



# Implementing a regression discontinuity design to explore the heterogeneous effects of obesity on labour income: the case of Mexico

Pierre Levasseur<sup>1,2</sup>

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## Abstract

**Objective** This study aims to explore within-country heterogeneity in the causal relationship between body mass and labour income. We focus on Mexico, which is an emerging country where overweight is predominant and hunger has become marginal.

**Subjects and methods** Based on the working-age population from the Mexican Family Life Survey (2002–2012), we use a regression discontinuity design to test for significant discontinuities along the body mass-income relationship. More specifically, we investigate the presence of income gaps along the body mass distribution.

**Results** Our findings suggest that the overweight status is not particularly penalised in the Mexican labour market. By contrast, the obesity status decreases hourly wages by about 15%. Regarding heterogeneity, obesity-related wage penalties are stronger for female than male employees and higher in service employments, urban areas and the latest survey.

**Conclusion** We conclude on a co-occurrence of pro- and anti-fat social norms in emerging countries. Our results might be generalised to other middle-income economies with similar nutritional patterns where hunger is marginal and overweight predominant.

**Keywords** Mexico · Emerging countries · Labour income · Obesity · Regression discontinuity design

**JEL classification** O1 · J3 · I1

## Introduction

In the last decades, the number of overweight people has rapidly increased worldwide. This fact led some authors to assess

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**Key points** Overweight status is not particularly penalised in the Mexican labour market.

Obesity status decreases hourly wages by about 15%.

Obesity-related wage penalties are stronger for female than male employees and higher in service employments, urban areas and the latest survey.

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✉ Pierre Levasseur  
pierre.levasseur@u-bordeaux.fr

<sup>1</sup> GREThA, Université de Bordeaux, 16 Avenue Léon Duguit, 33608 Pessac Cedex, France

<sup>2</sup> Departamento de Economía Aplicada, Universidad de Granada, Granada, Spain

the repercussion of body mass on unemployment and earning penalties, given that the labour market is a key sector of economic performance and an important dimension of social well-being. The existing literature suggests that the impacts of bodyweight on professional success depend on the development level of the country concerned. Globally, the overweight status negatively affects employment and earnings in rich economies, while excess weight still leads to high social positions in the poorest and traditional societies. However, this issue appears to be ambiguous in the case of middle-income countries. Given the high standard deviation of the body mass index (BMI)<sup>1</sup> in emerging economies, the latest findings suppose a non-linear causal relationship between weight and labour market outcomes.

An empirical analysis implemented in China shows that the impact of the BMI on wages is characterised by a U-inverted

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<sup>1</sup> BMI = [weight(kg)/height(m)<sup>2</sup>]. The World Health Organisation classifies the BMI for an adult as follows (WHO 2000): underweight (<18.5 kg/m<sup>2</sup>); normal weight (18.5–25 kg/m<sup>2</sup>); overweight (25–30 kg/m<sup>2</sup>); obesity (>30 kg/m<sup>2</sup>).

form: normal-weight workers earn significantly more than their thinner and fatter counterparts (Shimokawa 2008). The author attributes this result to the coexistence of hunger and overweight in China (the normal-weight status being the physical and social norm). Focusing on the effect of the BMI on employment in China, Pan et al. (2013) observe the same U-inverted shape: normal-weight adults have a higher probability of working (particularly in a good quality job) compared with their underweight and overweight peers. In Mexico, another middle-income country, Lévassieur (2017, *MPRA paper*) finds relatively similar findings. Nonetheless, the functional form of the tested relationship slightly differs from the Chinese case. In Mexico, the overweight status leads to better wages than the normal-weight and obesity statuses. In other words, the causal relationship between body mass and earnings takes a right-leaning U-inverted form. The author considers that this finding is mainly due to the specific BMI distribution that characterises the Mexican society. As the overweight status is the physical norm in Mexico (two-thirds and one-third of adults are overweight and obese, respectively), it is likely that this BMI category becomes the social norm too.

