigrants cannot apply for asylum, but can make use of healthcare and education. In 2014, the Turkish government distributed Temporary Protection identity cards for the Syrians, and in order to have access to health and education they need to be registered in the system.

Table 2.1: Demographic Characteristics of Syrians and Natives

	Syrian Refugees	**Natives**
Gender		
Male	54.1	49.9
Female	45.9	50.1
Age Groups		
0-9	28.6	16.2
10-14	10.2	7.8
15-24	23.5	15.1
25-34	17.3	15.7
35-44	9.7	15.4
45-54	5.7	12.2
55-64	3.0	9.1
65+	1.8	8.6
Education		
Illiterate	23.0	10.3
Literate	14.5	10.9
Primary School	26.0	32.8
Middle School	15.8	18.3
High School	12.4	15.1
University	8.4	12.7

NOTES: Demographic characteristics of Syrians are taken from The Ministry of Interior Directorate General for Migration Management (DGM). Education information is taken from The Disaster and Emergency Management Authority(2017) report. We use 2017 LFS for native population demographics.

Table 2.1 gives a summary of demographics for the Syrians and Turkish natives. On average Syrians are younger than the natives, and their share of the male population is higher. Almost 40% of the Syrians are younger than 15 and 29% are younger than the age of 10 which we can assume as not capable of working in any job. According to ILOSTAT, the labour force participation rate in Syria before the civil war was around 43% and this ratio was around 14% for females. With the language barrier and lack of work permits these ratios are assumed to be lower in Turkey. We do not have data on the labour market status of the Syrians. However according to The Disaster and Emergency Management Authority (DEMA) 2017 survey study, 23% of the Syrian refugees have a job. While the employment ratio is around 37% for males, only 9% of the female Syrians have a job. The young population of Syrians and low labour force participation rates for the females would lower the possible effects on natives. Moreover Syrians are less educated than the natives as 37.5% of the refugees have no educational attainment and 23% of them are illiterate. These ratios are lower for natives and for each education level share for natives is higher than that of the refugees. Comparing education levels, one can conjecture that immigrants (especially males) could be a good substitute for the less-skilled native population. Moreover even the high-skilled immigrants might be downgraded because of the work permit limits or language barrier which leads them to compete with the less skilled natives in the informal market.

2.4 Theoretical Framework

Our theoretical discussion follows Borjas (2014) and Ottaviano and Peri (2012) where we assess possible outcomes of a canonical immigrant model. Massive refugee influx creates a supply shock on the labour market. However the possible effects of this shock might differ for formal and informal sector workers. Ottaviano and Peri (2012) and Dustmann et al.(2016) studied the effects on natives for different education, experience levels, and their study is extendable for different genders as well. They assume that natives and immigrants are imperfect substitutes while according to Borjas (2012) these two groups are perfect substitutes.

Suppose the aggregate production function for the national market is represented by $Q = f(K, L)$ where Q is output, K is capital and L denotes labour. Next assume that for the labour market we have an aggregator function that aggregates formal and informal labour by $L = g(L_F, L_I)$ where subscripts F and I stands for formal and informal labour, respectively. We know that refugees cannot work in the formal market but could work in the informal labour market, therefore we use two different aggregator functions for formal and informal labour in the following forms,

$$L_F = h(L_F^M, L_F^W)$$

$$L_I = k(L_I^M, L_I^W, L_I^R)$$

where superscripts M and W stand for native men and women, R stands for refugees.

In a competitive economy where each factor is paid its marginal product, wage for formal and informal native men (women) would be;

$$w_F^M = f_L(K, L) g_{L_F}(L_F, L_I) h_{L_F^M}(L_F^M, L_F^W)$$

$$w_I^M = f_L(K, L) g_{L_I}(L_F, L_I) k_{L_I^M}(L_I^M, L_I^W, L_I^R)$$

Since L depends on refugees, refugees will have an effect on the wages and labour outcomes of the natives would be affected. This effect would be identified by various components such as substitutability of formal and informal labour, substitutability of native and refugees, capital adjustments at least in the long-run and substitutability of labour and capital in the production function. Borjas (2013,2014) and Ottaviano and Peri (2012) papers assume nested CES functional forms and derive the wage equations analytically. Since we do not have detailed information for the refugees' wage and employment, we cannot reproduce the existing studies and we focus on a more descriptive reduced form equation.

For Turkey, Aksu et al.(2018) assumes that natives in formal employment and Syrian refugees are complements and natives in the informal sector and migrants are substitutes. We agree that immigrants are substitutes for informal native workers. However, formal native workers could be substituted with an immigrant as it is less costly for the employer. Clearly, if we assume that there is a substitutability between formal and informal labour, then one has to assume that immigrants are also substitute for formal native workers. Moreover anecdotal evidence suggests that employers replace their formal native workers with informal refugees while the magnitude of this substitution needs to be measured with the data.

There is a labour supply shift on the informal market which possibly lowers the wages of natives and their employment. This effect could be more visible for less skilled natives and for females. For sectors like agriculture and manufacturing, there will be no (or less) need for communication skills but some bodily power. Therefore one can expect immigrants are better substitutes for females in these sectors and the higher the substitutability the more negative employment effects. The effect is expected to be lower for the male workers as found in our estimations. According to the Labour Law, if an informal native worker reports his employer to the official authorities about his informal status, there will be a fine for the employer. However this is less likely for a refugee: hiring an immigrant would be less risky than employing a native informally.

If refugees are less substitutable with formal workers, one expects a lower negative effect on formal employment. Moreover if refugees are complements with formal workers, we can see a positive effect on formal employment. Our results suggest that these effects are differentiated by gender.

The elasticity of labour demand plays a crucial role for magnitude of the negative effects on natives. Borjas (2013) shows that the demand elasticity depends on the elasticity of substitution between capital and labour, the elasticity of product demand and the supply elasticity of capital and labour. Due to increased population in the refugee host region there will be increases in the productivity of capital, at least in the long run. But in the short run increased population will increase the demand for goods and services. This general equilibrium effects would shift the labour demand outwards for both formal and informal markets. Aksu et al.(2018) and Cengiz and Tekguc (2018) analyse the effects on the number of firms run by Syrians. Their results suggest that immigrants also bring their capital which leads to a shift in the labour demand.

Since the change in wages is identified by the elasticities of labour demand and supply, effect on native employment will be identified by these elasticities. Therefore the final effect on native wages and employment will be identified by these shifts in labour demand and supply for both the formal and informal sectors.

2.5 Data

The study mainly utilizes Turkish Household Labour Force Surveys (LFS) conducted by the Turkish Statistical Institute (TurkStat) and focuses on the working population aged 15 to 64. We study quarterly data from 2005 to 2017 for DiD analysis, hence we have, in total, 13 years and 52 quarters for 26 NUTS-2 regions. Since the number of the refugees in 2011 was too low, for DiD analysis we consider 2012 as the first year of treatment. For 2SLS and non-linear estimations we utilize data for 2012-2017. Our intensity of treatment variable for all estimations is the ratio of the refugees to the native population for each region.

All of the existing studies about the effect of the Syrian refugees assume that there are no Syrians in the LFS. However, since the surveys have an addressed based sampling procedure, if a refugee is living in the selected address they conduct the survey with the refugees as well. Although there is a nationality question in the surveys, TurkStat is not sharing this information due to political reasons. Also TurkStat officials mentioned that the data is not representative for the immigrant population. However, in the survey there is a question about the birthplace, hence this question separates the Syrian working age population as they were all born abroad. Therefore we drop the individuals born outside of Turkey.

Although the LFS has a rotating sampling procedure, TurkStat does not distribute the panel identifier hence we cannot utilize the panel dimension of the data. These repeated cross-sections cover half million observations per year and for each quarter we have on average 80,000 observations for working age population. The LFS is representative for 26 NUTS-2 level regions in Turkey. Figure 2.2 shows the Nomenclature of Territorial Units for Statistics (NUTS-1, NUTS-2 and NUTS-3) classifications of Turkey. The thick black line shows the 12 NUTS-1 regions, whereas different colours show the 26 NUTS-2 regions. Finally, the thin lines are border for each 81 NUTS-3 regions(cities).

Figure 2.2: NUTS Classifications

NOTES: Thick Black Line: NUTS-1 Regions. Colours: NUTS-2 Regions, Thin Line: NUTS-3 Regions

The LFS provide labour market outcomes of the individuals with a rich personal characteristics. Other than the employment status of the agents, the LFS contains information on wages, occupation, formal and informal sector employment, and type of the job. In Turkey informal labour is defined with the registration status of the worker with the Social Security Institution which is asked in the surveys. Therefore if a worker is not registered with the Social Security Institution we accept him as an informal worker.

Data on the numbers of the immigrants mainly comes from the Ministry of Interior Directorate General for Migration Management (DGM) database which was established in 2013. After 2016 DGM has been publishing the allocation of the Syrians to the cities weekly but before 2016 the number of Syrians was announced every 2 or 3 months. The construction and maintenance of the refugee camps are conducted by The Disaster and Emergency Management Authority (DEMA) and in the beginning of the crisis Syrians were mainly settled in these camps. The 2012 and 2013 Syrian refugees city allocation is taken from DEMA reports. We combine the data from DGM and DEMA, and construct the allocation of the Syrians for each quarter, then merge the ratio of the Syrians with the LFS.

DGM also records the number and city allocation of the residence permit holders. However city allocations are only available for years 2016 and 2017. Before 2016 we have the total number of residence permit holders for the whole country. Fortunately, Ministry of Family, Labour and Social Services (MFLS) reports the city allocation of work permits for each year and it has the monthly distribution as well. We compare the DGM data for 2016 and 2017 with MFLS work permit city allocation and they matched pretty well in terms of the city allocation. Thus, for the years before 2016 we use the work permit city allocation to construct the city allocation for residence permit holders.

For the distance instrument we use Google Maps to calculate travel distances between each city of Turkey and Syria provinces. Finally, we use TurkStat trade data for the total trade volume.

2.6 Econometric Framework

All of the existing papers estimate the labour market effect of Syrians on Turkish natives by using a DiD approach or DiD-IV methodology. While some of them use a binary treatment variable Del Carpio and Wagner (2016) and Aksu et al. (2018) utilize the fraction of immigrants as their continuous intensity parameter. For the sake of comparability with the existing studies, first we will employ the DiD analysis with our new data. Possible failure of the common trend assumption and endogeneity problem due to the location choice of the refugees lead us to estimate the labour market effects via OLS and 2SLS methods. To check the linear structure of these two, we finally implement Logit and IV-Probit techniques.

2.6.1 Difference-in-Differences (DiD) Specification

For DiD analysis, we estimate the following baseline equation,

$$Y_{irt} = \alpha + \beta R_{rt} + \delta X_{irt} + \theta Z_{rt} + \phi_r + \tau_y + \varphi_{rq} + \varepsilon_{irt} \tag{2.1}$$

where i, r and t index individuals, regions and time. Y is various outcome of interest, R_{rt} is refugee to native ratio which takes a value in the $(0, 1)$ interval after treatment year 2012. X_{irt} is a vector of individual characteristics which includes gender, ten age groups (by 5 years), four marital status, three education levels (low, medium, high), and Z_{rt} is the regional measure of economic performance which includes the logarithm of the trade volume for each NUTS-2 region. Agents with a lower degree than high school are characterized as low educated, high school graduates are medium educated and agents with a university degree are regarded as highly educated agents. While ϕ_r is NUTS-2 level region fixed effect, τ_y is time dummies for each year. Finally, φ_{rq} is NUTS-2 specific season dummies to control for seasonal heterogeneity among the regions. Our preferred equation controls for region and year effects. Additionally, since seasonal effects can vary for each region (especially for agriculture and tourism), in our preferred specification we introduce region specific season effects. In the robustness check section we have two different specifications. For the first specification we relax the common trend assumption of the DiD, thus we add NUTS-1 region specific linear time trends to the equation. In the second specification we add NUTS-1 region specific year effects. All equations are weighted by the sampling weights provided by TurkStat.

Ceritoglu et al. (2017) estimates the effect of Syrians by using 2012 and 2013 as their post treatment years. They construct their treatment region according to the ratio of refugees to the native population and they use top 5 regions as their treatment regions. They compare these regions with the neighbouring 4 regions in which the immigrant to native ratio is very low. Akgündüz et al. (2015) applies a similar DiD analysis where they define the top 6 refugee hosting regions as treatment group and use the other NUTS-2 regions as their control group. Cengiz and Tekguc (2018) applies DiD by using 3 border regions as their treatment group and compare these regions with their control group consist of 16 NUTS-2 regions. However Del Carpio and Wagner (2016) and Aksu et al. (2018) use a continuous intensity parameter, thus include all NUTS-2 regions in their DiD analysis.

For the DiD analysis the selection of the treatment and control groups plays a critical role as existing studies report conflicting results. Figure 2.3 shows the Syrian to native ratios for 26 NUTS-2 regions from beginning of 2012 to the end of 2017. Five regions above the upper dashed red line are very close to Syria border and hosts a very large proportion of Syrians. Therefore it seems plausible to take these regions as the treatment group. However since we utilize a continuous intensity parameter we include all NUTS-2 regions in our DiD estimations, but will check the validity of the common-trend assumption by comparing the labour market outcomes of the regions above upper red dashed line and below the lower red dashed line. To account for the effect of group selection, we create three different treatment allocations. First, we use top 5 refugee hosting regions as treatment group and for the control regions, we use the ones below the lower dashed red line where the Syrian ratio is nil for most of the period and is lower than 0.5% even at the end of 2017. Therefore we drop the regions between the two red dashed lines. Second, we again take the top five regions as treatment group and compare them with the rest of the regions. Third, we separate the regions with dashed black line (2%) and we define the upper part as the treatment group and the lower part as the control group. We left this comparison to the robustness section where we conclude that groups design affects the DiD coefficients but does not alter the general results.

2.6.1.1 Instruments

Since the location choice of the immigrants may depend on the regional economic performance, one should deal with the endogeneity problem. At the beginning of the crisis the government placed immigrants in refugee camps which is believed to be exogenous to the economic factors. Camps are generally located in border cities and they are very close to the border. However there are camps in the neighbouring

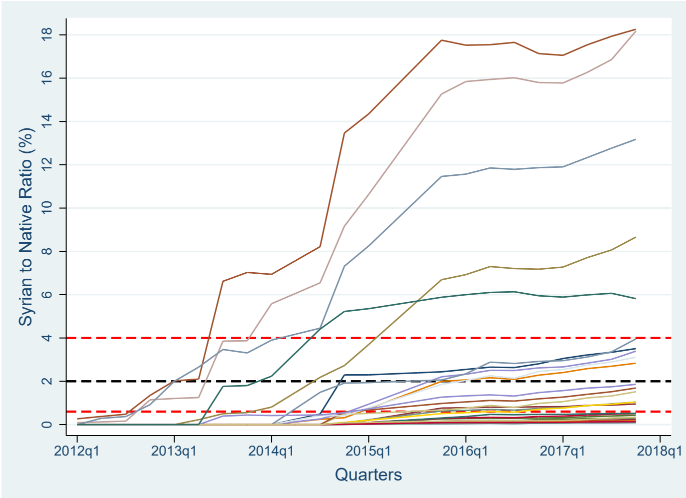

Figure 2.3: Syrian to Native Population Ratio by Regions

cities as well. The crucial thing here is the location choice of the government. Camps that are constructed in non-border cities(Kahramanmaras, Malatya, Adana, Adiyaman) are not due to location choice of the refugees. The government built the camps and settled the refugees to the camps. Before the construction of camps, there were no Syrians in these cities. After 2013 the number of immigrants exceeded the camp capacities and they spread all over the country. To deal with the potential endogeneity problem we employ a two-piece instrument where the first part uses the camp population. The second part is a very common distance instrument similar to Del Carpio and Wagner (2016) and Aksu et al.(2018). There are 81 cities in Turkey and 13 different governorates in Syria. We calculate the travel distance from each city in Turkey to each region in Syria and utilize this distance to create an instrument for the Syrian share. We define the instrument as follows;

$$IV_{ct} = Camp_{ct} + \sum_{s=1}^{13} \frac{\pi_s T_t}{d_{cs}}$$

where $Camp_{ct}$ is the number of immigrants living in refugee camps in city c at time t, π_s is the share of Syrians living in Turkey who is originally from region s in Syria. Disaster And Emergency Management Presidency (DEMA) makes survey analysis for immigrants background information in which they include the shares of their past settlement in Syria. Figure 2.4 presents the regional background of the Syrians for 2017 where we get the information from DEMA (2014, 2017) reports. We have regional background of the Syrians for the years before 2015 and after 2015. T_t is the total number of Syrians in Turkey staying outside of the camps at time t, and d_{cs} is the travel distance from city c in Turkey to region s in Syria. Since LFS is representative for 26 NUTS-2 regions, we aggregate the city instruments for NUTS-2 levels. The second part of our instrument is similar to that of Aksu et al.(2018) where they use the total number of Syrians. However we subtract the camp populations and distribute the total out of camp population by cities.

Location choice of the Syrian immigrants in Turkey is highly related to proximity to Syria due to two main reasons. First, all the refugee camps are located either in border cities or neighbouring cities. Second, surveys and anecdotal evidence suggest that many refugees have family members in Syria. Moreover, some of the refugees still run their business and there are peasants who still utilize their lands in Syria. In this respect, it seems quite rational to settle down near the border. Taking these into consideration, our distance-based instrument is expected to be a strong instrument as it is highly correlated with the Syrian settlement pattern. It is important to note that regional economic performance is not correlated with our instrument in a systematical way. High refugee-hosting cities like Gaziantep, Hatay, Adana and Mersin are major industrialized cities in Turkey. Moreover, there are no monotonic changes in employment opportunities as one moves away from the border region. The second part of our instrument allocate the off-camp Syrian refugees to cities in Turkey, therefore it gives more weight to the border cities. Allocating the whole population is another alternative as Aksu et al. (2018) employs. However, our instrument has better first-stage regression results with a higher F-statistics. Nevertheless, these two instruments give very similar results as the share of the camp population is only around 7% of the whole refugees.

For the sake of comparability with the existing studies, we will first analyse the Syrian refugees under temporary protection status. However as we mentioned before, there is a significant Syrian population with residence permit. Additional to the Syrians we take into account the all other residence permit holders. Since endogeneity is also present here, we instrument the number of residence permit holders with a past settlement variable. From TurkStat International Migration Statistics we have the city allocation of the immigrants for year 2000. We use city allocation information to distribute the total number of residence permit holders for the years 2012-2017. So we add the following piece to our instrument,

$$\sigma_c P_t$$

where σ_c is the share of immigrants in city c in year 2000 and P_t is the total number of residence permit holders at time t.

2.6.2 OLS and 2SLS Specifications

DiD analysis depends on the common-trend assumption for treatment and control groups which might failed to be satisfied in our case. We use an intensity parameter for the treatment therefore DiD assumes that regions with low number of refugees

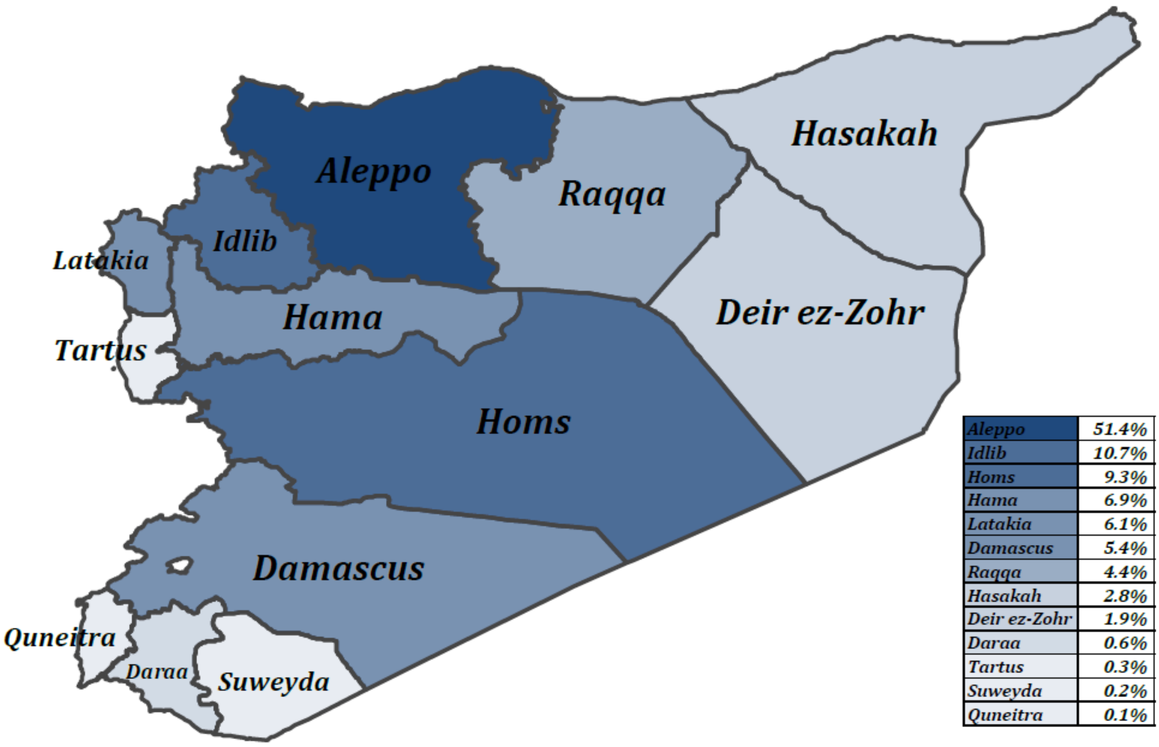

Figure 2.4: Regional Background of Syrian Refugees

and top refugee hosting regions have similar patterns for the dependent variables. Changes in the coefficients when we include region specific time trends can be an argument against the common-trend assumption. In Appendix B Figure B1, we present the shares of selected labour market outcomes for both treatment (above upper red line in Figure 2.3) and control (below lower red line) regions. Visually, one can say that while the common-trend assumption holds for some labour outcomes, it fails to satisfy all labour market outcomes. Aksu et al.(2018) also points out the failure of the common-trend assumption by using years 2004-2015. Therefore, we analyse the effects of the Syrians by using Ordinary Least Square method. Our specification is very similar to equation (2.1), where we use the ratio of immigrants to native population for each region. We apply the analysis for 2012-2017. Next, by using the same (three-piece for all immigrants analysis) instrument we employ 2SLS to estimate the effect of the immigrants.

2.6.3 Logit and IV-Probit

Since we have a binary dependent variable applying a linear probability model could be problematic. Therefore we relax the linear structure of equation (2.1) and estimate the following equation for the various labour market outcomes.

$$logit(Y_{irt}) = \alpha + \beta R_{rt} + \delta X_{irt} + \theta Z_{rt} + \phi_r + \tau_y + \varphi_{rq} + \varepsilon_{irt} \tag{2.2}$$

First we apply a logistic estimation which assumes a logistic distribution for the error terms ε_{ist}. Since Logit model also suffers from possible endogeneity, next we apply a IV-Probit model. Our aim for non-linear estimation could be regarded as a robustness check to verify the performance of the linear probability model.

2.7 Results

2.7.1 Employment Effects

Tables 2.2 and 2.3 present the estimation results for males and females, respectively and we left the estimation results for the full sample to the Appendix B Table B1. While the left panel of each table shows the DiD results which covers 2005-2017 period, the right panel presents the results for OLS, 2SLS and non-linear estimations where we restrict the sample to 2012-2017 period. The first row of the table presents the total employment effect which summation of formal and informal employment. While the public worker category covers all public employees, other workers are referred to private workers and wage worker category contains all paid employees in the public and private sector. The estimations are generally consistent, especially for the significant coefficients values are similar for DiD-2SLS and 2SLS. According to the DiD-2SLS 1% increase in refugee native ratio corresponds to a 0.70% ($\frac{0.338}{0.479}$) increase in formal male employment, and from 2SLS we have a 0.77% ($\frac{0.389}{0.503}$) increase in formal male employment. We report the average marginal effects for Logit and IV-Probit. Estimates for linear and non-linear models are pretty close, hence linear model works well in this setup. We report first stage regression results and F-statistics which is higher than what is suggested in the literature. Since the refugees settled down in border cities, it seems normal to have such a strong instrument.

For the formal employment, while employment of men increases, there is a reduction in the formal employment of women. Comparing the mean of dependent variables for men and women, there is a huge decrease in the formal employment of native women. As for the informal sector, employment for males decreases with immigration and female informal employment increases. It seems that immigrants are substitutes for females in the formal market as employers substitute formal native female workers with cheaper informal immigrants. This might lead female workers to the informal labour market. Additionally for women, the likelihood of being a public worker increases with the immigrants share which can be due to the increased government investments in the refugee hosting regions or simply the increased population in the region. We observe a significant reduction in the employment of male wage workers. In Appendix B Table B1 we present the results for the total sample. Since the effects are opposite for males and females, the resulting effects are small in magnitude and mostly insignificant. However even for the full sample, we observe a positive and significant change in formal employment.

Table 2.2: Effect of Syrians on Native Males

Males	Mean Y	DiD-OLS	DiD-2SLS	Mean Y	OLS	2SLS	Logit	IV-Probit
Employment	0.689	-0.004	-0.057	0.699	0.042	0.025	0.033	0.018
		(0.120)	(0.137)		(0.165)	(0.236)	(0.154)	(0.219)
Formal Emp	0.479	0.276***	0.338***	0.503	0.189***	0.389***	0.183***	0.405***
		(0.071)	(0.113)		(0.039)	(0.122)	(0.045)	(0.084)
Informal Emp	0.210	-0.280*	-0.395*	0.196	-0.147	-0.365	-0.094	-0.228
		(0.162)	(0.228)		(0.158)	(0.260)	(0.137)	(0.228)
LFP	0.766	0.051	-0.040	0.770	0.147	0.159	0.133	0.132
		(0.226)	(0.333)		(0.239)	(0.451)	(0.221)	(0.408)
Private Worker	0.599	-0.048	-0.154	0.608	0.029	-0.032	0.036	-0.017
		(0.127)	(0.173)		(0.155)	(0.215)	(0.154)	(0.216)
Public Worker	0.087	0.024	0.066	0.088	0.006	0.052	-0.017	0.031
		(0.021)	(0.040)		(0.034)	(0.057)	(0.034)	(0.052)
Wage Worker	0.473	-0.121**	-0.071	0.487	-0.159**	-0.141	-0.160**	-0.145
		(0.053)	(0.089)		(0.067)	(0.094)	(0.066)	(0.108)
Self-Employed	0.140	-0.029	-0.142	0.137	0.075	0.008	0.055	0.006
		(0.043)	(0.090)		(0.072)	(0.118)	(0.064)	(0.115)
Employer	0.043	0.046	0.073*	0.042	0.024	0.034	0.024	0.023
		(0.043)	(0.043)		(0.034)	(0.044)	(0.041)	(0.054)
Observations	2,049,811			964,849				
First Stage			3.211***			3.466***		3.466***
			(0.413)			(0.647)		(0.647)
F-Statistics			140.84			129.07		129.07
Year		Yes	Yes		Yes	Yes	Yes	Yes
Region-Season		Yes	Yes		Yes	Yes	Yes	Yes

NOTES: Table reports the coefficient for the ratio of the immigrants. Control variables include gender, age groups (by 5 years), education (3 categories), marital status (4 categories) and log trade volume. Standard errors clustered at the NUTS-2 level are reported in parentheses. Significance levels are denoted as follows: ***1 percent, **5 percent, *10 percent.

One can argue that results could be affected by alternative channels like demand shifts, an increase in local spending in the refugee regions and increased demand for public services. Moreover, there could be an endogenous change in enforcement of informality. Cengiz and Tekguc (2018) finds no adverse effects on native employment and wages. Their study suggests that there is a significant increase in the construction sector in refugee-hosting regions and Syrians are bringing their capital as there is an increase in the number of new companies in the region. Therefore, they conclude that increases in demand and capital supply enable local labour markets to absorb labour supply shock. Similarly, Aksu et al. (2018) put forward the increased new firm openings in the region which will mitigate the possible adverse labour market effects. Our results for the full sample in Table B1 is in line with these findings as there is no adverse effect of the refugees on total employment. Moreover, there is an increase in formal employment. However, these possible positive effects of other channels seem to occur in favour of males and as formal employment of women reduced significantly which seems to make them the disadvantaged group to immigration. Since the Turkish government has an open-door policy for all Syrians, public authorities may ignore the illegal refugee workers which would lower the enforcement of informality. Moreover, anecdotal evidence suggests that natives in refugee-hosting regions have complaints about informal refugee firms and informal workers. However, in total, we do not observe a significant increase in informal employment which is again due to the opposite effects on genders.

Table 2.3: Effect of Syrians on Native Females

Female	Mean Y	DiD-OLS	DiD-2SLS	Mean Y	OLS	2SLS	Logit	IV-Probit
Employment	0.290	0.013	-0.122	0.304	0.182	0.064	0.266	0.148
		(0.251)	(0.288)		(0.253)	(0.346)	(0.326)	(0.462)
Formal Emp	0.144	-0.179***	-0.327***	0.160	-0.074**	-0.156***	-0.063	-0.129
		(0.048)	(0.112)		(0.027)	(0.044)	(0.049)	(0.083)
Informal Emp	0.146	0.193	0.204	0.144	0.257	0.220	0.215	0.246
		(0.276)	(0.319)		(0.260)	(0.347)	(0.259)	(0.372)
LFP	0.333	0.067	-0.099	0.348	0.253	0.129	0.348	0.240
		(0.261)	(0.323)		(0.257)	(0.384)	(0.330)	(0.508)
Private Worker	0.244	-0.053	-0.284	0.253	0.097	-0.137	0.172	-0.096
		(0.241)	(0.325)		(0.228)	(0.324)	(0.312)	(0.436)
Public Worker	0.039	0.032*	0.103**	0.042	0.025	0.105*	0.018	0.092**
		(0.018)	(0.044)		(0.020)	(0.055)	(0.018)	(0.042)
Wage Worker	0.169	-0.056	-0.092*	0.184	-0.001	0.007	0.079	0.241
		(0.046)	(0.054)		(0.078)	(0.117)	(0.124)	(0.222)
Self-Employed	0.029	-0.024	-0.117	0.028	0.001	-0.101	-0.002	-0.128
		(0.087)	(0.102)		(0.070)	(0.094)	(0.069)	(0.096)
Employer	0.004	0.000	-0.007	0.004	0.001	-0.004	0.004	-0.004
		(0.005)	(0.007)		(0.004)	(0.007)	(0.008)	(0.010)
Observations	2,172,213			1,005,384				
First Stage			3.219***			3.486***		3.486***
			(0.417)			(0.643)		(0.643)
F-Statistics			251.36			196.62		196.62
Year		Yes	Yes		Yes	Yes	Yes	Yes
Region-Season		Yes	Yes		Yes	Yes	Yes	Yes

NOTES: Table reports the coefficient for the ratio of the immigrants. Control variables include gender, age groups (by 5 years), education (3 categories), marital status (4 categories) and log trade volume. Standard errors clustered at the NUTS-2 level are reported in parentheses. Significance levels are denoted as follows: ***1 percent, **5 percent, *10 percent.

Effects of the refugees are expected to be more visible on the low skilled or low educated natives. We left the OLS results to the Appendix B Table B2 and report the 2SLS estimation results for three different education levels in Table 2.4. We create three education levels, low education is for agents without an high school degree, high school graduates are medium educated and high education level is for university graduates. As expected, effects on the low educated Turkish natives are more visible. For females, reduction in formal employment is higher than the average, but also increase in informal employment is higher for low educated natives. For men, increase in formal employment is lower than average but reduction in informal employment is similar to the average estimate.

