# Minimum wages and unemployment during economic shocks*

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**Abstract**

This paper studies whether a minimum wage changes how labour markets respond to economic shocks. Using data from South Africa, we show that an agricultural minimum wage leads to higher mean wages with no significant impacts on mean employment for men. However, these positive aggregate outcomes hide important heterogeneity: the imposition of the minimum wage leads to substantial declines in employment – especially overall hours – in the sector in the wake of negative weather-related economic shocks, which typically exert downward pressure on wages. The increased variance of employment across years in the post-law period suggests caution in interpreting the overall welfare impacts of minimum wage laws.

*Keywords*: minimum wage, agriculture, shocks, weather, South Africa
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# 1 Introduction

Minimum wage policies are highly politically contentious. Yet, while neoclassical economic theory predicts that raising wages should cause involuntary unemployment, the majority of studies from the US and other industrialised countries have found only small or non-existent disemployment effects (see reviews in Neumark et al., 2014; Card and Krueger, 2016). In addition, these results may not be expected to generalise to emerging economies, where instituted wage increases tend to be larger and affect more workers and where labour market characteristics and policy enforcement may be very different (Neumark et al., 2007; Lemos, 2009). However, in the research to date in developing countries, most studies also seem to find at most modest adverse effects on overall employment, though effects may be larger for more vulnerable groups, including the youth and low-skilled (see reviews in Betcherman, 2015; Broecke et al., 2017).

Surprisingly absent from the minimum wage literature has been any examination of how employment effects may differ over time depending on economic conditions. Even if a minimum wage has a limited impact on overall or group employment, it could affect how labour markets respond to economic shocks. By making the wage bill less affordable for employers and/or reducing the flexibility of employers to adjust wages to shocks (Franklin and Labonne, 2019), the minimum wage could increase the elasticity of employment to negative shocks, with substantial welfare implications.

In developing countries, where typically a large share of the labour force works in agriculture, weather shocks can translate into important economic shocks. With climate change increasing the frequency of these shocks, there has been growing attention to their impacts on labour markets (e.g. Jayachandran, 2006; Jessoe et al., 2018). In this paper, we bring minimum wages and economic shocks together to explore how the introduction of an agriculture minimum wage law in South Africa affects how labour markets adjust to weather-driven economic shocks, leading to important, previously undocumented, heterogeneity.

Agriculture accounts for a substantial share of employment of low-skilled workers in South Africa, notwithstanding a trend towards commercialisation and mechanisation, which caused over one million agricultural jobs to be shed in the three decades between 1980 and 2010 (Liebenberg and Johann, 2013). Agricultural employment is also highly variable due to currency and, in particular, weather fluctuations (BFAP, 2016). There is anecdotal and descriptive evidence of droughts causing massive destruction in the agricultural economy (Vogel and Drummond, 1993; BFAP, 2016), even though no studies to date have attempted to examine causal economic effects of the interaction between minimum wages and these shocks. With climate change becoming an increasingly worrying part of everyday life, weather shocks may play even larger role in the future.

In 2003, the South African government implemented a national agricultural minimum wage. This was set at the 70$^{\text{th}}$ percentile of the prevailing wage distribution, leading to a substantial increase in the median wage. In the single published national study, Bhorat et al. (2014) find evidence of a positive effect of the law on the income of agricultural workers but a negative effect on their employment (with no significant effect on hours worked). However, a few smaller-scale studies papers surveying farm owners and/or workers in regional agricultural sub-industries found more modest or no disemployment effects (Conradie, 2003; Murray and Van Walbeek, 2007; Naidoo, 2019).

While our main focus is on the impacts of the interaction between the law and economic shocks, we first reanalyse the main effects of the law, improving the matching of minimum wage levels to district boundaries. Using large, nationally representative labour surveys from September 2001 to September 2007, our empirical strategy involves changes over time across district councils that are differentially affected by the new minimum wage law. Specifically, we create a variable that measures the difference between the new minimum wage law and prevailing agricultural wages in a given district council, similar to much previous work on minimum wages (e.g. Lee, 1999; Dinkelman and Ranchhod, 2012; Engbom and Moser, 2022). We focus on men due to another minimum wage law enacted at a similar time that predominantly affected women.

The minimum wage was announced in December of 2002 and took effect just months later, leaving little time for employers and employees to react in advance of the change. Guided by a simple model of labour allocation, we first show that the minimum wage had large effects on prevailing agricultural wages in South Africa. A one-standard-deviation increase in the wage gap is correlated with an increase in the prevailing (agricultural) wage of around 9 percent following implementation of the minimum wage law. Importantly, we find no disemployment effects in the agricultural sector; in fact, while overall employment does not respond to the wage gap measure, hours per month in agriculture actually increase.

We present additional evidence that this wage gap variable does not predict changes prior to the implementation of the minimum wage. We also demonstrate that the impacts of the law on employment and agricultural wages are immediate and are constant across the four years following implementation. In other words, if trends or confounders are responsible for the effects, it would have to be the case that they acted immediately upon implementation of the law and then not again for the remainder of our sample period.

Our main focus is how the agricultural minimum wage law affects the ability of the labour market to adjust following shocks. We show that average effects on wages and employment can hide important changes related to agricultural productivity levels, proxied by rainfall. Following Jayachandran (2006), we define a productivity shock variable based on historical rainfall patterns. We then show that the effect of the minimum wage differs substantially (and significantly) depending on agricultural productivity levels. Specifically, during normal years, we see an increase in hours worked and wages for those who are employed in agricultural wage employment. However, we see a noticeable relative reduction in agricultural hours during bad years and a symmetric increase during good years. This increase in the variance carries over to the entire population of male adults.

Carrying out further tests, it does not appear that men in South Africa are able to cushion the disemployment effects of negative post-law shocks by moving into non-agricultural employment. Total employment hours decreases by more than 14 hours per month for men – relative to prior to the minimum wage – during negative shocks and increases by approximately the same magnitude during positive shocks. These effects are only slightly attenuated relative to focusing on only agricultural employment.

We contribute to the literature on the effects of minimum wages in developing countries (e.g. Neumark et al., 2006; Gindling and Terrell, 2007; Dinkelman and Ranchhod, 2012; Engbom and Moser, 2022). Minimum wages are often considered an important welfare policy (Eyraud and Saget, 2008), but particularly so in developing countries where there are there large numbers of low-skilled workers operating in relatively poor conditions. However, we show that in our setting there is an unexplored trade-off of higher wages for some against larger variation in employment. When employment is seasonal (Breza et al., 2021) and when households have limited liquidity, as is often the case in developing countries (Casaburi and Willis, 2018; Fink et al., 2020), households may not be able to fully cope with variability. We have ample evidence that seasonal hunger is a prevalent condition in developing countries with long-term impacts (e.g. Christian and Dillon, 2018; Dostie et al., 2002). Our results suggest caution in interpreting average effects of minimum wages in such conditions, as increased variance can lead to reduced welfare (Ravallion, 1988), especially for the poor, for whom unexpected shocks and variance are an important part of life (Merfeld and Morduch, 2022). However, this does not mean that the minimum wage increase decreased welfare; instead, we aim to bring attention to the distributional effects that can accompany policy changes, especially in areas with high levels of seasonality.

We also contribute to the literature on labour market responses to weather-related economic shocks (Townsend, 1994; Jayachandran, 2006; Henderson et al., 2017; Jessoe et al., 2018; Kaur, 2019). A subset of this research explores the interaction between these shocks and labour market policies (Adhvaryu et al., 2013; Chaurey, 2015; Santangelo, 2019; Colmer, 2021). None of these papers has focused on the influence of minimum wage legislation on the effects of these economic shocks. However, our findings accord with evidence in Chaurey (2015) that stronger labour market restrictions (in that paper, related to firing costs) may cause firms to hire more casual labour in response to temporary shocks. In the wider literature, Kaur (2019) finds that nominal wage rigidities can prevent labour markets from clearing after economic shocks, leading to disemployment effects. We show that this result is also found where the wage rigidities are due to legislation.

## 2 A simple model of labour allocation

In this section, we present a simple model of labour allocation in agriculture. Most of the model comes directly from Jayachandran (2006), with a few changes. Most notably, we abstract away from financial markets, without loss of generality with respect to our main result, and discuss the addition of a minimum wage. In an agricultural economy, there are $N$ agents, each of whom has time endowment $\bar{h}$ (which does not vary across agents). Agents derive utility from leisure, $l_i$, and consumption, $c_{it}$, across two time periods, $t = \{1, 2\}$.