Since different BMI distributions among middle-income countries lead to different impacts of weight on professional success, one can also assume that the effect of BMI on labour market outcomes is heterogeneous within a given society. Indeed, this effect may depend on various characteristics such as gender, type of occupation, living area or observation time. The present article aims to explore this heterogeneity that may occur within a middle-income country. We focus on Mexico: an emerging economy where hunger is marginal and overweight is predominant, like in many middle-income countries located in South America, North Africa, the Middle East and South Africa. Using panel data from the Mexican Family Life Survey (MxFLS, 2002–2012), we implement an original approach based on a regression discontinuity design (RDD) to test for discontinuities in the weight-related earning penalties. A similar identification strategy is used by Card et al. (2008). The underlying idea of using an RDD is to assess the local income gap (discontinuity) between different BMI cut-offs. Around each cut-off, the continuity of the BMI guarantees a quasi-random distribution of the workers located just to the left and just to the right of this cut-off. In other words, as randomised studies, an RDD offers the opportunity to overcome estimation problems induced by the presence of unobservable heterogeneity that simultaneously affects BMI and labour outcomes, such as socio-cognitive abilities or other individual characteristics. We find that the BMI cut-off that leads to a significant wage gap is 30 kg/m<sup>2</sup>. Surprisingly, this tipping point corresponds to the official clinical classification of the obesity status.

The rest of the article is organised as follows: Section 2 presents the original methodology used to explore the heterogeneous effects of BMI on labour income; Sect. 3 describes

the results; Sect. 4 discusses the main findings and limitations before the conclusion.

## Methods

### Conceptual framework

In line with Cawley (2004), we consider two fundamental pathways through which obesity may affect labour outcomes such as wages: *productivity loss* and *social stigmatisation*. As pointed out by Poulain (2017), this dual approach makes it possible to distinguish medical factors that are space- and time-invariant (diseases, physical incapacities) from social factors that are subject to perpetual change (social stigmatisation). The local sociocultural specificities, denoted by  $S$ , are supposed to determine how weight is perceived and stigmatised in a given society at a given time. Therefore, we adopt the following conceptual framework, where the impact of obesity on labour outputs is a linear function of the *productivity loss* and the *social stigmatisation*:

$$\text{Labour Outcomes}_S = F(\text{productivity}; \text{stigmatisation}_S)$$

The effect of the *productivity loss* pathway on professional success does not depend on sociocultural aspects ( $S$ ) and is always supposed to be negative. There is no doubt that the *productivity loss* due to obesity-related health problems leads to worse labour outputs, through absenteeism at work and presenteeism (i.e. loss of productivity during the working day). In addition to being related to poor physical abilities, the overweight and obesity statuses are related to various non-transmissible diseases (diabetes, heart coronary attacks, cancers, etc.) as well as chronic fatigue syndrome (sleeping apnoea, inefficient brain oxygenation), which limit the worker's attendance and concentration.

By contrast, the effect of *weight stigmatisation* on labour outcomes is ambiguous, since it depends on the system of values in place ( $S$ ). In societies where obesity is a major health problem and hunger has completely disappeared, such as in Western countries, excess weight generally is discriminated against and penalised at work. Several authors emphasise the negative causal relationship between BMI and professional success that characterises the richest economies (Cawley 2004; Caliendo and Gehrsitz 2016; Pinkston 2017). Note that the weight-related penalties are generally stronger for women, probably because of the high pressure on the female body in western societies. Moreover, Cawley (2004) argues that Caucasian women are more subject to self-discrimination than men. Indeed, psychological studies show that women generally have lower self-confidence and self-esteem compared with men in Western countries (Bleidorn et al. 2016). Reversely, in sociocultural environments where hunger

prevails, as in the poorest and traditional societies, excess weight is well perceived and rewarded. In other words, concerning the most vulnerable populations, the preference for overweight more than offsets the productivity loss induced by this nutritional status. This is, for example, the case in sub-Saharan African countries (Glick and Sahn 1998; Schultz 2003).