Table 2.4: Effect of Syrians by Education Level - 2SLS

	Low Educated		Medium Educated		High Educated	
	Men	Women	Men	Women	Men	Women
Employment	-0.039	0.073	0.120	0.099	0.102	-0.315
	(0.252)	(0.386)	(0.327)	(0.205)	(0.122)	(0.270)
Formal Emp	0.325***	-0.209***	0.341	-0.041	-0.010	-0.281
	(0.106)	(0.064)	(0.284)	(0.091)	(0.133)	(0.258)
Informal Emp	-0.364	0.282	-0.220	0.140	0.112	-0.034
	(0.329)	(0.396)	(0.149)	(0.178)	(0.078)	(0.113)
LFP	0.114	0.116	0.260	0.238	0.231	0.021
	(0.489)	(0.403)	(0.481)	(0.329)	(0.182)	(0.387)
Private Worker	-0.057	-0.051	0.232	0.043	0.500**	0.134
	(0.262)	(0.353)	(0.291)	(0.185)	(0.255)	(0.232)
Public Worker	0.013	0.016	-0.087	0.040	-0.433*	-0.429*
	(0.026)	(0.016)	(0.117)	(0.043)	(0.224)	(0.247)
Wage Worker	-0.259***	-0.049	-0.130	0.042	-0.086	-0.252
	(0.064)	(0.121)	(0.206)	(0.107)	(0.144)	(0.278)
Self-Employed	0.083	-0.093	-0.018	-0.056	-0.046	-0.084
	(0.153)	(0.101)	(0.063)	(0.050)	(0.089)	(0.064)
Employer	0.016	-0.002	0.083*	-0.003	0.161*	-0.006
	(0.049)	(0.006)	(0.045)	(0.011)	(0.088)	(0.032)
Observations	610,105	741,134	209,104	152,023	145,640	112,227
Year	Yes	Yes	Yes	Yes	Yes	Yes
Region-Season	Yes	Yes	Yes	Yes	Yes	Yes

NOTES: Table reports the coefficient for the ratio of the immigrants. Control variables include gender, age groups (by 5 years), education (3 categories), marital status (4 categories) and log trade volume. Standard errors clustered at the NUTS-2 level are reported in parentheses. Significance levels are denoted as follows: ***1 percent, **5 percent, *10 percent.

We then apply a similar analysis to skill groups. The ISCO-88 occupation classification categorize the occupation according to their skill level. There are four skill levels and we define the low skilled occupations as skill levels 1 and 2. Additionally, effects of natives could be more dramatic for agriculture and construction sectors as both of these sectors have more informal labour market. Table 2.5 presents the employment results for these skill levels and sectors. As expected, low skilled agents are affected by the refugees whereas we observe a limited change for the high skilled. Since there could be a language barrier one can expect a lower change in the service sector and we can verify this from our results. There is a significant reduction in informal native employment for the construction sector but there is no significant change in informal agriculture employment. On the contrary, we observe a positive change in formal agriculture employment.

Table 2.5: Effect of Syrians by Skill Level and Sector

	Men		Women	
	OLS	2SLS	OLS	2SLS
Formal Low Skilled	0.147***	0.288***	-0.102**	-0.213***
	(0.036)	(0.109)	(0.037)	(0.057)
Informal Low Skilled	-0.132	-0.329	0.257	0.213
	(0.170)	(0.272)	(0.257)	(0.345)
Formal High Skilled	0.040	0.111**	0.019	0.024
	(0.027)	(0.044)	(0.018)	(0.026)
Informal High Skilled	-0.010	-0.041	-0.002	-0.001
	(0.014)	(0.035)	(0.003)	(0.003)
Formal Service Sector	0.062	0.116	-0.003	0.030
	(0.041)	(0.072)	(0.019)	(0.046)
Informal Service Sector	-0.005	-0.023	-0.002	-0.008
	(0.015)	(0.029)	(0.006)	(0.009)
Formal Agriculture	0.115**	0.111**	-0.014	-0.000
	(0.045)	(0.048)	(0.009)	(0.011)
Informal Agriculture	0.026	-0.080	0.182	0.087
	(0.124)	(0.174)	(0.209)	(0.277)
Formal Construction	-0.020	-0.005	-0.004	-0.002
	(0.029)	(0.036)	(0.003)	(0.003)
Informal Construction	-0.127***	-0.219***	0.001	0.002
	(0.035)	(0.075)	(0.001)	(0.001)
Observations	964,849	964,849	1,005,384	1,005,384
Year	Yes	Yes	Yes	Yes
Region-Season	Yes	Yes	Yes	Yes

NOTES: Table reports the coefficient for the ratio of the immigrants. Control variables include gender, age groups (by 5 years), education (3 categories), marital status (4 categories) and log trade volume. Standard errors clustered at the NUTS-2 level are reported in parentheses. Significance levels are denoted as follows: ***1 percent, **5 percent, *10 percent.

2.7.2 Wage and Hours Effects

Clearly, immigration causes a shift in the labour supply which might change wages. This could also change the intensive margin of the labour supply. Therefore we check the change in weekly working hours. Table 2.6 presents the results for monthly wage, hourly wage and weekly working hours for males and females. We left the analysis for full sample to the Appendix B Table B3.

Table 2.6: Effect of Syrians on Native Wages

	Male				Female			
	DiD-OLS	DiD-IV	OLS	2SLS	DiD-OLS	DiD-IV	OLS	2SLS
Formal								
Log Monthly Wage	0.136	0.253	0.047	0.134	-0.057	0.025	0.119	0.008
	(0.121)	(0.174)	(0.104)	(0.160)	(0.174)	(0.283)	(0.170)	(0.360)
Log Hourly Wage	0.106	0.137	0.047	0.245	0.064	0.075	0.207	0.192
	(0.236)	(0.382)	(0.145)	(0.238)	(0.260)	(0.385)	(0.304)	(0.578)
Log Weekly Hours	0.030	0.116	-0.000	-0.110	-0.121	-0.049	-0.088	-0.184
	(0.146)	(0.254)	(0.123)	(0.167)	(0.151)	(0.210)	(0.180)	(0.289)
Observations	664,771	664,771	346,668	346,668	216,548	216,548	123,480	123,480
Informal								
Log Monthly Wage	0.242	0.751	-0.306	-0.180	0.765	1.952	0.581	1.953*
	(0.306)	(0.516)	(0.239)	(0.466)	(0.782)	(1.456)	(0.455)	(1.174)
Log Hourly Wage	-0.268	-0.148	-0.659	-0.955	-0.044	0.472	-0.126	0.713
	(0.474)	(0.632)	(0.607)	(0.989)	(0.438)	(0.800)	(0.477)	(0.971)
Weekly Hours	0.510	0.899*	0.353	0.775	0.809	1.481*	0.706*	1.240
	(0.369)	(0.489)	(0.446)	(0.683)	(0.539)	(0.870)	(0.347)	(0.778)
Observations	173,650	173,650	64,701	64,701	62,537	62,537	29,564	29,564
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region-Season	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

NOTES: Table reports the coefficient for the ratio of the immigrants. Control variables include gender, age groups (by 5 years), education (3 categories), marital status (4 categories) and log trade volume. Standard errors clustered at the NUTS-2 level are reported in parentheses. Significance levels are denoted as follows: ***1 percent, **5 percent, *10 percent.

Similar to the existing studies for Turkey, we find very few statistically significant effects on native wages. For men, there is a positive change in formal wages and a negative change in informal market wages (2SLS). We observe a significant increase in formal male employment in Table 2.2. These results suggest that male workers who passed from the informal labour market to formal market get a higher wage on average, and male workers who are still in the informal market have to bear lower wages. Since the effects would be more visible in low-income groups, in Table 2.7, we check the change in wages for low educated and low skilled workers. Results have the same signs as in Table 2.6 but the magnitude of the coefficients is generally larger for these low-income groups. Coefficient for low skilled formal male workers is higher than the average which coincides with the idea that male workers find better-paid jobs in formal market.

While weekly hours show a limited change in the formal sector, there is a rise in working hours of informal male workers. Hence, we observe a change in the intensive margin for informal male workers. They face lower wages on average with increased working hours.

For women, there is almost no change in formal market monthly wages. In Table 2.3 we show a significant decrease in formal female employment. Therefore, women who are still working in formal jobs are getting similar wages. However, the ones who pass to the informal market get higher wages. Similar to informal male workers, informal female workers face a higher number of working hours.

Table 2.7: Effect of Syrians on Low Skilled Native Wages

	Low Educated -2SLS			Low Skilled-2SLS		
	Total	Male	Female	Total	Male	Female
Formal						
Log Monthly Wage	0.147	0.204	0.355	0.104	0.090	0.532
	(0.225)	(0.209)	(0.609)	(0.156)	(0.142)	(0.422)
Log Hourly Wage	0.400	0.398	1.267*	0.252	0.193	1.018*
	(0.353)	(0.359)	(0.756)	(0.253)	(0.245)	(0.539)
Log Weekly Hours	-0.254	-0.194	-0.912***	-0.147	-0.103	-0.486**
	(0.201)	(0.227)	(0.279)	(0.194)	(0.207)	(0.224)
Observations	190,672	155,856	34,816	327,374	256,009	71,365
Informal						
Log Monthly Wage	0.268	-0.370	1.820	0.308	-0.308	1.944*
	(0.589)	(0.451)	(1.211)	(0.577)	(0.468)	(1.164)
Log Hourly Wage	-0.677	-1.045	0.459	-0.673	-1.086	0.696
	(0.901)	(1.028)	(1.002)	(0.891)	(1.017)	(0.964)
Weekly Hours	0.945	0.675	1.362	0.981	0.778	1.248
	(0.815)	(0.703)	(0.894)	(0.767)	(0.667)	(0.797)
Observations	77,591	52,695	24,896	89,633	61,207	28,426
Year	Yes	Yes	Yes	Yes	Yes	Yes
Region-Season	Yes	Yes	Yes	Yes	Yes	Yes

NOTES: Table reports the coefficient for the ratio of the immigrants. Control variables include gender, age groups (by 5 years), education (3 categories), marital status (4 categories) and log trade volume. Standard errors clustered at the NUTS-2 level are reported in parentheses. Significance levels are denoted as follows: ***1 percent, **5 percent, *10 percent.

We accept that wage data could be noisy as we observe very few significant coefficients. The changes in wages for formal market seem plausible however it seems puzzling to have different wage effects in the informal market for genders. While wages for informal male workers are decreasing, there is an increase in wages for female informal wages. This could be a result of different job formations for genders which are needed to be analysed in further detail.

2.8 Additional Analysis

2.8.1 Effect of all Immigrants

The preceding analysis includes only the Syrian population under temporary protection status. However as mentioned earlier, there is a significant number of Syrians staying in Turkey with a residence permit. Additional to the Syrians, there are immigrants from Iraq, Afghanistan and Turkic countries in Middle Asia. In this section we estimate equation (2.1) for all immigrants living in Turkey after 2012. We use the ratio of total immigrants to native population for OLS analysis and we add the third piece to our instrument for 2SLS. Tables 2.8 and 2.9 present the results for males and females, respectively. Immigrants from Iraq and Afghanistan have similar characteristics with Syrian refugees. Therefore the effect of these immigrants would be similar to the Syrian refugees. However, their distribution to the cities is significantly different than the Syrians. Since 85% of the whole immigrant population consists of Syrian refugees, the coefficients are very close to the ones in Tables 2.2 and 2.3.

2.8.2 Administrative Data

The Social Security Institution of Turkey distributes detailed monthly reports for the number of the registered (formal) workers at city and sector level. The data is publicly available and we utilize the years 2014 to 2017. We run the following equation for city level quarterly administrative data.

$$Y_{ict} = \alpha + \beta R_{ct} + \theta Z_{ct} + \phi_c + \tau_y + \varphi_{cq} + \varepsilon_{ict} \tag{2.3}$$

where Y_{ict} is the ratio of various employment to population, R_{ct} share of refugee in city c at time t, Z_{ct} trade volume of city c, ϕ_c is city fixed effect and τ_y and φ_{cq} are year effects and city specific seasonal effects.

Table 2.8: Effect of All Immigrants on Native Males

Males	Mean Y	DiD-OLS	DiD-2SLS	Mean Y	OLS	2SLS
Employment	0.689	-0.007	-0.050	0.699	0.045	0.018
		(0.116)	(0.138)		(0.162)	(0.226)
Formal Emp	0.479	0.267***	0.367***	0.503	0.180***	0.385***
		(0.069)	(0.113)		(0.045)	(0.128)
Informal Emp	0.210	-0.274*	-0.416*	0.196	-0.134	-0.366
		(0.159)	(0.229)		(0.156)	(0.254)
LFP	0.766	0.066	-0.030	0.770	0.154	0.166
		(0.224)	(0.341)		(0.233)	(0.459)
Private Worker	0.599	-0.026	-0.115	0.608	0.034	-0.044
		(0.126)	(0.166)		(0.152)	(0.204)
Public Worker	0.087	0.013	0.063	0.088	0.003	0.058
		(0.021)	(0.040)		(0.035)	(0.062)
Wage Worker	0.473	-0.156***	-0.135*	0.487	-0.166**	-0.148*
		(0.048)	(0.072)		(0.064)	(0.089)
Self-Employed	0.140	0.001	-0.071	0.137	0.086	0.017
		(0.047)	(0.077)		(0.074)	(0.116)
Employer	0.043	0.042	0.069	0.042	0.025	0.035
		(0.043)	(0.047)		(0.034)	(0.045)
Observations	2,049,811			964,849		
First Stage			3.454***			3.568***
			(0.474)			(0.720)
F-Statistics			53.95			27.20
Year		Yes	Yes		Yes	Yes
Region-Season		Yes	Yes		Yes	Yes

NOTES: Table reports the coefficient for the ratio of the immigrants. Control variables include gender, age groups (by 5 years), education (3 categories), marital status (4 categories) and log trade volume. Standard errors clustered at the NUTS-2 level are reported in parentheses. Significance levels are denoted as follows: ***1 percent, **5 percent, *10 percent.

Table 2.9: Effect of All Immigrants on Native Females

Female	Mean Y	DiD-OLS	DiD-2SLS	Mean Y	OLS	2SLS
Employment	0.290	0.031	-0.155	0.304	0.195	0.048
		(0.251)	(0.290)		(0.249)	(0.340)
Formal Emp	0.144	-0.147***	-0.271***	0.160	-0.073**	-0.155***
		(0.049)	(0.099)		(0.027)	(0.045)
Informal Emp	0.146	0.178	0.116	0.144	0.268	0.203
		(0.267)	(0.317)		(0.255)	(0.342)
LFP	0.333	0.105	-0.106	0.348	0.270	0.119
		(0.265)	(0.321)		(0.254)	(0.380)
Private Worker	0.244	-0.007	-0.277	0.253	0.118	-0.155
		(0.244)	(0.321)		(0.228)	(0.320)
Public Worker	0.039	0.018	0.102**	0.042	0.017	0.107*
		(0.023)	(0.046)		(0.022)	(0.060)
Wage Worker	0.169	-0.048	-0.089	0.184	-0.001	0.008
		(0.048)	(0.054)		(0.076)	(0.119)
Self-Employed	0.029	-0.004	-0.115	0.028	0.008	-0.108
		(0.090)	(0.104)		(0.070)	(0.098)
Employer	0.004	0.003	-0.006	0.004	0.002	-0.005
		(0.006)	(0.007)		(0.004)	(0.008)
Observations	2,172,213			1,005,384		
First Stage			3.466***			3.590***
			(0.476)			(0.714)
F-Statistics			349.99			68.63
Year		Yes	Yes		Yes	Yes
Region-Season		Yes	Yes		Yes	Yes

NOTES: Table reports the coefficient for the ratio of the immigrants. Control variables include gender, age groups (by 5 years), education (3 categories), marital status (4 categories) and log trade volume. Standard errors clustered at the NUTS-2 level are reported in parentheses. Significance levels are denoted as follows: ***1 percent, **5 percent, *10 percent.

Table 2.10 reports the results and although we have very few statistically significant estimates, sign and the magnitude of the coefficients are consistent with the LFS data. The administrative data only covers the formal labour market, but for the formal market we have similar results to LFS. Agriculture apart we have an increasing pattern in all formal employment outcomes with immigration. From administrative data, 1% increase in refugee share corresponds to a 0.38% ($\frac{0.098}{0.259}$) increase in total formal employment. From Table B1 in Appendix B for LFS data, 1% increase in immigrant share leads to an increase by 0.36% ($\frac{0.113}{0.312}$). We do not have the numbers by gender for each employment outcome, therefore we report the results by gender only for some of the employment outcomes. Similarly, we have a positive change in public employment for males and females which is in line with the results from LFS data.

Table 2.10: Effect of Syrians on Natives - Administrative Data

	Social Security Data		
Dependent Variable	Mean Y	OLS	2SLS
Total Formal Emp	0.259	0.016	0.098
		(0.026)	(0.062)
Total Private Formal Employment	0.185	0.003	0.088
		(0.029)	(0.067)
Total Public Employment	0.037	0.011***	0.028*
		(0.004)	(0.015)
Male Public Employment	0.024	0.009**	0.020*
		(0.003)	(0.012)
Female Public Employment	0.013	0.002**	0.008*
		(0.001)	(0.004)
Total Employer	0.026	0.005	0.003
		(0.004)	(0.004)
Male Employer	0.020	0.003	-0.002
		(0.003)	(0.003)
Female Employer	0.006	0.002	0.005
		(0.001)	(0.004)
Total Agriculture Emp	0.011	-0.002	-0.021
		(0.008)	(0.019)
Observations	1,296		
Year		Yes	Yes
Region-Season		Yes	Yes

NOTES: Table reports the coefficient for the ratio of the immigrants. Years 2014-2017 are used. Standard errors clustered at the NUTS-2 level are reported in parentheses. Significance levels are denoted as follows: ***1 percent, **5 percent, *10 percent.

2.9 Robustness Checks

2.9.1 Alternative Group Design for DiD

All of the existing studies on the Syrian refugee impact on Turkish natives employ DiD analysis. For the DiD analysis design of the treatment and control groups are crucially important which is the key point in the differentiated results of the existing studies. So as noted in the DiD section we create three alternative treatment-control group allocation. First, we use 5 NUTS-2 regions as a treatment group where the refugee to native ratio is above 4%, and compare these regions with the lowest refugee hosting 10 NUTS-2 regions where the refugee to native ration is lower than 0.5% even at the end of 2017. Hence we drop the regions where the refugee to native ratio is between 0.5% and 4%. Second, we again take the top five regions as treatment group and compare them with the rest of the regions. Third, we separate the regions into two. The regions with a higher refugee ratio than 2% make the treatment group and we use the other groups as our control group. Tables 2.11 and 2.12 present the results for males and females.

Table 2.11: DiD Results for Different Designs - Males

	(1)		(2)		(3)	
Males	OLS	2SLS	OLS	2SLS	OLS	2SLS
Employment	0.109	0.142	-0.047	-0.035	-0.011	-0.029
	(0.131)	(0.153)	(0.106)	(0.116)	(0.114)	(0.125)
Formal Emp	0.310***	0.343***	0.238***	0.259**	0.268***	0.298***
	(0.070)	(0.094)	(0.065)	(0.101)	(0.067)	(0.102)
Informal Emp	-0.201	-0.201	-0.284*	-0.294	-0.280*	-0.327
	(0.156)	(0.216)	(0.148)	(0.198)	(0.154)	(0.209)
LFP	0.149	0.233	-0.024	0.042	0.048	0.050
	(0.223)	(0.332)	(0.203)	(0.281)	(0.215)	(0.302)
Private Worker	0.053	0.115	-0.100	-0.078	-0.050	-0.084
	(0.118)	(0.146)	(0.120)	(0.134)	(0.122)	(0.145)
Public Worker	0.013	0.007	0.033	0.034	0.024	0.043*
	(0.029)	(0.026)	(0.022)	(0.021)	(0.021)	(0.025)
Wage Worker	-0.119*	-0.138**	-0.080	-0.100	-0.121**	-0.099
	(0.062)	(0.068)	(0.060)	(0.061)	(0.050)	(0.064)
Self-Employed	0.040	0.049	-0.079	-0.077*	-0.027	-0.085
	(0.046)	(0.049)	(0.054)	(0.046)	(0.042)	(0.053)
Employer	0.059	0.081*	0.039	0.056	0.043	0.062
	(0.045)	(0.042)	(0.040)	(0.038)	(0.041)	(0.040)
Observations	1,004,483	1,004,483	2,049,811	2,049,811	2,049,811	2,049,811
Year	Yes	Yes	Yes	Yes	Yes	Yes
Region-Season	Yes	Yes	Yes	Yes	Yes	Yes

NOTES: Table reports the coefficient for the ratio of the immigrants. Control variables include gender, age groups (by 5 years), education (3 categories), marital status (4 categories) and log trade volume. Standard errors clustered at the NUTS-2 level are reported in parentheses. Significance levels are denoted as follows: ***1 percent, **5 percent, *10 percent.

When we compare these results with Tables 2.2 and 2.3, there are some differences. However especially for the significant estimates, the sign of all estimations are consistent with each other. We have small differences in magnitudes which is to be expected. Note that all of our estimations utilize an intensity treatment parameter. Since the existing studies use binary treatment, for the sake of the comparability with their results, we assume there is no refugees for the control groups which means the refugee to native ratio is zero. However our preferred estimation uses all regions with the continuous intensity parameter.

Table 2.12: DiD Results for Different Designs - Females

	(1)		(2)		(3)	
Females	OLS	2SLS	OLS	2SLS	OLS	2SLS
Employment	0.170	0.268	-0.067	-0.013	0.013	-0.014
	(0.260)	(0.281)	(0.223)	(0.235)	(0.238)	(0.252)
Formal Emp	-0.113**	-0.137**	-0.189***	-0.218***	-0.172***	-0.241***
	(0.046)	(0.055)	(0.048)	(0.062)	(0.045)	(0.074)
Informal Emp	0.283	0.405	0.112	0.205	0.185	0.228
	(0.282)	(0.311)	(0.247)	(0.272)	(0.262)	(0.292)
LFP	0.241	0.362	-0.045	0.029	0.067	0.028
	(0.266)	(0.302)	(0.234)	(0.253)	(0.247)	(0.273)
Private Worker	0.124	0.242	-0.151	-0.092	-0.048	-0.115
	(0.228)	(0.256)	(0.217)	(0.239)	(0.229)	(0.260)
Public Worker	0.007	0.009	0.055***	0.056***	0.030*	0.062***
	(0.013)	(0.013)	(0.018)	(0.017)	(0.017)	(0.022)
Wage Worker	-0.013	-0.000	-0.060	-0.058	-0.056	-0.068
	(0.051)	(0.053)	(0.043)	(0.042)	(0.044)	(0.046)
Self-Employed	0.017	0.042	-0.063	-0.043	-0.023	-0.045
	(0.083)	(0.070)	(0.076)	(0.070)	(0.083)	(0.076)
Employer	0.004	0.005	-0.003	-0.002	0.001	-0.002
	(0.005)	(0.005)	(0.004)	(0.004)	(0.005)	(0.005)
Observations	1,078,134	1,078,134	2,172,213	2,172,213	2,172,213	2,172,213
Year	Yes	Yes	Yes	Yes	Yes	Yes
Region-Season	Yes	Yes	Yes	Yes	Yes	Yes

NOTES: Table reports the coefficient for the ratio of the immigrants. Control variables include gender, age groups (by 5 years), education (3 categories), marital status (4 categories) and log trade volume. Standard errors clustered at the NUTS-2 level are reported in parentheses. Significance levels are denoted as follows: ***1 percent, **5 percent, *10 percent.

2.9.2 Region Trends and Region Specific Time Effects

In our preferred specification we control the region, year and region specific season effects. In this section we relax the common-trend assumption and add region specific linear time trends to the equation. Note that NUTS-2 level region specific linear time trend is perfectly collinear with the parameter of interest. Therefore we add NUTS-1 level region specific time trends to the equation. This variable still create a multi-collinearity for some regions as the ratio of the refugees shows a linear time trend in time. In the second specification we add NUTS-1 region specific year effects which could also be collinear with the parameter of interest at least for some regions. We should note that for some of the regions we observe perfect multi-collinearity when we add these additional region specific time effects. Tables B4 and B5 in Appendix B present the results of these two specifications for males.

While Table B4 shows the results for DiD analysis, Table B5 presents the results for all other inference methods. Similarly, Tables B6 and B7 show the estimation results for women, Tables B8 and B9 cover all genders.

Some of the coefficients change dramatically in magnitude but for statistically significant coefficients, we have a consistency with our preferred estimation. As noted earlier inclusion of these controls suffer from collinearity problem. Aksu et al.(2018) also controls for time trends, however since they use yearly LFS and use the yearly averages of refugee ratios, adding these control to the equation does not change the coefficients for their study.

2.10 Conclusion

This paper analyses the labour market effects of the refugees and immigrants in Turkey. Our study presents the most precise estimations so far. We analyse the change in the labour market outcomes by gender, skill level (education and occupation skill level) and sector. Results are differentiated by gender in a systematic way where females are adversely affected by the immigrants. Our results suggest that firms replace their female formal workers with Syrian refugees as it is less costly. Considering the low labour force participation rates of the female refugees, one could say that male refugees are substitutes for the female formal workers. For males, formal employment increases and there is a reduction in informal employment. These results partially agree with the existing literature about Turkey. We find that there is no negative employment effects due to mass immigration. However there is a clear compositional change in the native labour market.

Chapter 3

Labour Market Effect of the Minimum Wage in Turkey

3.1 Introduction

Minimum wage is one of the most discussed policy instruments as it has both efficiency and equity consequences. While the opponents put forward the possible inefficient outcomes in labour markets, advocates point to the fair living standards for workers especially for the less fortunate. The classical theory suggests that increased wages in the lower part of the distribution lead to an adverse effect on the employment of low-income earners.

There is still an ongoing contentious discussion about the effects of the minimum wage. The new discussion on minimum wage started in the early 1990s (Card (1992), Neumark and Wascher (1992), Card and Krueger (1995)) and is still going on. In the US and UK context, many of the studies focus on employment in specific sectors or teen employment[1]. While some studies report sizeable negative effects on employment (Neumark and Wascher (1992, 2000)), many other find no adverse effect of the minimum wage(Card and Krueger (1995), Machin and Manning (1994), Machin et al. (2003)).

The studies on developed countries generally report very few significant effects that are small in magnitude. This could be due to the relatively low minimum wage levels or to the small increments in the minimum wage. Lemos (2009) points out the difference in the role of the minimum wage for the developing countries. In many of the developing countries (including Turkey), the minimum wage is not set for an individual. Both the politicians and decision-makers regard it as a living wage for the family. Therefore the relative level of the minimum wage (bite of MW) is

[1]See Neumark and Wascher (2007), Dube et al. (2010), Allegretto et al. (2011 and 2017), Neumark et al. (2014)

higher[2] compared to the developed countries and a hike in minimum wage could possibly create sizeable effects on labour market outcomes as the wage distribution is concentrated around the minimum wage. Moreover, developing countries have a significant informal share in their labour market which leads to low compliance with labour market regulations. Another common feature of these countries is their fragile macroeconomic environment which makes them vulnerable to global crisis. Hence it seems plausible to expect different consequences of the minimum wage for developing countries. At one side, the concentration of the wage distribution around minimum wage could amplify the consequences of a minimum wage increase. However, on the other side, high informality rates would lower the compliance rates and might reduce the effects of the minimum wage.

The canonical Two-Sector Model (Welch-Gramlich-Mincer) anticipates an increase in formal wages with the minimum wage hike. Due to this increase, there will be job losses in the formal market and these individuals will seek a job in the informal market. As a result, the wages in the informal market will decrease and there will be an increase in informal employment. The few studies concerning the effects of the minimum wage in developing countries often test this theoretical prediction.

The existing research confirms the compression effect of the minimum wage. A minimum wage increase leads to an increase in wages for low-income earners which leads to a shift in the left tail of the wage distribution. The change in formal market wages is to be expected but theory tells us the opposite for informal wages. On the contrary, Khamis(2013) for Argentina and Baanante(2004) for Peru find even stronger effects in informal market wages than the wages in the formal market.

However, results for employment effects of the minimum wage are quite controversial. For Brazil, Fajnzylber(2001) finds negative employment effects for both formal and informal workers. Interestingly, the negative elasticity is higher for the informal market which is explained as a result of an increase in formal job-seeking. On the other hand, Lemos (2009) utilizes household labour surveys and shows a significant change in the wage distribution. However, she finds small adverse employment effects in Brazil.

For Colombia, Maloney and Mendez(2004) suggests a lighthouse effect in the labour market: The formal minimum wage serves as a reference for the informal labour market. They find a significant negative effect of minimum wage on overall employment. Similarly, Bell (1997) results indicate an adverse effect on employment in Colombia. Montenegro and Pages (2005) comes up with similar results for Chile. They find negative effects of an increase in minimum wage on employment by using a time series data for the years 1960-1998. Away from the South American countries,

[2] Among the OECD countries Turkey and Latin American countries have the highest minimum wage to average wage ratios.

results are also differentiated for employment effects. For South Africa, Bhorat et al.(2013) finds no significant effect of minimum wage on employment. However, Broniatowska et al.(2015) shows adverse effects on employment for Poland and for Greece Karageorgiou (2004) finds a disemployment effect of an increase in minimum wage.

The introduction of the minimum wage in Turkey dates back to 1800s where a regional minimum wage has been implemented for some specific sectors (Gerek (1999)). These limited applications lasted until the late 1920s. The first modern minimum wage legislation was passed in 1936. During the following years, regional commissions set the minimum wages which lead to inconsistent wage rates even in close neighbourhoods. Thus, beginning with 1967 a central committee was established to set the minimum wage rates for some regions and sectors. After 1989, a minimum wage that applies to all sectors and regions is set by a central committee made of workers, employees and government representatives. This committee used to meet at the end of the year and set the minimum wages for the first and second[3] half of the next year (except for the years 2005 and 2006). After 2016 the committee sets a minimum wage that applies to the entire country for the whole year.

Contrasting with the long history of the minimum wage in Turkey, there are only a handful of studies dealing with the labour market effects of the minimum wage.

Ozturk(2009) estimates a structural model by considering the inflexible labour market structure of Turkey. By using Labour Force Surveys for 1988-1999 she suggests that minimum wage leads to a shortage of part-time jobs that causes a significant reduction in employment. Agents who prefer flexible working hours (mainly females) suffer from this shortage and they eventually quit the labour force.

Pelek(2015) examines the effect of minimum wage on employment in Turkey for the years 2004-2014. She finds no adverse effect on total and formal employment but an increase in informal employment with the minimum wage changes. Pelek(2015) focuses on the teens as the population of interest. However, in Turkey, minimum wage earners are not necessarily the young population. In our study, we extend the analysis for all age groups. To measure the impact of minimum wage, she uses the Kaitz index which is defined as the ratio of the minimum wage to the mean or median wages. However, the Kaitz index is not taking the non-compliance into account. Moreover, she utilizes yearly LFS but during the period minimum wage had been updating every six months. She uses the average minimum wage for years which might lead to a bias in her estimates.

Yüncüler and Yüncüler (2016) investigates the 2004 minimum wage hike in Turkey by using a difference-in-differences(DiD) method. They find a wage compression effect of the minimum wage at the lower part of the wage distribution. They found

[3]From January 1^{st} to June 30^{th} and from July 1^{st} to December 31^{st}.

no adverse effect on overall employment. Their results do not agree with the predictions of the dual market hypothesis as there is no negative effect for the formal workers and they do not observe a positive change in the informal market. They point out the so-called lighthouse effect in Turkey. Namely, wages in the informal market increases with the minimum wage.

Papps (2012) compares the effects of a similar size changes in the minimum wage and social security contribution for 2004. By using the Labour Force Surveys he suggests that higher social security contribution leads to larger employment loss.

In this study, we focus on the consequences of the minimum wage in Turkey and mainly explore wage and employment effects for both formal and informal labour markets. Ulyssea (2018) points out two margins of informality that firms can exploit. On the extensive margin, agents give a decision about registering their business and become a taxpayer. However, even if the firm is officially registered they could hire workers without a formal contract which refers to the intensive margin. In Turkey, it is very common to hire formal and informal labour at the same time. The present study focuses on the intensive margin responses to the changes in the minimum wage. Since there is a small number of study on the minimum wage in Turkey, our study shed lights on the effect of minimum wage under the presence of high informality.

Since the minimum wage in Turkey is set at the national level, there is a limited variation in the minimum wage that only arises from the change in minimum wage along the time. Therefore we aggregate the individual data over regions and exploit the regional variation in wages within and across the regions in time to assess the effects of the minimum wage.