In the first period, agents allocate time between leisure and labour, $h_i$, while in the second period income is exogenous, leading to no labour/leisure choice, so we suppress subscripts for these variables.[1] We assume Stone-Geary preferences over consumption and leisure:

$$u(c_{it}, l_i) = \log(c_{it} - \underline{c}) + \frac{1-\alpha}{\alpha} \log l_i, \tag{1}$$

where $\alpha \in (0, 1)$. We assume utility is additive and separable across the two periods, with

[1]Since leisure in the second period enters as a constant, we also suppress second-period leisure to make presentation clearer.

a discount factor of $b$. We also assume that agents can save income from period one to consume in period two, but they do not receive interest and they are not able to borrow.

Agents are also endowed with land, $k_i$, with $\sum_i k_i = K$. Agents can hire in labour to work on their land and agricultural production follows a Cobb-Douglas technology,

$$f(d_i, k_i) = \gamma d_i^{\beta} k_i^{1-\beta}, \tag{2}$$

where $d_i$ is the amount of labour applied to land, $k_i$, and $\beta \in (0, 1)$. $\gamma$ is a stochastic productivity shock which takes on two possible values, $\gamma_L$ and $\gamma_H$, each with probability 0.5 and $\gamma_H > \gamma_L$.

Putting these together, the agent's problem is

$$\max_{c_{it}, l_i, d_i} \log(c_{i1} - \underline{c}) + \frac{1-\alpha}{\alpha} \log l_i + b \log(c_{i2} - \underline{c}) \tag{3}$$

subject to

$$c_{i2} = \gamma d_i^{\beta} k_i^{1-\beta} - d_i + w(\bar{h} - l_i) - ci1 + y_i, \tag{4}$$

where Equation 4 imposes that the agent spend all remaining money in period 2.

All landholders maximise on-farm profits by setting the returns to hiring equal to the wage rate:

$$\frac{\partial f}{\partial d_i} = \beta\gamma \left(\frac{k_i}{d_i}\right)^{1-\beta} = w. \tag{5}$$

Rearranging, we can write optimal labour demand as

$$d_i^* = k_i \left(\frac{\gamma\beta}{w}\right)^{\frac{1}{1-\beta}}. \tag{6}$$

As Jayachandran (2006) shows, optimal labour supply equals

$$h_i^* = \frac{1-\alpha}{1+\alpha b}\left[\frac{\alpha(1-b)}{1-\alpha}\bar{h} - \frac{y-2\underline{c}}{w} - \frac{1-\beta}{w}\left(\frac{\gamma^\beta}{w^\beta}\right)^{\frac{1}{1-\beta}} k_i\right]. \tag{7}$$

## 2.1 Imposing a minimum wage

The wage rate is determined endogenously, with the equilibrium wage being the wage, $w^*$, that equalises labour demand and labour supply:

$$\sum_{i=1}^{N} h_i^*(w^*) = \sum_{i=1}^{N} d_i^*(w^*). \tag{8}$$

The equilibrium wage, $w^*$, is increasing in agricultural productivity, or $w^*(\gamma_H) > w^*(\gamma_L)$. Consider the imposition of a minimum wage, $\underline{\mathrm{w}}$, which acts as a wage floor and prevents $w^*$ from falling below $\underline{\mathrm{w}}$.

For simplicity, assume that $w^*(\gamma_H) > \underline{\mathrm{w}}$.[2] In this case, the imposition of the wage floor has no effect on equilibrium values $d_i^*(\gamma_H)$ and $h_i^*(\gamma_H)$. Now consider negative productivity shocks, where $w^*(\gamma_L) < \underline{\mathrm{w}}$. In this case, the minimum wage will prevent the equilibrium wage from falling to equalise labour demand and labour supply, leading to a labour surplus. Moreover, the size of this new labour surplus is increasing in the difference between the minimum wage and the optimal equilibrium wage, since $\frac{\partial d_i^*}{\partial w} < 0$ and $\frac{\partial h_i^*}{\partial w} > 0$. However, we do not observe desired labour supply, but only actual hiring, which equals $d_i^*$. Nonetheless, the same predictions hold when just looking at $d_i^*$ since the derivative is negative. This is the core prediction we aim to test in this paper.

[2]To generate the comparative statics below, we only require that $w^*(\gamma_H) > w^*(\gamma_L)$. We make the assumption here regarding the minimum wage just to simplify the exposition in this paragraph.

# 3 Context

## 3.1 The agricultural sector

Farm labour in South Africa has been shaped by the country's long history of separate development along racial lines (see Atkinson, 2007; Binswanger and Deininger, 1993; Devereux, 2020). Over three centuries, land ownership was consolidated by White farmers and taken away from Black farmers.[3] During the 20$^{th}$ century, Black workers in the sector were either restricted to impoverished 'homelands' or employed as low-paid labourers or sharecroppers on heavily protected and subsidised White-owned commercial farms. A system of pass laws concentrated black labour on these commercial farmers and entrenched what has been characterised as a 'quasi-feudal social order' (Atkinson, 2007, pg 15). Poor conditions for workers persisted even after the end of Apartheid in 1994; right before the minimum wage was introduced, an Employment Conditions Commission found that there were high rates of food insecurity and poverty, widespread employment of children and a high level of indebtedness to farm owners (Department of Labour, 2001; Naidoo et al., 2007).

Shortly after the end of Apartheid, the government moved to deregulate and liberalise the agriculture sector. Since then, a substantial share of smallholder farms in the commercial sector have consolidated into larger farms, many of which are oriented towards the export market. With the collective power of producers substantially reduced, they have become price takers and are on the defensive to protect their waning profit margins (Barrientos and Kritzinger, 2004; Visser and Ferrer, 2015).

Despite the agriculture sector's relatively small contribution to GDP – it contributed only 2.33-3.88% of annual GDP between 2001 and 2007 (World Bank, 2020) – and the fact that industrialisation of the sector has resulted in a downward trend in agricultural

[3]'Black' here refers to both African and so-called 'Coloured' people according to the Apartheid definition.

employment, the sector still employs a substantial number of mostly low-skilled workers.[4] During our period of study, 2001-2007, just over one million people were employed in the agricultural sector as their primary activity (accounting for approximately 6% of the labour force), the vast majority of whom had not completed high school. However, the sector also indirectly benefits or involves a wider group of people. According to the 2011 Census, in addition to workers who counted agriculture as their primary activity, an additional one million people were casually involved in agriculture at the time of the census (Liebenberg and Johann, 2013). Furthermore, a large number of jobs are created in industries with backward and forward linkages to the sector.

### 3.2 The 2003 agricultural minimum wage

The agricultural minimum wage was officially introduced in March 2003. Until this time the agricultural sector had been barely unionised and reported the lowest wages of any sector in the country (Department of Labour, 2001; Bhorat et al., 2014). In addition to setting a legal wage floor, the new law also defined conditions of employment for the agriculture sector that included maximum working hours and the establishment of a written employment contract for employees. According to Sectoral Determination No. 75 of 1997, the law was to apply to 'the employment of farmworkers in all farming activities in South Africa'. The law was intentionally vague about what was entailed by 'farming activities': the exact wording was: "Without limiting its meaning, 'farming activities' includes primary and secondary agriculture, mixed farming, horticulture, aqua farming and the farming of animal products or field crops excluding the Forestry Sector."

Importantly, the minimum wage set for the agriculture industry in South Africa resulted in changes to low-skilled worker wages that are several times greater those brought about by minimum wages in developed country contexts. The median district experienced a

[4]During our period of study, 2001-2007, agricultural workers represented approximately 19% of the workforce with fewer than ten years of education.

43% increase in agricultural monthly wages for full-time workers after the minimum wage was implemented.

A higher minimum wage was applicable in more urbanised local municipalities – classified as Area A municipalities – while a lower minimum wage applied to more rural municipalities – classified as Area B municipalities. Labour market data prior to September 2003 (described below) do not contain any information regarding the local municipality of residence of participants; however it is possible to work out the district council (a larger administrative unit) of residence from the unique identification numbers. Most district councils overlap with only Area A or Area B municipalities; where they overlap with local municipalities of both categories, we assign a minimum wage level depending on the relative proportions in terms of land area.

In 2003, over 80% of farm workers were earning less than the urban minimum, and over 60% were earning less than the rural minimum (Bhorat et al., 2014). To support implementation of the new legislation, labour inspectors were tasked with enforcement activities, visiting farms, reviewing worker contracts and interviewing a sample of workers. However, the fact that some farms were very remote made this task quite difficult. Still, some regional studies have found evidence of a relatively high rate of compliance in terms of granting of key rights (Conradie, 2003; Naidoo, 2019). This also accords with the findings of Dinkelman and Ranchhod (2012), which find high rates of compliance to a minimum wage for domestic workers in South Africa even when enforcement is weak.

It is easy to see the increase in wages in Figure 1, which shows kernel density plots of (hourly) agricultural wages in each wave of the survey. The four dashed density estimates are wages before the implementation of the minimum wage law; they are relatively tightly bunched together, with overlap across the range of the distributions. The other densities show that the wage distribution changed substantially upon implementation of the law. The average and mode increased, though not quite to the level of the minimum wage (the dotted vertical line). Also noteworthy is that the wage distribution for agricultural (wage) workers appears more compressed following the imposition of the wage floor, which is consistent with some previous evidence on minimum wages in developing countries (Gindling and Terrell, 1995; Lemos, 2009).