It is worth noting that the role of weight discrimination in employment and labour income is unclear in sociocultural environments (*S*) where obesity is constantly rising and poverty persists, such as in emerging countries. In this particular context, Lvasseur (2017, *MPRA paper*) describes three concomitant phenomena that are potentially occurring in middle-income economies with a high obesity prevalence. First, cultural factors may still influence weight perception. In the poorest economies, for instance, a moderate excess weight would be viewed as a sign of health and strength and be rewarded because of past nutritional deprivations (Guendelman et al. 2011). Cawley (2004) and Slade (2017) reach similar conclusions concerning African Americans in the USA. These authors find a positive effect of BMI on wages among male African American workers, which is particularly strong in manual jobs. Second, given the large spread of Western lifestyles through the globalisation process since the 1980s, Brewis et al. (2011) describe a progressive adoption of thinness ideals in developing countries. Huang et al. (2016) make analogous conclusions observing that overweight-related wage penalties increase over time in China, particularly for women. Hence, one can assume that the positive appreciation of obesity (which characterises or characterised developing countries) may disappear in a long-term perspective, given the worldwide convergence of beauty standards. In other words, the causal relationship between body mass and labour outcomes gradually changes from positive to negative during this process of sociocultural homogenisation. This phenomenon can explain why the relationship is quadratic (U-inverted) in emerging economies (Shimokawa 2008; Pan et al. 2013). This U-inverted curve symbolises the transition from a system of values where overweight is preferred in the labour market to a situation where thinness is sought and leads to professional success. Finally, a third phenomenon reveals a contemporary change in weight perception and stigmatisation due to the recent generalisation of overweight and obesity in several rich and emerging countries (Classen 2017).<sup>2</sup> In this case, the social environment would progressively become more tolerant concerning overweight given the increasing number of individuals with this nutritional status.

<sup>2</sup> For example, in the US, Robinson and Christiansen (2014) observe a social acceptance process for obesity in areas where overweight has become the physical norm. It is likely that this process is also occurring in emerging countries where overweight and obesity rates have reached the same level as in the US.

In the Mexican context, Lvasseur (2017, *MPRA paper*) assumes that overweight is socially accepted (phenomena 1 and 3), but only up to a certain BMI threshold. Indeed, excessive weight may increase the risk of social stigmatisation due to the progressive integration of Western stereotypes of beauty (phenomenon 2). According to this author, phenomenon 3 is particularly important in Mexico because it explains why the causal relationship between BMI and hourly income takes a right-leaning U-inverted form in Mexico: the turning point being close to the obesity status [and not at the level of normal weight as Shimokawa (2008) observed in China].

In the present article, we contribute to the existing literature by introducing the concept of weight perception heterogeneity within a given society. Indeed, it is likely that each phenomenon is not homogeneously distributed in Mexico considering the high levels of socioeconomic inequality and ethnic diversity that characterise this country. As described by Bourdieu (1986), each socio-professional category would be influenced by a specific class culture (related to consumption habits, tastes and lifestyles). Therefore, one can suppose that each socio-professional group is associated with a specific sociocultural environment (*S*) and differs from other groups in terms of weight perception. Furthermore, the process of acculturation may also contribute to diversifying the weight perception within Mexican society. Several authors show that high social groups are particularly sensitive to Western middle class lifestyles, including healthier nutritional behaviours (Hazuda et al. 1988). Consequently, we speculate that the highest social categories tend to incorporate Western norms related to weight perception, whereas overweight remains socially acceptable (or preferable) in lower/traditional social groups. If this assumption is verified, overweight would still be seen as a sign of strength and good health in modest socio-professional structures where low-skilled manual occupations prevail (phenomenon 1), while obesity would be penalised in “Westernised” socio-professional structures (phenomenon 2), especially in activities that require social skills and an attractive appearance (Johar and Katayama 2012).

## Data and sample restrictions

The data used in this study come from the *Mexican Family Life Survey* (MxFLS), the first survey with a representative sample of the Mexican population at the national, rural-urban and regional levels. Sampling directives were drawn up by the Mexican Institute of Statistics. The survey covers a 10-year period with three distinct waves. The first wave was carried out in 2002 with 35,677 individuals surveyed in 8440 households (living in 150 municipalities across 16 Mexican states). Given the longitudinal dimension of the survey, the second (2005–06) and third (2009–12) waves are based on the initial sample from 2002. For both waves, the follow-up rate of the initial sample exceeds 90% at the household level.