Our analysis suggests that while formal wages are increasing with the minimum wage, there is no significant change in informal market wages. For the employment outcomes, we observe a significant increase in informal employment however there is no significant change in formal employment. The increased share of informal labour is mainly due to increased labour force participation. Since females are paid less than males, the wage and employment effects are much stronger for women. Although minimum wage is set for a calendar month, we observe no changes in formal and informal working hours.

It turns out that our results partially confirm the predictions of the Two-Sector Model. We observe a transition into informal labour market however it is due to the increased labour force participation. We can confirm that there is no adverse change in total employment associated with an increase in the minimum wage.

The high informality rate in the labour market complicates the analysis. We propose a novel approach to differentiate the effects on formal and informal workers. Studies do not differentiate the bite of the minimum wage for formal and informal workers and instead utilize a single overall measure for all workers. However, the magnitude of the minimum wage bite for formal and informal markets have differentiated consequences on wages and employment. Our results suggest that when there is sizeable informal labour, defining the bite of the minimum wage plays a crucial role in the estimation. To the best of our knowledge, this is the first study that points out this important issue.

Previous studies typically focus on the effect of one increase. However minimum wage in Turkey has a dynamic setting structure and generally leads the overall wages in the economy. Other than Pelek(2015), there is no study of the minimum wage in Turkey on a long period 2005-2017. We use quarterly LFS which enables us to assess all minimum wage changes in the 2005-2017 period. The main drawback of using yearly LFS is in defining the incidence parameter for minimum wage. Our study does not suffer from these problems and we believe that our results are the most precise available so far.

The paper proceeds as follows. Section 3.2 describes the data and presents descriptive statistics for Turkey. Section 3.3 presents the econometric analysis and finally, section 3.4 concludes.

3.2 Data and Descriptive Statistics

We mainly utilize Turkish Household Labour Force Surveys (LFS) conducted by the Turkish Statistical Institute (TurkStat) and focus on the working population aged 15 to 65. We study quarterly data from 2005 to 2017, hence we have, in total, 13 years and 52 quarters. We aggregate the data to cover all different minimum wage periods. Minimum wage was updated every six months before 2016 and it was set for the whole year for 2016 and 2017. The LFS contains information on employment, wages, occupation, sector, registration status to the Social Security Institution (SSI) and demographic characteristics of respondents for a representative sample of individuals in the economy.

The LFS has a rotating sampling procedure. However, TurkStat does not distribute the panel identifier hence we cannot utilize the panel dimension of the data. Thus, we have repeated cross-sections covering half million observations per year and for each quarter we have on average 80,000 observations for working age population. By aggregating the data over regions we create a pseudo-panel which contains 22 different minimum wage periods. The LFS is representative for 26 NUTS-2 level regions in Turkey. Figure 3.1 shows the Nomenclature of Territorial Units for Statistics (NUTS-1, NUTS-2 and NUTS-3) classifications of Turkey. The thick black line shows the 12 NUTS-1 regions, whereas different colours show the 26 NUTS-2 regions. Finally, the thin lines are the border for each 81 NUTS-3 regions(cities).

Figure 3.1: NUTS Classifications

NOTES: Thick Black Line: NUTS-1 Regions. Colours: NUTS-2 Regions, Thin Line: NUTS-3 Regions

In Turkey, the minimum wage has always been a hot topic for debate both economically and politically as it affects a sizeable fraction of the population. Figure 3.2 shows the wage distribution in 2016 and there is a dramatic hike around the minimum wage shown by the red line. In 2016, around 40% of the workers get a wage lower than the minimum wage. This feature of the wage distribution may induce significant changes in labour market outcomes after a change in the minimum wage. On the other hand, the low compliance rate attracts attention to another feature of Turkey's labour market. A relatively high share of the total labour market in Turkey consists of informal workers i.e. represents workers unregistered in the social security system. On average, the informal market is around 30-35% of the labour market, however, this reaches 80% in agriculture and 50% for some service sectors like tourism. The high informality rate in labour market complicates the analysis of the effects of a minimum wage increase.

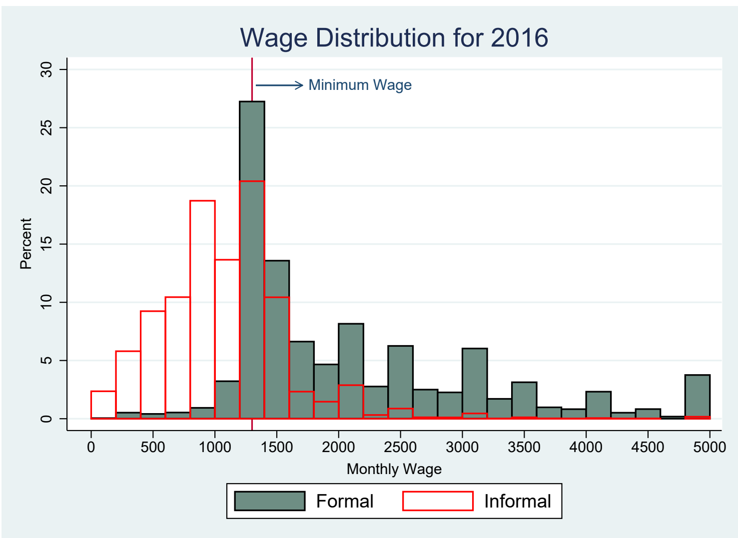

Figure 3.2: 2016 Wage Distribution

Figure 3.3 shows the nominal and real minimum wages for the past 15 years. The nominal minimum wage follows a steady increasing path up to 2016 and then shows a dramatic hike in the past 3 years. However, in real terms after the jump in 2016, the real wage decreases due to increasing inflation. Figure 3.3 draws quarterly real minimum wages and since the minimum wages are updated every six months, we observe a reduction in real terms for the second and the fourth quarters of each year. Although the scales are different, nominal and real minimum rates show similar trends. It seems that the committee takes inflation into consideration while updating the minimum wage.

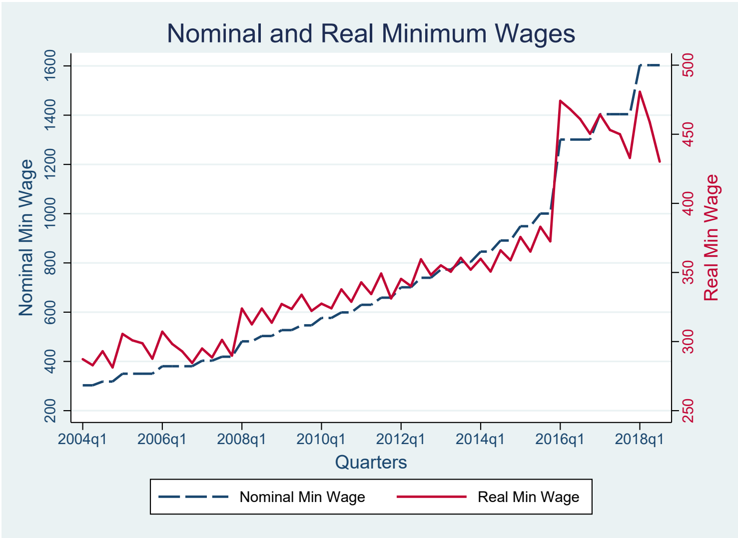

Figure 3.3: Nominal and Real Minimum Wages

In Turkey, public workers' salaries are set by a special procedure. Moreover, part-time workers, seasonal workers and workers in agriculture get a daily wage or piece-rate payments which are independent of the minimum wage set for a calendar month. Therefore we drop these individuals for our analysis. Finally, workers with a second job are excluded as their wage information could be misleading. Figure 3.4 shows the wage distributions for the excluded observations and the restricted sample. While the left panel presents the distributions for years 2010 and 2011, the right panel shows the distributions for 2015 and 2016. For the restricted sample, wage distribution is concentrated around the minimum wage. The excluded observations do not exhibit a similar pattern which justifies our restriction. For the wage estimations, we also report the changes in wages for the overall sample. However, we focus on the restricted sample for the employment effect analysis.

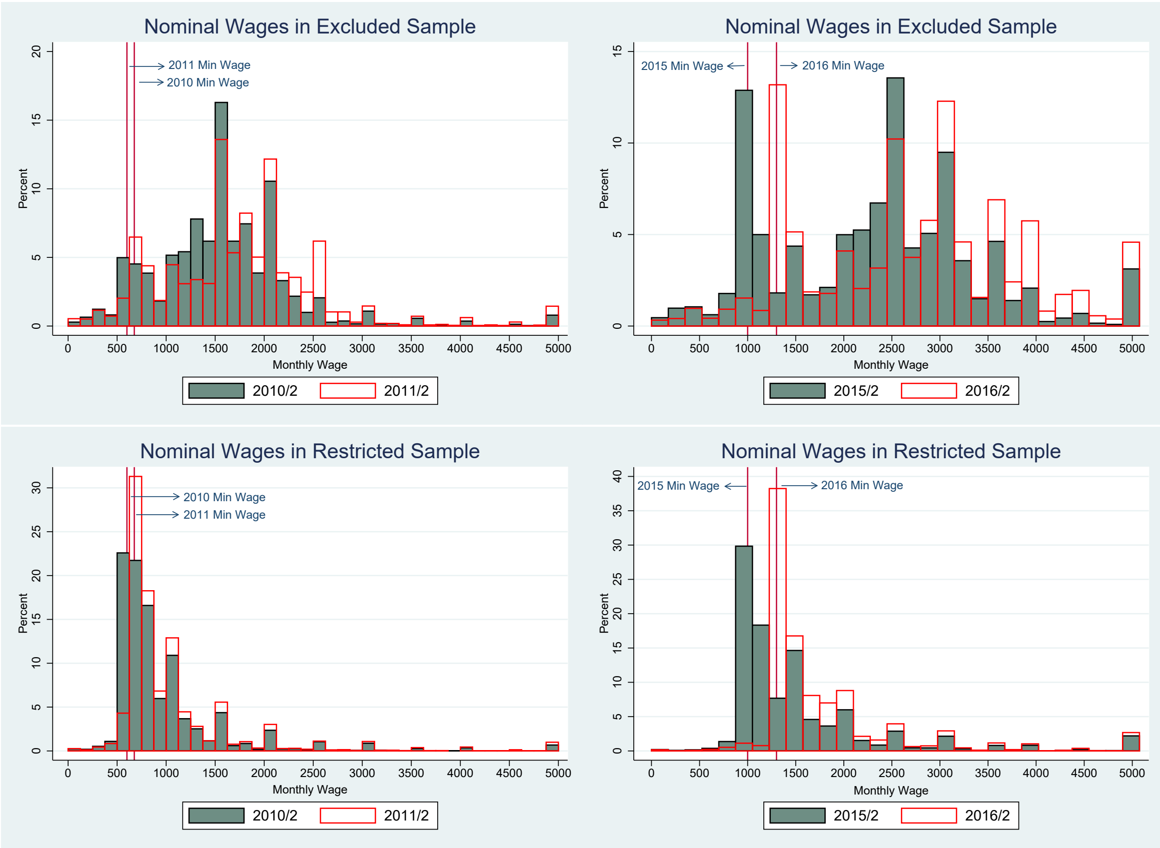

Figure 3.4: Wage Distributions for Excluded and Restricted Samples

In January 2008, the government introduces a Minimum Living Allowance (MLA) calculated on the basis of the minimum wage, depending on the marital status and the number of children. MLA is deducted from the income tax. While the cost of the minimum wage to the employer is unchanged, the after-tax net minimum wage of the agents differs. MLA is paid to the employee by the employer on behalf of the state and deducted from the employer's total tax. Hence, MLA is perceived by the employers as an additional cost and it is highly criticized. It mostly applies to workers in large firms and strictly monitored sectors. Additionally, MLA is paid to the household head (i.e. member of the family whose social security is used by other members of the family) which makes it very hard to identify who is eligible for MLA. One possibility could be using the minimum wage with MLA instead of the minimum wage by restricting the MLA receivers to household heads. In LFS there is a question about household head however due to cultural reasons 99% of this group are male. This might create misleading results as we still do not have any information about how wide MLA is used in the labour market. Moreover, when we checked the wage distributions we do not see any significant difference for the potential MLA receivers. Due to its limited implementation, difficulties in controlling and relation to the family structure instead of a direct minimum wage idea we disregard MLA in our estimations.

For the wage statistics, we drop employers, self-employed and unpaid family workers as there is no wage information for these groups and they are not subject to the minimum wage. Agents who are hired just before the survey and have not get their first wage yet are dropped in the analysis. For the outliers, we applied a winsorization which sets 15,000 Turkish Liras(TL) as the highest income level, hence replaces the higher wage incomes with this maximum (in total 263 observations for the whole period).

Table 3.1 presents summary statistics on the Turkish labour market, while Table 3.2 separates the formal and informal labour markets. Before 2016 minimum wages were updated every six months, January 1st and July 1st. Monthly wage is calculated for 30 days for all months in Turkey and the minimum wage is set for 30 days. Hence hourly wages are calculated by using agents monthly wage and weekly hours. The effect of 2016 minimum wage hike is remarkable for all statistics. The increase in the ratio of the minimum wage to the median wage in 2016 shows the compression effect of the minimum wage increase.

Table 3.1: Summary Statistics

Variable / Year	2013/1	2013/2	2014/1	2014/2	2015/1	2015/2	2016	2017
Minimum Wage	773.01	803.68	846.00	891.03	949.07	1000.54	1300.99	1404.06
Net % Increase	4.49	3.97	5.27	5.32	6.51	5.42	30.03	7.92
Real Min Wage	352.83	356.28	355.21	362.40	370.33	377.72	463.24	449.81
Median Wage	1000	1000	1100	1200	1250	1300	1500	1700
MW/Median	0.773	0.804	0.769	0.743	0.759	0.770	0.867	0.826
50-10%	400	300	370	400	450	550	500	600
90-50%	1500	1500	1700	1600	1750	1700	2000	2100
Mean Wage	1390.89	1432.14	1517.56	1569.23	1654.33	1712.73	1974.45	2169.90
	(1074.84)	(1046.07)	(1136.52)	(1141.42)	(1199.67)	(1202.21)	(1292.84)	(1419.24)
Δ in Mean	6.18	2.97	5.96	3.40	5.42	3.53	15.28	9.90
MW/Mean	0.556	0.561	0.557	0.568	0.574	0.584	0.659	0.647
Weekly Hours	49.40	50.11	49.22	49.50	48.64	49.12	48.12	47.94
	(12.65)	(12.67)	(12.74)	(12.46)	(12.23)	(12.28)	(11.79)	(11.56)
Hourly Wage	7.27	7.36	7.92	8.15	8.67	8.96	10.41	11.45
	(6.72)	(6.35)	(6.97)	(7.00)	(7.34)	(8.62)	(8.12)	(8.92)
Δ in Hourly Wage	8.18	1.24	7.61	2.90	6.38	3.34	16.18	9.99
Average Age	34.57	34.78	34.74	34.92	34.98	35.02	35.35	35.68
	(10.04)	(10.15)	(10.20)	(10.38)	(10.30)	(10.43)	(10.46)	(10.53)
Informal Share*	17.21	17.07	15.86	16.35	14.50	15.68	14.40	14.47
Informal Share**	35.92	35.43	33.80	33.95	32.25	32.64	32.26	32.68
Observations	48,934	48,597	47,595	47,945	48,067	49,002	95,679	96,550

NOTES: Turkish Liras. Standard deviations are reported in parentheses. *Includes wage earners only. **Includes all employed agents

The size of the minimum wage rise in 2016 was totally unexpected. Before the November 2015 elections, opposition parties proposed unrealistic minimum wage levels prior to the election. Main (left) opposition party promised %50 net increase in the minimum wage. The ruling (right) party first did not take it seriously but opposition offers created strong pressure on the ruling party. As a result, they proposed a %30 net increase in the minimum wage. Usually the minimum wage committee holds its meetings in December and announces the new minimum wage a couple of days before the new year.

Table 3.2: Summary Statistics for the Formal and Informal Markets

Variable / Year	2013/1	2013/2	2014/1	2014/2	2015/1	2015/2	2016	2017
				Formal Market				
Median Wage	1120	1200	1200	1300	1400	1500	1650	1800
50-10%	366	400	350	430	460	500	350	400
90-50%	1530	1528	1800	1700	1600	1520	1850	2200
Mean Wage	1531.39	1567.81	1655.20	1712.46	1787.49	1860.49	2132.54	2341.09
	(1111.74)	(1081.81)	(1169.97)	(1177.34)	(1230.79)	(1233.59)	(1311.62)	(1439.24)
Weekly Hours	48.93	49.36	48.76	48.78	48.13	48.29	47.52	47.44
	(11.46)	(11.33)	(11.26)	(10.99)	(10.73)	(10.66)	(10.29)	(10.13)
Hourly Wage	8.04	8.13	8.66	8.95	9.40	9.77	11.30	12.41
	(6.97)	(6.62)	(7.17)	(7.25)	(7.51)	(7.65)	(8.29)	(9.12)
Average Age	34.76	34.96	34.91	35.03	35.06	35.18	35.40	35.73
	(9.38)	(9.46)	(9.52)	(9.64)	(9.65)	(9.71)	(9.76)	(9.80)
Observations	40,286	39,949	39,427	39,266	40,527	40,764	81,008	81,692
				Informal Market				
Median Wage	700	750	750	800	800	900	1000	1000
50-10%	450	450	450	460	500	500	600	570
90-50%	500	450	450	600	700	600	500	800
Mean Wage	714.82	772.80	787.20	836.23	868.99	918.15	1034.47	1157.65
	(463.76)	(447.81)	(498.31)	(484.17)	(521.22)	(534.43)	(590.30)	(691.58)
Weekly Hours	51.68	53.80	51.67	53.20	51.61	53.54	51.70	50.86
	(17.10)	(17.35)	(18.55)	(17.78)	(18.47)	(18.07)	(17.93)	(17.52)
Hourly Wage	3.53	3.63	3.98	4.05	4.37	4.60	5.16	5.80
	(3.52)	(2.63)	(3.87)	(3.32)	(4.14)	(4.32)	(4.12)	(4.62)
Average Age	33.64	33.90	33.85	34.40	34.51	34.14	35.07	35.37
	(12.71)	(12.97)	(13.20)	(13.52)	(13.49)	(13.64)	(13.88)	(14.07)
Observations	8,648	8,648	8,168	8,679	7,540	8,238	14,671	14,858

NOTES: Turkish Liras. Standard deviations are reported in parentheses.

Without controlling for agents characteristics(age, gender, education etc.), the informal worker monthly mean wage is half of that of the formal worker. Since working hours are higher for informal workers, the average hourly wage is less than half of the formal workers' hourly wage. The lower panel of Table 3.2 presents the summary statistics for informal workers. Although minimum wage legislation applies to the formal market, one can see remarkable changes in informal worker wages. This feature of the market could be an argument for the lighthouse effect where employers and workers take formal market minimum wage as a reference point.

The existing literature on minimum wage generally focuses on the young population, low paid sectors and unskilled agents. In Turkey, minimum wage earners are younger on average but the minimum wage affects almost all age groups. Moreover, many high school graduates and even individuals with a university degree work for a minimum wage. Figure 3.5 shows the age distribution and education levels by wages. It graphs the distributions for all wage earners and distributions for individuals who get a wage between ±10% of the minimum wage. Due to this feature of Turkey, we do not focus only on specific groups in the population.

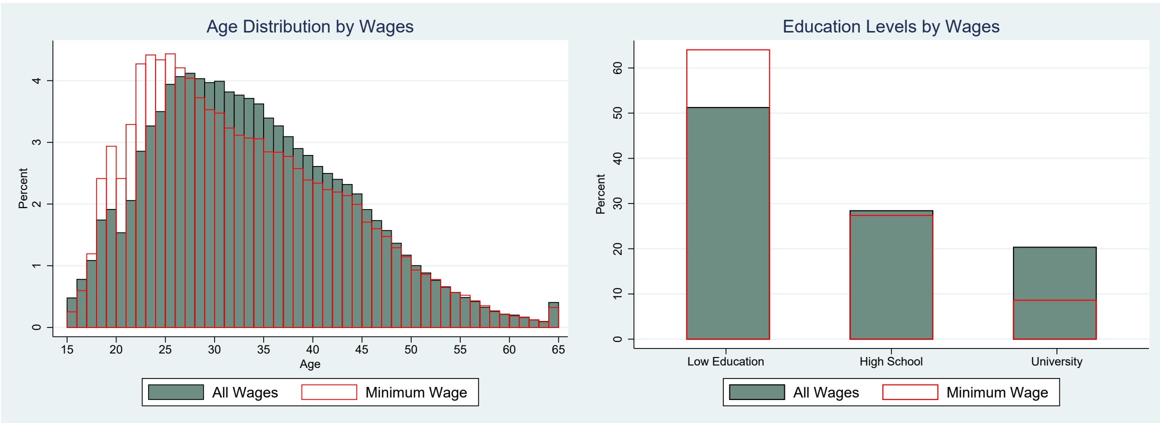

Figure 3.5: Age and Education Distributions by Wages

The gender pay gap is a global phenomenon which is discussed in the economics literature. Figure 3.6 presents the wage distributions by gender for 2016. Female workers are paid lower than male workers and their wages are more concentrated around the minimum wage. One should note that this fact is present for all years. If the Two-Sector Model predictions hold for Turkey, we should see a stronger wage effect for females and also more distinct changes in their employment outcomes.

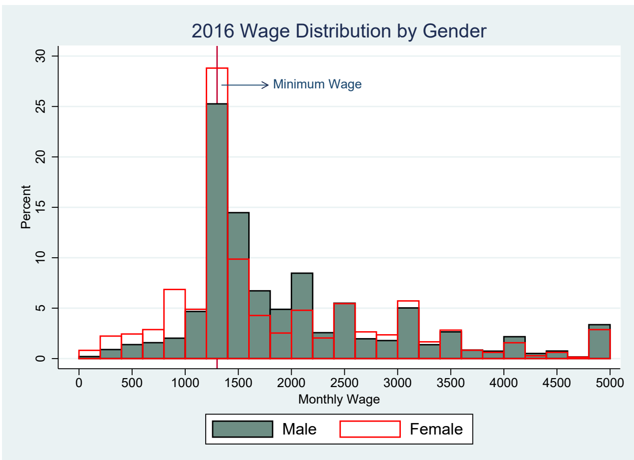

Figure 3.6: 2016 Wage Distribution by Gender

Tables 3.3 and 3.4 show the bite of the minimum wage in Turkey. During the last 15 years, around 20-25% of the people get a wage lower than the official minimum wage rate, and this ratio is around 10-15% when only the formal labour market is considered. This quite high ratio reflects the difficulty in applying the minimum wage legislation. The first row of Table 3.3 gives the percentage of workers who earn less than the minimum wage. So, for example, 23.55% of the workers in the second half of 2013 are having a lower wage than the minimum wage. The second row gives the percentages of workers who earn less than the minimum wage of the following year. Then, 26.18% of the workers in 2013/2 are getting a lower wage than the minimum wage in 2014/1. While the percentage of people below the minimum wage of the following period is around 30% before 2016, as we have a dramatic increase in 2016 the percentage of workers in 2015/2 with a lower wage than the 2016 minimum wage rate jumps over 50%. Moreover, it seems that the economy could not respond sufficiently to this wage increase as the post-minimum percentage is 39.02%. It is worth noting that there is a stable 10% difference between the percentages of workers who earn less than the next minimum wage and the percentage of workers in the following period who earn less than the actual minimum wage. The third row shows the share of workers earning less than the previous year's minimum wage. It seems that the labour market reacts slowly to changes in the minimum wage as 14.27% of the workers in 2017 get a wage lower than the 2016 minimum wage.

Following Machin et al. (2003) we define a gap parameter as the proportional increase in wages needed to bring workers paid below minimum wage at the minimum wage rate. The wage gap is defined as

$$GAP_t = \frac{\sum_i max\{MW_t - W_{it}, 0\}}{\sum_i W_{it}}$$

where MW_t is the relevant minimum wage at time t and W_{it} is agent i's monthly wage. While the necessary average increase is 2.8% before 2016, it jumps to 4% in 2016. To see how dense the wage distribution is around the minimum wage, Table 3.3 presents the share of the workers with a wage level in the interval (i $\mp$ 10%) of the minimum wage rate. The concentration around the minimum wage level is quite high (as 25-30% of the wage earners are in this 10 percentage interval).

Table 3.3: Bite of the Minimum Wage

Variable	2013/1	2013/2	2014/1	2014/2	2015/1	2015/2	2016	2017
% Paid less than MW of t	20.84	23.55	17.36	20.06	19.00	32.78	39.02	34.08
% Paid less than MW of t+1	32.44	26.18	27.98	29.24	37.50	50.52	42.86	48.69
% Paid less than MW of t-1	13.78	13.42	14.87	12.96	12.33	13.25	12.53	14.27
MW Gap	0.031	0.028	0.028	0.027	0.029	0.028	0.040	0.035
Share of ±10% around MW	25.68	21.00	23.90	19.82	26.33	25.86	29.30	33.45

Table 3.4 shows the difference between the formal and informal markets. A significant portion of the informal workers get a wage lower than the minimum wage and this is still the case when we compare their wage with previous year minimum wage. For example in 2016, 80.13% of the informal workers earn less than the minimum wage. Moreover, in 2017, 61.69% of the workers still get a lower wage than the 2016 minimum wage. On the other hand, 32.11% of the formal workers in 2016 get a wage lower than the 2016 minimum wage. However, this share drops to 6.25% when we compare 2017 wages with the 2016 minimum wage.

Table 3.4: Bite of the Minimum Wage for Formal and Informal Markets

Variable	2013/1	2013/2	2014/1	2014/2	2015/1	2015/2	2016	2017
Formal Market								
% Paid less than MW of t	12.53	15.32	9.07	12.43	11.86	24.89	32.11	27.31
% Paid less than MW of t+1	24.38	18.34	20.61	21.78	30.51	43.97	36.19	42.05
% Paid less than MW of t-1	5.27	5.39	6.36	4.74	5.18	5.39	4.85	6.25
Share of ±10% around MW	25.72	21.27	24.13	20.86	26.54	26.45	30.44	34.42
Observations	40,286	39,949	39,427	39,266	40,527	40,764	81,008	81,692
Informal Market								
% Paid less than MW of t	60.82	63.50	61.35	59.13	61.09	75.16	80.13	74.14
% Paid less than MW of t+1	71.20	64.30	67.07	67.42	78.74	85.74	82.52	87.96
% Paid less than MW of t-1	54.73	52.46	60.05	55.07	54.47	55.48	58.22	61.69
Share of ±10% around MW	25.48	19.70	22.68	14.50	25.06	22.71	22.49	27.72
Observations	8,648	8,648	8,168	8,679	7,540	8,238	14,671	14,858

Figure 3.7 shows the cumulative distribution of wages for 2016 and 2017. Wages are set for a month and we have increments by multiples of 10 Turkish Liras. However, we observe a concentration around the 50s and 100s. While the red dashed lines show the minimum wages for 2016 and 2017 respectively, black dashed lines show the multiples of 100.

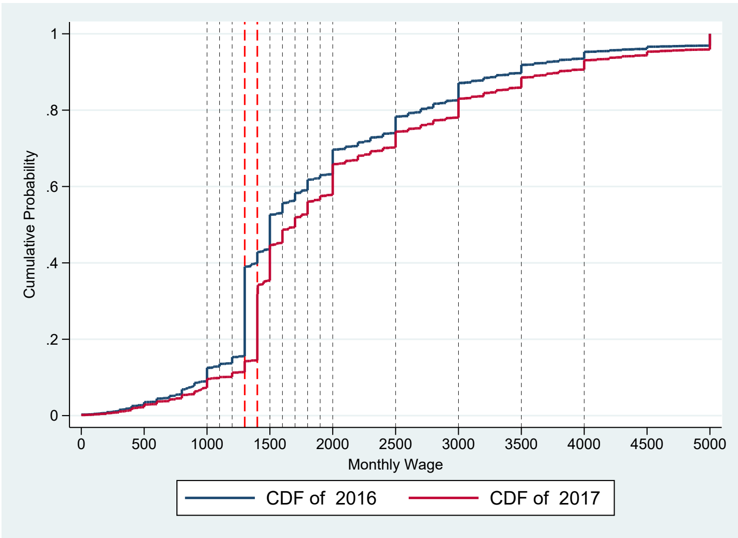

Figure 3.7: Cumulative Wage Distributions for 2016 and 2017

This feature is a common fact of the wages in Turkey as most of the wage bargaining is negotiated by multiples of 50 Turkish Liras. But this could affect the calculations of the summary statistics and estimations. Hence by using rounded minimum wages we replicate Table 3.3 in Table 3.5 and give the difference between Tables 3.3 and 3.5 in Table 3.6.

One can say that rounding creates limited differences. Moreover, for our estimations using exact minimum wages or rounded minimum wages do not create any significant change in coefficients. Therefore we use the exact value of the minimum wage in this study.

Table 3.5: Bite of the Minimum Wage with Rounded Wages

Variable	2013/1	2013/2	2014/1	2014/2	2015/1	2015/2	2016	2017
Minimum Wage	773.01	803.68	846.00	891.03	949.07	1000.54	1300.99	1404.06
Rounded Minimum Wage	775	805	850	900	950	1001	1301	1405
% Paid less than MW of t	21.45	23.84	25.35	28.32	24.56	32.78	39.02	34.26
% Paid less than MW of t+1	32.46	31.25	34.41	31.07	37.50	50.52	42.86	48.71
% Paid less than MW of t-1	18.61	13.69	15.01	16.50	16.73	16.07	12.53	14.27
Share of ±10% around MW	25.68	21.00	23.90	19.88	26.34	25.86	29.30	33.45

Table 3.6: Percentage Difference Between Tables 3.3 and 3.5

Variable	2013/1	2013/2	2014/1	2014/2	2015/1	2015/2	2016	2017
Minimum Wage	773.01	803.68	846.00	891.03	949.07	1000.54	1300.99	1404.06
Rounded Minimum Wage	775	805	850	900	950	1001	1301	1405
% Paid less than MW of t	0.61	0.29	7.99	8.26	5.56	0.00	0.00	0.18
% Paid less than MW of t+1	0.02	5.07	6.43	1.83	0.00	0.00	0.00	0.02
% Paid less than MW of t-1	4.83	0.27	0.14	3.54	4.40	2.82	0.00	0.00
Share of ±10% around MW	0.00	0.00	0.00	0.06	0.01	0.00	0.00	0.00

The following graphs show a clear picture of the effect of the minimum wage in Turkey. On the left panel of Figure 3.8, we have nominal wages for the years 2015 and 2016. For both years, the left side of the distributions are concentrated around minimum wage and once the minimum wage changes we have a shift for the mode of the distribution. The change in real wage distribution is on the right panel and a similar shift is visible. Kernel density estimations show the shift in wage distributions with the minimum wage.