### 3.3 Drought trends & impacts

Droughts are important for agricultural output in South Africa (Baudoin et al., 2017).[5] While all areas of production are affected by droughts, field crop production is particularly volatile due its greater share of dry-land production (BFAP, 2016). For example, maize, the country's staple crop, is rain-fed and limited water availability reduces maize output by interrupting growth at several points in the growing season (Le Roux et al. (2009), cited in Dinkelman (2017)). Since the 1960s, the frequency of extreme heat events has accelerated in South Africa (Kruger and Sekele, 2013). Over the same period, interannual rainfall variability has increased and droughts have become more intense and widespread in South Africa (Fauchereau et al., 2003).

## 4 Data and empirical strategy

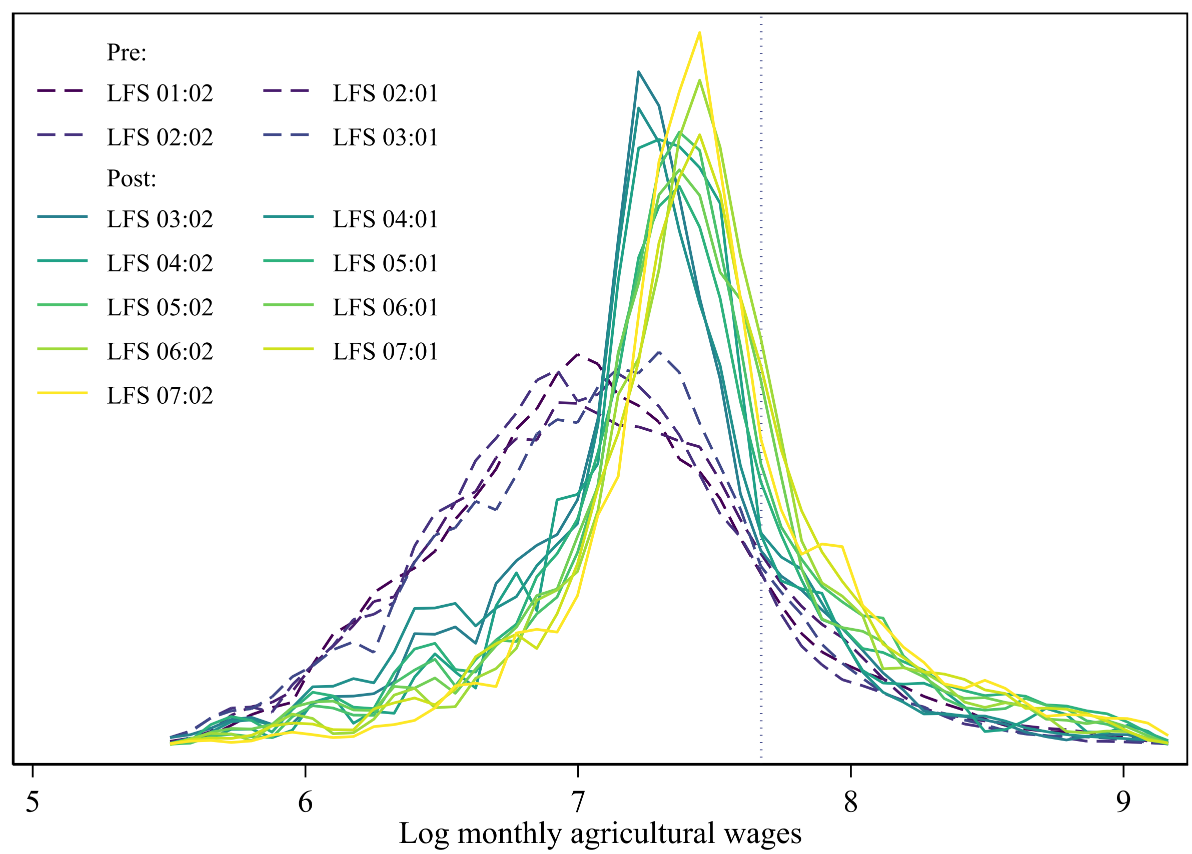
### 4.1 Labour market data

The labour market data for this study come from 13 waves of the South African Labour Force Survey (LFS) conducted between September 2001 and September 2007. These LFS surveys are biannual rotating panel surveys, conducted in February/March and September each year and include detailed data on work and unemployment experiences of 60,000 to 70,000 working-age individuals living in 30,000 households. In each wave, 20% of households interviewed in the previous wave are rotated out of the survey entirely.[6] The

[5]There is some anecdotal evidence that severe flooding may affect agriculture in South Africa, but this seems to be much less important than droughts (Dinkelman, 2017).

[6]There is a panel data component of the LFS survey, but this is not well maintained (and also not made publicly available) and, following others, we choose not to use it because of serious concerns about the

Figure 1: Minimum wage and agricultural wages




*Notes:* The four dashed lines are from survey waves prior to the implementation of the minimum wage. Lighter lines indicate later waves, with LFS 03:02 referring to the very first wave following implementation of the new wage floor.

chosen sample includes four waves prior to and including the legislation's effective date (March 2003) and nine afterwards. While there are three earlier waves of data going back to March 2000, the baseline sample was redrawn for the September 2001 round and so we start the analysis with data from this round, following Dinkelman and Ranchhod (2012). We treat all 13 waves as repeated cross sections over time.

The sample of workers includes all urban and rural employed and unemployed men aged 18 to 64. We drop women from the analysis due to another minimum wage – in the domestic sector – around the same time that predominantly affected women (Dinkelman and Ranchhod, 2012). We identify agricultural workers in each wave of the LFS using the the South African Standard Classification of Occupations (SASCO) codes, as well as the three-digit International Standard Industrial Classification (ISIC) industry codes. The LFS contains information on wages and hours worked, which allows us to construct data on wages, total income, and hours. There is very little income information for self-employed workers. In the analysis with these workers, we impute income in different ways, a topic to which we return below in the results section.

The labour force surveys give geographic information only for provinces, of which there are nine in the country. It is possible to work out magisterial districts (an administrative layer) for the period September 2001 to January 2003 based on the unique identification codes for respondents. However, for the period September 2003 to September 2007, the unique identification codes give information only about local municipalities, which were not defined in the earlier period. District councils were constant over the period of study and both magisterial districts and local municipalities fit neatly into district councils. These are therefore used as our geographic units of analysis is this paper.[7]

representativeness and quality of the panel data set of workers (cf. Dinkelman and Ranchhod (2012) for a longer discussion).

[7]While it is possible that some of the larger district councils could be seen as including more than one local labour market, district councils have been used as the geographic unit of analysis in several well-published papers (e.g. Bhorat et al., 2014) and it is even quite common for papers to use provincial units, which is the highest administrative layer in the country (e.g. Magruder, 2010; Dinkelman and Ranchhod, 2012). For this particular analysis, larger geographic units may be preferable since the effects of weather shocks may

### 4.1.1 Sample restrictions

As mentioned, we drop women from the analysis due to another minimum wage implemented at around the same time that predominantly affected women (Dinkelman and Ranchhod, 2012). We restrict the sample in one other way, dropping all of the major urban municipalities since we are interested in the agricultural sector. Specifically, we drop the Category A municipalities in all empirical analyses.

## 4.2 Baseline estimation

In order to identify the effects of the minimum wage increase, we create a new variable that measures the difference between pre-law agricultural wages and the post-law official minimum wage. While there is a time component to the law, there is also substantial geographic diversity in the law's "bite"; areas with wages further below the new floor face larger effects from the wage change. This variable identifies the cross-sectional variation in the wage gap between district councils in the pre-law period. Following Lee (1999) and similarly to Dinkelman and Ranchhod (2012) and Bhorat et al. (2014), we define the district-level wage gap as:

$$WG = log[min(W_{d}*)] - log[median(W'_{d})], \tag{9}$$

where $log[min(W_{d}*)]$ is the new minimum wage and $log[median(W'_{d})]$ is the median prevailing agricultural wage in a given district. With this wage-gap variable, we are able to analyse the heterogeneous effects of the new law in combination with the temporal component of the data. We allow for negative values in $WG_d$, under the assumption that the distance from the wage is still informative, even if the median wage is above the new minimum wage.

not be captured at high resolutions because rainfall in a limited area may not have enough of an impact on local labour market outcomes when there is smoothing across agricultural markets (Harari and Ferrara, 2018).