MxFLS data include detailed information on socioeconomic characteristics of households and individuals. Moreover, anthropometric data were collected for all household members directly at their home by trained staff from the Mexican Institute of Public Health. Weight was measured with a set of digital scales (accuracy of 0.1 kg) and height with a stadiometer (accuracy of 0.5 cm).

We restrict the sample to comply with the objective of the study. First, pregnant and lactating women were withdrawn from the sample to limit anthropometric biases. Second, in line with the labour economics literature, we analyse only the Mexican working-age population from 15 to 65 years old (Gong et al. 2004). Third, we mainly focus on the hourly earnings gap between workers. The advantage of this labour output is to capture aspects that other indicators (e.g. employment probability) cannot identify. The study is restricted to employees and self-employed workers, who represent 44.5% and 12.5% of the working-age population in Mexico, respectively (Table A.1 of the Appendix).<sup>3</sup> Employers are excluded because of the few observations available in this category (only 3% of the working-age population). Self-employed workers and employees are analysed individually as the former group receives profits and the latter receives salaries. Moreover, in theory, the sources of discrimination differ between both work statuses. While obese employees are generally stigmatised by their employer and/or colleagues, self-employed workers can only be discriminated by clients. We should note that all obese workers (employees, self-employed, and employers), in particular women, are potentially sensitive to what Cawley (2004) refers to as self-discrimination.

As mentioned above, two main samples of workers are analysed: employees and self-employed workers. To better explore the potential presence of weight perception heterogeneity within the Mexican society, and more particularly in the employee sample, we distinguish different aspects.<sup>4</sup> First, we produce gender-specific (male and female employees), area-specific (rural and urban employees) and time-specific analyses. Second, given the obvious presence of employment heterogeneity, we identify three groups of occupation in Fig. 1. This figure illustrates the distribution of employees according to the type of occupation and nutritional status.<sup>5</sup>

Group A brings together manual workers from the primary and secondary sectors (technicians, agricultural and blue

collar employees, machine operators and production assistants). Note that such occupations are associated with relatively low BMI. This is not surprising considering that these jobs are extremely physical. In theory, obesity may lead to wage gaps in manual jobs through both of the transmission pathways discussed earlier: *productivity loss* and *social stigmatisation*.

Group B is characterised by occupations in the service sector, which generally require social skills and an attractive appearance (entertainment workers, administrative assistants, sellers and service workers). Employees of this group are also relatively thin in terms of BMI. In the US context, Johar and Katayama (2012) show that obesity is highly stigmatised in this type of occupation. Thus, it seems relevant to test whether their results are confirmed in the Mexican case.

Group C contains high-skilled employees (*profesionistas*,<sup>6</sup> education workers, senior public servants and directors in the public and private sectors, heads, coordinators and supervisors in the service sector, foremen). Figure 1 shows that overweight and obese individuals predominantly occupy these types of jobs. In this group, the hypothesis that weight significantly affects hourly earnings is unrealistic for two main reasons. On the one hand, high-skilled workers do not appear sensitive to the *productivity loss* pathway (often sedentary tasks). On the other hand, high-skilled workers are not likely to be threatened by the *social stigmatisation* pathway because they occupy decision-making positions. By contrast, the presence of a reverse causality is much more plausible. Indeed, Levasseur (2015) concludes that the sedentary and stressful nature of high-skilled positions tends to increase the risk of general and central adiposity.

## An RDD

The RDD aims to compare individuals just below (control group) and above (treatment group) a cut-off based on a continuous variable. In practice, this method is mainly used in economics to assess the impact of social programs when the treated population is selected from a continuous variable, such as a schooling test score or a multidimensional poverty score (Imbens and Lemieux 2008; Andalon 2011). In theory, the proximity of individuals around the cut-off guarantees a quasi-random distribution of both the treatment and control groups and makes it possible to establish a causal effect. In other words, observable and non-observable characteristics are assumed to be relatively similar, on average, between both treatment and control groups.