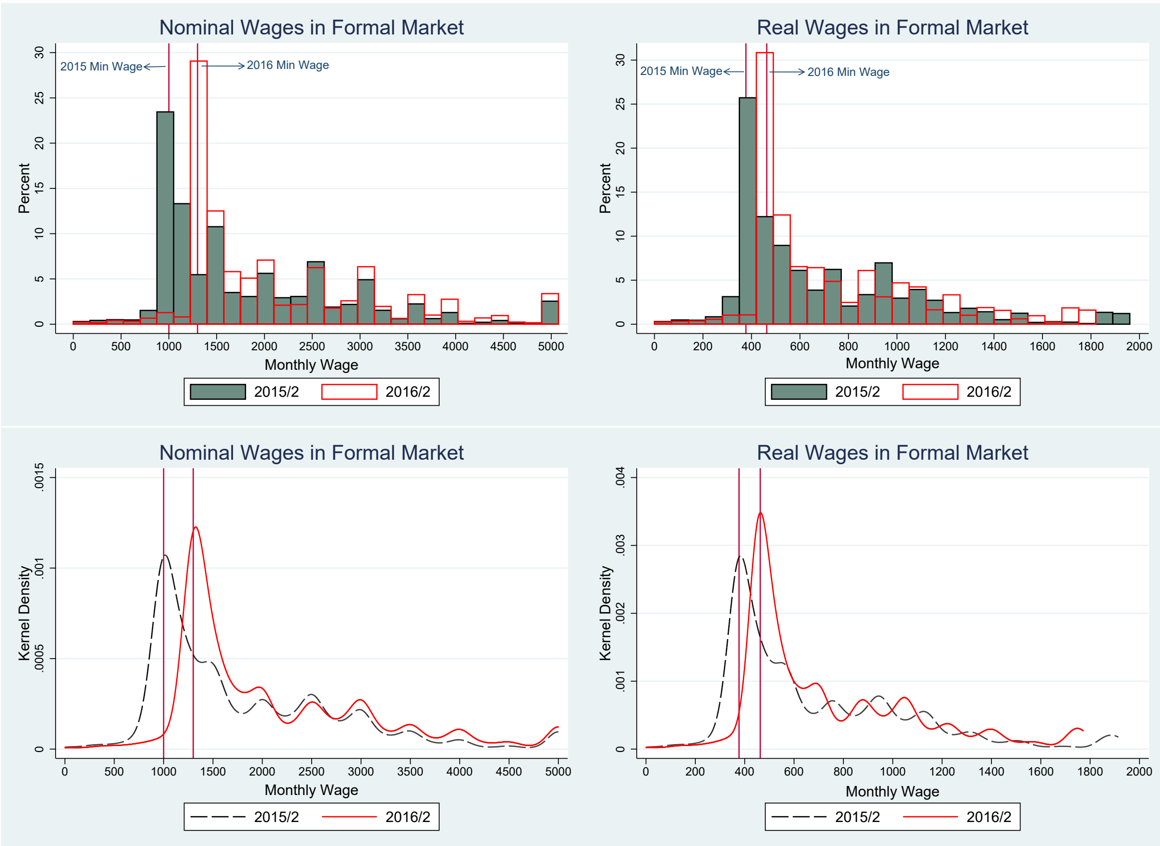

Figure 3.8: Formal Market Wage Distributions for 2015 and 2016

The shift in formal wages is something to be expected. However, more interestingly, a similar pattern can be observed for the informal market in Figure 3.9. The standard textbook model with two types of labour inputs (formal and informal) anticipates a decrease in the informal market wage when the formal market wage is increased exogenously. The model says once you increase the minimum wage level in the formal market, some of the formal workers may lose their jobs and possibly look for a job in the informal market which leads to a reduction in informal worker wages. The Two-Sector model assumes a segmented labour market, however if the labour market works as an integrated competitive market, the prediction of the

Two-Sector model may not hold. There are several explanations about the increase in informal wages due to the minimum wage. If the hike in the minimum wage leads to a capital reallocation into the labour-intensive informal market, this could increase the wages for informal workers. Moreover, the increase in minimum wage could increase the demand for the goods that are produced by the informal labour and the increased prices could lead to an increase in informal wages. Or simply, firms may take minimum wage as a reference while setting their wages and increase wages for their informal workers. It is important to note that the change in informal wages might be due to the large scale increase in 2016. In the following sections, we will assess the effect of the minimum wage for the 2005-2017 period.

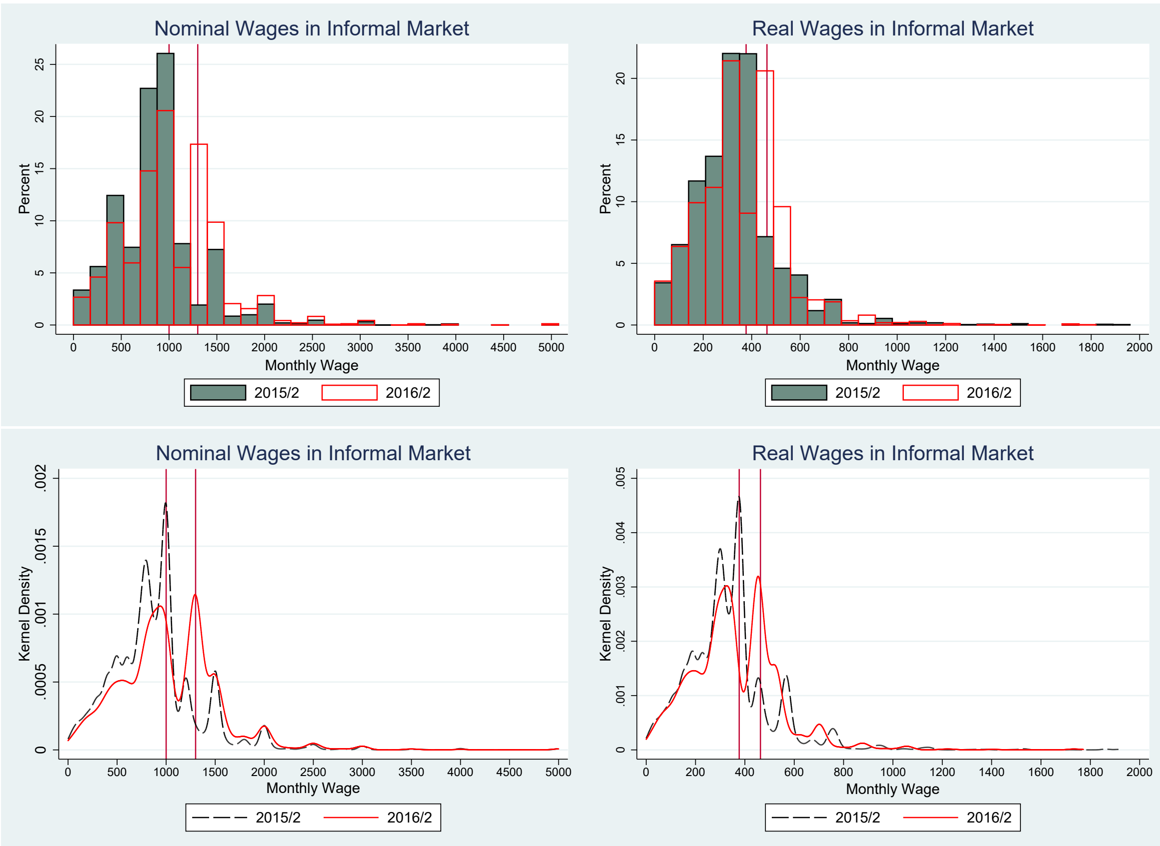

Figure 3.9: Informal Market Wage Distributions for 2015 and 2016

Figure 3.10 shows the change in real hourly wages for the same years. Again the shifts are visible for both markets, however, it seems that the rise in the informal hourly wages is smaller in size which could be argued as a result of an intensive margin response. But the working hour distributions in Figure 3.11 show that people are working fewer hours in both formal and informal markets.

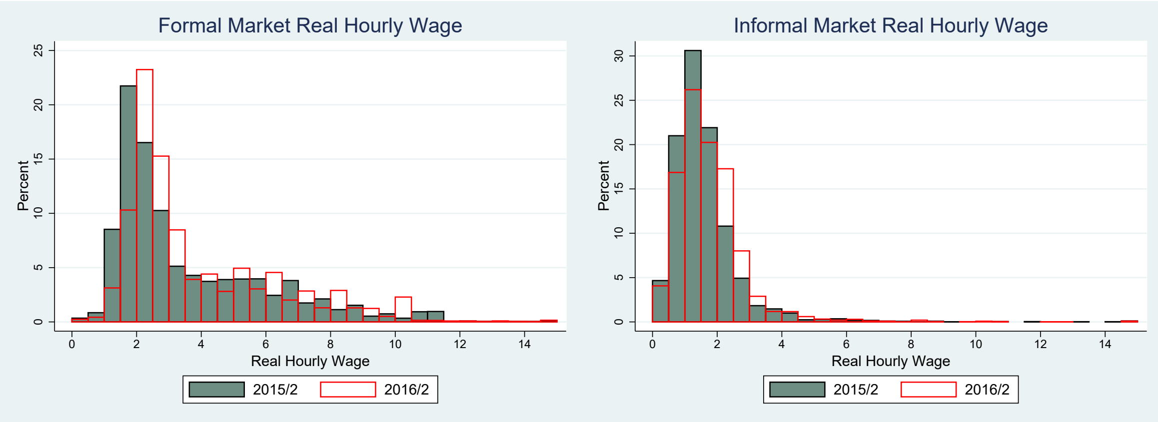

Figure 3.10: Hourly Wage Distributions for 2015 and 2016

Therefore, the intensive margin responses seem limited after minimum wage hike. For Turkey, the intensive margin analysis needs more attention. The minimum wage is set for a month and according to the Labour Law weekly working hours cannot exceed 45 hours. Although there is an overtime payment legislation, many companies do not apply this rule and workers with different working hours get the same monthly wage. This feature might affect the employer's working hour demand, but we cannot directly observe it from the hour's distributions.

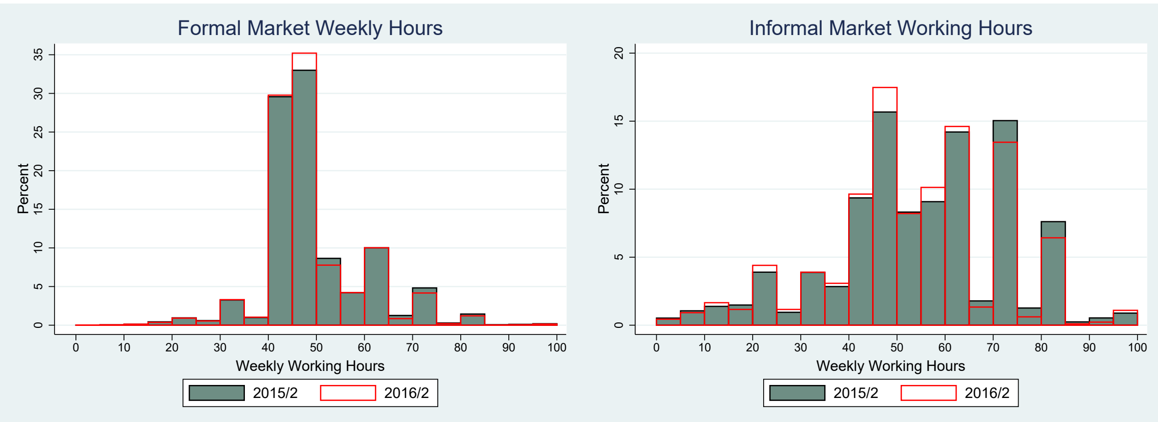

Figure 3.11: Weekly Working Hour Distributions for 2015 and 2016

One of the aims of this study is to analyse the effects of minimum wage changes on labour market outcomes such as employment(formal and informal), unemployment and participation rates. Figure 3.12 shows the share of the employed, unemployed and inactive agents for the past 15 years. In 2016, there is a very limited negative movement in the share of the employed. Global crisis during 2008 and 2009 creates a huge hike in unemployment and we observe a significant jump in the second half of 2016. The second panel of Figure 3.12 shows the share of the formal and informal labour markets. Again we can observe the reduction in the formal share for the second half of 2016.

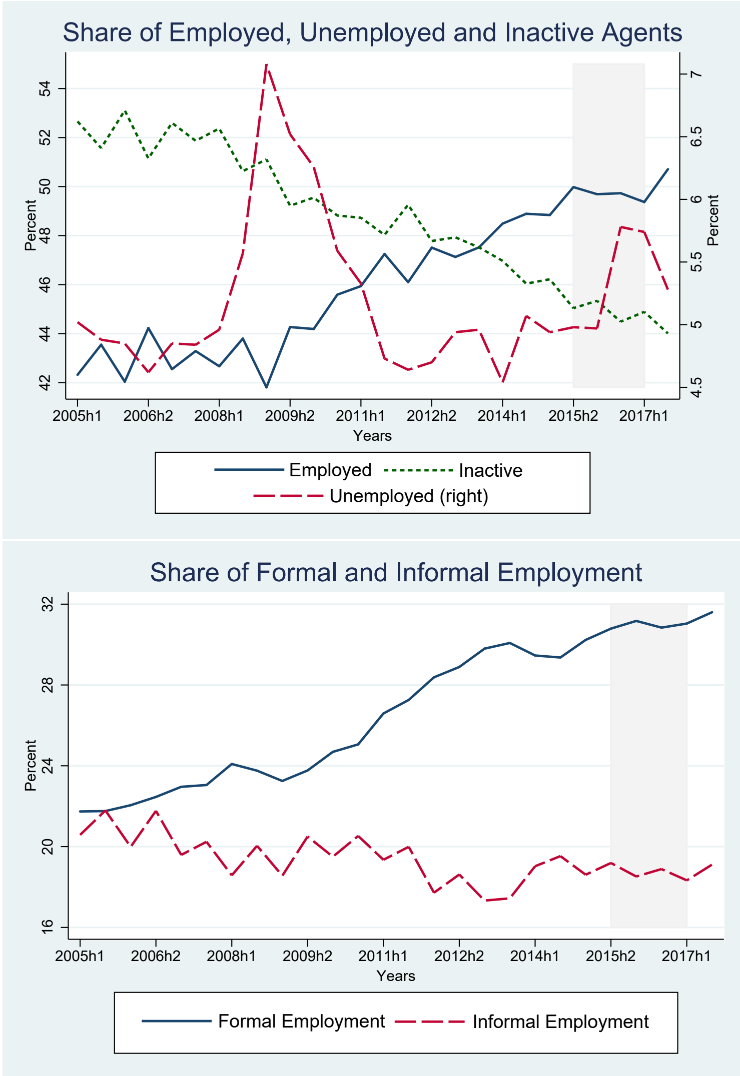

Figure 3.12: Share of Employed, Unemployed and Inactive Agents

Finally, Figure 3.13 shows the transition probabilities from each state of the labour market. The negative effect of the global financial crisis on transition probabilities is visible in Figure 3.13. We can observe that transition to employment from all three states decreased considerably in 2016. Moreover, transition probabilities to unemployment increased in 2016. These features could be associated with possible negative effects of the minimum wage on the labour market. However, there are similar fluctuations for the other years and it is very hard to conclude that the minimum wage hike in 2016 leads to negative outcomes on the labour market.

To sum up, from the descriptive statistics and graphs, there is a clear change in wages with the minimum wage. However for the employment outcomes, even for the 2016 minimum wage hike, we do not observe a clear change. The next section estimates wage and employment effect of the minimum wage for our study period.

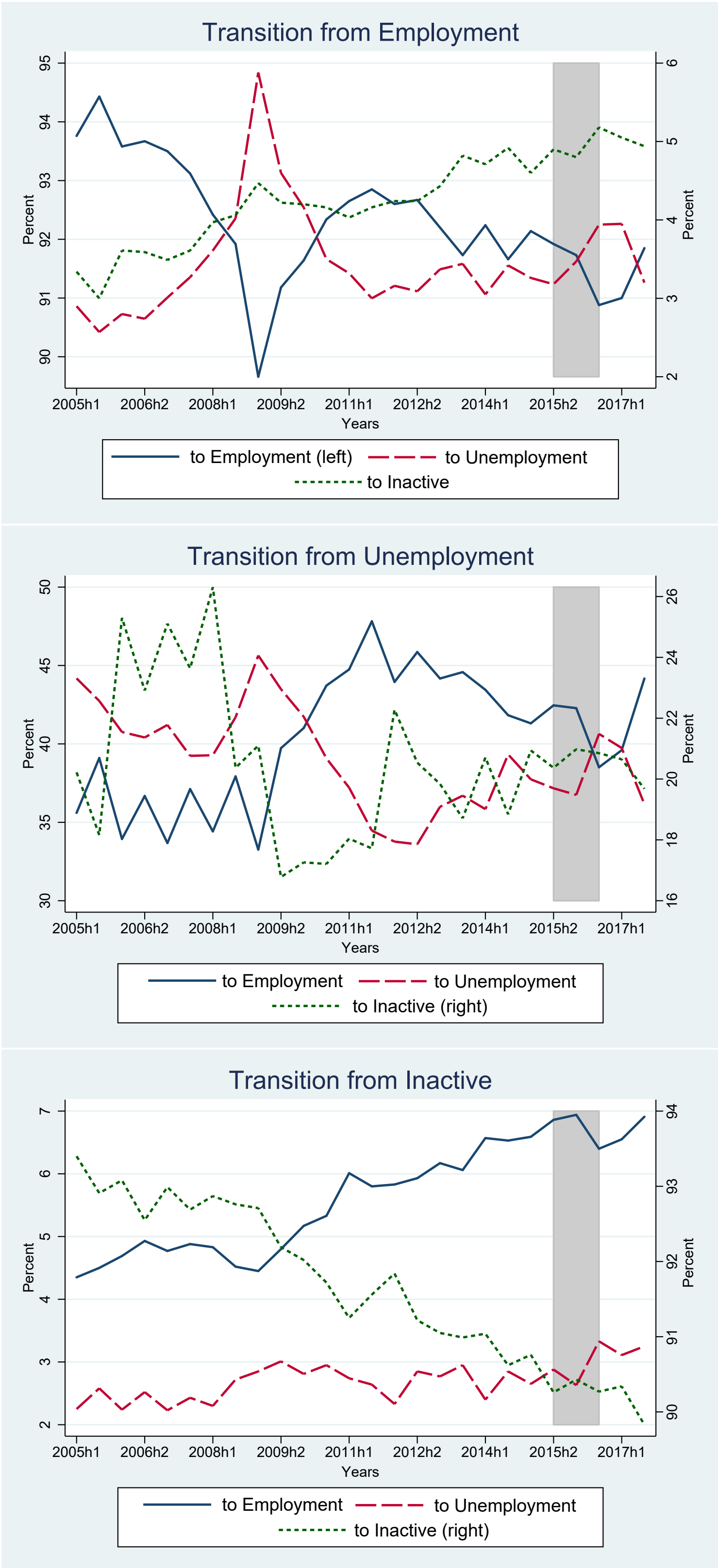

Figure 3.13: Transition Probabilities from Each State

3.3 Econometric Analysis

The existing literature utilizes both the individual level and aggregate data for assessing the effects of the minimum wage. Since the nominal minimum wage is set for the entire country it is not possible to use individual level data for Turkey. Therefore, we analyse the correlation of minimum wage with wages and labour market outcomes by aggregating the data for NUTS-2 level regions which creates a pseudo-panel. In this analysis identifying variation emerges from regional differences which depend on the initial condition of the different regions, groups or sectors.

3.3.1 Wages

There is still an ongoing discussion on the effect of minimum wages. First, we focus on the changes in wages with the minimum wage. Figures 3.8 and 3.9 show the effect of the rise in 2016 on both the formal and informal markets. Here we evaluate the effect for the 2005-2017 period. Following Machin et al. (2003) and Harasztosi and Lindner (2018), we regress the change in log mean real wages among different regions of Turkey on minimum wage measure. Our regression takes the following form:

$$\Delta \log \overline{W_{st}} = \alpha + \beta MW_{st-1} + \lambda unemp_{st} + \delta X_{st} + \phi_s + \tau_t + \varepsilon_{st} \qquad (3.1)$$

where $\Delta \log \overline{W_{st}}$ is the change in the logarithm of average wages[4] in region s for time t and MW_{st-1} is the measure of the minimum wage at date t in region s. While $unemp_{st}$ stands for the unemployment rate in region s at time t, the other control variables X_{st} include average age, proportion of female in the region, proportion of low educated agents, proportion of singles, proportion of small firms, proportion of occupations requiring low skills, proportion of low paid sectors (includes manufacturing, wholesale and retail trade, accommodation and food services) and proportion of seasonal and part-time workers. ϕ_s and τ_t are NUTS-2 level region and time fixed effects. All regressions are weighted by the sampling weights of the individuals of that particular region in time t. In order to create well-defined minimum wage measures, here we aggregate the data for different minimum wage level periods. Namely, we use 6 months periods before 2016, and for 2016 and 2017 we use yearly data.

There are several ways to measure the incidence of minimum wage. Here we test six different measures commonly used in the literature. First, our preferred measure is Fraction Affected(FA) which is the share of agents who get a higher current

[4] Using log differences could be problematic for large percentage changes, however for our case results are almost identical when we use percentage change in average real wage as the dependent variable. Since log difference is symmetrical for the increase and decrease of the same magnitudes, we prefer the change in the log of average wages.

wage than the actual minimum wage but a lower wage than the following period's minimum wage. This measure assumes agents with a lower wage than the actual minimum wage will not primarily be affected by the subsequent minimum wage increase. Hence Fraction Affected takes non-compliance into consideration and we prefer to use this measure for our analysis. To compare with Fraction Affected, we use a second measure Fraction At which is defined as the fraction of the agents with wage in $0.98MW_t \leq W_t \leq 1.02MW_t$. Fraction At measure is a subset of Fraction Affected as the increase in the minimum wage is always greater than 2%. Hence compared to other measures, Fraction At gives the closest estimates to Fraction Affected. To point out the effect of non-compliance we use the third impact measure; Fraction Lower which is the fraction of agents whose wage is below the minimum wage of the following time period. As mentioned above, there is a considerable informal market in Turkey and consequently, the compliance rate differs across regions and sectors. However, Fraction Lower disregards this fact and expects an increase in the wages of agents whose wage is lower than the minimum wage. The final three measures are popular in the minimum wage literature, however, all of these disregard the non-compliance problem to some degree. Kaitz index is the ratio of the minimum wage to average wage, whereas the so-called Toughness parameter is the ratio of the minimum wage to the median wage. Finally, we compare other parameters with the Machin et al. (2003) Gap measure defined above. Table 3.7 gives a summary of the measures we use for the minimum wage.

Table 3.7: Minimum Wage Measures of Impact

Name of the Measure		**Definition**
Fraction Affected	$MW_t \leq W_t \leq MW_{t+1}$	Share of the agents with a higher wage than actual minimum wage and a lower wage than the next minimum wage
Fraction At	$0.98MW_t \leq W_t \leq 1.02MW_t$	Share of the agents in the 4% interval of actual minimum wage
Fraction Lower	$W_t \leq MW_{t+1}$	Share of the agents below the next minimum wage
Kaitz (MW/AW)	$MW_{t+1}/AverageW_t$	Ratio of next minimum wage to actual average wage
Toughness (MW/Median)	$MW_{t+1}/MedianW_t$	Ratio of next minimum wage to actual median wage
Gap	$\frac{\sum_i max\{MW_{t+1}-W_{it},0\}}{\sum_i W_{it}}$	Average increase in actual wages needed to bring workers paid below next minimum wage to next minimum wage

Here we exploit the variation in minimum wage measure within regions in time and across the regions. Therefore variation comes from the initial condition of the wages. As Machin et al.(2003) mentioned, the identification assumption here is independence of change in wages and initial wage levels. Namely, there should be no relationship between the change in wages and the initial level of wages. Machin et al.(2003) tests this assumption by comparing the relation of initial wages and wage changes for minimum wage period(1998/1999) with an earlier period (1992/1993) where no minimum wage was in place. In our case, we have a minimum wage for the whole data period. Actually, the minimum wage in Turkey has been updated regularly since 1974. Therefore it is not possible to test the independence assumption directly.

Table 3.8 presents the results for equation (3.1) by using six incidence parameters. Appendix C Table C1 reports the results for the full sample and other restricted samples. We present the restricted sample results in Table 3.8 for formal and informal wages separately. The upper panel shows the results for real wages, and in the lower panel, we report the change in log nominal wage. Here the coefficient of interest gives the elasticity of change in log average wages for minimum wage.

Table 3.8: Effect of the Minimum Wage on Wages

	Fraction Affected	Fraction At	Fraction Lower	Kaitz (MW/AW)	Toughness (MW/Median)	Gap
Restricted Sample - Real Wages						
All Wages	0.119**	0.080*	0.370***	0.718***	0.269***	0.853***
	(0.052)	(0.046)	(0.051)	(0.090)	(0.056)	(0.116)
Formal Wages	0.158**	0.093*	0.285***	0.797***	0.249***	0.811***
	(0.063)	(0.049)	(0.054)	(0.128)	(0.067)	(0.150)
Informal Wages	-0.161	-0.112	0.135**	0.126**	0.050	0.322
	(0.120)	(0.100)	(0.057)	(0.056)	(0.042)	(0.189)
Restricted Sample - Nominal Wages						
All Wages	0.113**	0.078*	0.374***	0.734***	0.273***	0.904***
	(0.053)	(0.046)	(0.050)	(0.095)	(0.058)	(0.124)
Formal Wages	0.152**	0.090*	0.287***	0.811***	0.252***	0.879***
	(0.063)	(0.049)	(0.050)	(0.132)	(0.070)	(0.159)
Informal Wages	-0.170	-0.116	0.139**	0.141**	0.050	0.368**
	(0.121)	(0.099)	(0.056)	(0.053)	(0.041)	(0.172)
Observations	546	546	546	546	546	546

NOTES: Dependent variable is the change in logarithm of average wages. Results are reported for the coefficients on different minimum wage incidence parameters. Control variables include unemployment rate, average age, share of females, share of low educated agents, share of singles, share of small firms, share of occupations requiring low skills, share of low paid sectors (includes manufacturing, wholesale and retail trade, accommodation and food services), share of seasonal and part-time workers. All regressions include region fixed effects, time fixed effects and region controls. Standard errors clustered at the NUTS-2 level are reported in parentheses. Significance levels are denoted as follows: ***1 percent, **5 percent, *10 percent.

Several studies about Turkey and developing countries with high inflation rates utilize real wages instead of nominal values[5]. To asses the employment effects of the minimum wage, it would be better to use real minimum wage as the employment decisions of the agents and firms depend on the real values of wages. Therefore we focus on the change in real wages with the real value of the minimum wage. However, since we deflate the minimum wage and individual wages with the same regional CPI, results are almost the same for real and nominal wages.

We observe a positive change in overall wages and this change is more apparent for formal wages. Appendix C Table C1 presents the result for the full sample and we still have a significant effect of minimum wage on formal wages. This might be interesting for some other countries. However, in Turkey the minimum wage has an impact on the formal wage distribution even if we consider all positive wage earners without any restriction. For the informal market, minimum wages correspond to a non-significant reduction.

In Table C1, the coefficients for young workers under 40 and 25 are smaller in magnitude due to the high informality rate for these age groups. The informality rate is around 32% for under 25 and the increase in the minimum wage leads to a non-significant increase in formal wages but a significant decrease in real wages for informal workers.

Minimum wage measures in Table 3.8 aggregate formal and informal workers. However, it is very unlikely that the Fraction Affected(FA) in the formal and informal market would affect the outcomes in a similar way. Therefore we are also interested in separate effects of formal and informal market minimum wage measures. Namely, instead of defining one MW_{st-1} measure we define two different parameters $MW^F_{st-1}$and MW^I_{st-1} for formal and informal workers separately. Then we estimate equation (3.1) and results are reported in Table 3.9. The impact of the formal and informal measures differ significantly. For the restricted sample, if Fraction Affected increases for formal workers, this leads to an increase in formal wages but a limited non-significant decrease in informal wages. On the other hand, if informal Fraction Affected increases this leads to a reduction in both formal and informal wages. This feature seems reasonable. If formal Fraction Affected is higher for region s, then once the minimum wage increases, it leads to a higher percentage increase for formal market wages. Moreover, a high Fraction Affected in the formal market leads more workers to enter the informal market and this will reduce the informal market wages which we see from the results. This transition from the formal market to the informal market is confirmed by the employment effects of the minimum wage. The negative change in informal wages is driven by the Fraction

[5]See Pelek(2013) for Turkey, Baanante(2004) for Peru, Lemos(2009) for Brazil, Menon and Rodgers(2017) for India

Affected in the informal market. When minimum wage increases and if FA in the informal market is high, the competition for an informal job is harder which leads to a further reduction in the informal market wages. Similarly, a higher share of informal FA increases the supply for formal jobs and creates a negative effect on formal wages. It turns out that our results for wage changes are consistent with the predictions of the Two-Sector Model.

Table 3.9: Effect of the Minimum Wage on Wages with Separate Incidence Parameters

		Fraction Affected	Fraction At	Fraction Lower	Kaitz (MW/AW)	Toughness (MW/Median)	Gap
Restricted Sample							
All Wages	MW^F	0.147**	0.108*	0.299***	0.765***	0.337***	0.917***
		(0.055)	(0.054)	(0.062)	(0.102)	(0.085)	(0.306)
	MW^I	-0.184	-0.174	0.501***	0.063**	0.061	0.822***
		(0.220)	(0.345)	(0.052)	(0.026)	(0.041)	(0.218)
Formal Wages	MW^F	0.204***	0.134**	0.331***	0.890***	0.360***	1.180***
		(0.061)	(0.055)	(0.066)	(0.122)	(0.102)	(0.241)
	MW^I	-0.458**	-0.397	0.165**	-0.025	0.005	0.512**
		(0.179)	(0.306)	(0.080)	(0.025)	(0.045)	(0.225)
Informal Wages	MW^F	-0.087	-0.050	0.070	0.033	-0.046	0.127
		(0.134)	(0.122)	(0.083)	(0.037)	(0.043)	(0.591)
	MW^I	-0.692***	-0.547**	0.250***	0.646***	0.314***	0.409**
		(0.169)	(0.233)	(0.082)	(0.047)	(0.047)	(0.176)
Restricted Sample- Nominal							
All Wages	MW^F	0.144**	0.111**	0.307***	0.781***	0.345***	1.033***
		(0.057)	(0.054)	(0.060)	(0.106)	(0.087)	(0.287)
	MW^I	-0.216	-0.223	0.496***	0.071***	0.067*	0.841***
		(0.215)	(0.346)	(0.055)	(0.024)	(0.039)	(0.228)
Formal Wages	MW^F	0.203***	0.139**	0.338***	0.905***	0.369***	1.290***
		(0.063)	(0.056)	(0.064)	(0.127)	(0.104)	(0.229)
	MW^I	-0.518***	-0.478	0.155*	-0.016	0.011	0.546**
		(0.177)	(0.292)	(0.080)	(0.022)	(0.043)	(0.233)
Informal Wages	MW^F	-0.090	-0.047	0.082	0.050	-0.035	0.250
		(0.134)	(0.120)	(0.083)	(0.035)	(0.041)	(0.577)
	MW^I	-0.744***	-0.619**	0.239***	0.654***	0.321***	0.421**
		(0.169)	(0.235)	(0.077)	(0.049)	(0.048)	(0.182)
Observations		546	546	546	546	546	546

NOTES: Dependent variable is the change in logarithm of average wages. Results are reported for the coefficients on different minimum wage incidence parameters. Control variables include unemployment rate, average age, share of females, share of low educated agents, share of singles, share of small firms, share of occupations requiring low skills, share of low paid sectors (includes manufacturing, wholesale and retail trade, accommodation and food services), share of seasonal and part-time workers. All regressions include region fixed effects, time fixed effects and region controls. Standard errors clustered at the NUTS-2 level are reported in parentheses. Significance levels are denoted as follows: ***1 percent, **5 percent, *10 percent.

Note that a higher informal FA also means that the informal wages in the region are relatively higher. Then, the share of the potential substitutes to a formal worker is higher for that region. This is the reason behind the different signs of the coefficients of informal Fraction Affected and informal Fraction Lower. Fraction Lower takes the share of agents with a wage lower than the minimum wage, therefore it also measures the effect of being a low wage region or similarly the effect of non-compliance on the change in wages.

These tables show that the effect of the minimum wage is positive and significant for the formal labour market. However, this is not the case for the informal market in general. There is a negative but non-significant effect of the minimum wage for informal workers. Hence one can say, wages in the informal market do not follow the increases in minimum wages and there is no evidence for presence of a lighthouse effect in Turkey. According to the standard textbook model, this result is not surprising as the standard model anticipates a transition from the formal market to the informal market which leads to a reduction for the informal wages. Manning (2016) points out the general consensus about the wage effect of the minimum wage and our results suggest that it is still apparent even with a high informality in the labour market.