Based on a review of the Department of Labour documentation on setting the agricultural minimum wage, it appears that the potential impact of the wage on employment had minimal, if any, role in the policy decision. For example, in DoL (2001) it states that "...a minimum wage cannot be opposed purely on grounds of its adverse effect on employment" (cited in Garbers et al., 2015). This gives credence to the assumption that the size of the wage gaps used in this study are not correlated with trends in employment or wages. Figure A1 in the appendix shows the distribution of this "wage gap" variable across the country. Wages were highest in the Cape region (far southwest) and closer to the large cities (e.g. Pretoria/Johannesburg in the middle of the country and Durban to the southeast).

We present summary statistics in Table A1 of the appendix. Since the wage gap variable is constinuous, it is difficult to define a treatment and a comparison group. To show differences, we opt to divide the sample based on the median value of the wage gap variable. While one might think areas with higher wages are less agricultural, that is not the case, at least based on this sample. The higher wage areas have higher levels of agricultural employment (9.3 percent of adults relative to 6.8 percent of adults in lower wage areas), along with substantially higher agricultural wages. Part of this might be due to the fact that we remove the urban municipalities from our sample; this means that the "high-wage" areas are still relatively less urban than the highest wage areas in the country. The distribution of rainfall shocks is relatively similar across areas, which is expected given that they are calculated with respect to the area mean and standard deviation.

We focus mostly on the agricultural sector in this paper. We first examine the effects of the minimum wage law using the following specification:

$$y_{idt} = \alpha_d + \gamma_t + \beta Post_t \times WG_d + X_{idt} + \varepsilon_{idt}, \tag{10}$$

where $y_{idt}$ is the outcome of interest for person $i$ in district $d$ in wave $t$, $\alpha_d$ is district fixed effects, $\gamma_t$ is survey wave fixed effects, $Post_t$ is a dummy that takes the value of one after implementation of the minimum wage law, $X_{idt}$ is a vector of individual-level covariates: age, age squared, gender, (years of) education, education squared, and race. The coefficient of interest is $\beta$, which is a type of differences-in-differences estimator, similar in spirit to that used in Duflo (2001). Due to the fixed effects, both $Post_t$ and $WG_d$ drop out of the equation, leaving just the interaction term. Since the law took effect simultaneously across the country, there are fewer concerns regarding possible bias in two-way fixed effects models (Callaway and Sant'Anna, 2021; De Chaisemartin and d'Haultfoeuille, 2020; Goodman-Bacon, 2021). Nonetheless, the key identification assumption of parallel trends is still required. We present evidence in support of this assumption in the results section.

We are interested in several key outcomes: agricultural employment, hours worked in agriculture, hourly wage in agriculture, and total monthly income in agriculture. We analyse these outcomes with respect to different subsamples of the data. For example, in some specifications, we include only individuals working in the agricultural sector, in others we include all adults in the labour force, and in yet others we include all adults whether in or out of the labour force.

Our primary goal in this paper is to examine how the minimum wage impacts labour market flexibility in a developing country. One peculiarity of developing country labour markets is how much they are affected by the weather, owing to a relatively large share of workers being in rainfed agriculture; wages can be volatile and move in response to weather shocks (Jayachandran, 2006). A key question is how labour markets will adjust in response to shocks when there is a wage floor in the form of a minimum wage. To answer this question, we define a rainfall variable – $rainShock$ – that is meant to capture agricultural productivity. We define this variable identically to Jayachandran (2006): it takes on the value of one if yearly rainfall is above the 80th percentile of that district's rainfall distribution, negative one if it is below the 20th percentile, and zero otherwise. We then estimate regressions of the form:

$$
\begin{aligned}
y_{idt} = \alpha_d + \gamma_t + \beta_1 Post_t \times WG_d + \beta_2 Post_t \times WG_d \times I(rainShock == -1) + \\
\beta_3 Post_t \times WG_d \times I(rainShock == 1) + \beta_4 WG_d \times I(rainShock == -1) + \\
\beta_5 WG_d \times I(rainShock == 1) + \beta_6 I(rainShock == -1) + \\
\beta_7 I(rainShock == 1) + X_{idt} + \varepsilon_{idt},
\end{aligned}
\tag{11}
$$

where $I()$ is the indicator function and other variables are defined as before. Again, $Post_t$ and $WG_d$ drop out of estimation due to the fixed effects. Essentially, we compare the effects of the minimum wage based on the wage gap variable and whether it was a good agricultural year or not, relative to what it was before the minimum wage change.

In all regressions, we cluster standard errors at both the district level and the survey-year level. This will help take into account intracluster correlations within districts as well as country-wide correlations in the same year.

The model predicts that the minimum wage will have hetereogeneous impacts depending on the agricultural productivity shocks. In particular, the change in employment should be correlated with the bite of the new minimum wage. This suggests that a negative productivity shock will have a more negative effect on equilibrium labour allocation following the imposition of the minimum wage, relative to no shock, assuming that the new minimum wage is binding in at least the former. On the other hand, a positive productivity shock will have a more positive effect on equilibrium labour allocation following the imposition of the minimum wage, relative to no shock, if the minimum wage is more binding in the latter.

# 5 Results

## 5.1 Minimum wage effects

We begin by analysing the effects of the introduction of the minimum wage on different agricultural employment variables. We present this first set of results in Table 1. The outcome in column (1) is a simple dummy for whether a man is employed in the agricultural sector or not. We restrict the sample to everyone in the labour force. Column (2), on the other hand, expands the sample to include all adults (assuming anyone not in the labour force is not employed in the agricultural sector). In both cases, we see no changes in the overall probability of agricultural employment in response to the imposition of the new minimum wage. Columns (3) and (4) look at effects on total hours in agriculture. Column (3) restricts the sample to only those engaged in agricultural employment. Interestingly, overall monthly agricultural hours go up in response to the minimum wage, not down. When we expand the sample to all adults – not just those working – we do not see any increases, but we also do not see any decreases. In fact, we can rule out an average decrease of anything more than around 1.7 hours per month (based on confidence intervals).

Lastly, columns (5) and (6) look at average (log) hourly wages and total (log) monthly income, respectively. The wage is only defined for those engaged in wage employment, so the sample is restricted to this subsample in both columns. Perhaps unsurprisingly, we see large increases in the average hourly wage in response to the new minimum wage. The coefficient is not directly interpretable as the "effect" of the minimum wage since the independent variable is not a dichotomous variable but rather a continuous variable based on how far the district's average agricultural wage was from the new minimum wage. To put the coefficient in context, the interquartile range for the sample in column (5) is approximately 0.45. Combining this with the coefficient shows that moving from the 25th percentile to the 75th percentile leads to a wage increase of slightly more than 17 percent. Since the wage increased and hours went up slightly, we also see an increase in

Table 1: Effects of the minimum wage on agricultural employment

| | Employment | | Hours | | Wage/Income | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | In LF | All adults | Working | All adults | Wage | Income |
| Post times wage gap | 0.026 | 0.019 | 16.621* | 6.794 | 0.353*** | 0.379*** |
| | (0.019) | (0.017) | (7.798) | (4.351) | (0.044) | (0.039) |
| Age (10s) | −0.080*** | 0.088*** | 29.828*** | 22.027*** | 0.408*** | 0.398*** |
| | (0.024) | (0.014) | (5.196) | (2.742) | (0.047) | (0.041) |
| Age (10s) squared | 0.010*** | −0.011*** | −4.010*** | −2.860*** | −0.042*** | −0.042*** |
| | (0.003) | (0.002) | (0.605) | (0.383) | (0.006) | (0.005) |
| Education (years) | −0.034*** | −0.019*** | −0.888** | −4.267*** | −0.010 | −0.006 |
| | (0.003) | (0.002) | (0.338) | (0.538) | (0.007) | (0.006) |
| Education squared | 0.001*** | 0.000* | −0.059** | 0.073** | 0.004*** | 0.003*** |
| | (0.000) | (0.000) | (0.027) | (0.032) | (0.001) | (0.000) |
| Observations | 155,780 | 247,657 | 28,818 | 247,657 | 20,931 | 20,744 |

*Notes:* Standard errors are in parentheses and are clustered at the district council and the survey wave level. District-level and survey-year-leave fixed effects are included in all specifications. Column (1) includes only individual in the labour force. Columns (2) and (4) include all adults. Column (3) includes only individuals in the agricultural sector. Columns (5) and (6) include only individuals in the agricultural wage sector.
* p<0.1 ** p<0.05 *** p<0.01

agricultural income for those who engage in agricultural wage employment.