In the context of this study, an original RDD strategy is implemented. Instead of selecting treated and control individuals according to program participation, we use the nutritional

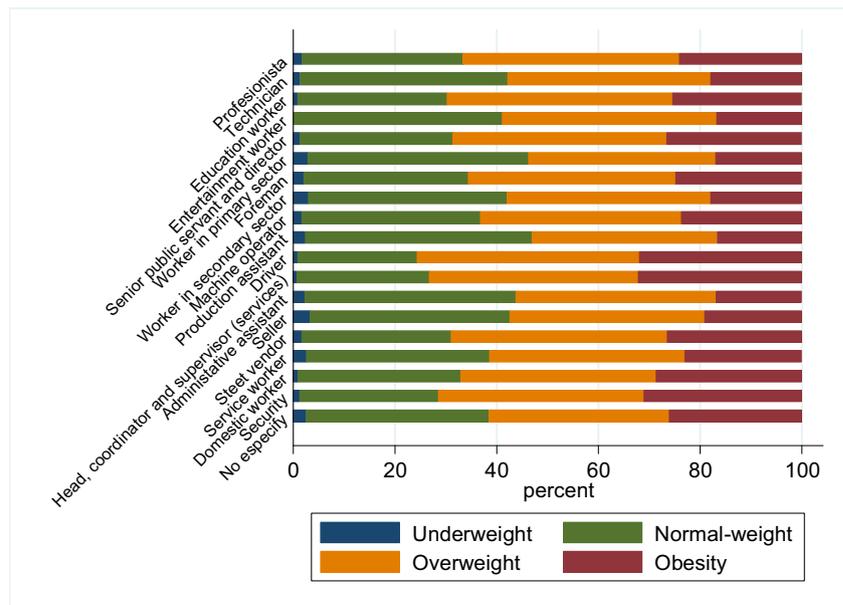
<sup>3</sup> The MxFLS reports five work statuses in Mexican cities: (1) inactive and unemployed people; (2) unpaid workers; (3) employees; (4) self-employed workers; (5) employers.

<sup>4</sup> Given the relatively low proportion of self-employed workers in the Mexican labour force, the potential heterogeneity within this sample is not investigated.

<sup>5</sup> Apart from these three occupational groups, we also identify four outlier occupations in Fig. 1 that we cannot classify in any specific group (transport workers, street vendors, security workers and domestic workers). Despite their singularities, these outlier employees have one thing in common: high rates of overweight and obesity (probably due to the sedentary, monotonous and/or stressful nature of their occupation).

<sup>6</sup> This Spanish-speaking term refers to occupations that derive from academic and engineering studies.

**Fig. 1** Distribution of employees according to type of occupation and nutritional status



Source: MxFLS (2002-2012).

status (overweight and obesity) derived from the BMI as the treatment variable. Since the WHO’s classification of BMI is known and approved by the Mexican Official Norm for the Treatment of Overweight and Obesity,<sup>7</sup> the cut-offs between BMI categories are clearly identified. Hence, a *sharp* RDD can be executed.<sup>8</sup> Almond et al. (2016) produce interesting results using a similar *sharp* RDD. Using a child cohort, these authors estimate the effect of having been classified and reported as overweight on the current nutritional status. In our case, we assess the impact of BMI categories on labour income. First, we compare the average income of individuals narrowly classified as overweight with individuals narrowly classified as having a healthy BMI. Second, we compare the average income of individuals narrowly classified as obese with individuals narrowly classified as overweight. Note that estimates from an RDD measure local average treatment effects (LATE) around BMI official cut-offs. The LATE around each cut-off is not generalisable to the whole relationship, which connects nutritional status and labour income. For more information regarding the overall functional form of the relationship between BMI and earnings in Mexico, see Levasseur (2017, *MPRA paper*).

We measure the outcome variable using the individual income from the principal activity during a regular month and the individual number of working hours during a regular week

<sup>7</sup> Available online: [http://dof.gob.mx/nota\\_detalle.php?codigo=5154226&fecha=04/08/2010](http://dof.gob.mx/nota_detalle.php?codigo=5154226&fecha=04/08/2010). Note that we aggregate individuals initially classified as “underweight” into the “normal-weight” category because of the low proportion of underweight workers in Mexico. In our sample, only 2% of the labour force is underweight (Table A.1 of the Appendix).

<sup>8</sup> By contrast, a *fuzzy* RDD must be implemented when the cut-off between control and treatment groups is more ambiguous (Imbens and Lemieux 2008).