3.3.2 Hours

In this section, we study whether a change in the minimum wage induces changes in the number of hours worked (intensive margin). We use equation (3.1) and our dependent variable is the change in log average hours for the restricted sample. Table 3.10 presents the results. We observe a non-significant small reduction in formal working hours and almost no change in the informal hours. The lower panel of Table 3.10 presents the results when we use the incidence parameters separately for the formal and informal market. Again we observe no significant change in working hours. Considering the monthly minimum wage in Turkey, one can expect an increase in working hours with the minimum wage hikes. As the overtime payments are not common for the low paid jobs, firms might have the incentive to increase working hours. However, changes in the minimum wage do not have any effect on the intensive margin which verifies the pattern in Figure 3.11.

The next section presents the effect of the minimum wage on employment.

Table 3.10: Effect of the Minimum Wage on Working Hours

		Fraction Affected	Fraction At	Fraction Lower	Kaitz (MW/AW)	Toughness (MW/Median)	Gap
Restricted Sample							
Hours		-0.028	-0.054*	-0.095***	-0.149***	-0.061***	-0.240**
		(0.030)	(0.030)	(0.027)	(0.033)	(0.021)	(0.100)
Formal Hours		-0.042	-0.065**	-0.057*	-0.116***	-0.046**	-0.125
		(0.028)	(0.027)	(0.028)	(0.031)	(0.021)	(0.091)
Informal Hours		0.006	0.025	-0.061*	-0.063*	0.032	-0.100
		(0.045)	(0.055)	(0.035)	(0.034)	(0.033)	(0.109)
Separate Incidence Parameters							
Hours	MW^F	-0.029	-0.057*	-0.067*	-0.150***	-0.091***	-0.038
		(0.029)	(0.031)	(0.036)	(0.037)	(0.022)	(0.190)
	MW^I	-0.004	0.013	-0.145***	-0.001	-0.011	-0.340***
		(0.143)	(0.168)	(0.034)	(0.018)	(0.012)	(0.119)
Formal Hours	MW^F	-0.046	-0.067**	-0.053	-0.123***	-0.084***	0.042
		(0.029)	(0.029)	(0.035)	(0.035)	(0.024)	(0.128)
	MW^I	0.022	0.008	-0.068*	0.010	-0.001	-0.261**
		(0.110)	(0.129)	(0.035)	(0.016)	(0.011)	(0.109)
Informal Hours	MW^F	-0.034	-0.039	-0.094*	-0.070*	-0.020	-0.063
		(0.044)	(0.053)	(0.049)	(0.038)	(0.031)	(0.339)
	MW^I	0.332	0.600**	-0.004	-0.010	-0.030	-0.117
		(0.202)	(0.255)	(0.063)	(0.028)	(0.020)	(0.158)
Observations		546	546	546	546	546	546

NOTES: Dependent variable is the change in logarithm of average hours. Results are reported for the coefficients on different minimum wage incidence parameters. Control variables include unemployment rate, average age, share of females, share of low educated agents, share of singles, share of small firms, share of occupations requiring low skills, share of low paid sectors (includes manufacturing, wholesale and retail trade, accommodation and food services), share of seasonal and part-time workers. All regressions include region fixed effects, time fixed effects and region controls. Standard errors clustered at the NUTS-2 level are reported in parentheses. Significance levels are denoted as follows: ***1 percent, **5 percent, *10 percent.

3.3.3 Employment

We analyse the employment effects of the minimum wage by using the right-hand side of equation (3.1) for different dependent employment variables. We apply a similar analysis to capture the change in employment with the minimum wage. We estimate the following form of equation;

$$\Delta \log N_{st} = \alpha + \beta MW_{st-1} + \lambda unemp_{st} + \delta X_{st} + \phi_s + \tau_t + \varepsilon_{st} \tag{3.2}$$

where the right-hand side of the equation is identical to that of equation (3.1) and the dependent variable $\Delta \log N_{st}$ is the change in the logarithm of relevant population share for region s in time t. Table 3.11 presents the results for equation (3.2).

It seems that the minimum wage has mostly limited effect on total employment. For the restricted sample, there is a small decrease in formal market share and the coefficient is non-significant. However, the informal market share increases with the minimum wage. Labour force participation increases with the minimum wage with additional unemployed and moves to the informal market. These results are in line with the standard textbook model which predicts an increase in the informal market after a hike in minimum wage. However we do not observe a significant reduction in formal employment share.

Table 3.11: Effect of the Minimum Wage on Employment

	Fraction Affected	Fraction At	Fraction Lower	Kaitz (MW/AW)	Toughness (MW/Median)	Gap
Restricted Sample						
Employment Share	0.030	0.069	0.117**	0.179***	0.079*	0.431**
	(0.072)	(0.064)	(0.054)	(0.046)	(0.042)	(0.159)
Formal Share	-0.045	0.072	0.334***	0.465***	0.250***	1.090***
	(0.081)	(0.054)	(0.107)	(0.103)	(0.087)	(0.304)
Informal Share	0.270**	0.128	-0.274	-0.323**	-0.243*	-0.780*
	(0.129)	(0.193)	(0.169)	(0.127)	(0.131)	(0.395)
Unemp Share	0.163	0.010	-0.271	-0.187	-0.293**	-0.812
	(0.188)	(0.166)	(0.159)	(0.190)	(0.126)	(0.597)
Labour Force Share	0.084*	0.096*	0.042	0.075	0.018	0.083
	(0.046)	(0.053)	(0.052)	(0.055)	(0.052)	(0.110)
Observations	546	546	546	546	546	546

NOTES: Dependent variable is the change in logarithm of labour market shares. Results are reported for the coefficients on difference minimum wage incidence parameters. Control variables include unemployment rate, average age, share of females, share of low educated agents, share of singles, share of small firms, share of occupations requiring low skills, share of low paid sectors (includes manufacturing, wholesale and retail trade, accommodation and food services), share of seasonal and part-time workers. All regressions include region fixed effects, time fixed effects and region controls. Standard errors clustered at the NUTS-2 level are reported in parentheses. Significance levels are denoted as follows: ***1 percent, **5 percent, *10 percent.

To understand the different dynamics of formal and informal workers, we define separate measures and Table 3.12 shows the results for separate incidence parameters. For the restricted sample, if Fraction Affected increases for the formal market this leads to an increase in the informal market share and a non-significant reduction in formal share. If Fraction Affected for informal workers increases, we have a reduction in the informal share but an increase in formal share. Once the minimum wage increases, if the share of affected informal workers is high, then many of these workers become either unemployed or formal worker. This is visible from the estimate of MW^I for formal and unemployed share.

Table 3.12: Effect of the Minimum Wage on Employment with Separate Incidence Parameters

		Fraction Affected	Fraction At	Fraction Lower	Kaitz (MW/AW)	Toughness (MW/Median)	Gap
Restricted Sample							
Emp Share	MW^F	0.083	0.105*	0.087	0.140***	0.123**	-0.051
		(0.066)	(0.060)	(0.063)	(0.046)	(0.045)	(0.319)
	MW^I	-0.481	-0.220	0.172*	0.046	0.045	0.670**
		(0.304)	(0.370)	(0.088)	(0.039)	(0.030)	(0.258)
Formal Share	MW^F	-0.060	0.027	0.001	0.329***	0.273***	-0.439
		(0.073)	(0.057)	(0.072)	(0.083)	(0.073)	(0.341)
	MW^I	0.136	0.599*	0.944***	0.036	0.041	1.846***
		(0.374)	(0.345)	(0.178)	(0.053)	(0.039)	(0.441)
Informal Share	MW^F	0.577***	0.461**	0.450**	-0.103	-0.062	1.400
		(0.138)	(0.210)	(0.165)	(0.133)	(0.124)	(0.955)
	MW^I	-2.628***	-2.863***	-1.603***	0.015	-0.028	-1.858***
		(0.567)	(0.738)	(0.258)	(0.084)	(0.077)	(0.573)
Unemp Share	MW^F	0.091	-0.104	0.021	-0.024	-0.122	1.332
		(0.192)	(0.182)	(0.179)	(0.185)	(0.145)	(0.878)
	MW^I	0.875	1.192	-0.806**	-0.212**	-0.093	-1.873**
		(0.618)	(0.909)	(0.304)	(0.099)	(0.095)	(0.703)
LF Share	MW^F	0.094	0.077	0.085	0.086	0.074	0.197
		(0.058)	(0.059)	(0.061)	(0.058)	(0.055)	(0.279)
	MW^I	-0.007	0.314	-0.038	-0.005	0.015	0.026
		(0.176)	(0.218)	(0.099)	(0.032)	(0.025)	(0.151)
Observations		546	546	546	546	546	546

NOTES: Dependent variable is the change in logarithm of labour market shares. Results are reported for the coefficients on difference minimum wage incidence parameters. Control variables include unemployment rate, average age, share of females, share of low educated agents, share of singles, share of small firms, share of occupations requiring low skills, share of low paid sectors (includes manufacturing, wholesale and retail trade, accommodation and food services), share of seasonal and part-time workers. All regressions include region fixed effects, time fixed effects and region controls. Standard errors clustered at the NUTS-2 level are reported in parentheses. Significance levels are denoted as follows: ***1 percent, **5 percent, *10 percent.

Although the LFS has a rotation sampling procedure, TURKSTAT does not share the panel dimension of the surveys. However, questions about previous year labour market status lead us to create panel dummies. We create $[Y_{it}|Y_{it-1}]$ dummy variable depending on this year and last year employment status. Emp_Emp dummy takes the value of 1 if the agent is employed last year and this year as well. Similarly, Emp_Unemp will be 1 if the agent is employed last year but unemployed this year. We aggregate these transitions and create share of each transition, and check the change in these shares with the minimum wage.

Table 3.13 presents the results for the restricted sample. Estimates are consistent with the results in Table 3.11. Given that the agents are employed at $t-1$, the transition to the informal market is significantly higher than the transition to formal jobs. This pattern is similar when we check agents who are unemployed or out of labour force previously.

Table 3.13: Effect of the Minimum Wage on Transition

	Fraction Affected	Fraction At	Fraction Lower	Kaitz (MW/AW)	Toughness (MW/Median)	Gap
Restricted Sample						
Emp_Emp Share	0.028	0.073	0.188***	0.250***	0.129**	0.564***
Emp_Formal Share	-0.021	0.102*	0.378***	0.507***	0.279***	1.147***
Emp_Informal Share	0.236	0.041	-0.196	-0.268*	-0.196	-0.862**
Emp_Unemp Share	0.221	-0.207	-0.322	-0.317	-0.417	-1.918**
Emp_Out Share	-0.180	-0.155	-0.528***	-0.211	-0.360	-1.080*
Restricted Sample						
Unemp_Emp Share	-0.285	-0.327	-0.566***	-0.427**	-0.467**	-0.003
Unemp_Formal Share	-0.683*	-0.473	-0.254	-0.251	-0.132	0.688
Unemp_Informal Share	0.692	0.102	-0.607	-0.526	-0.946***	-0.566
Unemp_Unemp Share	0.201	0.178	-0.507*	-0.443*	-0.423**	-0.680
Unemp_Out Share	0.210	0.481	-0.491	0.085	-0.234	-0.078
Restricted Sample						
Out_Emp Share	0.311	0.314	-0.372*	-0.375	-0.176	-1.440**
Out_Formal Share	0.247	0.110	-0.167	0.197	-0.060	-0.192
Out_Informal Share	0.348	0.550	-0.431	-0.488	-0.112	-1.123
Out_Unemp Share	0.100	-0.150	-0.414	-0.264	-0.444*	-0.783
Out_Out Share	-0.068**	-0.081**	0.015	-0.003	-0.004	0.097**
Observations	546	546	546	546	546	546

NOTES: Dependent variable is the change in logarithm of labour market transition shares. Results are reported for the coefficients on difference minimum wage incidence parameters. Control variables include unemployment rate, average age, share of females, share of low educated agents, share of singles, share of small firms, share of occupations requiring low skills, share of low paid sectors (includes manufacturing, wholesale and retail trade, accommodation and food services), share of seasonal and part-time workers. All regressions include region fixed effects, time fixed effects and region controls. Standard errors clustered at the NUTS-2 level but not reported for presenting purposes. Significance levels are denoted as follows: ***1 percent, **5 percent, *10 percent.

In Table 3.13, we have very few significant coefficients and this is due to the opposite effects of separate minimum wage measures. Table 3.14 presents the transition results when we have separate incidence parameters for formal and informal markets. For transition to informal market, while formal FA increases the share, a higher informal FA goes with a reduction in transition to informal labour.

Table 3.14: Effect of the Minimum Wage on Transitions with Separate Incidence

		Fraction Affected	Fraction At	Fraction Lower	Kaitz (MW/AW)	Toughness (MW/Median)	Gap
Restricted Sample							
Emp_Emp Share	MW^F	0.082	0.110*	0.130*	0.199***	0.169***	-0.115
	MW^I	-0.495	-0.221	0.295***	0.065	0.066**	0.901***
Emp_Formal Share	MW^F	-0.030	0.065	0.053	0.374***	0.314***	-0.339
	MW^I	0.118	0.544	0.975***	0.037	0.048	1.882***
Emp_Informal Share	MW^F	0.547***	0.359	0.483**	-0.057	-0.026	0.456
	MW^I	-2.753***	-2.854***	-1.441***	0.085	0.065	-1.515***
Emp_Unemp Share	MW^F	0.312	0.087	0.253	-0.058	-0.027	0.514
	MW^I	-0.628	-2.812**	-1.376**	-0.049	0.035	-3.121***
Emp_Out Share	MW^F	-0.074	0.041	-0.288	-0.091	-0.272	1.460
	MW^I	-1.239	-2.064	-0.967**	-0.055	-0.087	-2.337***
Restricted Sample							
Unemp_Emp Share	MW^F	-0.119	-0.169	-0.333	-0.337*	-0.346**	1.490
	MW^I	-1.743	-1.688	-0.993**	-0.105	0.093	-0.742
Unemp_Formal Share	MW^F	-0.655	-0.607	-0.576*	-0.384	-0.230	-0.028
	MW^I	-1.054	0.834	0.336	0.016	0.205	1.042
Unemp_Informal Share	MW^F	1.290	0.913	0.584	-0.128	-0.509*	5.156*
	MW^I	-4.321**	-7.085***	-2.792***	-0.278	0.010	-3.398
Unemp_Unemp Share	MW^F	0.121	-0.020	-0.116	-0.194	-0.195	3.456**
	MW^I	0.997	2.148	-1.224***	-0.306*	-0.153	-2.726***
Unemp_Out Share	MW^F	0.328	0.581	-0.194	0.339	-0.179	4.080**
	MW^I	-0.749	-0.162	-1.034*	-0.336	-0.398***	-2.135*
Restricted Sample							
Out_Emp Share	MW^F	0.181	0.232	-0.244	-0.391*	-0.126	-1.290
	MW^I	1.371	1.053	-0.608	-0.109	-0.289*	-1.515**
Out_Formal Share	MW^F	-0.039	0.041	-0.669**	-0.021	-0.217	-4.012**
	MW^I	2.742**	1.020	0.753	-0.002	-0.323	1.698
Out_Informal Share	MW^F	0.452	0.620	0.370	-0.292	0.052	4.537***
	MW^I	-0.695	-0.090	-1.899***	-0.204	-0.207	-3.924***
Out_Unemp Share	MW^F	-0.009	-0.274	-0.204	-0.224	-0.258	-0.796
	MW^I	1.161	0.953	-0.797	-0.203	-0.105	-0.776
Out_Out Share	MW^F	-0.066**	-0.073**	-0.032	-0.024	-0.011	-0.181
	MW^I	-0.074	-0.163	0.101**	0.017	0.011	0.234**
Observations		546	546	546	546	546	546

NOTES: Dependent variable is the change in logarithm of labour market transition shares. Results are reported for the coefficients on difference minimum wage incidence parameters. Control variables include unemployment rate, average age, share of females, share of low educated agents, share of singles, share of small firms, share of occupations requiring low skills, share of low paid sectors (includes manufacturing, wholesale and retail trade, accommodation and food services), share of seasonal and part-time workers. All regressions include region fixed effects, time fixed effects and region controls. Standard errors clustered at the NUTS-2 level but not reported for presenting purposes. Significance levels are denoted as follows: ***1 percent, **5 percent, *10 percent.

To sum up, changes in minimum wage have a significant increasing effect on formal wages and informal employment share. However it does not lead to significant change in informal wages and formal employment. Similarly, we do not observe any change in working hours due to change in minimum wage.

3.3.4 Changes in Wages and Employment by Gender

As noted in the descriptive statistics section, women are paid less than men in Turkey. Moreover, their wages are more concentrated around the minimum wage. Then the Two-Sector Model predicts a stronger wage effect on women wages and an increase in informal employment. Table 3.15 presents the change in wages for males and females separately. As expected there is an increase in women formal wages and the magnitude of increase is greater than the change in male wages. The informal female wages are reduced, but there is no significant change in male informal wages.

Table 3.15: Effect of the Minimum Wage on Wages - by Gender

	Fraction Affected	Fraction At	Fraction Lower	Kaitz (MW/AW)	Toughness (MW/Median)	Gap
Male						
All Wages	0.115**	0.087	0.349***	0.666***	0.284***	0.803***
	(0.054)	(0.051)	(0.050)	(0.073)	(0.056)	(0.139)
Formal Wages	0.117**	0.072	0.256***	0.744***	0.257***	0.837***
	(0.054)	(0.053)	(0.051)	(0.102)	(0.067)	(0.148)
Informal Wages	-0.027	-0.003	0.175**	0.107	0.053	0.287
	(0.101)	(0.115)	(0.067)	(0.066)	(0.062)	(0.219)
Female						
All Wages	0.141	0.046	0.476***	0.954***	0.203***	1.222***
	(0.120)	(0.088)	(0.084)	(0.160)	(0.091)	(0.194)
Formal Wages	0.299**	0.167*	0.406***	0.968***	0.228**	0.878***
	(0.140)	(0.092)	(0.096)	(0.214)	(0.092)	(0.275)
Informal Wages	-0.545**	-0.456**	-0.022	0.124	0.017	0.331
	(0.258)	(0.178)	(0.117)	(0.126)	(0.086)	(0.381)
Observations	546	546	546	546	546	546

NOTES: Dependent variable is the change in logarithm of average wages. Results are reported for the coefficients on different minimum wage incidence parameters. Control variables include unemployment rate, average age, share of females, share of low educated agents, share of singles, share of small firms, share of occupations requiring low skills, share of low paid sectors (includes manufacturing, wholesale and retail trade, accommodation and food services), share of seasonal and part-time workers. All regressions include region fixed effects, time fixed effects and region controls. Standard errors clustered at the NUTS-2 level are reported in parentheses. Significance levels are denoted as follows: ***1 percent, **5 percent, *10 percent.

Table 3.16 reports the employment results by gender. Informal women employment increases but there is no reduction in formal female employment. The change in female labour force share with the minimum wage is very remarkable for females. The increase in minimum wage does not induce a reduction in formal employment but an increase in informal employment. It increases the women labour force participation who work mainly in the informal market. The increase in formal female employment is very limited and non-significant. Therefore while the model prediction holds for change in wages, the change in labour market outcomes are not in line with the basic theoretical model.

Table 3.16: Effect of the Minimum Wage on Employment - by Gender

	Fraction Affected	Fraction At	Fraction Lower	Kaitz (MW/AW)	Toughness (MW/Median)	Gap
Male						
Employment Share	-0.024	-0.032	0.090	0.156***	0.057	0.446**
	(0.079)	(0.078)	(0.053)	(0.052)	(0.046)	(0.175)
Formal Share	-0.070	-0.007	0.297***	0.408***	0.230***	0.952***
	(0.094)	(0.072)	(0.106)	(0.096)	(0.079)	(0.266)
Informal Share	0.142	-0.043	-0.264	-0.300**	-0.269	-0.532
	(0.130)	(0.186)	(0.179)	(0.136)	(0.158)	(0.479)
Unemp Share	0.055	-0.045	-0.353**	-0.280	-0.336**	-1.118*
	(0.212)	(0.191)	(0.151)	(0.182)	(0.149)	(0.558)
Labour Force Share	0.035	0.018	0.012	0.043	0.000	0.028
	(0.049)	(0.053)	(0.054)	(0.060)	(0.058)	(0.114)
Female						
Employment Share	0.297**	0.519***	0.287	0.379	0.246	0.368
	(0.138)	(0.158)	(0.171)	(0.222)	(0.174)	(0.465)
Formal Share	0.075	0.411**	0.538**	0.957***	0.413**	2.200***
	(0.155)	(0.161)	(0.214)	(0.244)	(0.196)	(0.598)
Informal Share	0.770**	0.723**	-0.363	-0.589	-0.270	-2.007***
	(0.323)	(0.326)	(0.272)	(0.394)	(0.248)	(0.595)
Unemp Share	0.130	0.039	0.067	0.141	-0.109	0.433
	(0.238)	(0.241)	(0.303)	(0.278)	(0.173)	(0.882)
Labour Force Share	0.300**	0.419***	0.261	0.290	0.161	0.379
	(0.130)	(0.144)	(0.165)	(0.181)	(0.145)	(0.473)
Observations	546	546	546	546	546	546

NOTES: Dependent variable is the change in logarithm of labour market shares. Results are reported for the coefficients on difference minimum wage incidence parameters. Control variables include unemployment rate, average age, share of females, share of low educated agents, share of singles, share of small firms, share of occupations requiring low skills, share of low paid sectors (includes manufacturing, wholesale and retail trade, accommodation and food services), share of seasonal and part-time workers. All regressions include region fixed effects, time fixed effects and region controls. Standard errors clustered at the NUTS-2 level are reported in parentheses. Significance levels are denoted as follows: ***1 percent, **5 percent, *10 percent.

We observe a significant increase in informal employment which is due to the increased labour force participation. However, there is no significant change in formal employment. Comparing with the results in Table 3.11, we conclude that the significant changes in total employment are mainly driven by the changes in women employment outcomes.

3.3.5 Robustness Check

Neumark et al.(2007,2014) and Allegretto et al.(2011,2017) mainly discuss the time fixed effects controls. Dube et al.(2010) suggests that a general time fixed effect control is not capable of capturing the heterogeneity in underlying employment patterns. In our baseline model, we only control for time fixed effects. In this section, we add linear time trends for each NUTS-2 region as there could be differentiated time trends for different regions. Tables C2 and C3 in Appendix C present the results for wages and employment where Table C3 uses the separate incidence parameters. There are some limited changes in coefficients but results are consistent with the case without the trends. The regional trends in wages and employment outcomes do not significantly change the results.

3.4 Conclusion

In this study, we focus on the consequences of the minimum wage in Turkey and explore its effect on wage and employment for both formal and informal labour markets.

Following the literature we analyse the change in labour market outcomes by using the regional variation in minimum wage bite. Our results partially in line with the predictions of the Two-Sector Model. We show that minimum wage has a significant positive effect on the formal wages. However, there is no significant change in informal market wages with the minimum wage. For the employment outcomes, while the share of the informal employment increases with the minimum wage there is no significant change in formal employment. The increased share of informal labour is mainly due to increased labour force participation. Since females are paid less than males, the wage and employment effects are much stronger for women. Although minimum wage is set for a calendar month, we observe no changes in formal and informal working hours.

We propose a novel approach to differentiate the effects on formal and informal workers. Studies on develop countries utilize a single measure for the bite of the minimum wage. However under high informality rate, it is better to use separate minimum wage parameters for formal and informal labour market. We show that formal and informal incidence parameters have different consequences on the wage and employment outcomes. These separate incidence parameters clarify our understanding about the effect of minimum wage under the presence of high informality.

Since we utilize quarterly Labour Force Surveys we can observe all different minimum wage periods. Moreover, we have well-defined incidence parameters for each minimum wage period. Therefore the present study reports the most precise results for the effect of the minimum wage in Turkey so far.

Bibliography

[1] Akgündüz, Y.E., van den Berg, M. and Hassink, W. (2015). "The Impact of the Syrian Refugee Crisis on Firm Entry and Performance in Turkey". IZA Discussion Paper No. 884.

[2] Aksu, G., Erzan, R. and Kırdar, M.G. (2018). "The Impact of Mass Migration of Syrians on the Turkish Labor Market. Koç University". Working Paper No. 1815.

[3] Allegretto, S. A., Dube, A., and Reich, M. (2011). "Do minimum wages really reduce teen employment? Accounting for heterogeneity and selectivity in state panel data". Industrial Relations 50(2): 205–40.

[4] Allegretto, S. A., Dube, A., Reich, M., and Zipperer, B. (2017). "Credible Research Designs for Minimum Wage Studies: A Response to Neumark, Salas and Wascher." ILR Review 70(3):559-592.

[5] Altonji, J.G., and Card, D. (1991). "The Effects of Immigration on the Labor Market Outcomes of Less-skilled Natives." In Immigration, Trade, and the Labor Market, Abowd and Freeman. 201–234. University of Chicago Press.

[6] Atkinson, A.B., (1983), "How Progressive Should Income Tax Be?", Chapter 15, Social Justice and Public Policy, MIT Press.

[7] Baanante, M.J. (2004). "Minimum Wage Effects under Endogenous Compliance: Evidence from Peru". Económica, La Plata, Vol. L, Nro. 1-2.

[8] Barth, E., Bratsberg B., Naylor R. A. and Raaum, O. (2002) "Why and how wage curves differ: Evidence by union status for the United States, Great Britain and Norway", Working Paper, Department of Economics University of Oslo.

[9] Bastani, S., (2013), "Using the Discrete Model to Derive Optimal Income Tax Rates", Working Paper 2013:11, Uppsala Center for Fiscal Studies.

[10] Bell, L., (1997), "The Impact of Minimum Wages in Mexico and Colombia". Journal of Labor Economics, 15 (3), pp. 102-135.

[11] Bhorat, H., Kanbur, R., Mayet, N., (2013), "The Impact of Sectoral Minimum-wage Laws on Employment, Wages, and Hours of Work in South Africa". IZA Journal of Labor & Development, 2 (1), pp. 1-27.

[12] Blanchflower, D.G., Oswald, A.J. (1994). "The wage curve". MIT Press, Cambridge MA

[13] Blanchflower, D.G., Oswald, A.J. (2000). "International wage curves". In: Freeman R, Katz L (eds) Differences and changes in wage structures. University of Chicago Press and NBER, Chicago, IL

[14] Blundell, R. and MaCurdy T. (1999), "Labor Supply: A Review of Alternative Approaches", in O. Ashenfelter and D. Card (eds.), Handbook of Labor Economics, Vol. 3, North-Holland, Amsterdam, pp. 1559-1695.

[15] Boadway, R., Marchand, M., Pestieau, P., Del Mar Racionero, M. (2002), "Optimal Redistribution with Heterogeneous Preferences for Leisure", Journal of Public Economic Theory, 4-4, pp. 475-498.

[16] Bohn, S. and Owens, E.G., (2012), "Immigration and Informal Labor", Industrial Relations, Vol. 51, No. 4.

[17] Borjas, G.J. (2003). "The Labor Demand Curve is Downward Sloping: Reexamining the Impact of Immigration on the Labor Market". Quarterly Journal of Economics, 118, 1335–1374.

[18] Borjas, G.J. (2013). "The Analytics of the Wage Effect of Immigration". IZA Journal of Migration, 2:22.

[19] Borjas, G.J. (2014). "Immigration Economics". Harvard University Press, Cambridge, MA.

[20] Borjas, G.J. & Monras J. (2016). "The Labor Market Consequences of Refugee Supply Shocks". Economic Policy, 32, 361-413.

[21] Borjas, G.J., Freeman, R. B., and Katz, L. F. (1996). "Searching for the Effect of Immigration on the Labor Market". American Economic Review, 86, 246–251.

[22] Bosh, M. and Farre, L., (2013), "Immigration and the Informal Labor Market", IZA DP No. 7843.

[23] Bourguignon, F. and Spadaro, A., (2008), "Tax-benefit revealed social preferences", EUROMOD Working Papers

[24] Brett, C. and Weymark, J. (2015), “Voting Over Selfishly Optimal Nonlinear Income Tax Schedules”, Working Paper

[25] Broniatowska, P., A. Majchrowska, and Z. Zolkiewski (2015). “Minimum wage and youth unemployment in local labor markets in Poland”. Unpublished Working Paper

[26] Calderon-Mejia, V. and Ibanez, A. M. (2016). “Labour market effects of migrationrelated supply shocks: Evidence from internal refugees in Colombia”. Journal of Economic Geography 16 (3), 695–713.

[27] Card, D. (1990). “The Impact of the Mariel Boatlift on the Miami Labor Market”. Industrial and Labor Relations Review, 43, 245–257.

[28] Card, D. (2009). “Immigration and Inequality”. American Economic Review 99(2): 1–21.

[29] Card, D. (1992). “Using regional variation in wages to measure the effects of the federal minimum wage”. ILR Review, 46(1): 22–37.

[30] Card, D. and Krueger, A.B. (1995). “Myth and measurement: the new economics of the minimum wage”. New Jersey: Princeton University Press.

[31] Cengiz, D. and Tekgüç H. (2018). “Is It Merely A Labor Supply Shock? Impacts of Syrian Migrants on Local Economies in Turkey”. Mimeo.

[32] Ceritoğlu, E., Yüncüler, H.B., Torun, H., and Tümen, S. (2017). “The Impact of Syrian Refugees on Natives’ Labor Market Outcomes in Turkey: Evidence from a Quasi-Experimental Design”. Central Bank of Turkey Working Paper No: 17/05.

[33] Choné, P. and Laroque, G. (2005) “Optimal Incentives for Labor Force Participation”, J. Public Econ. 89(2--3) (2005) 395-425.

[34] Del Carpio, X., and Wagner, M. (2016). “The Impact of Syrian Refugees on the Turkish Labor Market”. Policy Research Working Paper Series 7402.

[35] Diamond, P. (1980), “Income taxation with fixed hours of work”, Journal of Public Economics 13(1), 101-110.

[36] Diamond, P. (1998), “Optimal Income Taxation: An Example with a U-Shaped Pattern of Optimal Marginal Tax Rates”, The American Economic Review Vol. 88, No. 1, pp. 83-95

[37] Dube, A., Lester, T. W., and Reich, M. (2010). "Minimum wage effects across state borders: estimates using contiguous counties". The Review of Economics and Statistics, 92(4): 945–964.

[38] Dustmann, C., Schönberg, U., and Stuhler, J. (2016). "The Impact of Immigration: Why Do Studies Reach Such Different Results?" Journal of Economic Perspectives, 30(4): 31–56.

[39] Dustmann, C., Schönberg, U. and Stuhler J. (2017). "Labor Supply Shocks, Native Wages, and the Adjustment of Local Employment". Quarterly Journal of Economics 132(1), 435-483.

[40] Ebert, U. (1992), "A reexamination of the optimal nonlinear income tax". Journal of Public Economics, 49(1): 47-73

[41] Fajnzylber, P. (2001). "Minimum-Wage Effects Throughout the Wage Distribution: Evidence from Brazil's Formal and Informal Sectors". CEDEPLAR W.P. No. 151.

[42] Fallah, B., Krafft, C., Wahba, J. (2019). "The impact of refugees on employment and wages in Jordan". Journal of Development Economics 139 (2019) 203–216

[43] Gerek, S. (1999), "Türkiye'de Asgari Ücretler ve Enflasyon (1974-1999)", T.C. Anadolu Üniversitesi Yayınları, No.1094, Eskişehir.

[44] Gindling, T., Terrell, K., (2007). "The effect of multiple minimum wages throughout the labor market: the case of Costa Rica". Labour Economics 14, 485–511.

[45] Guesnerie, R., (1995). "A Contribution to the Pure Theory of Taxation", Econometric Society Monograph. Cambridge University Press

[46] Guesnerie R., Seade J. (1982), "Nonlinear pricing in a finite economy". Journal of Public Economics, 57:157-179

[47] Hammond, P., (1979), "Straightforward individual incentive compatibility in large economies". Review of Economic Studies 46, 263-282.

[48] Harasztosi, P. and Lindner, A., (2017) "Who Pays for the Minimum Wage?". Working Paper.

[49] Hellwig, M. F. (2007). "A contribution to the theory of optimal utilitarian income taxation". Journal of Public Economics, 91:1449-1477.

[50] Homburg, S. (2002). “The Optimal Income Tax: Restatement and Extensions”. Hannover Economic Papers (HEP) dp-252, Leibniz Universität Hannover, Wirtschaftswissenschaftliche Fakultät.