These results are quite different from those in Bhorat et al. (2014). There are three possible explanations. First, they use all of the pre-minimum wage waves while we restrict the pre-change waves following Dinkelman and Ranchhod (2012). However, Table A3 in the appendix shows that using these waves does not recover their overall estimates. While the coefficients are now more negative, they are still far from significant and much smaller in magnitude than those in Bhorat et al. (2014). A second possible explanation for the differing results is changes we made to the matching of administrative units as well as to the matching of minimum wage levels to district boundaries to improve the precision of assignment of minimum wage levels to workers. This has an important effect: it changes the median wage used to calculate the wage gap. A final possible explanation is the used of fixed effects in the estimation; in their empirical strategy, Bhorat et al. (2014) do not use district or year fixed effects, both of which we include in our regressions. However, Table A2 in the appendix shows our results when we remove fixed effects. The overall results are identical to our main results. This leads us to conclude that the most likely explanation for the differences in the probability of working in the agricultural sector is due to the change in matching we implement.

It is worth mentioning that we are not able to check what the effect of the law was on non-cash benefits – including food and water, clothes, medical care, interest-free loans, costs related to farm workers' food gardens and livestock - given to labourers and their families living on farms, which could add up to a substantial proportion of the cash wage (Atkinson, 2007). It is possible that these in-kind transfers declined in the wake of the law. There are anecdotal reports that the provision in the law that limited employers from deducting any portion of farm workers' pay for non-monetary compensation, with the exception of a maximum of 10 percent for housing and 10 percent for food, generated some discontent among employers (ibid.). A small-scale survey in 2003 found that after the law came into effect, some farmers started deducting house rentals from their workers' wages or stopped sharing their crops (Atkinson, 2003).

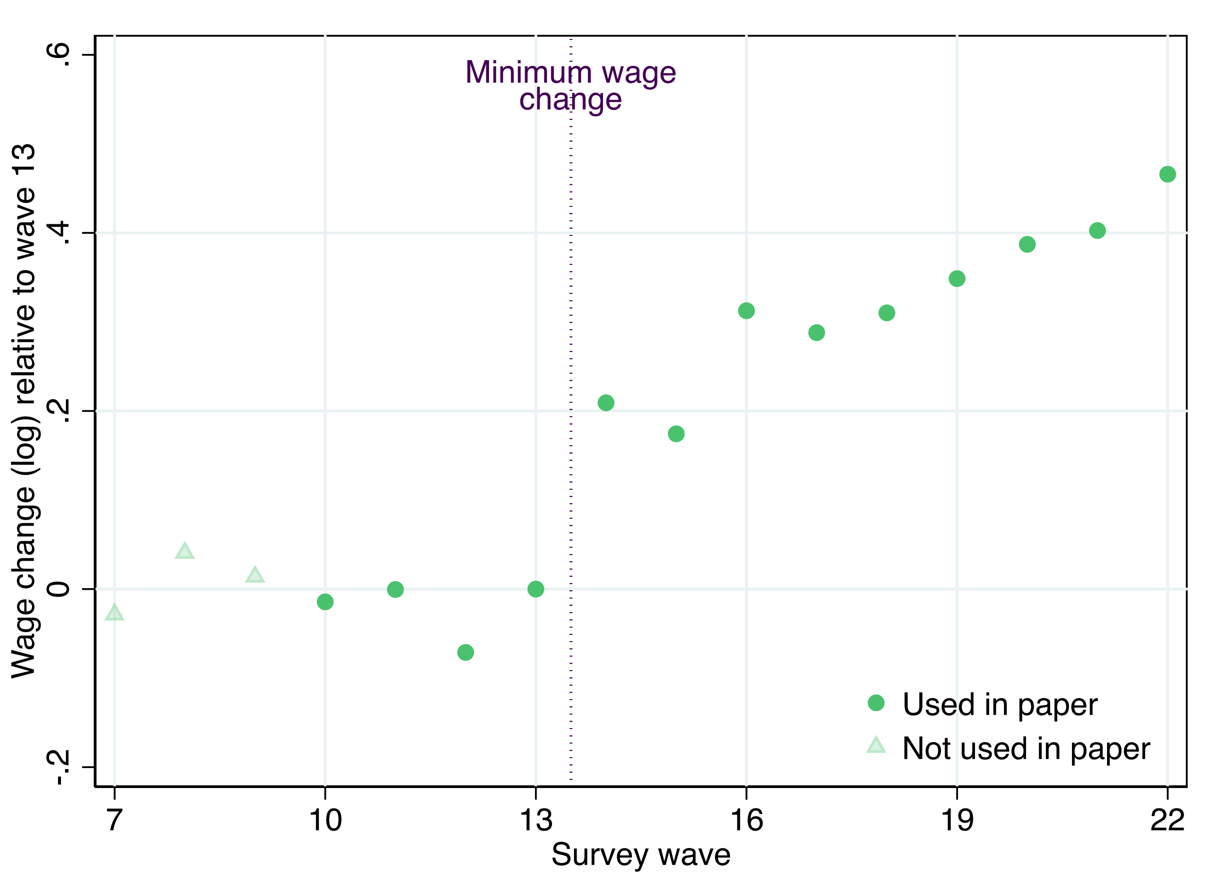
## 5.2 Testing for parallel trends

Since the estimator is a differences-in-differences estimator, the assumption of parallel trends is important for causal identification. In our case, we have data from before and after the minimum wage change. While this does not allow us to explicitly test the parallel trends assumption – an assumption that is inherently untestable – it does allow us to present evidence from prior to the wage change that suggests the assumption is plausible.

Figure 2 presents average agricultural wages across the waves of the survey. The dashed line shows the point in time at which the minimum wage changes. There are seven survey waves from before the change and nine waves from after.[8] There are two important patterns to note. First, average wages were constant prior to the minimum wage change; there was no noticeable upward trend of average wages. Second, there is a noticeable, immediate increase in average agricultural wages immediately upon implementation of the new minimum wage.

[8]We do not use the first three waves in our main results due to a change in the sampling structure (cf. Dinkelman and Ranchhod, 2012). However, in the appendix we present robustness checks for our main results using these waves.

Figure 2: Average wages across waves




*Notes:* The three triangles indicate the survey ways prior to the change in the sample design. We do not include these waves in our main results, but do include them in the pre-trends tests.

Figure 2 provides prima facie evidence that the parallel trends assumption is valid. However, it is not an exact graphical depiction of our identification strategy since we are actually using variation in the district's distance from the new minimum wage prior to its implementation.

We present two sets of empirical results to provide credence to the parallel trends assumptions. First, Table 2 presents the common test for pre-trends. We create a new "post" variable that takes the value of one in the three waves just prior to implementation of the new law and a zero for the waves prior to that. If trends prior to implementation are driving our results, the coefficients in Table 2 should be similar to those in our main

Table 2: Testing for pre-trends

| | Employment | | Hours | | Wage/Income | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | In LF | All adults | Working | All adults | Wage | Income |
| Post times wage gap | −0.023 | −0.016 | −5.281 | −4.150 | −0.047 | −0.115 |
| | (0.019) | (0.013) | (10.347) | (3.157) | (0.071) | (0.065) |
| Age (10s) | −0.134*** | 0.076*** | 33.033*** | 20.097*** | 0.581*** | 0.489*** |
| | (0.032) | (0.014) | (8.557) | (3.095) | (0.076) | (0.055) |
| Age (10s) squared | 0.017*** | −0.009*** | −4.382*** | −2.596*** | −0.063*** | −0.053*** |
| | (0.004) | (0.002) | (1.069) | (0.427) | (0.009) | (0.007) |
| Education (years) | −0.033*** | −0.022*** | −1.097 | −5.352*** | −0.005 | 0.004 |
| | (0.002) | (0.002) | (0.727) | (0.434) | (0.010) | (0.007) |
| Education squared | 0.001** | 0.000** | −0.179 | 0.107** | 0.004** | 0.002** |
| | (0.000) | (0.000) | (0.111) | (0.033) | (0.001) | (0.001) |
| Observations | 73,737 | 111,755 | 14,296 | 111,755 | 10,202 | 10,082 |

*Notes:* Standard errors are in parentheses and are clustered at the district council and the survey wave level. District-level and survey-year-leave fixed effects are included in all specifications. Individual-level controls include age, age squared, education, and education squared. The "Post (proxy)" variable takes the value of one in the three waves just prior to implementation of the new law and a zero for the waves prior to that. Column (1) includes only individual in the labour force. Columns (2) and (4) include all adults. Column (3) includes only individuals in the agricultural sector. Columns (5) and (6) include only individuals in the agricultural wage sector.
* p<0.1 ** p<0.05 *** p<0.01

Table 3: Effects on agriculture over time

| | (1)<br>First year | (2)<br>Second year | (3)<br>Third year | (4)<br>Fourth year |
|---|---|---|---|---|
| Post times wage gap | 0.355*** | 0.305** | 0.339*** | 0.340*** |
| | (0.061) | (0.096) | (0.065) | (0.055) |
| Age (10s) | 0.439*** | 0.479*** | 0.465*** | 0.451*** |
| | (0.059) | (0.069) | (0.057) | (0.062) |
| Age (10s) squared | −0.046*** | −0.051*** | −0.049*** | −0.048*** |
| | (0.007) | (0.008) | (0.007) | (0.007) |
| Education (years) | −0.001 | −0.011 | −0.012 | −0.013 |
| | (0.011) | (0.009) | (0.010) | (0.010) |
| Education squared | 0.003** | 0.004*** | 0.004*** | 0.004*** |
| | (0.001) | (0.001) | (0.001) | (0.001) |
| Observations | 9,517 | 9,725 | 9,647 | 9,643 |

*Notes:* Standard errors are in parentheses and are clustered at the district council and the survey wave level. District-level and survey-year-leave fixed effects are included in all specifications. Individual-level controls include age, age squared, education, and education squared. Each year is composed of two separate survey waves.
* p<0.1 ** p<0.05 *** p<0.01

results. This is not the case for any of the significant main results.

The second set of empirical results looks at heterogeneity in the effects of the minimum wage law over time. Since we have nine waves after the wage change, we can look at the evolution of the effect over these different waves. Specifically, we look at the effects of the new law on wages in each of the 4 years following the change. We present these results in Table 3. The key pattern is that effects are relatively consistent across all four years. This is especially true for wages, for which the coefficients vary from just 0.306 to 0.340. In other words, if a failure of the parallel trends assumption is responsible for our results, it must be the case that this failure was not apparent before the minimum wage law took effect and that these differential trends did not persist at all following the initial change.

## 5.3 Agricultural shocks and binding minimum wages

When looking at the average effects of the minimum law change, there seem to be no negative effects. However, labour market policies can also affect how the labour market responds to shocks. In developing countries, for example, agricultural productivity shocks – usually proxied by deviations of rainfall from historical averages – can have important effects on employment and wages (Jayachandran, 2006). We might expect minimum wages to have more bite during bad rainfall years, when there is downward pressure on wages. In these cases, it is reasonable to expect larger disemployment effects of the minimum wage (Neumark, 2019). In this section, we show how a new wage floor interacts with these agricultural productivity shocks and how this can lead to important changes in employment, which are not revealed in the average effects.

Table 4 presents the first set of results. We interact the differences-in-differences estimator ($Post_t \times WG_d$) with an indicator for whether rainfall in the year was bad, normal, or good. Normal is the omitted category, so the interpretation of $Post_t \times WG_d$ in Table 4 is the change due to the minimum wage increase during normal rainfall years, when rainfall is between the 20th and 80th percentile in a given district's historical rainfall distribution. During normal years, there is an increase in hours worked for those in agricultural wage employment, but no significant increase when we expand the sample to include everyone in the labour force or all adults (columns (4) and (5), respectively). We also see an increase in wages, consistent with the main results in Table 1.[9]

We start to see important differences when we look at effects during negative agricultural shocks. There are large negative effects on employment on men in the labour force. Importantly, these effects persist when we expand the sample to include all adult men. In other words, there is a significant decrease in hours devoted to agricultural wage employment during poor rainfall years for all adults, not just for those who are employed. Moreover, the linear combination of the first two rows is significantly negative for all three specifications with hours.

During good years, we see opposite effects, with a large increase in hours spent in

[9]Table A5 in the appendix shows the effects of shocks prior to the minimum wage change; we do not see the same patterns and heterogeneity that we see following the law change.

Table 4: Effects of rainfall shocks

| | Employment | | Hours | | | Wage |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | In LF | All adults | Working | In LF | All adults | |
| Post times wage gap | 0.027 | 0.020 | 14.274** | 10.462 | 7.414 | 0.397*** |
| | (0.027) | (0.024) | (6.015) | (6.326) | (5.040) | (0.063) |
| Post times wage gap times negative shock | −0.076** | −0.052 | −25.702 | −23.680*** | −16.235** | −0.284 |
| | (0.032) | (0.033) | (21.572) | (5.896) | (5.560) | (0.312) |
| Post times wage gap times positive shock | 0.099** | 0.077** | 14.209 | 22.659*** | 15.175*** | −0.116 |
| | (0.042) | (0.029) | (13.769) | (6.874) | (4.266) | (0.094) |
| **Linear combinations (p-value)** | | | | | | |
| Negative | 0.046 | 0.124 | 0.572 | 0.015 | 0.026 | 0.702 |
| Positive | 0.001 | 0.002 | 0.074 | 0.000 | 0.000 | 0.003 |
| Negative=Positive | 0.000 | 0.001 | 0.143 | 0.000 | 0.000 | 0.598 |
| Observations | 155,780 | 247,657 | 28,818 | 155,780 | 247,657 | 20,931 |

*Notes:* Standard errors are in parentheses and are clustered at the district council and the survey wave level. District-level and survey-year-leave fixed effects are included in all specifications. Individual-level controls include age, age squared, education, and education squared. Columns (1) and (4) include only individuals in the labour force. Columns (2) and (5) include all adults. Column (3) includes only adults in the agricultural sector. Column (6) includes only adults in the agricultural wage sector. A negative shock is defined as rainfall below the 20th percentile of the historical distribution for a given district, while a positive shock is defined as rainfall above the 80th percentile.

* p<0.1 ** p<0.05 *** p<0.01

agricultural wage employment. The effect is quite substantial relative to mean hours worked. In the sample in column (5), the overall mean is slightly less than 20 hours. Going from the 25th to the 75th percentile of the wage exposure variable leads to a decrease in hours worked of around 4.6 hours, or approximately 23 percent relative to the mean. For positive shocks, on the other hand, the increase is almost 60 percent of the overall mean across waves.

These effects on both the intensive and extensive margins are in opposite directions for negative and positive effects across the first five columns. Additionally, these coefficients are significantly different from one another in all columns except column three. We do not see any effects on wages – though we lack precision – but we see large effects on employment, indicating changes in how the labour market responds to rainfall shocks after the imposition of the minimum wage.

Treatment happens everywhere at the same time, which lessens concerns related to some of the recent literature on two-way fixed effects and bias (Callaway and Sant'Anna, 2021; De Chaisemartin and d'Haultfoeuille, 2020; Goodman-Bacon, 2021). Nonetheless, one way to check robustness to possible issues is to remove fixed effects entirely. Table A7 in the appendix presents these results. Conclusions are identical to the main results presented here.

A final set of results on heterogeneity is in Table A8 of the appendix. We split the sample based on education, defining a "low education" variable if someone has six or fewer years of education. This is around the end of the "intermediate" phase of education in South Africa and this variable equals one for around 31 percent of our sample. The results include all adults – since education might also affect the probability of being in the labour force – and show that the effects are larger in magnitude for those with lower levels of education; in other words, the cyclicality of employment and hours increased more for those with lower levels of education than those with higher levels of education. This is true despite the fact that changes in normal years were relatively similar across the two groups. These results also indicate that differences in education across districts are not the cause of labour market changes.

Table A6 in the appendix shows that wages vary with agricultural shocks in the expected directions prior to the minimum wage law. The coefficients are consistent with wages decreasing more in places with a larger wage gap during negative shocks (relative to normal years) and increasing during positive shocks, but we lack power to say much due to the shorter time period. Employment, on the other hand, does not vary with rainfall shocks, again indicating a change in how the labour market adjusts when wages are not able to move. Overall, these results also suggest that districts with very different wage gaps prior to the minimum wage change do not have a higher latent sensitivity to shocks, at least not in such a way that it would lead to the main results we present here.

Finally, it could also be that people are sorting into different sectors in response to agricultural productivity shocks. If people lose employment in agriculture but turn around and gain employment in non-agricultural sectors, the overall effects of the minimum wage could be muted. We focus just on total hours worked and overall employment. We present these results in Table 5. Columns (1) and (2) include overall employment while columns (3) and (4) include total (monthly) hours of employment, with the sample restricted to those in the labour force in the first column of each pair.

We do not see differences on either the intensive or extensive margins when looking only at men in the labour force, but we see large differences in outcomes when looking at all male adults. Following the minimum wage, total employment in all sectors decreases more following negative rainfall shocks and increases more following positive rainfall shocks. Moreover, these differences are significant. We see the exact same pattern with hours worked, which leads us to the same conclusion regarding changes in labour market adjustment.