[51] Hunt, J. (1992). “The Impact of the 1962 Repatriates from Algeria on the French Labor Market”. Industrial and Labor Relations Review, 43, 556–572.

[52] Jacquet, L. (2010), “Optimal Labor Income Taxation under Maximin: An Upper Bound”, Economics Bulletin, 30(4): 3152-3160.

[53] Karageorgiou, L. (2004). “The impact of minimum wage on youth and teenage employment in Greece”, SPOUDAI-Journal of Economics and Business, 54, 39-67.

[54] Khamis, M. (2013) “Does the minimum wage have a higher impact on the informal than on the formal labour market? Evidence from quasi-experiments”, Applied Economics, 45:4, 477-495,

[55] Kimball, M., (1990), “Precautionary saving in the small and in the large”. Econometrica, 58:53-73

[56] Laroque, G. (2005), “Income Maintenance and Labor Force Participation”, Econometrica, 73(2): 341-376 American Economic Review, 88(1), 83-95.

[57] Lemos, Sara (2009) “Minimum wage effects in a developing country”, Labour Economics 16 (2009) 224–237.

[58] Loayza, N., Ulyssea, G. and Utsumi, T. (2018). “Informality and the Labor Market Effects of Mass Migration: Theory and Evidence from Syrian Refugees in Turkey”. Unpublished Working Paper.

[59] Lollivier S., Rochet J-C, (1983), “Bunching and second-order conditions: a note on optimal tax theory”. Journal of Economic Theory, 31:392-400

[60] Lorenz, N. and Sachs, D., (2012), “Optimal Participation Taxes and Efficient Transfer Phase-Out”. No 2012-37, Working Paper Series of the Department of Economics, University of Konstanz.

[61] Machin, S., Manning, A., and Rahman, L., (2003). “Where the Minimum Wage Bites Hard : the Introduction of the UK National Minimum Wage to a Low Wage Sector”. Journal of European Economic Association.

[62] Machin, S. and Manning, A. (1994). “The effects of minimum wages on wage dispersion and employment: Evidence from the UK Wages Councils”, Industrial & Labor Relations Review, 47, 319-329.

[63] Maloney, W., Mendez, J., (2004). "Minimum wages in Latin America". In: Heckman, J., Pagés, C. (Eds.), Law and Employment: Lessons from Latin America and the Caribbean. NBER and University of Chicago, Cambridge, MA.

[64] Manning, A. (2016). "The Elusive Employment Effect of the Minimum Wage", CEP Discussion Paper No 1428.

[65] Maystadt, J.F. and Verwimp, P. (2014). "Winners and losers among a refugee-hosting population". Economic Development and Cultural Change 62 (4), 769–809.

[66] Menon, N., Rodgers, Y.M. (2017). "The Impact of the Minimum Wage on Male and Female Employment and Earnings in India". Asian Development Review, vol. 34, no. 1, pp. 28–64

[67] Mincer, J. (1974) "Schooling, experience and earnings". Columbia University Press, New York

[68] Mirrlees, J. (1971), "An Exploration in the Theory of Optimum Income Taxation", Review of Economic Studies, 38(114), 175-208.

[69] Montenegro, C., Pagès, C., (2004), "Who Benefits from Labor-Market Regulations? Chile, 1960-1998", in Heckman, J. J., Pagès, C. (Eds), Law and employment: Lessons from Latin America and the Caribbean, pp. 401-434, University of Chicago Press.

[70] Neumark, D., and Wascher,W. (1992). "Employment effects of minimum and subminimum wages: panel data on state minimum wage laws". ILR Review, 46(1): 55–81.

[71] Neumark, D. and Wascher, W. (2000). "Minimum wages and employment: A case study of the fast-food industry in New Jersey and Pennsylvania: Comment", American Economic Review, 1362-1396.

[72] Neumark, D., and Wascher,W. (2007). "Minimum Wages and Employment". Foundations and Trends in Microeconomics 3: 1–2.

[73] Neumark, D., Salas J.M.I., and Wascher,W. (2014). "Revisiting the minimum wage and employment debate: Throwing out the baby with the bathwater?", ILR Review 67(Supplement): 608–48.

[74] Ottaviano, G. and Peri, G. (2012). "Rethinking the Effect of Immigration on Wages". Journal of the European Economic Association, 10, 152-197.

[75] Ozturk, O. D. (2009). "Employment Effects of Minimum Wages in Inflexible Labor Markets". MPRA Paper No. 16233.

[76] Papps, K. L., (2012), "The Effects of Social-Security Taxes and Minimum Wages on Employment: Evidence from Turkey", Industrial and Labor Relations Review, 65 (3), pp. 686-707.

[77] Pelek, S. (2015). "The Employment Effect of the Minimum Wage: An Empirical Analysis from Turkey". Ekonomi-tek, 4, pp. 49-68.

[78] Pelek, S. (2013). "The impact of the minimum wage on the wage distribution: Evidence from Turkey", Giam Working Paper No:13-08

[79] Piketty, T. and Saez, E. (2012). "Optimal labor income taxation". NBER Working Papers 18521, National Bureau of Economic Research, Inc.

[80] Sadka, E. (1976), "On income distribution, incentive effects and optimal income taxation", Review of Economic Studies, 43(2), 261-8.

[81] Sadka, E. (1976), "On Progressive Income Taxation", The American Economic Review, Vol. 66, No. 5, pp. 931-935.

[82] Saez, E. (2001), "Using Elasticities to Derive Optimal Income Tax Rates", Review of Economics Studies, 68, 205-229.

[83] Seade, J. (1977), "On the Shape of Optimal Tax Schedules", Journal of Public Economics, 7(2), 203--235.

[84] Simula, L. (2010). "Optimal nonlinear income tax and nonlinear pricing: optimality conditions and comparative static properties". Social Choice and Welfare, 35(2):199-220.

[85] Stantcheva, S., (2014), "Optimal Income Taxation with Adverse Selection in the Labor Market", Review of Economic Studies 81: 1296-1329.

[86] Stiglitz, J. E. (1982), "Self-Selection and Pareto Efficient Taxation", Journal of Public Economics, 17(2): 213--40.

[87] Tuomala, M. (1990), "Optimal Income Tax and Redistribution", Oxford University Press, USA.

[88] Tuomala, M. (2010), "On optimal non-linear income taxation: numerical results revisited", International Tax and Public Finance, vol. 17-3, pages 259-270

[89] Turkish Disaster and Emergency Management Authority (DEMA). (2013). "Syrian refugees in Turkey, 2013: Field survey results". Ankara, Turkey.

[90] Turkish Disaster and Emergency Management Authority (DEMA). (2014). "Population Influx From Syria to Turkey, 2014". Ankara, Turkey.

[91] Turkish Disaster and Emergency Management Authority (DEMA). (2016). "Syrian Guests in Turkey, 2016". Ankara, Turkey.

[92] Turkish Disaster and Emergency Management Authority (DEMA). (2017). "Field Survey on Demographic View, Living Conditions and Future Expectations of Syrians in Turkey, 2017". Ankara, Turkey.

[93] Ulyssea, G. (2018). "Firms, informality and development: Theory and evidence from Brazil", American Economic Review.

[94] UNHCR (2016). "Global Trends: Forced Displacement in 2015". UNHCR, Geneva.

[95] UNHCR (2018). "Global Trends: Forced Displacement in 2017". UNHCR, Geneva.

[96] UNHCR (2019). "Registered Syrian Refugees by Date". Online Link: https://data2.unhcr.org/en/situations/syria/location/113

[97] UWT (2009). "The relationship between migration status and employment outcomes". Undocumented Worker Transitions, Work Package 10 Final Report.

[98] Weymark, J.A., (1986), "A reduced-form optimal nonlinear income tax problem". Journal of Public Economics, 30:199--217

[99] Weymark, J.A., (1987), "Comparative static properties of optimal nonlinear income taxes". Econometrica, 55:1165--1185

[100] Yüncüler, B. G. and Yüncüler, Ç. (2016). "Minimum Wage Effects on Labor Market Outcomes in Turkey", Central Bank of the Republic of Turkey, Working Paper No: 16/14.

Appendices

Appendix A

Appendix for Chapter 1

Proof of Lemma 1:

From $IC_{i,i-1}$ and $IC_{i-1,i}$ we have;

$\left[v\left(\frac{y_i}{w_{i-1}}\right) - v\left(\frac{y_i}{w_i}\right)\right] - \left[v\left(\frac{y_{i-1}}{w_{i-1}}\right) - v\left(\frac{y_{i-1}}{w_i}\right)\right] \geq 0$

The function $f(y) = v\left(\frac{y}{w_{i-1}}\right) - v\left(\frac{y}{w_i}\right)$ is increasing in y since its derivative;

$v'\left(\frac{y}{w_{i-1}}\right)\frac{1}{w_{i-1}} - v'\left(\frac{y}{w_i}\right)\frac{1}{w_i}$ is positive by the convexity of $v(.)$ and sorting condition $w_i > w_{i-1}$. Hence, $IC_{i,i-1}$ and $IC_{i-1,i}$ imply $y_i \geq y_{i-1}$. Rewrite $IC_{i,i-1}$ as $c_i - c_{i-1} \geq v\left(\frac{y_i}{w_i}\right) - v\left(\frac{y_{i-1}}{w_i}\right)$ so if $y_i \geq y_{i-1}$ then we have $c_i \geq c_{i-1}$. Suppose $c_i = c_{i-1}$ but $y_i \neq y_{i-1}$, then from $IC_{i,i-1}$ and $IC_{i-1,i}$ we have: $v\left(\frac{y_{i-1}}{w_i}\right) \geq v\left(\frac{y_i}{w_i}\right)$ and $v\left(\frac{y_i}{w_{i-1}}\right) \geq v\left(\frac{y_{i-1}}{w_{i-1}}\right)$, since these inequalities cannot hold at the same time, we should have $y_i = y_{i-1}$, otherwise one of the IC constraints would be violated.

Proof of Lemma 2:

First, local downward incentive compatibility constraints $IC_{i,i-1}$ and $IC_{i-1,i-2}$ implies global downward incentive compatibility constraint $IC_{i,i-2}$. From $IC_{i,i-1}$ and $IC_{i-1,i-2}$ we have;

$v\left(\frac{y_{i-1}}{w_i}\right) - v\left(\frac{y_i}{w_i}\right) \geq c_{i-1} - c_i$

$v\left(\frac{y_{i-2}}{w_{i-1}}\right) - v\left(\frac{y_{i-1}}{w_{i-1}}\right) \geq c_{i-2} - c_{i-1}$

Adding the conditions imply

$v\left(\frac{y_{i-1}}{w_i}\right) - v\left(\frac{y_i}{w_i}\right) + v\left(\frac{y_{i-2}}{w_{i-1}}\right) - v\left(\frac{y_{i-1}}{w_{i-1}}\right) \geq c_{i-2} - c_i \ (\bigstar)$

Note that the function $f(w) = v\left(\frac{y_{i-2}}{w}\right) - v\left(\frac{y_{i-1}}{w}\right)$ is increasing in w since its derivative $v'\left(\frac{y_{i-1}}{w}\right)\frac{y_{i-1}}{w^2} - v'\left(\frac{y_{i-2}}{w}\right)\frac{y_{i-2}}{w^2}$ is positive by the convexity of $v(.)$.

The LHS of ($\bigstar$) is smaller than $v\left(\frac{y_{i-1}}{w_i}\right) - v\left(\frac{y_i}{w_i}\right) + v\left(\frac{y_{i-2}}{w_i}\right) - v\left(\frac{y_{i-1}}{w_i}\right) = v\left(\frac{y_{i-2}}{w_i}\right) - v\left(\frac{y_i}{w_i}\right)$ hence $IC_{i,i-2}$ is satisfied: $v\left(\frac{y_{i-2}}{w_i}\right) - v\left(\frac{y_i}{w_i}\right) \geq c_{i-2} - c_i$.

Second, local upward incentive compatibility constraints $IC_{i-1,i}$ and $IC_{i-2,i-1}$ implies global upward incentive compatibility constraint $IC_{i-2,i}$. From $IC_{i-1,i}$ and $IC_{i-2,i-1}$ we have

$$v\left(\frac{y_i}{w_{i-1}}\right) - v\left(\frac{y_{i-1}}{w_{i-1}}\right) \geq c_i - c_{i-1}$$

$$v\left(\frac{y_{i-1}}{w_{i-2}}\right) - v\left(\frac{y_{i-2}}{w_{i-2}}\right) \geq c_{i-1} - c_{i-2}$$

Adding the conditions imply

$$v\left(\frac{y_i}{w_{i-1}}\right) - v\left(\frac{y_{i-1}}{w_{i-1}}\right) + v\left(\frac{y_{i-1}}{w_{i-2}}\right) - v\left(\frac{y_{i-2}}{w_{i-2}}\right) \geq c_i - c_{i-2}$$

Similarly, the LHS is smaller than

$$v\left(\frac{y_i}{w_{i-2}}\right) - v\left(\frac{y_{i-1}}{w_{i-2}}\right) + v\left(\frac{y_{i-1}}{w_{i-2}}\right) - v\left(\frac{y_{i-2}}{w_{i-2}}\right) = v\left(\frac{y_i}{w_{i-2}}\right) - v\left(\frac{y_{i-2}}{w_{i-2}}\right)$$

hence $IC_{i-2,i}$ is satisfied:

$$v\left(\frac{y_i}{w_{i-2}}\right) - v\left(\frac{y_{i-2}}{w_{i-2}}\right) \geq c_i - c_{i-2}$$

Proof of Lemma 3:

If both $IC_{i,i+1}$ and $IC_{i+1,i}$ bind we have;

$c_{i+1} - v\left(\frac{y_{i+1}}{w_{i+1}}\right) = c_i - v\left(\frac{y_i}{w_{i+1}}\right)$ and $c_i - v\left(\frac{y_i}{w_i}\right) = c_{i+1} - v\left(\frac{y_{i+1}}{w_i}\right)$

Adding the conditions imply;

$$v\left(\frac{y_{i+1}}{w_{i+1}}\right) - v\left(\frac{y_i}{w_{i+1}}\right) = v\left(\frac{y_{i+1}}{w_i}\right) - v\left(\frac{y_i}{w_i}\right)$$

Note that the function $f(w) = v\left(\frac{y_{i+1}}{w}\right) - v\left(\frac{y_i}{w}\right)$ is decreasing in w. Since we have $w_{i+1} > w_i$, this can happen only in bunching case *i.e.* $y_{i+1} = y_i$ and $c_{i+1} = c_i$

Proof of Proposition 4:

Marginal tax function for agent i with $GISW$:

$$T_i'(y_i^{GI}) = \frac{F_{i-1}-\beta_{i-1}}{F_i-\beta_{i-1}}\left[1 - v'\left(\frac{w_i l_i^{GI}}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]$$

Since under maximax we have only δ^N this condition will be as follows;

$$T_i'(y_i^{M}) = \frac{F_{i-1}}{F_i}\left[1 - v'\left(\frac{w_i l_i^{M}}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]$$

In *Proposition* 3 we show if δ^j where $j \geq i$ increases, β_{i-1} term will be zero. So the optimality conditions would be exactly the same and there is no change in the labour supply. So marginal tax rates are same. However if δ^j where $j < i$ increases, then β_{i-1} will be positive, and we have higher labour supply in maximax which leads to the result.

Proof of Proposition 5:

The agent condition is:

$$v'\left(\frac{y_i}{w_i}\right)\frac{1}{w_i} = 1 - \frac{\mu_{i+1,i}}{[\pi_i\delta^i+\mu_{i,i-1}+\mu_{i,i+1}]}\left[1-v'\left(\frac{y_i}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]$$
$$-\frac{\mu_{i-1,i}}{[\pi_i\delta^i+\mu_{i,i+1}+\mu_{i,i-1}]}\left[1-v'\left(\frac{y_i}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]$$

There is no need to discuss the cases 2, 3, 8 and 9 since in these cases agent i would be undistorted. So labour supply will be between the Rawlsian and Maximax cases so the marginal tax rates. For the remaining cases we need to consider each case separately;

In Rawlsian case the condition is: $v'\left(\frac{y_i^R}{w_i}\right)\frac{1}{w_i} = 1-\frac{1-F_i}{1-F_{i-1}}\left[1-v'\left(\frac{y_i^R}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]$

Similarly in maximax case: $v'\left(\frac{y_i^M}{w_i}\right)\frac{1}{w_i} = 1-\frac{F_{i-1}}{F_i}\left[1-v'\left(\frac{y_i^M}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]$

1-) If $\beta_{i-1} > F_{i-1}$ and $\beta_i > F_i$ then $IC_{i,i-1}$ and $IC_{i+1,i}$ bind. Optimality condition:

$v'\left(\frac{y_i}{w_i}\right)\frac{1}{w_i} = 1-\frac{\mu_{i+1,i}}{\pi_i\delta^i+\mu_{i,i-1}}\left[1-v'\left(\frac{y_i}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]$ where the distortion depends on agent $i+1$.

$\frac{\mu_{i+1,i}}{\pi_i\delta^i+\mu_{i,i-1}} = \frac{\beta_i-F_i}{\beta_i-F_{i-1}}$ which is less than or equal to $\frac{1-F_i}{1-F_{i-1}}$. Result follow by the convexity of $v(.)$. Since in maximax there is an upward distortion, result trivially holds for maximax case.

4-) If $\beta_{i-1} < F_{i-1}$ and $\beta_i > F_i$ then $IC_{i-1,i}$ and $IC_{i+1,i}$ binds. Optimality condition:

$v'\left(\frac{y_i}{w_i}\right)\frac{1}{w_i} = 1-\frac{\mu_{i-1,i}}{\pi_i\delta^i}\left[1-v'\left(\frac{y_i}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]-\frac{\mu_{i+1,i}}{\pi_i\delta^i}\left[1-v'\left(\frac{y_i}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]$ where the distortion depends on agents $i-1$ and $i+1$. This is the only case that we do not know the sign of the distortion. If $IC_{i-1,i}$ is binding then agent $i-1$ is either FB or distorted upward. Then second term is a positive number. We could show that the result would hold even we do not have this positive term. We have $\frac{\mu_{i+1,i}}{\pi_i\delta^i} = \frac{\beta_i-F_i}{\pi_i\delta^i}$.

Result holds under $\frac{1-F_i}{1-F_{i-1}} \geq \frac{\beta_i-F_i}{\pi_i\delta^i}$

Suppose the opposite is true so; $\frac{1-F_i}{1-F_{i-1}} < \frac{\beta_i-F_i}{\pi_i\delta^i}$

rewrite the condition as:

$$[\pi_{i+1}+...+\pi_N]\pi_i\delta^i < \pi_{i+1}[\pi_i+...+\pi_N][1-\delta^i]+...+\pi_N[\pi_i+...+\pi_N][1-\delta^N]$$

by rearranging we have;

$$\pi_i\delta^i+...+\pi_N\delta^N < \pi_i+...+\pi_N - \frac{\pi_i}{[\pi_{i+1}+...+\pi_N]}[\pi_{i+1}\delta^{i+1}+...+\pi_N\delta^N]$$

Which is not possible since $\beta_{i-1} < F_{i-1}$ implies $\pi_i\delta^i+...+\pi_N\delta^N > \pi_i+...+\pi_N$

5-) If $\beta_{i-1} < F_{i-1}$ and $\beta_i < F_i$ then $IC_{i-1,i}$ and $IC_{i,i+1}$ bind. Optimality condition:

$v'\left(\frac{y_i}{w_i}\right)\frac{1}{w_i} = 1 - \frac{\mu_{i-1,i}}{\pi_i\delta^i + \mu_{i,i+1}}\left[1 - v'\left(\frac{y_i}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]$ where distortion depends on agent $i-1$, and $\frac{\mu_{i-1,i}}{\pi_i\delta^i+\mu_{i,i+1}} = \frac{F_{i-1}-\beta_{i-1}}{F_i-\beta_{i-1}}$

Since there is an upward distortion for the agent i, labour supply is higher than Rawlsian case. For the comparison between maximax and this possibility:

In maximax we have: $\left[1 - v'\left(\frac{y_i^M}{w_i}\right)\frac{1}{w_i}\right] = \frac{F_{i-1}}{F_i}\left[1 - v'\left(\frac{y_i^M}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]$

Since $\frac{F_{i-1}}{F_i} \geq \frac{F_{i-1}-\beta_{i-1}}{F_i-\beta_{i-1}}$, we have

$\frac{\left[1-v'\left(\frac{y_i^M}{w_i}\right)\frac{1}{w_i}\right]}{\left[1-v'\left(\frac{y_i^M}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]} \geq \frac{\left[1-v'\left(\frac{y_i}{w_i}\right)\frac{1}{w_i}\right]}{\left[1-v'\left(\frac{y_i}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]}$ then by convexity of $v(.)$ we have $y_i^M \geq y_i$.

6-) If $\beta_{i-1} < F_{i-1}$ and $\beta_i = F_i$ then only $IC_{i-1,i}$ binds. Optimality condition:

$v'\left(\frac{y_i}{w_i}\right)\frac{1}{w_i} = 1 - \frac{\mu_{i-1,i}}{\pi_i\delta^i}\left[1 - v'\left(\frac{y_i}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]$ where the distortion depends on agent $i-1$, and $\frac{\mu_{i-1,i}}{\pi_i\delta^i} = \frac{F_{i-1}-\beta_{i-1}}{\pi_i\delta^i}$

Since there is an upward distortion for the agent i, labour supply is higher than Rawlsian case.

For the maximax we have $\left[1 - v'\left(\frac{y_i^M}{w_i}\right)\frac{1}{w_i}\right] = \frac{F_{i-1}}{F_i}\left[1 - v'\left(\frac{y_i^M}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]$

So, if $\frac{F_{i-1}}{F_i} \geq \frac{F_{i-1}-\beta_{i-1}}{\pi_i\delta^i}$ result holds.

Suppose the opposite; $\frac{F_{i-1}}{F_i} < \frac{F_{i-1}-\beta_{i-1}}{\pi_i\delta^i}$

by using $\beta_i = F_i$, we can write the term as $[\pi_1 + ... + \pi_i] < \delta^i\pi_i$ which is not possible.

7-) If $\beta_{i-1} = F_{i-1}$ and $\beta_i > F_i$ then only $IC_{i+1,i}$ binds. Optimality condition:

$v'\left(\frac{y_i}{w_i}\right)\frac{1}{w_i} = 1 - \frac{\mu_{i+1,i}}{\pi_i\delta^i}\left[1 - v'\left(\frac{y_i}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]$ where distortion depends on agent $i+1$,

and $\frac{\mu_{i+1,i}}{\pi_i\delta^i} = \frac{\beta_i - F_i}{\pi_i\delta^i}$

Result holds if $\frac{1-F_i}{1-F_{i-1}} \geq \frac{\beta_i-F_i}{\pi_i\delta^i}$

Suppose the opposite is true: $\frac{1-F_i}{1-F_{i-1}} < \frac{\beta_i-F_i}{\pi_i\delta^i}$

by using $\beta_{i-1} = F_{i-1}$, we can write the condition as: $\pi_i + ... + \pi_N < \delta^i\pi_i$. However this is not possible since $\beta_{i-1} = F_{i-1}$ implies $\pi_i\delta^i + ... + \pi_N\delta^N = \pi_i + ... + \pi_N$.

Proof of Proposition 10:

Table A1 presents the counterpart of Table 1.2 for bunching case supposing agent 3 and 4 bunched and we have 6 agents.

Table A1: Binding IC Constraints and Sign of Distortions for Bunching Case

Cases	***Distortion***	***Agent*** **1**	***Agent*** **2**	***Agent*** **3** ***and*** **4**	***Agent*** **5**	***Agent*** **6**
1	Downward	$IC_{2,1}$	$IC_{2,1}, IC_{3,2}$	$(IC_{4,3}, IC_{3,4}) - IC_{3,2}, IC_{5,4}$	$IC_{5,4}, IC_{6,5}$	$-$
7	Downward	$-$	$IC_{3,2}$	$(IC_{4,3}, IC_{3,4}) - IC_{5,4}$	$IC_{6,5}$	$-$
5	Upward	$-$	$IC_{1,2}, IC_{2,3}$	$(IC_{4,3}, IC_{3,4}) - IC_{2,3}, IC_{4,5}$	$IC_{4,5}, IC_{5,6}$	$IC_{5,6}$
6	Upward	$-$	$IC_{1,2}$	$(IC_{4,3}, IC_{3,4}) - IC_{2,3}$	$IC_{4,5}$	$-$
4	Ambiguous	$-$	$IC_{1,2}, IC_{3,2}$	$(IC_{4,3}, IC_{3,4}) - IC_{2,3}, IC_{5,4}$	$IC_{4,5}, IC_{6,5}$	$-$
2	Undistorted	$IC_{1,2}$	$IC_{2,1}, IC_{2,3}$	$(IC_{4,3}, IC_{3,4}) - IC_{3,2}, IC_{4,5}$	$IC_{5,4}, IC_{5,6}$	$IC_{6,5}$
3	Undistorted	$-$	$IC_{2,1}$	$(IC_{4,3}, IC_{3,4}) - IC_{3,2}$	$IC_{5,4}$	$-$
8	Undistorted	$-$	$IC_{2,3}$	$(IC_{4,3}, IC_{3,4}) - IC_{4,5}$	$IC_{5,6}$	$-$
9	Undistorted	$None$	$None$	$(IC_{4,3}, IC_{3,4})$	$None$	$None$

For notational convenience suppose that agents i and $i+1$ are bunched at the optimum. Then we will have 9 possible cases for binding IC constraints. Each case leads to less downward distortion compared to Rawlsian, and less upward distortion compared to Maximax. This leads to the result that marginal tax rates are highest in Rawlsian SWF and lowest in maximax case. General optimality condition is as follows:

$$\left[1 - v'\left(\frac{y_b}{w_i}\right)\frac{1}{w_i}\right] = \frac{\mu_{i-1,i}}{\pi_i\delta^i + \mu_{i,i-1}}\left[1 - v'\left(\frac{y_b}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right] - \frac{\pi_{i+1}\delta^{i+1} + \mu_{i+1,i+2}}{\pi_i\delta^i + \mu_{i,i-1}}\left[1 - v'\left(\frac{y_b}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right] + \frac{\mu_{i+2,i+1}}{\pi_i\delta^i + \mu_{i,i-1}}\left[1 - v'\left(\frac{y_b}{w_{i+2}}\right)\frac{1}{w_{i+2}}\right]$$

All possible case are;

1-) $IC_{i+1,i} - IC_{i,i+1} - IC_{i+2,i+1}$

$$\left[1 - v'\left(\frac{y_b}{w_i}\right)\frac{1}{w_i}\right] = \frac{\mu_{i+2,i+1}}{\pi_i\delta^i}\left[1 - v'\left(\frac{y_b}{w_{i+2}}\right)\frac{1}{w_{i+2}}\right] - \frac{\pi_{i+1}\delta^{i+1}}{\pi_i\delta^i}\left[1 - v'\left(\frac{y_b}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]$$

2-) $IC_{i+1,i} - IC_{i,i+1} - IC_{i+1,i+2}$

$$\left[1 - v'\left(\frac{y_b}{w_i}\right)\frac{1}{w_i}\right] = -\frac{\pi_{i+1}\delta^{i+1} - \mu_{i+1,i+2}}{\pi_i\delta^i}\left[1 - v'\left(\frac{y_b}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]$$

3-) $IC_{i+1,i} - IC_{i,i+1} - IC_{i-1,i}$

$$\left[1 - v'\left(\frac{y_b}{w_i}\right)\frac{1}{w_i}\right] = \frac{\mu_{i-1,i}}{\pi_i\delta^i}\left[1 - v'\left(\frac{y_b}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right] - \frac{\pi_{i+1}\delta^{i+1}}{\pi_i\delta^i}\left[1 - v'\left(\frac{y_b}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]$$

4-) $IC_{i+1,i} - IC_{i,i+1} - IC_{i,i-1}$

$$\left[1 - v'\left(\frac{y_b}{w_i}\right)\frac{1}{w_i}\right] = -\frac{\pi_{i+1}\delta^{i+1}}{\pi_i\delta^i + \mu_{i,i-1}}\left[1 - v'\left(\frac{y_b}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]$$

5-) $IC_{i+1,i} - IC_{i,i+1} - IC_{i+1,i+2} - IC_{i-1,i}$ Maximax is a special case of this one.

$$\left[1 - v'\left(\frac{y_b}{w_i}\right)\frac{1}{w_i}\right] = \frac{\mu_{i-1,i}}{\pi_i\delta^i}\left[1 - v'\left(\frac{y_b}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right] - \frac{\pi_{i+1}\delta^{i+1}+\mu_{i+1,i+2}}{\pi_i\delta^i}\left[1 - v'\left(\frac{y_b}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]$$

6-) $IC_{i+1,i} - IC_{i,i+1} - IC_{i+1,i+2} - IC_{i,i-1}$

$$\left[1 - v'\left(\frac{y_b}{w_i}\right)\frac{1}{w_i}\right] = -\frac{\pi_{i+1}\delta^{i+1}+\mu_{i+1,i+2}}{\pi_i\delta^i+\mu_{i,i-1}}\left[1 - v'\left(\frac{y_b}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]$$

7-) $IC_{i+1,i} - IC_{i,i+1} - IC_{i+2,i+1} - IC_{i-1,i}$

$$\begin{aligned}\left[1 - v'\left(\frac{y_b}{w_i}\right)\frac{1}{w_i}\right] &= \frac{\mu_{i-1,i}}{\pi_i\delta^i}\left[1 - v'\left(\frac{y_b}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right] - \frac{\pi_{i+1}\delta^{i+1}}{\pi_i\delta^i}\left[1 - v'\left(\frac{y_b}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right] \\ &\quad + \frac{\mu_{i+2,i+1}}{\pi_i\delta^i}\left[1 - v'\left(\frac{y_b}{w_{i+2}}\right)\frac{1}{w_{i+2}}\right]\end{aligned}$$

8-) $IC_{i+1,i} - IC_{i,i+1} - IC_{i+2,i+1} - IC_{i,i-1}$

Rawlsian is a special case of this one.

$$\left[1 - v'\left(\frac{y_b}{w_i}\right)\frac{1}{w_i}\right] = \frac{\mu_{i+2,i+1}}{\pi_i\delta^i+\mu_{i,i-1}}\left[1 - v'\left(\frac{y_b}{w_{i+2}}\right)\frac{1}{w_{i+2}}\right] - \frac{\pi_{i+1}\delta^{i+1}}{\pi_i\delta^i+\mu_{i,i-1}}\left[1 - v'\left(\frac{y_b}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]$$

9-) $IC_{i+1,i} - IC_{i,i+1}$

$$\left[1 - v'\left(\frac{y_b}{w_i}\right)\frac{1}{w_i}\right] = -\frac{\pi_{i+1}\delta^{i+1}}{\pi_i\delta^i}\left[1 - v'\left(\frac{y_b}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]$$

We showed cases 5 and 8 above in the text. So need the check other cases one by one.