Table 5: Effects on total employment and hours

| | Employment | | Hours | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| | In LF | All adults | In LF | All adults |
| Post times wage gap | −0.028 | −0.022 | 6.145 | −0.231 |
| | (0.020) | (0.046) | (8.813) | (9.557) |
| Post times wage gap | 0.049 | −0.065 | −7.256 | −14.396 |
| times negative shock | (0.054) | (0.062) | (12.058) | (12.223) |
| Post times wage gap | −0.033 | 0.091** | 9.171 | 14.213** |
| times positive shock | (0.043) | (0.039) | (10.782) | (5.759) |
| **F-test (linear combination)** | | | | |
| Negative | 0.716 | 0.031 | 0.920 | 0.033 |
| Positive | 0.196 | 0.035 | 0.054 | 0.051 |
| Negative=Positive | 0.299 | 0.003 | 0.256 | 0.014 |
| Observations | 155.780 | 247.657 | 155.813 | 247.657 |

*Notes:* Standard errors are in parentheses and are clustered at the district council and the survey wave level. District-level and survey-year-leave fixed effects are included in all specifications. Individual-level controls include age, age squared, education, and education squared. Columns (1) and (3) include only individuals in the labour force. Columns (2) and (4) include all adults. A negative shock is defined as rainfall below the 20th percentile of the historical distribution for a given district, while a positive shock is defined as rainfall above the 80th percentile.
* p<0.1 ** p<0.05 *** p<0.01

# 6 Conclusion

In this paper, we analyse the effects of a new minimum wage law in the agricultural sector in South Africa. We find that the law led to large wage increases and even an increase in hours worked for some subsets of the population engaged in agriculture. Total agricultural income likewise increased in response to the new law. Overall, the initial results of the law paint an optimistic picture of the welfare effects of the minimum wage in this context, with marginal increases in employment and large increases in wages and income.

However, we document important heterogeneity in the effects of the minimum wage based on the state of agricultural productivity. While we see increases in wages and employment during normal years, we see reductions in total employment during poor rainfall years, with positive agricultural productivity shocks seeing the opposite effects. In effect, while the minimum wage increased the mean, it also increased the variance.

Importantly, South African men do not seem to be able to reallocate to the non-agricultural sector during these negative shocks nor does their income in agricultural self-employment increase.

Our results suggest caution in interpreting the effects of minimum wage interventions on mean labour market outcomes alone, especially when transitory shocks mean minimum wages may be more or less binding across years. This may be particularly true in developing countries, where large-scale employment shocks are rather common, especially in places where agricultural employment predominates, and the larger effects for those with lower levels of education underline this possibility. We encourage future research to continue focusing on the effects of restrictive labour market policies on higher moments of the employment and wage distribution.

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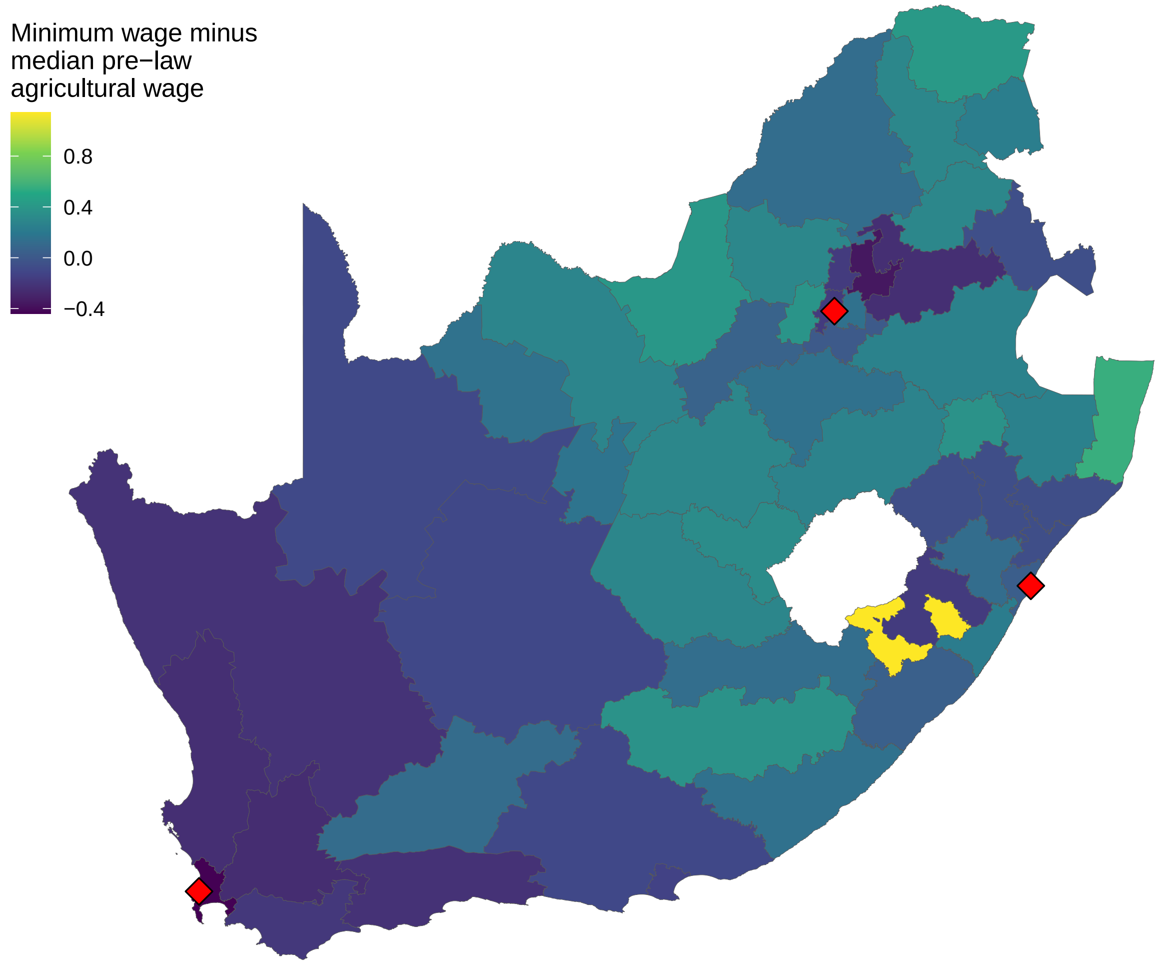
# Appendix

Figure A1: Pre-law wage gaps across district councils




*Notes:* The three points are the three largest cities in South Africa: Johannesburg to the north – very close to the administrative capital, Pretoria, which is not shown on the map – Cape Town to the southwest, and Durban to the southeast. The wage gap is defined as the difference between the mandated minimum wage (log ZAR) and the median pre-law wage (log ZAR) in each district council, such that higher values indicate areas with lower wages.

Table A1: Summary statistics

| | Low-wage areas | High-wage areas |
|---|---|---|
| | (1) | (2) |
| | mean | mean |
| | (sd) | (sd) |
| Ag worker (in LF only) | 0.127 | 0.160 |
| | (0.333) | (0.366) |
| Ag worker (all adults) | 0.068 | 0.093 |
| | (0.251) | (0.290) |
| Ag hours (in LF only) | 183.625 | 193.477 |
| | (86.946) | (71.923) |
| Ag hours (all adults) | 11.538 | 17.150 |
| | (49.604) | (59.013) |
| Ag wage (working only) | 1.622 | 1.986 |
| | (0.730) | (0.660) |
| Age | 3.492 | 3.508 |
| | (1.294) | (1.288) |
| Education (years) | 7.847 | 8.013 |
| | (3.951) | (3.951) |
| Low rainfall year | 0.234 | 0.218 |
| | (0.423) | (0.413) |
| High rainfall year | 0.213 | 0.230 |
| | (0.410) | (0.421) |
| Observations | 313,569 | 325,962 |

*Notes:* "Low-wage" areas are defined as areas with a wage gap higher than the median value in our sample. The "in LF" variables are defined only for adults who are in the labour force, while the "all adults" variables include all adults, regardless of labour force status.
* p<0.1 ** p<0.05 *** p<0.01

Table A2: Effects of the minimum wage on agricultural employment, no fixed effects

| | Employment | | Hours | | Wage/Income | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | In LF | All adults | Working | All adults | Wage | Income |
| Post times wage gap | 0.027** | 0.016* | 13.994** | 6.317** | 0.361*** | 0.376*** |
| | (0.010) | (0.008) | (4.958) | (2.090) | (0.034) | (0.039) |
| Age (10s) | −0.112*** | 0.079*** | 47.129*** | 21.110*** | 0.453*** | 0.440*** |
| | (0.029) | (0.016) | (10.074) | (2.970) | (0.052) | (0.047) |
| Age (10s) squared | 0.014*** | −0.010*** | −6.317*** | −2.767*** | −0.047*** | −0.047*** |
| | (0.004) | (0.002) | (1.235) | (0.409) | (0.006) | (0.006) |
| Education (years) | −0.036*** | −0.019*** | −1.903** | −4.372*** | −0.007 | −0.006 |
| | (0.003) | (0.002) | (0.713) | (0.553) | (0.008) | (0.007) |
| Education squared | 0.001*** | 0.000 | −0.005 | 0.070* | 0.004*** | 0.003*** |
| | (0.000) | (0.000) | (0.050) | (0.032) | (0.001) | (0.001) |
| Observations | 155,780 | 247,657 | 28,818 | 247,657 | 20,931 | 20,744 |

*Notes:* Standard errors are in parentheses and are clustered at the district council and the survey wave level. No fixed effects are included in the regressions. Individual-level controls include age, age squared, education, and education squared. Column (1) includes only individual in the labour force. Columns (2) and (4) include all adults. Column (3) includes only individuals in the agricultural sector. Columns (5) and (6) include only individuals in the agricultural wage sector.
* p<0.1 ** p<0.05 *** p<0.01

Table A3: Effects of the minimum wage on agricultural employment, all waves

| | Employment | | Hours | | Wage/Income | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | In LF | All adults | Working | All adults | Wage | Income |
| Post times wage gap | 0.021 | 0.017 | 20.199*** | 6.979* | 0.325*** | 0.331*** |
| | (0.023) | (0.018) | (5.832) | (3.973) | (0.056) | (0.054) |
| Age (10s) | −0.098*** | 0.083*** | 34.215*** | 21.233*** | 0.468*** | 0.429*** |
| | (0.025) | (0.013) | (6.159) | (2.733) | (0.052) | (0.040) |
| Age (10s) squared | 0.013*** | −0.010*** | −4.518*** | −2.739*** | −0.049*** | −0.046*** |
| | (0.003) | (0.002) | (0.742) | (0.379) | (0.006) | (0.005) |
| Education (years) | −0.034*** | −0.020*** | −0.925** | −4.563*** | −0.007 | −0.002 |
| | (0.002) | (0.002) | (0.373) | (0.492) | (0.006) | (0.005) |
| Education squared | 0.001*** | 0.000** | −0.112* | 0.086** | 0.004*** | 0.003*** |
| | (0.000) | (0.000) | (0.054) | (0.030) | (0.001) | (0.000) |
| Observations | 183,829 | 289,223 | 34,461 | 289,223 | 24,743 | 24,504 |

*Notes:* Standard errors are in parentheses and are clustered at the district council and the survey wave level. District-level and survey-year-leave fixed effects are included in all specifications. Individual-level controls include age, age squared, education, and education squared. Column (1) includes only individual in the labour force. Columns (2) and (4) include all adults. Column (3) includes only individuals in the agricultural sector. Columns (5) and (6) include only individuals in the agricultural wage sector.
* p<0.1 ** p<0.05 *** p<0.01

Table A4: Effects of the minimum wage on full-time agricultural employment

| | (1)<br>All adults | (2)<br>Working only |
|---|---|---|
| Post times wage gap | 0.005 | 0.072** |
| | (0.005) | (0.027) |
| Age (10s) | 0.009** | 0.176*** |
| | (0.003) | (0.034) |
| Age (10s) squared | −0.002*** | −0.023*** |
| | (0.000) | (0.004) |
| Education (years) | 0.001*** | −0.002 |
| | (0.000) | (0.002) |
| Education squared | 0.000 | 0.000** |
| | (0.000) | (0.000) |
| Observations | 247,657 | 28,818 |

*Notes:* Standard errors are in parentheses and are clustered at the district council and the survey wave level. District-level and survey-year-leave fixed effects are included in all specifications. Individual-level controls include age, age squared, education, and education squared. Column (1) includes only individual in the labour force. Columns (2) and (4) include all adults. Column (3) includes only individuals in the agricultural sector. Columns (5) and (6) include only individuals in the agricultural wage sector.
* p<0.1 ** p<0.05 *** p<0.01

Table A5: Effects of rainfall shocks, pre-minimum wage

| | Employment | | Hours | | | Wage |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | In LF | All adults | Working | In LF | All adults | |
| Wage gap times negative shock | −0.025 | −0.023 | 14.402 | −0.596 | −1.906 | −0.125 |
| | (0.040) | (0.027) | (15.816) | (7.500) | (5.200) | (0.165) |
| Wage gap times positive shock | −0.027 | −0.023 | −19.678 | −9.497** | −6.221*** | 0.171 |
| | (0.022) | (0.017) | (16.649) | (3.284) | (1.615) | (0.104) |
| **F-test** | | | | | | |
| Negative=Positive | 0.933 | 0.970 | 0.173 | 0.307 | 0.397 | 0.159 |
| Observations | 73,737 | 111,755 | 14,296 | 73,737 | 111,755 | 10,202 |

*Notes:* Standard errors are in parentheses and are clustered at the district council and the survey wave level. District-level and survey-year-leave fixed effects are included in all specifications. Individual-level controls include age, age squared, education, and education squared. Columns (1) and (4) include only individuals in the labour force. Columns (2) and (5) include all adults. Column (3) includes only individuals in the agricultural sector. Column (6) include only individuals in the agricultural wage sector.
* p<0.1 ** p<0.05 *** p<0.01

Table A6: Effects of rainfall shocks on employment outcomes, pre-minimum wage

| | (1)<br>Employment | (2)<br>Wage |
|---|---|---|
| Negative shock times wage gap | −0.025 | −0.125 |
| | (0.040) | (0.165) |
| Positive shock times wage gap | −0.027 | 0.171 |
| | (0.022) | (0.104) |
| **F-test** | | |
| Negative = positive | 0.933 | 0.159 |
| Observations | 73,737 | 10,202 |

*Notes:* Standard errors are in parentheses and are clustered at the district council and the survey wave level. District-level and survey-year-leave fixed effects are included in all specifications. Individual-level controls include age, age squared, education, and education squared. The sample is restricted to waves before the implementation of the minimum wage. The dependent variable in both columns is hourly (agricultural) wage.

* p<0.1 ** p<0.05 *** p<0.01

Table A7: Effects of rainfall shocks, no fixed effects

| | Employment | | Hours | | | Wage |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | In LF | All adults | Working | In LF | All adults | |
| Post times wage gap | 0.039 | 0.016 | 12.134* | 12.396* | 6.242 | 0.439*** |
| | (0.025) | (0.015) | (6.088) | (5.876) | (3.685) | (0.048) |
| Post times wage gap times negative shock | −0.211*** | −0.106** | −35.917 | −51.704*** | −27.127*** | −0.477** |
| | (0.066) | (0.039) | (22.677) | (13.773) | (7.609) | (0.213) |
| Post times wage gap times positive shock | 0.087 | 0.072 | 12.968 | 21.086 | 14.662* | −0.283* |
| | (0.067) | (0.041) | (23.051) | (12.776) | (8.182) | (0.140) |
| **Linear combinations (p-value)** | | | | | | |
| Negative | 0.004 | 0.007 | 0.262 | 0.001 | 0.001 | 0.862 |
| Positive | 0.036 | 0.034 | 0.238 | 0.004 | 0.014 | 0.259 |
| Negative=Positive | 0.000 | 0.000 | 0.033 | 0.000 | 0.000 | 0.436 |
| Observations | 155,780 | 247,657 | 28,818 | 155,780 | 247,657 | 20,931 |

*Notes:* Standard errors are in parentheses and are clustered at the district council and the survey wave level. No fixed effects are included in the regressions. Individual-level controls include age, age squared, education, and education squared. Columns (1) and (4) include only individuals in the labour force. Columns (2) and (5) include all adults. Column (3) includes only adults in the agricultural sector. Column (6) includes only adults in the agricultural wage sector. A negative shock is defined as rainfall below the 20th percentile of the historical distribution for a given district, while a positive shock is defined as rainfall above the 80th percentile.
* $p<0.1$ ** $p<0.05$ *** $p<0.01$

Table A8: Effects of rainfall shocks by education

| | Low education | | High education | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| | Emp. | Hours | Emp. | Hours |
| Post times wage gap | 0.036 | 9.369 | 0.010 | 6.171 |
| | (0.036) | (8.553) | (0.021) | (4.218) |
| Post times wage gap times negative shock | −0.089* | −23.771* | −0.027 | −11.351* |
| | (0.047) | (11.033) | (0.031) | (5.511) |
| Post times wage gap times positive shock | 0.116* | 24.379** | 0.062*** | 11.250*** |
| | (0.053) | (8.703) | (0.014) | (2.955) |
| **Linear combinations (p-value)** | | | | |
| Negative | 0.159 | 0.133 | 0.385 | 0.137 |
| Positive | 0.005 | 0.000 | 0.001 | 0.002 |
| Negative=Positive | 0.003 | 0.001 | 0.002 | 0.004 |
| Observations | 73,353 | 73,353 | 174,304 | 174,304 |

*Notes:* Standard errors are in parentheses and are clustered at the district council and the survey wave level. No fixed effects are included in the regressions. Individual-level controls include age, age squared, education, and education squared. Low education is defined as having six or fewer years of education; this group comprises around 31 comprises of our sample. Columns (1) and (4) include only individuals in the labour force. Columns (2) and (5) include all adults. Column (3) includes only adults in the agricultural sector. Column (6) includes only adults in the agricultural wage sector. A negative shock is defined as rainfall below the 20th percentile of the historical distribution for a given district, while a positive shock is defined as rainfall above the 80th percentile.

* p<0.1 ** p<0.05 *** p<0.01