1-) $IC_{i+1,i} - IC_{i,i+1} - IC_{i+2,i+1}$

Rewrite Rawlsian case as

$$\begin{aligned}\frac{\left[1-v'\left(\frac{y_b^R}{w_i}\right)\frac{1}{w_i}\right]}{\left[1-v'\left(\frac{y_b^R}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} &= \frac{\mu_{i+2,i+1}}{\pi_i\delta^i+\mu_{i,i-1}}\frac{\left[1-v'\left(\frac{y_b^R}{w_{i+2}}\right)\frac{1}{w_{i+2}}\right]}{\left[1-v'\left(\frac{y_b^R}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} - \frac{\pi_{i+1}\delta^{i+1}}{\pi_i\delta^i+\mu_{i,i-1}} \\ &= \frac{1-F_{i+1}}{1-F_{i-1}}\frac{\left[1-v'\frac{y_b^R}{w_{i+2}}\frac{1}{w_{i+2}}\right]}{\left[1-v'\left(\frac{y_b^R}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}\end{aligned}$$

$IC_{i+1i} - IC_{ii+1} - IC_{i+2i+1}$ are binding, we have:

$$\begin{aligned}\frac{\left[1-v'\left(\frac{y_b^1}{w_i}\right)\frac{1}{w_i}\right]}{\left[1-v'\left(\frac{y_b^1}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} &= \frac{\mu_{i+2,i+1}}{\pi_i\delta^i}\frac{\left[1-v'\left(\frac{y_b^1}{w_{i+2}}\right)\frac{1}{w_{i+2}}\right]}{\left[1-v'\left(\frac{y_b^1}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} - \frac{\pi_{i+1}\delta^{i+1}}{\pi_i\delta^i} \\ &= \frac{\beta_{i+1}-F_{i+1}}{\pi_i\delta^i}\frac{\left[1-v'\left(\frac{y_b^1}{w_{i+2}}\right)\frac{1}{w_{i+2}}\right]}{\left[1-v'\left(\frac{y_b^1}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} - \frac{\pi_{i+1}\delta^{i+1}}{\pi_i\delta^i}\end{aligned}$$

There are two possible cases for agents i and $i+1$. Both of them could be downward distorted or while agent i is upward distorted agent $i+1$ could be downward distorted. If agent i is upward distorted and $i+1$ is downward distorted we have;

$$\frac{\left[1-v'\left(\frac{y_b^1}{w_i}\right)\frac{1}{w_i}\right]}{\left[1-v'\left(\frac{y_b^1}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} < \left[1 - v'\left(\frac{y_b^R}{w_i}\right)\frac{1}{w_i}\right]\left[1 - v'\left(\frac{y_b^R}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right] \text{ which implies } y_b^1 > y_b^R.$$

If both agents are downward distorted then its better to rewrite the conditions as;

$$\frac{\left[1-v'\left(\frac{y_b^1}{w_{i+2}}\right)\frac{1}{w_{i+2}}\right]}{\left[1-v'\left(\frac{y_b^1}{w_i}\right)\frac{1}{w_i}\right]} = \frac{\pi_i\delta^i}{\mu_{i+2i+1}} + \frac{\pi_{i+1}\delta^{i+1}}{\mu_{i+2,i+1}}\frac{\left[1-v'\left(\frac{y_b^1}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}{\left[1-v'\left(\frac{y_b^1}{w_i}\right)\frac{1}{w_i}\right]} = \frac{\pi_i\delta^i+\pi_{i+1}\delta^{i+1}*A}{\beta_{i+1}-F_{i+1}} \text{ where } A > 1$$

and Rawlsian;

$$\frac{\left[1-v'\left(\frac{y_b^R}{w_{i+2}}\right)\frac{1}{w_{i+2}}\right]}{\left[1-v'\left(\frac{y_b^R}{w_i}\right)\frac{1}{w_i}\right]} = \frac{\pi_i\delta^i+\mu_{i,i-1}}{\mu_{i+2,i+1}} + \frac{\pi_{i+1}\delta^{i+1}}{\mu_{i+2,i+1}}\frac{\left[1-v'\left(\frac{y_b^R}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}{\left[1-v'\left(\frac{y_b^R}{w_i}\right)\frac{1}{w_i}\right]} = \frac{1-F_{i-1}}{1-F_{i+1}}$$

if $\frac{\pi_i\delta^i+\pi_{i+1}\delta^{i+1}}{\beta_{i+1}-F_{i+1}} \geq \frac{1-F_{i-1}}{1-F_{i+1}}$ then we have $y_b^{'} \geq y_b^R$.

Suppose not, and we have $\frac{\pi_i\delta^i+\pi_{i+1}\delta^{i+1}}{\beta_{i+1}-F_{i+1}} < \frac{1-F_{i-1}}{1-F_{i+1}}$

This implies $\frac{\pi_i\delta^i+\pi_{i+1}\delta^{i+1}}{\beta_{i+1}-F_{i+1}} < \frac{\pi_i+...+\pi_N}{\pi_{i+2}+...+\pi_N}$

$[\pi_i\delta^i + \pi_{i+1}\delta^{i+1}][\pi_{i+2} + ... + \pi_N] < [\beta_{i+1} - F_{i+1}][\pi_i + ... + \pi_N]$

$0 < [\beta_{i-1} - F_{i+1}][\pi_i + ... + \pi_N] + [\pi_i\delta^i + \pi_{i+1}\delta^{i+1}][\pi_i + \pi_{i+1}]$

since $\beta_{i-1} = F_{i-1}$ rewrite as

$0 < [\pi_i + \pi_{i+1}][\pi_i\delta^i + \pi_{i+1}\delta^{i+1}] - [\pi_i + \pi_{i+1}][\pi_i + ... + \pi_N]$

$0 < [\pi_i + \pi_{i+1}][\beta_{i+1} - 1]$ which is impossible.

To compare with maximax case; we have;

$$\frac{\left[1-v'\left(\frac{y_b^1}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}{\left[1-v'\left(\frac{y_b^1}{w_i}\right)\frac{1}{w_i}\right]} = \frac{\mu_{i+2,i+1}}{\pi_i\delta^i}\frac{\left[1-v'\left(\frac{y_b^1}{w_{i+2}}\right)\frac{1}{w_{i+2}}\right]}{\left[1-v'\left(\frac{y_b^1}{w_i}\right)\frac{1}{w_i}\right]} - \frac{\pi_i\delta^i}{\pi_{i+1}\delta^{i+1}}$$

and for maximax;

$$\frac{\left[1-v'\left(\frac{y_b^M}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}{\left[1-v'\left(\frac{y_b^M}{w_i}\right)\frac{1}{w_i}\right]} = -\frac{\pi_i\delta^i}{\pi_{i+1}\delta^{i+1}+\mu_{i+1,i+2}} + \frac{\mu_{i-1,i}}{\pi_{i+1}\delta^{i+1}+\mu_{i+1,i+2}}\frac{\left[1-v'\left(\frac{y_b^M}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]}{\left[1-v'\left(\frac{y_b^M}{w_i}\right)\frac{1}{w_i}\right]}$$

$$= \frac{F_{i-1}}{F_{i+1}}\frac{\left[1-v'\left(\frac{y_b^M}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]}{\left[1-v'\left(\frac{y_b^M}{w_i}\right)\frac{1}{w_i}\right]}$$

Again we need to check possible distortion cases for agents i and $i+1$. If both of them downward distorted then result trivially holds as in maximax there is an upward distortion for both agents. If agent i is upward distorted and agent $i+1$ is downward distorted then we have

$$\frac{\left[1-v'\left(\frac{y_b^1}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}{\left[1-v'\left(\frac{y_b^1}{w_i}\right)\frac{1}{w_i}\right]} < \frac{\left[1-v'\left(\frac{y_b^M}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}{\left[1-v'\left(\frac{y_b^M}{w_i}\right)\frac{1}{w_i}\right]} \text{ which implies } y_b^M > y_b^1.$$

2-) $IC_{i+1,i} - IC_{i,i+1} - IC_{i+1,i+2}$

$$\frac{\left[1-v'\left(\frac{y_b^2}{w_i}\right)\frac{1}{w_i}\right]}{\left[1-v'\left(\frac{y_b^2}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} = -\frac{\pi_{i+1}\delta^{i+1}+\mu_{i+1,i+2}}{\pi_i\delta^i}$$

Since this expression is negative we have;

$$\frac{\left[1-v'\left(\frac{y_b^R}{w_i}\right)\frac{1}{w_i}\right]}{\left[1-v'\left(\frac{y_b^R}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} > \frac{\left[1-v'\left(\frac{y_b^2}{w_i}\right)\frac{1}{w_i}\right]}{\left[1-v'\left(\frac{y_b^2}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} \text{ which implies } y_b^2 > y_b^R.$$

Similarly for the maximax case, rewrite the condition as;

$$\frac{\left[1-v'\left(\frac{y_b^2}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}{\left[1-v'\left(\frac{y_b^2}{w_i}\right)\frac{1}{w_i}\right]} = -\frac{\pi_i\delta^i}{\pi_{i+1}\delta^{i+1}+\mu_{i+1,i+2}}$$

again since it is a negative value, we have

$$\frac{\left[1-v'\left(\frac{y_b^M}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}{\left[1-v'\left(\frac{y_b^M}{w_i}\right)\frac{1}{w_i}\right]} > \frac{\left[1-v'\left(\frac{y_b^2}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}{\left[1-v'\left(\frac{y_b^2}{w_i}\right)\frac{1}{w_i}\right]} \text{ which implies } y_b^M > y_b^2.$$

3-) $IC_{i+1,i} - IC_{i,i+1} - IC_{i-1,i}$

$$\frac{\left[1-v'\left(\frac{y_b^3}{w_i}\right)\frac{1}{w_i}\right]}{\left[1-v'\left(\frac{y_b^3}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} = \frac{\mu_{i-1,i}}{\pi_i\delta^i}\frac{\left[1-v'\left(\frac{y_b^3}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]}{\left[1-v'\left(\frac{y_b^3}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} - \frac{\pi_{i+1}\delta^{i+1}}{\pi_i\delta^i}$$

There are two possibilities. Both i and $i+1$ are upward distorted, or agent i is upward distorted and agent $i+1$ is downward distorted. If both of them are upward distorted then there is nothing to discuss as in Rawlsian case both of them are distorted downwards. If agent i is upward distorted and agent $i+1$ is downward distorted then we have;

$$\frac{\left[1-v'\left(\frac{y_b^R}{w_i}\right)\frac{1}{w_i}\right]}{\left[1-v'\left(\frac{y_b^R}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} > \frac{\left[1-v'\left(\frac{y_b^3}{w_i}\right)\frac{1}{w_i}\right]}{\left[1-v'\left(\frac{y_b^3}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} \text{ which implies } y_b^3 > y_b^R.$$

For Maximax case we have the following conditions;

$$\frac{\left[1-v'\left(\frac{y_b^M}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}{\left[1-v'\left(\frac{y_b^M}{w_i}\right)\frac{1}{w_i}\right]} = -\frac{\pi_i\delta^i}{\pi_{i+1}\delta^{i+1}+\mu_{i+1,i+2}} + \frac{\mu_{i-1,i}}{\pi_{i+1}\delta^{i+1}+\mu_{i+1,i+2}}\frac{\left[1-v'\left(\frac{y_b^M}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]}{\left[1-v'\left(\frac{y_b^M}{w_i}\right)\frac{1}{w_i}\right]}$$

$$= \frac{\mu_{i-1,i}}{\pi_{i+1}\delta^{i+1}+\mu_{i+1,i+2}}\frac{\left[1-v'\left(\frac{y_b^M}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]}{\left[1-v'\left(\frac{y_b^M}{w_i}\right)\frac{1}{w_i}\right]}$$

and

$$\frac{\left[1-v'\left(\frac{y_b^3}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}{\left[1-v'\left(\frac{y_b^3}{w_i}\right)\frac{1}{w_i}\right]} = \frac{\mu_{i-1,i}}{\pi_{i+1}\delta^{i+1}}\frac{\left[1-v'\left(\frac{y_b^3}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]}{\left[1-v'\left(\frac{y_b^3}{w_i}\right)\frac{1}{w_i}\right]} - \frac{\pi_i\delta^i}{\pi_{i+1}\delta^{i+1}}$$

we need to check two possible cases. If agent i is upward and agent $i+1$ is downward distorted than we have;

$$\frac{\left[1-v'\left(\frac{y_b^3}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}{\left[1-v'\left(\frac{y_b^3}{w_i}\right)\frac{1}{w_i}\right]} < \frac{\left[1-v'\left(\frac{y_b^M}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}{\left[1-v'\left(\frac{y_b^M}{w_i}\right)\frac{1}{w_i}\right]} \text{ which implies } y_b^M > y_b^3.$$

If both of them are upward distorted then rewrite the conditions as;

$$\frac{\left[1-v'\left(\frac{y_b^M}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]}{\left[1-v'\left(\frac{y_b^M}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} = \frac{F_{i+1}}{F_{i-1}}$$

and

$$\frac{\left[1-v'\left(\frac{y_b^3}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]}{\left[1-v'\left(\frac{y_b^3}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} = \frac{\pi_{i+1}\delta^{i+1}}{\mu_{i-1,i}} + \frac{\pi_i\delta^i}{\mu_{i-1,i}}\frac{\left[1-v'\left(\frac{y_b^3}{w_i}\right)\frac{1}{w_i}\right]}{\left[1-v'\left(\frac{y_b^3}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} = \frac{\pi_{i+1}\delta^{i+1}+\pi_i\delta^i * A}{\mu_{i-1,i}} \text{ where } A > 1.$$

Suppose$A = 1$, then we should have $\frac{\pi_{i+1}\delta^{i+1}+\pi_i\delta^i}{F_{i-1}-\beta_{i-1}} > \frac{F_{i+1}}{F_{i-1}}$ for the result.

Rewriting and manipulations give that;

$F_{i-1}(\pi_{i+1}\delta^{i+1} + \pi_i\delta^i) > F_{i+1}F_{i-1} - F_{i+1}\beta_{i-1}$

Since we have $F_{i+1} = \beta_{i+1}$, it is equal to

$F_{i-1}(\pi_{i+1}\delta^{i+1} + \pi_i\delta^i) > \beta_{i+1}F_{i-1} - F_{i+1}\beta_{i-1}$ which implies
$0 > \beta_{i-1}[F_{i-1} - F_{i+1}]$, and this condition always holds as $F_{i+1} > F_{i-1}$.

4-) $IC_{i+1,i} - IC_{i,i+1} - IC_{i,i-1}$

From FOC we have;

$$\frac{\left[1-v'\left(\frac{y_b^4}{w_i}\right)\frac{1}{w_i}\right]}{\left[1-v'\left(\frac{y_b^4}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} = -\frac{\pi_{i+1}\delta^{i+1}}{\pi_i\delta^i+\mu_{i,i-1}}$$

so agent i is upward distorted and agent $i+1$ is downward distorted.

For Rawlsian we have

$$\frac{\left[1-v'\left(\frac{y_b^R}{w_i}\right)\frac{1}{w_i}\right]}{\left[1-v'\left(\frac{y_b^R}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} = \frac{\mu_{i+2,i+1}}{\pi_i\delta^i+\mu_{i,i-1}}\frac{\left[1-v'\left(\frac{y_b^R}{w_{i+2}}\right)\frac{1}{w_{i+2}}\right]}{\left[1-v'\left(\frac{y_b^R}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} - \frac{\pi_{i+1}\delta^{i+1}}{\pi_i\delta^i+\mu_{i,i-1}} = \frac{1-F_{i+1}}{1-F_{i-1}}\frac{\left[1-v'\left(\frac{y_b^R}{w_{i+2}}\right)\frac{1}{w_{i+2}}\right]}{\left[1-v'\left(\frac{y_b^R}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}$$

$$\frac{\left[1-v'\left(\frac{y_b^R}{w_i}\right)\frac{1}{w_i}\right]}{\left[1-v'\left(\frac{y_b^R}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} > \frac{\left[1-v'\left(\frac{y_b^4}{w_i}\right)\frac{1}{w_i}\right]}{\left[1-v'\left(\frac{y_b^4}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} \text{ which implies } y_b^4 > y_b^R.$$

For Maximax we have;

$$\frac{\left[1-v'\left(\frac{y_b^4}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}{\left[1-v'\left(\frac{y_b^4}{w_i}\right)\frac{1}{w_i}\right]} = -\frac{\pi_i\delta^i+\mu_{i,i-1}}{\pi_{i+1}\delta^{i+1}}$$

and Maximax condition;

$$\frac{\left[1-v'\left(\frac{y_b^M}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}{\left[1-v'\left(\frac{y_b^M}{w_i}\right)\frac{1}{w_i}\right]} = -\frac{\pi_i\delta^i}{\pi_{i+1}\delta^{i+1}+\mu_{i+1,i+2}} + \frac{\mu_{i-1,i}}{\pi_{i+1}\delta^{i+1}+\mu_{i+1,i+2}}\frac{\left[1-v'\left(\frac{y_b^M}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]}{\left[1-v'\left(\frac{y_b^M}{w_i}\right)\frac{1}{w_i}\right]}$$

$$= \frac{F_{i-1}}{F_{i+1}}\frac{\left[1-v'\left(\frac{y_b^M}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]}{\left[1-v'\left(\frac{y_b^M}{w_i}\right)\frac{1}{w_i}\right]}$$

$$\frac{\left[1-v'\left(\frac{y_b^M}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}{\left[1-v'\frac{y_b^M}{w_i}\frac{1}{w_i}\right]} > \frac{\left[1-v'\left(\frac{y_b^4}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}{\left[1-v'\left(\frac{y_b^4}{w_i}\right)\frac{1}{w_i}\right]} \text{ which implies that } y_b^M > y_b^4.$$

6-) $IC_{i+1,i} - IC_{i,i+1} - IC_{i+1,i+2} - IC_{i,i-1}$

$$\frac{\left[1-v'\left(\frac{y_b^6}{w_i}\right)\frac{1}{w_i}\right]}{\left[1-v'\left(\frac{y_b^6}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} = -\frac{\pi_{i+1}\delta^{i+1}+\mu_{i+1,i+2}}{\pi_i\delta^i+\mu_{i,i-1}}$$

since it is a negative term we have;

$$\frac{\left[1-v'\left(\frac{y_b^R}{w_i}\right)\frac{1}{w_i}\right]}{\left[1-v'\left(\frac{y_b^R}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} > \frac{\left[1-v'\left(\frac{y_b^6}{w_i}\right)\frac{1}{w_i}\right]}{\left[1-v'\left(\frac{y_b^6}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} \text{ which implies that } y_b^6 > y_b^R.$$

Similarly for the Maximax case we have;

$$\frac{\left[1-v'\left(\frac{y_b^M}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}{\left[1-v'\left(\frac{y_b^M}{w_i}\right)\frac{1}{w_i}\right]} > \frac{\left[1-v'\left(\frac{y_b^6}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}{\left[1-v'\left(\frac{y_b^6}{w_i}\right)\frac{1}{w_i}\right]} \text{ which implies that } y_b^M > y_b^6.$$

7-) $IC_{i+1,i} - IC_{i,i+1} - IC_{i+2,i+1} - IC_{i-1,i}$

$$\frac{\left[1-v'\left(\frac{y_b^7}{w_i}\right)\frac{1}{w_i}\right]}{\left[1-v'\left(\frac{y_b^7}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} = \frac{\mu_{i+2,i+1}}{\pi_i\delta^i}\frac{\left[1-v'\left(\frac{y_b^7}{w_{i+2}}\right)\frac{1}{w_{i+2}}\right]}{\left[1-v'\left(\frac{y_b^7}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} - \frac{\pi_{i+1}\delta^{i+1}}{\pi_i\delta^i} + \frac{\mu_{i-1,i}}{\pi_i\delta^i}\frac{\left[1-v'\left(\frac{y_b^7}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]}{\left[1-v'\left(\frac{y_b^7}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}$$

In this case we have three possibilities for agents i and $i+1$. Both of them could be downward distorted, or both of them could be upward distorted. Third possibility is that agent i is upward distorted and agent $i+1$ is downward distorted. If both of the are upward distorted there is nothing to discuss. If agent i is upward distorted and agent $i+1$ is downward distorted we have;

$$\frac{\left[1-v'\left(\frac{y_b^R}{w_i}\right)\frac{1}{w_i}\right]}{\left[1-v'\left(\frac{y_b^R}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} > \frac{\left[1-v'\left(\frac{y_b^7}{w_i}\right)\frac{1}{w_i}\right]}{\left[1-v'\left(\frac{y_b^7}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} \text{ which implies } y_b^R < y_b^7.$$

If both of the agents are downward distorted then rewrite the conditions as follows;

$$\frac{\left[1-v'\left(\frac{y_b^R}{w_{i+2}}\right)\frac{1}{w_{i+2}}\right]}{\left[1-v'\left(\frac{y_b^R}{w_i}\right)\frac{1}{w_i}\right]} = \frac{1-F_{i-1}}{1-F_{i+1}} \text{ which is positive for sure.}$$

$$\frac{\left[1-v'\left(\frac{y_b^7}{w_{i+2}}\right)\frac{1}{w_{i+2}}\right]}{\left[1-v'\left(\frac{y_b^7}{w_i}\right)\frac{1}{w_i}\right]} = \frac{\pi_i\delta^i}{\mu_{i+2,i+1}} + \frac{\pi_{i+1}\delta^{i+1}}{\mu_{i+2,i+1}}\frac{\left[1-v'\left(\frac{y_b^7}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}{\left[1-v'\left(\frac{y_b^7}{w_i}\right)\frac{1}{w_i}\right]} - \frac{\mu_{i-1,i}}{\mu_{i+2,i+1}}\frac{\left[1-v'\left(\frac{y_b^7}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]}{\left[1-v'\left(\frac{y_b^7}{w_i}\right)\frac{1}{w_i}\right]}$$

we should have the following condition for the result;

$$\frac{\pi_i\delta^i}{\mu_{i+2,i+1}} + \frac{\pi_{i+1}\delta^{i+1}}{\mu_{i+2,i+1}}\frac{\left[1-v'\left(\frac{y_b^7}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}{\left[1-v'\left(\frac{y_b^7}{w_i}\right)\frac{1}{w_i}\right]} - \frac{\mu_{i-1,i}}{\mu_{i+2,i+1}}\frac{\left[1-v'\left(\frac{y_b^7}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]}{\left[1-v'\left(\frac{y_b^7}{w_i}\right)\frac{1}{w_i}\right]} > \frac{1-F_{i-1}}{1-F_{i+1}}$$

$$\frac{\pi_i\delta^i}{\mu_{i+2,i+1}} + \frac{\pi_{i+1}\delta^{i+1}}{\mu_{i+2,i+1}}A - \frac{\mu_{i-1,i}}{\mu_{i+2,i+1}}\frac{\left[1-v'\left(\frac{y_b^7}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]}{\left[1-v'\left(\frac{y_b^7}{w_i}\right)\frac{1}{w_i}\right]} > \frac{1-F_{i-1}}{1-F_{i+1}}$$

$A > 1$ and the last term on the left hand side is positive. So suppose $A = 1$ and we do not have the last term, then;

$\frac{\pi_i\delta^i+\pi_{i+1}\delta^{i+1}}{\beta_{i+1}-F_{i+1}} > \frac{1-F_{i-1}}{1-F_{i+1}}$ suppose not and we have $\frac{\pi_i\delta^i+\pi_{i+1}\delta^{i+1}}{\beta_{i+1}-F_{i+1}} < \frac{\pi_i+...+\pi_N}{\pi_{i+2}+...+\pi_N}$

$$[\pi_i\delta^i + \pi_{i+1}\delta^{i+1}][\pi_{i+2} + ... + \pi_N] < [\beta_{i+1} - F_{i+1}][\pi_i + ... + \pi_N]$$

$$0 < \pi_1\delta[\pi_i + ... + \pi_N] + \pi_{i-1}\delta^{i-1}[\pi_i + ... + \pi_N] + \pi_i\delta^i[\pi_i + \pi_{i+1}] + \pi_{i+1}\delta^{i+1}[\pi_i + \pi_{i+1}] - F_{i+1}[\pi_i + ... + \pi_N]$$

$$0 < [\pi_1\delta^1 + \pi_{i-1}\delta^{i-1}][\pi_i + ... + \pi_N] + [\pi_i\delta^i + \pi_{i+1}\delta^{i+1}][\pi_i + \pi_{i+1}] - F_{i+1}[\pi_i + ... + \pi_N]$$

$$0 < [\pi_i + \pi_{i+1}][\beta_{i+1} - 1] + [\pi_{i+2} + ... + \pi_N][\beta_{i-1} - F_{i-1}]$$

which is impossible since $\beta_{i+1} < 1$ and $\beta_{i-1} < F_{i-1}$.

For Maximax case we have;

$$\frac{\left[1-v'\left(\frac{y_b^M}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}{\left[1-v'\left(\frac{y_b^M}{w_i}\right)\frac{1}{w_i}\right]} = -\frac{\pi_i\delta^i}{\pi_{i+1}\delta^{i+1}+\mu_{i+1,i+2}} + \frac{\mu_{i-1,i}}{\pi_{i+1}\delta^{i+1}+\mu_{i+1,i+2}}\frac{\left[1-v'\left(\frac{y_b^M}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]}{\left[1-v'\left(\frac{y_b^M}{w_i}\right)\frac{1}{w_i}\right]}$$

$$= \frac{F_{i-1}}{F_{i+1}}\frac{\left[1-v'\left(\frac{y_b^M}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]}{\left[1-v'\left(\frac{y_b^M}{w_i}\right)\frac{1}{w_i}\right]}$$

$$\frac{\left[1-v'\left(\frac{y_b^7}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}{\left[1-v'\left(\frac{y_b^7}{w_i}\right)\frac{1}{w_i}\right]} = \frac{\mu_{i-1,i}}{\pi_{i+1}\delta^{i+1}}\frac{\left[1-v'\left(\frac{y_b^7}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]}{\left[1-v'\left(\frac{y_b^7}{w_i}\right)\frac{1}{w_i}\right]} + \frac{\mu_{i+2,i+1}}{\pi_{i+1}\delta^{i+1}}\frac{\left[1-v'\left(\frac{y_b^7}{w_{i+2}}\right)\frac{1}{w_{i+2}}\right]}{\left[1-v'\left(\frac{y_b^7}{w_i}\right)\frac{1}{w_i}\right]} - \frac{\pi_i\delta^i}{\pi_{i+1}\delta^{i+1}}$$

again we have 3 possibilities. If both of them are downward distorted result holds trivially as in Maximax case both of them are distorted upwards. If agent i is upward and agent $i+1$ is downward distorted then we have;

$\frac{\left[1-v'\left(\frac{y_b^M}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}{\left[1-v'\left(\frac{y_b^M}{w_i}\right)\frac{1}{w_i}\right]} > \frac{\left[1-v'\left(\frac{y_b^7}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}{\left[1-v'\left(\frac{y_b^7}{w_i}\right)\frac{1}{w_i}\right]}$ which implies $y_b^M > y_b^7$.

If both agents i and $i+1$ is upward distorted, then rewrite the equations as;

$$\frac{\left[1-v'\left(\frac{y_b^M}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]}{\left[1-v'\left(\frac{y_b^M}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} = \frac{F_{i+1}}{F_{i-1}}$$

$$\frac{\left[1-v'\left(\frac{y_b^7}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]}{\left[1-v'\left(\frac{y_b^7}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} = \frac{\pi_i\delta^i}{\mu_{i-1,i}}\frac{\left[1-v'\left(\frac{y_b^7}{w_i}\right)\frac{1}{w_i}\right]}{\left[1-v'\left(\frac{y_b^7}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} + \frac{\pi_{i+1}\delta^{i+1}}{\mu_{i-1,i}} - \frac{\mu_{i+2,i+1}}{\mu_{i-1,i}}\frac{\left[1-v'\left(\frac{y_b^7}{w_{i+2}}\right)\frac{1}{w_{i+2}}\right]}{\left[1-v'\left(\frac{y_b^7}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}$$

we should have; $\frac{\left[1-v'\left(\frac{y_b^7}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]}{\left[1-v'\left(\frac{y_b^7}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} > \frac{\left[1-v'\left(\frac{y_b^M}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]}{\left[1-v'\left(\frac{y_b^M}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}$

$$\frac{\pi_i\delta^i}{\mu_{i-1,i}}\frac{\left[1-v'\left(\frac{y_b}{w_i}\right)\frac{1}{w_i}\right]}{\left[1-v'\left(\frac{y_b}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} + \frac{\pi_{i+1}\delta^{i+1}}{\mu_{i-1,i}} - \frac{\mu_{i+2,i+1}}{\mu_{i-1,i}}\frac{\left[1-v'\left(\frac{y_b}{w_{i+2}}\right)\frac{1}{w_{i+2}}\right]}{\left[1-v'\left(\frac{y_b}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} > \frac{F_{i+1}}{F_{i-1}}$$

$$\frac{\pi_i\delta^i}{\mu_{i-1,i}}A + \frac{\pi_{i+1}\delta^{i+1}}{\mu_{i-1,i}} - \frac{\mu_{i+2,i+1}}{\mu_{i-1,i}}\frac{\left[1-v'\left(\frac{y_b}{w_{i+2}}\right)\frac{1}{w_{i+2}}\right]}{\left[1-v'\left(\frac{y_b}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} > \frac{F_{i+1}}{F_{i-1}}$$

$A > 1$and the last term on the left hand side is positive. So suppose $A = 1$ and we do not have the last term, then we have;

$\frac{\pi_i \delta^i + \pi_{i+1}\delta^{i+1}}{F_{i-1} - \beta_{i-1}} > \frac{F_{i+1}}{F_{i-1}}$

$F_{i-1}(\pi_i \delta^i + \pi_{i+1}\delta^{i+1}) > F_{i+1}(F_{i-1} - \beta_{i-1})$ Since $\beta_{i+1} > F_{i+1}$ rewrite as

$F_{i-1}(\pi_i \delta^i + \pi_{i+1}\delta^{i+1}) > \beta_{i+1}(F_{i-1} - \beta_{i-1})$

$0 > \beta_{i-1}(F_{i-1} - \beta_{i+1})$ which holds for sure.

9-) $IC_{i+1,i} - IC_{i,i+1}$

$$\frac{\left[1 - v'\left(\frac{y_b^9}{w_i}\right)\frac{1}{w_i}\right]}{\left[1 - v'\left(\frac{y_b^9}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} = -\frac{\pi_{i+1}\delta^{i+1}}{\pi_i \delta^i}$$

since it is negative we have;

$$\frac{\left[1 - v'\left(\frac{y_b^R}{w_i}\right)\frac{1}{w_i}\right]}{\left[1 - v'\left(\frac{y_b^R}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} > \frac{\left[1 - v'\left(\frac{y_b^9}{w_i}\right)\frac{1}{w_i}\right]}{\left[1 - v'\left(\frac{y_b^9}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}$$ which implies that $y_b^9 > y_b^R$.

Similarly for the Maximax case we have;

$$\frac{\left[1 - v'\left(\frac{y_b^M}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}{\left[1 - v'\left(\frac{y_b^M}{w_i}\right)\frac{1}{w_i}\right]} > \frac{\left[1 - v'\left(\frac{y_b^9}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}{\left[1 - v'\left(\frac{y_b^9}{w_i}\right)\frac{1}{w_i}\right]}$$ which implies that $y_b^M > y_b^9$.

Proof of Proposition 12:

The condition comes from the relation of social weight δ^i with the marginal tax rates $T_i^{'}$ and $T_{i-1}^{'}$. From the proposition we have;

$$\delta^i = \frac{\left[1 - v'\left(\frac{y_i}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]}{\left[v'\left(\frac{y_i}{w_i}\right)\frac{1}{w_i} - v'\left(\frac{y_i}{w_{i+1}}\right)\frac{1}{w_{i+1}}\right]} - \frac{\pi_{i-1}}{\pi_i}\left\{\frac{\left[1 - v'\left(\frac{y_{i-1}}{w_{i-1}}\right)\frac{1}{w_{i-1}}\right]}{\left[v'\left(\frac{y_{i-1}}{w_{i-1}}\right)\frac{1}{w_{i-1}} - v'\left(\frac{y_{i-1}}{w_i}\right)\frac{1}{w_i}\right]}\right\}$$

we also have;

$$v'\left(\frac{y_i}{w_i}\right)\frac{1}{w_i} = 1 - T_i^{'}(y_i)$$

$$y_i = w_i\left[v^{'-1}\left[w_i(1 - T_i^{'}(y_i))\right]\right]$$

$$y_{i-1} = w_{i-1}\left[v^{'-1}\left[w_{i-1}(1 - T_{i-1}^{'}(y_{i-1}))\right]\right]$$

Plugging the terms yields;

$$\delta^i = \frac{\left[1 - v'\left\{\left[v^{'-1}\left[w_i(1 - T_i^{'}(y_i))\right]\right]\frac{w_i}{w_{i+1}}\right\}\frac{1}{w_{i+1}}\right]}{\left[1 - T_i^{'}(y_i) - v'\left\{\left[v^{'-1}\left[w_i(1 - T_i^{'}(y_i))\right]\right]\frac{w_i}{w_{i+1}}\right\}\frac{1}{w_{i+1}}\right]}$$
$$- \frac{\pi_{i-1}}{\pi_i}\left\{\frac{T_{i-1}^{'}(y_{i-1})}{\left[1 - T_{i-1}^{'}(y_{i-1}) - v'\left\{\left[v^{'-1}\left[w_{i-1}(1 - T_{i-1}^{'}(y_{i-1}))\right]\right]\frac{w_{i-1}}{w_i}\right\}\frac{1}{w_i}\right]}\right\}$$

Appendix B

Appendix for Chapter 2

Figure B1: Trends for Treatment and Control Groups

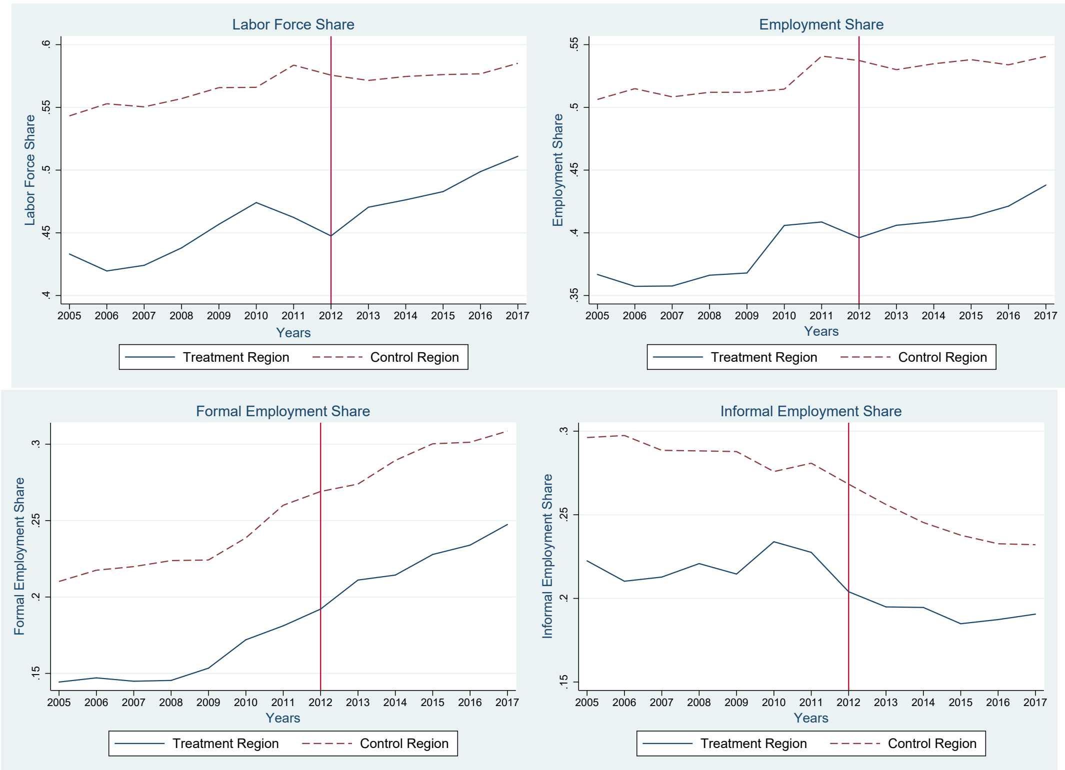

Figure B1: Treatment and Control Group Trends

Table B1: Results for the Full Sample

Table B1: Effect of Syrians on Natives - All Results

Total	Mean Y	DiD-OLS	DiD-2SLS	Mean Y	OLS	2SLS	Logit	IV Probit
Employment	0.490	0.009	-0.087	0.502	0.117	0.048	0.136	0.075
		(0.180)	(0.208)		(0.202)	(0.283)	(0.215)	(0.310)
Formal Emp	0.312	0.043	-0.004	0.332	0.056**	0.113**	0.112***	0.253***
		(0.054)	(0.104)		(0.023)	(0.047)	(0.037)	(0.070)
Informal Emp	0.178	-0.034	-0.083	0.170	0.062	-0.065	0.050	-0.015
		(0.204)	(0.265)		(0.200)	(0.294)	(0.174)	(0.271)
LFP	0.550	0.066	-0.063	0.560	0.206	0.149	0.225	0.171
		(0.234)	(0.313)		(0.245)	(0.408)	(0.258)	(0.435)
Private Worker	0.422	-0.048	-0.220	0.431	0.067	-0.084	0.101	-0.042
		(0.180)	(0.247)		(0.188)	(0.261)	(0.208)	(0.300)
Public Worker	0.063	0.028*	0.086**	0.065	0.015	0.080	-0.001	0.049
		(0.015)	(0.041)		(0.021)	(0.051)	(0.019)	(0.039)
Wage Worker	0.321	-0.086**	-0.082*	0.336	-0.077	-0.064	-0.069	0.006
		(0.042)	(0.049)		(0.062)	(0.094)	(0.071)	(0.135)
Self-Employed	0.084	-0.029	-0.129	0.083	0.038	-0.046	0.027	-0.065
		(0.047)	(0.084)		(0.062)	(0.094)	(0.057)	(0.101)
Employer	0.024	0.024	0.033	0.023	0.012	0.015	0.013	0.009
		(0.023)	(0.024)		(0.019)	(0.024)	(0.023)	(0.031)
Observations	4,222,024			1,970,233				
First Stage			3.215***			3.476***		3.476***
			(0.415)			(0.645)		(0.645)
F-Statistics			93.51			78.40		78.40
Year		Yes	Yes		Yes	Yes	Yes	Yes
Region-Season		Yes	Yes		Yes	Yes	Yes	Yes

NOTES: Table reports the coefficient for the ratio of the immigrants. Control variables include gender, age groups (by 5 years), education (3 categories), marital status (4 categories) and log trade volume. Standard errors clustered at the NUTS-2 level are reported in parentheses. Significance levels are denoted as follows: ***1 percent, **5 percent, *10 percent.

Table B2: Effects by education levels - OLS Results

Table B2: Effect of Syrians on Natives by Education Level

	Low Educated			Medium Educated			High Educated		
	Total	Men	Women	Total	Men	Women	Total	Men	Women
Employment	0.139	0.051	0.205	-0.019	-0.034	0.005	-0.148	-0.041	-0.290
	(0.232)	(0.188)	(0.284)	(0.154)	(0.175)	(0.139)	(0.091)	(0.067)	(0.171)
Formal Emp	0.033	0.183***	-0.093**	0.090	0.150	0.004	-0.111	-0.085	-0.141
	(0.034)	(0.058)	(0.036)	(0.091)	(0.117)	(0.094)	(0.072)	(0.067)	(0.125)
Informal Emp	0.106	-0.132	0.298	-0.110	-0.184**	0.002	-0.037	0.044	-0.148
	(0.250)	(0.220)	(0.300)	(0.076)	(0.084)	(0.084)	(0.070)	(0.071)	(0.097)
LFP	0.208	0.147	0.246	0.126	0.139	0.115	0.044	0.098	-0.018
	(0.267)	(0.261)	(0.280)	(0.216)	(0.265)	(0.155)	(0.141)	(0.107)	(0.219)
Private Worker	0.094	0.039	0.131	-0.053	-0.061	-0.037	0.024	0.156	-0.159*
	(0.224)	(0.201)	(0.257)	(0.151)	(0.166)	(0.146)	(0.120)	(0.151)	(0.085)
Public Worker	0.006	0.005	0.007	0.014	0.016	0.012	-0.183*	-0.205	-0.147
	(0.014)	(0.027)	(0.009)	(0.055)	(0.083)	(0.021)	(0.096)	(0.167)	(0.124)
Wage Worker	-0.080	-0.183***	0.004	-0.095	-0.168*	0.020	-0.173**	-0.107	-0.258*
	(0.063)	(0.064)	(0.087)	(0.075)	(0.099)	(0.078)	(0.073)	(0.097)	(0.148)
Self-Employed	0.061	0.130	0.002	-0.050	-0.083*	-0.008	-0.020	-0.027	-0.008
	(0.073)	(0.100)	(0.077)	(0.033)	(0.044)	(0.042)	(0.037)	(0.048)	(0.033)
Employer	0.008	0.016	0.002	0.041	0.064	0.010	0.009	0.023	-0.012
	(0.019)	(0.038)	(0.004)	(0.027)	(0.040)	(0.012)	(0.036)	(0.051)	(0.024)
Observations	1,351,239	610,105	741,134	361,127	209,104	152,023	257,867	145,640	112,227
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region-Season	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

NOTES: Table reports the coefficient for the ratio of the immigrants. Control variables include gender, age groups (by 5 years), education (3 categories), marital status (4 categories) and log trade volume. Standard errors clustered at the NUTS-2 level are reported in parentheses. Significance levels are denoted as follows: ***1 percent, **5 percent, *10 percent.

Table B3: Wage and Hours Effect For Full Sample

Table B3: Effect of Syrians on Native Wages

	Total			
	DiD-OLS	DiD-IV	OLS	2SLS
Formal				
Log Monthly Wage	0.134	0.269	0.086	0.161
	(0.136)	(0.196)	(0.116)	(0.185)
Log Hourly Wage	0.151	0.205	0.124	0.309
	(0.236)	(0.369)	(0.162)	(0.264)
Log Weekly Hours	-0.017	0.064	-0.038	-0.148
	(0.134)	(0.233)	(0.118)	(0.152)
Observations	881,319	881,319	470,148	470,148
Informal				
Log Monthly Wage	0.416	1.042	0.013	0.435
	(0.461)	(0.802)	(0.249)	(0.599)
Log Hourly Wage	-0.229	-0.044	-0.494	-0.542
	(0.418)	(0.603)	(0.478)	(0.875)
Weekly Hours	0.645	1.086*	0.508	0.978
	(0.415)	(0.632)	(0.424)	(0.776)
Observations	236,187	236,187	94,265	94,265
Year	Yes	Yes	Yes	Yes
Region-Season	Yes	Yes	Yes	Yes

NOTES: Table reports the coefficient for the ratio of the immigrants. Control variables include gender, age groups (by 5 years), education (3 categories), marital status (4 categories) and log trade volume. Standard errors clustered at the NUTS-2 level are reported in parentheses. Significance levels are denoted as follows: ***1 percent, **5 percent, *10 percent.

Table B4: Results for Different Specifications -DiD - Males

Table B4: Effect of Syrians on Native Males - DiD

		DiD OLS		DiD 2SLS	
Male	Mean Y	1	2	1	2
Employment	0.689	0.080	0.147	0.124	0.250
		(0.152)	(0.169)	(0.168)	(0.223)
Formal Emp	0.479	0.332***	0.455***	0.494***	0.471***
		(0.074)	(0.081)	(0.135)	(0.112)
Informal Emp	0.210	-0.252*	-0.307*	-0.370*	-0.221
		(0.139)	(0.167)	(0.224)	(0.248)
LFP	0.766	-0.028	-0.178	-0.112	-0.247
		(0.165)	(0.215)	(0.303)	(0.302)
Private Worker	0.599	0.125	0.103	0.266	0.260
		(0.167)	(0.184)	(0.295)	(0.327)
Public Worker	0.087	-0.025	0.011	-0.053	-0.048
		(0.070)	(0.070)	(0.099)	(0.109)
Wage Worker	0.473	-0.161	-0.087	-0.237**	-0.155
		(0.104)	(0.107)	(0.094)	(0.104)
Self-Employed	0.140	0.164**	0.145**	0.229**	0.254***
		(0.065)	(0.063)	(0.096)	(0.095)
Employer	0.043	0.032	0.060	0.049	0.106
		(0.054)	(0.061)	(0.080)	(0.082)
Observations	2,049,811				
Year		Yes	Yes	Yes	Yes
Region-Season		Yes	Yes	Yes	Yes
NUTS1 Trend		Yes	Yes	Yes	Yes
NUTS1-Year Effect			Yes		Yes

NOTES: Table reports the coefficient for the ratio of the immigrants. Control variables include gender, age groups (by 5 years), education (3 categories), marital status (4 categories) and log trade volume. Standard errors clustered at the NUTS-2 level are reported in parentheses. Significance levels are denoted as follows: ***1 percent, **5 percent, *10 percent.

Table B5: Results for Different Specifications - Males

Table B5: Effect of Syrians on Native Males

		OLS		2SLS		Logit		IV Probit	
Male	Mean Y	1	2	1	2	1	2	1	2
Employment	0.699	0.073	0.076	0.041	-0.031	0.076	0.075	0.038	-0.032
		(0.172)	(0.190)	(0.175)	(0.250)	(0.169)	(0.187)	(0.172)	(0.236)
Formal Emp	0.503	0.228*	0.291***	0.164	0.199*	0.206*	0.262***	0.142	0.159
		(0.113)	(0.101)	(0.146)	(0.105)	(0.108)	(0.099)	(0.161)	(0.149)
Informal Emp	0.196	-0.155	-0.215	-0.124	-0.231	-0.122	-0.186	-0.048	-0.166
		(0.163)	(0.156)	(0.257)	(0.240)	(0.151)	(0.152)	(0.222)	(0.213)
LFP	0.770	-0.002	-0.072	0.179	-0.062	0.003	-0.066	0.160	-0.060
		(0.194)	(0.207)	(0.487)	(0.376)	(0.186)	(0.198)	(0.439)	(0.350)
Private Worker	0.608	0.031	0.002	-0.017	-0.111	0.036	0.006	-0.006	-0.101
		(0.153)	(0.167)	(0.173)	(0.238)	(0.151)	(0.166)	(0.172)	(0.233)
Public Worker	0.088	0.031	0.061	0.041	0.072	0.017	0.039	0.030	0.046
		(0.066)	(0.056)	(0.084)	(0.074)	(0.061)	(0.053)	(0.088)	(0.078)
Wage Worker	0.487	-0.119	-0.082	-0.172	-0.050	-0.116	-0.079	-0.164	-0.045
		(0.085)	(0.073)	(0.146)	(0.112)	(0.084)	(0.072)	(0.125)	(0.113)
Self-Employed	0.137	0.102**	0.085	0.091	0.012	0.070*	0.059	0.113*	0.039
		(0.048)	(0.065)	(0.067)	(0.090)	(0.039)	(0.056)	(0.062)	(0.080)
Employer	0.042	0.046	0.046	0.078	0.049	0.025	0.027	0.063	0.038
		(0.044)	(0.047)	(0.062)	(0.060)	(0.050)	(0.055)	(0.077)	(0.077)
Observations	964,849								
Year		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region-Season		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
NUTS1 Trend		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
NUTS1-Year			Yes		Yes		Yes		Yes

NOTES: Table reports the coefficient for the ratio of the immigrants. Control variables include gender, age groups (by 5 years), education (3 categories), marital status (4 categories) and log trade volume. Standard errors clustered at the NUTS-2 level are reported in parentheses. Significance levels are denoted as follows: ***1 percent, **5 percent, *10 percent.

Table B6: Results for Different Specifications -DiD - Females

Table B6: Effect of Syrians on Native Females - DiD

		DiD-OLS		DiD-2SLS	
Female	Mean Y	1	2	1	2
Employment	0.290	-0.030	-0.117	-0.079	-0.131
		(0.231)	(0.215)	(0.294)	(0.275)
Formal Emp	0.144	-0.050	-0.062	-0.022	0.002
		(0.048)	(0.070)	(0.068)	(0.101)
Informal Emp	0.146	0.020	-0.055	-0.057	-0.133
		(0.228)	(0.223)	(0.281)	(0.262)
LFP	0.333	-0.004	-0.162	-0.055	-0.155
		(0.209)	(0.150)	(0.295)	(0.216)
Private Worker	0.244	-0.067	-0.158	-0.175	-0.261
		(0.160)	(0.183)	(0.226)	(0.256)
Public Worker	0.039	0.033***	0.043***	0.058***	0.058***
		(0.010)	(0.007)	(0.019)	(0.011)
Wage Worker	0.169	-0.046	-0.051	-0.026	-0.005
		(0.063)	(0.046)	(0.081)	(0.069)
Self-Employed	0.029	-0.085	-0.147*	-0.157*	-0.194**
		(0.073)	(0.076)	(0.084)	(0.087)
Employer	0.004	-0.004	-0.006	-0.005	-0.005
		(0.005)	(0.005)	(0.006)	(0.007)
Observations	2,172,213				
Year		Yes	Yes	Yes	Yes
Region-Season		Yes	Yes	Yes	Yes
NUTS1 Trend		Yes	Yes	Yes	Yes
NUTS1-Year Effect			Yes		Yes

NOTES: Table reports the coefficient for the ratio of the immigrants. Control variables include gender, age groups (by 5 years), education (3 categories), marital status (4 categories) and log trade volume. Standard errors clustered at the NUTS-2 level are reported in parentheses. Significance levels are denoted as follows: ***1 percent, **5 percent, *10 percent.

Table B7: Results for Different Specifications - Females

Table B7: Effect of Syrians on Native Females

		OLS		2SLS		Logit		IV Probit	
Female	Mean Y	1	2	1	2	1	2	1	2
Employment	0.304	0.011	0.008	-0.070	-0.272	-0.043	-0.072	-0.115	-0.496
		(0.212)	(0.218)	(0.250)	(0.313)	(0.220)	(0.230)	(0.313)	(0.343)
Formal Emp	0.160	-0.048	-0.013	-0.040	-0.013	0.052	0.091**	0.105	0.114
		(0.029)	(0.031)	(0.038)	(0.050)	(0.042)	(0.040)	(0.076)	(0.106)
Informal Emp	0.144	0.058	0.021	-0.030	-0.259	-0.033	-0.084	-0.048	-0.373
		(0.196)	(0.204)	(0.231)	(0.292)	(0.170)	(0.180)	(0.245)	(0.248)
LFP	0.348	-0.040	-0.061	-0.066	-0.274	-0.083	-0.136	-0.086	-0.466
		(0.188)	(0.192)	(0.281)	(0.313)	(0.198)	(0.210)	(0.382)	(0.354)
Private Worker	0.253	-0.050	-0.047	-0.161	-0.351	-0.132	-0.150	-0.256	-0.659**
		(0.202)	(0.210)	(0.218)	(0.288)	(0.220)	(0.229)	(0.272)	(0.309)
Public Worker	0.042	0.030**	0.035**	0.055*	0.056**	0.023	0.026	0.066	0.058*
		(0.013)	(0.015)	(0.030)	(0.028)	(0.021)	(0.023)	(0.042)	(0.032)
Wage Worker	0.184	-0.042	-0.029	-0.000	-0.059	-0.012	-0.015	0.071	-0.077
		(0.071)	(0.067)	(0.127)	(0.122)	(0.091)	(0.096)	(0.221)	(0.208)
Self-Employed	0.028	-0.079	-0.102	-0.099	-0.133*	-0.082*	-0.097**	-0.127	-0.140*
		(0.061)	(0.062)	(0.086)	(0.077)	(0.044)	(0.045)	(0.092)	(0.073)
Employer	0.004	0.001	0.000	0.001	0.000	0.002	0.001	0.003	0.004
		(0.005)	(0.005)	(0.005)	(0.006)	(0.010)	(0.010)	(0.015)	(0.020)
Observations	1,005,384								
Year		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region-Season		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
NUTS1 Trend		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
NUTS1-Year			Yes		Yes		Yes		Yes

NOTES: Table reports the coefficient for the ratio of the immigrants. Control variables include gender, age groups (by 5 years), education (3 categories), marital status (4 categories) and log trade volume. Standard errors clustered at the NUTS-2 level are reported in parentheses. Significance levels are denoted as follows: ***1 percent, **5 percent, *10 percent.

Table B8: Results for Different Specifications -DiD - Full Sample

Table B8: Effect of Syrians on Natives - DiD

		DiD-OLS		DiD-2SLS	
Total	Mean Y	1	2	1	2
Employment	0.490	0.026	0.015	0.021	0.014
		(0.186)	(0.191)	(0.228)	(0.240)
Formal Emp	0.312	0.137***	0.193***	0.238**	0.196***
		(0.045)	(0.063)	(0.093)	(0.046)
Informal Emp	0.178	-0.111	-0.177	-0.218	-0.249
		(0.179)	(0.187)	(0.247)	(0.246)
LFP	0.550	-0.012	-0.164	-0.082	-0.252
		(0.175)	(0.162)	(0.277)	(0.232)
Private Worker	0.422	0.030	-0.028	0.043	-0.109
		(0.157)	(0.178)	(0.249)	(0.272)
Public Worker	0.063	0.005	0.027	0.003	0.015
		(0.036)	(0.034)	(0.050)	(0.050)
Wage Worker	0.321	-0.102	-0.067	-0.127**	-0.085
		(0.067)	(0.067)	(0.062)	(0.070)
Self-Employed	0.084	0.038	-0.004	0.030	-0.001
		(0.058)	(0.050)	(0.073)	(0.068)
Employer	0.024	0.014	0.027	0.022	0.050
		(0.028)	(0.032)	(0.043)	(0.053)
Observations	4,222,024				
Year		Yes	Yes	Yes	Yes
Region-Season		Yes	Yes	Yes	Yes
NUTS1 Trend		Yes	Yes	Yes	Yes
NUTS1-Year Effect			Yes		Yes

NOTES: Table reports the coefficient for the ratio of the immigrants. Control variables include gender, age groups (by 5 years), education (3 categories), marital status (4 categories) and log trade volume. Standard errors clustered at the NUTS-2 level are reported in parentheses. Significance levels are denoted as follows: ***1 percent, **5 percent, *10 percent.

Table B9: Results for Different Specifications - Full Sample

Table B9: Effect of Syrians on Natives - Full Sample

		OLS		2SLS		Logit		IV Probit	
Total	Mean Y	1	2	1	2	1	2	1	2
Employment	0.502	0.046	0.045	-0.018	-0.149	0.037	0.030	-0.023	-0.195
		(0.186)	(0.197)	(0.203)	(0.271)	(0.189)	(0.202)	(0.212)	(0.278)
Formal Emp	0.332	0.091	0.139***	0.068	0.096**	0.109	0.154***	0.098	0.103
		(0.059)	(0.047)	(0.071)	(0.046)	(0.067)	(0.059)	(0.093)	(0.100)
Informal Emp	0.170	-0.045	-0.094	-0.086	-0.245	-0.058	-0.107	-0.042	-0.207
		(0.167)	(0.170)	(0.226)	(0.246)	(0.154)	(0.161)	(0.207)	(0.214)
LFP	0.560	-0.016	-0.062	0.050	-0.164	-0.022	-0.079	0.059	-0.200
		(0.186)	(0.194)	(0.366)	(0.327)	(0.186)	(0.198)	(0.393)	(0.337)
Private Worker	0.431	-0.006	-0.019	-0.090	-0.229	-0.017	-0.035	-0.107	-0.300
		(0.173)	(0.182)	(0.188)	(0.254)	(0.178)	(0.190)	(0.194)	(0.269)
Public Worker	0.065	0.030	0.047*	0.048	0.064*	0.021	0.035*	0.045	0.050
		(0.029)	(0.024)	(0.045)	(0.034)	(0.024)	(0.019)	(0.051)	(0.040)
Wage Worker	0.336	-0.077	-0.052	-0.082	-0.052	-0.076	-0.052	-0.063	-0.048
		(0.071)	(0.068)	(0.122)	(0.113)	(0.078)	(0.075)	(0.144)	(0.141)
Self-Employed	0.083	0.009	-0.010	-0.007	-0.062	-0.005	-0.020	-0.010	-0.061
		(0.044)	(0.046)	(0.060)	(0.056)	(0.039)	(0.042)	(0.070)	(0.065)
Employer	0.023	0.023	0.023	0.041	0.025	0.013	0.013	0.032	0.019
		(0.024)	(0.025)	(0.033)	(0.032)	(0.029)	(0.031)	(0.044)	(0.046)
Observations	1,970,233								
Year		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region-Season		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
NUTS1 Trend		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
NUTS1-Year			Yes		Yes		Yes		Yes

NOTES: Table reports the coefficient for the ratio of the immigrants. Control variables include gender, age groups (by 5 years), education (3 categories), marital status (4 categories) and log trade volume. Standard errors clustered at the NUTS-2 level are reported in parentheses. Significance levels are denoted as follows: ***1 percent, **5 percent, *10 percent.

Appendix C

Appendix for Chapter 3

Table C1: Effect of the Minimum Wage on Wages - Full Sample

Table C1: Effect of the Minimum Wage on Wages - Full Sample

	Fraction Affected	Fraction At	Fraction Lower	Kaitz (MW/AW)	Toughness (MW/Median)	Gap
Full Sample						
All Wages	0.088	0.152**	0.466***	0.987***	0.425***	1.414***
Formal Wages	0.156**	0.158**	0.266***	0.863***	0.312***	0.739***
Informal Wages	0.025	0.067	0.291***	0.216**	0.161***	0.936***
Restricted Sample						
All Wages	0.119**	0.080*	0.370***	0.718***	0.269***	0.853***
Formal Wages	0.158**	0.093*	0.285***	0.797***	0.249***	0.811***
Informal Wages	-0.161	-0.112	0.135**	0.126**	0.050	0.322
Restricted Sample under 40						
All Wages	0.053	0.047	0.350***	0.687***	0.259***	0.856***
Formal Wages	0.092**	0.078	0.216***	0.723***	0.218***	0.665***
Informal Wages	-0.225	-0.200	0.103	0.120*	0.009	0.467**
Restricted Sample under 25						
All Wages	-0.047	-0.019	0.303***	0.640***	0.271***	0.598***
Formal Wages	0.060	0.122***	0.136***	0.527***	0.134***	0.229**
Informal Wages	-0.255*	-0.334**	0.245**	0.491***	0.252**	0.667***
Observations	546	546	546	546	546	546

NOTES: Dependent variable is the change in logarithm of average real wages. Results are reported for the coefficients on difference minimum wage incidence parameters. Control variables include unemployment rate, average age, share of females, share of low educated agents, share of singles, share of small firms, share of occupations requiring low skills, share of low paid sectors (includes manufacturing, wholesale and retail trade, accommodation and food services), share of seasonal and part-time workers. All regressions include region fixed effects, time fixed effects and region controls. Standard errors clustered at the NUTS-2 level are reported in parentheses. Significance levels are denoted as follows: ***1 percent, **5 percent, *10 percent.

Table C2: Effect of the Minimum Wage with Time Trends

Table C2: Effect of the Minimum Wage with Time Trends

	Fraction Affected	Fraction At	Fraction Lower	Kaitz (MW/AW)	Toughness (MW/Median)	Gap
Restricted Sample - Real Wages						
All Wages	0.128**	0.078*	0.381***	0.762***	0.285***	0.798***
	(0.056)	(0.040)	(0.052)	(0.085)	(0.062)	(0.119)
Formal Wages	0.176**	0.107**	0.305***	0.840***	0.264***	0.803***
	(0.075)	(0.048)	(0.051)	(0.126)	(0.074)	(0.156)
Informal Wages	-0.164	-0.138	0.103	0.091*	0.049	0.242
	(0.128)	(0.108)	(0.076)	(0.053)	(0.043)	(0.207)
Restricted Sample - Employment						
Employment Share	-0.024	-0.001	0.094	0.179***	0.064	0.442**
	(0.083)	(0.073)	(0.068)	(0.057)	(0.058)	(0.189)
Formal Share	-0.099	-0.009	0.291***	0.476***	0.215**	1.037***
	(0.094)	(0.058)	(0.102)	(0.104)	(0.091)	(0.310)
Informal Share	0.192	0.064	-0.268*	-0.358***	-0.231*	-0.610
	(0.142)	(0.213)	(0.155)	(0.106)	(0.120)	(0.388)
Unemp Share	0.188	0.041	-0.223*	-0.157	-0.261**	-0.635
	(0.215)	(0.190)	(0.124)	(0.175)	(0.121)	(0.663)
Labour Force Share	0.043	0.044	0.025	0.069	0.012	0.104
	(0.055)	(0.060)	(0.054)	(0.056)	(0.066)	(0.116)
Observations	546	546	546	546	546	546
Region Trends	Yes	Yes	Yes	Yes	Yes	Yes

NOTES: Results are reported for the coefficients on different minimum wage incidence parameters. Control variables include unemployment rate, average age, share of females, share of low educated agents, share of singles, share of small firms, share of occupations requiring low skills, share of low paid sectors (includes manufacturing, wholesale and retail trade, accommodation and food services), share of seasonal and part-time workers. All regressions include region fixed effects, time fixed effects and region controls. Standard errors clustered at the NUTS-2 level are reported in parentheses. Significance levels are denoted as follows: ***1 percent, **5 percent, *10 percent.

Table C3: Effect of the Minimum with Time Trends - Separate Incidence

Table C3: Effect of the Minimum Wage with Time Trends - Separate Incidence

		Fraction Affected	Fraction At	Fraction Lower	Kaitz (MW/AW)	Toughness (MW/Median)	Gap
Restricted Sample - Real Wages							
All Wages	MW^F	0.144**	0.091*	0.307***	0.819***	0.362***	0.915***
		(0.059)	(0.046)	(0.054)	(0.097)	(0.090)	(0.308)
	MW^I	-0.077	-0.019	0.529***	0.043	0.030	0.738***
		(0.225)	(0.358)	(0.065)	(0.028)	(0.039)	(0.223)
Formal Wages	MW^F	0.207***	0.137***	0.337***	0.944***	0.376***	1.179***
		(0.073)	(0.045)	(0.062)	(0.119)	(0.109)	(0.229)
	MW^I	-0.307	-0.261	0.216**	-0.033	-0.019	0.476*
		(0.209)	(0.302)	(0.085)	(0.024)	(0.045)	(0.240)
Informal Wages	MW^F	-0.112	-0.110	0.023	-0.036	-0.071	-0.075
		(0.144)	(0.121)	(0.103)	(0.041)	(0.049)	(0.597)
	MW^I	-0.545***	-0.290	0.253**	0.662***	0.294***	0.386**
		(0.189)	(0.241)	(0.099)	(0.047)	(0.043)	(0.175)
Restricted Sample- Employment							
Emp Share	MW^F	0.034	0.048	0.053	0.130**	0.130**	-0.112
		(0.075)	(0.066)	(0.067)	(0.050)	(0.051)	(0.295)
	MW^I	-0.634**	-0.467	0.178*	0.024	0.050	0.723**
		(0.300)	(0.325)	(0.100)	(0.040)	(0.035)	(0.286)
Formal Share	MW^F	-0.101	-0.033	-0.022	0.348***	0.319***	-0.469
		(0.082)	(0.054)	(0.074)	(0.081)	(0.073)	(0.335)
	MW^I	-0.041	0.323	0.918***	-0.007	0.030	1.804***
		(0.397)	(0.344)	(0.195)	(0.053)	(0.044)	(0.461)
Informal Share	MW^F	0.494***	0.407*	0.371**	-0.183	-0.132	1.252
		(0.144)	(0.226)	(0.169)	(0.113)	(0.102)	(0.929)
	MW^I	-2.820***	-3.212***	-1.545***	0.031	0.065	-1.558**
		(0.562)	(0.727)	(0.303)	(0.097)	(0.082)	(0.565)
Unemp Share	MW^F	0.102	-0.071	0.019	-0.018	-0.139	1.406
		(0.220)	(0.212)	(0.154)	(0.176)	(0.149)	(0.902)
	MW^I	1.065	1.258	-0.707*	-0.233**	-0.064	-1.674*
		(0.632)	(1.035)	(0.405)	(0.097)	(0.100)	(0.867)
LF Share	MW^F	0.052	0.031	0.045	0.065	0.063	0.116
		(0.065)	(0.064)	(0.060)	(0.058)	(0.060)	(0.246)
	MW^I	-0.056	0.196	-0.016	-0.029	0.023	0.098
		(0.187)	(0.206)	(0.123)	(0.029)	(0.024)	(0.160)

NOTES: Dependent variable is the change in logarithm of average wages. Control variables include unemployment rate, average age, share of females, share of low educated agents, share of singles, share of small firms, share of occupations requiring low skills, share of low paid sectors (includes manufacturing, wholesale and retail trade, accommodation and food services), share of seasonal and part-time workers. All regressions include region fixed effects, time fixed effects and region controls. Standard errors clustered at the NUTS-2 level are reported in parentheses. Significance levels are denoted as follows: ***1 percent, **5 percent, *10 percent.