<sup>9</sup> Hourly income =  $\frac{\text{monthly income}}{\text{weekly working hours} \times 30,5}$ .

from this principal activity.<sup>9</sup> The hourly earnings are expressed in Mexican pesos using the year 2002 and the Centre-South region as the baseline to neutralise the inflation and price gaps between regions. Then, we drop hourly incomes below and above the 1st and 99th percentile from the sample to exclude extreme values. Finally, the hourly earning variable is log-transformed. Hence, only individuals with a log-hourly income between 0.6 and 5.1 are analysed (between 2 and 166 Mexican pesos).

### Estimation procedure

$T_{it}$ , the treatment variable (overweight or obese), is based on the BMI (continuous variable),  $B_{it}$ , of an individual  $i$  at period  $t$ . Note that on the right side of a given cut-off ( $C$ ),  $T_{it} = 1$ , and on the left side of this cut-off,  $T_{it} = 0$ .  $Y_{it}$  refers to the outcome variable (hourly income). The local average treatment effect (LATE) is estimated near the threshold  $C$ , when we restrict  $B_{it}$  to a bandwidth of size  $H$ :

$$LATE = \lim_{h \rightarrow C} E[\log Y_{it}(1) | B_{it} = H] - \lim_{C \rightarrow -h} E[\log Y_{it}(0) | B_{it} = H] \tag{1}$$

We can reformulate this as follows:

$$LATE = E[\log Y_{it}(1) - \log Y_{it}(0) | B_{it} = H] \tag{2}$$

Here LATE is the average effect of overweight or obesity around the threshold  $C$  (25 or 30 kg/m<sup>2</sup>) based on  $B_{it}$  (BMI) of an individual  $i$  at period  $t$ .<sup>10</sup> The bandwidth  $H$  is

<sup>10</sup> The relevance of both thresholds is tested using a placebo procedure. This test shows that 25 kg/m<sup>2</sup> and 30 kg/m<sup>2</sup> are the unique BMI cut-offs that lead to significant earning gaps for self-employed and salaried workers, respectively.

symmetrical on each side of the cut-off  $C$  ( $H = [-h; h]$ ).  $H$  guarantees a quasi-random distribution of treated ( $T_{it} = 1$ ) and untreated ( $T_{it} = 0$ ) groups because only individuals with a narrow BMI are compared. We test the sensitivity of results according to different bandwidth sizes  $H$  to determine the scope that maximises the number of observations (accuracy of estimates) and minimises the presence of heterogeneity between treated and untreated groups. We also implement placebo tests at different BMI cut-offs to check for the relevance of using official BMI cut-offs (overweight and obesity) in the Mexican context.

In practice, we include an interaction term between  $T_{it}$  and  $B_{it}$  to estimate consistent LATE even when the slopes of  $B_{it}$  vary across the cut-off  $C$ . Hence, the following OLS model is regressed:

$$\log Y_{it} = \beta_0 + \beta_1 T_{it} + \beta_2 (B_{it} = H) + \beta_3 T_{it} (B_{it} = H) + \varepsilon_{it} \quad (3)$$

Here  $\beta_1$  is the LATE,  $\beta_2$  is the slope of the relationship in the absence of treatment, and  $\beta_3$  is the coefficient of the interaction term between  $T_{it}$  and  $B_{it}$ . Note that the preferred specification is a first-order regression of Eq. [3] (linear) and does not include any control variables. However, alternative specifications, including higher-order terms of BMI (quadratic and cubic specifications) and/or a set of control variables, are also performed to test the robustness of the results.

Several individual determinants of labour income are included as control variables in the alternative specification: age, age square (a proxy of experience), gender, marital status (in a couple or not), years of schooling and cognitive skills score (measured using a mental test based on Raven matrices). We also incorporate a variable counting the number of children in the household to control for a worker's budgetary constraints. Then, we add variables that control for survey years and area differences: a score of infrastructural development of the municipality given by the highest authority available in the municipality (i.e. the president or the vice-president of the municipality),<sup>11</sup> the region (southeast or not) and the geographic area (rural area, small city, middle-sized city or large city).

### Additional robustness checks

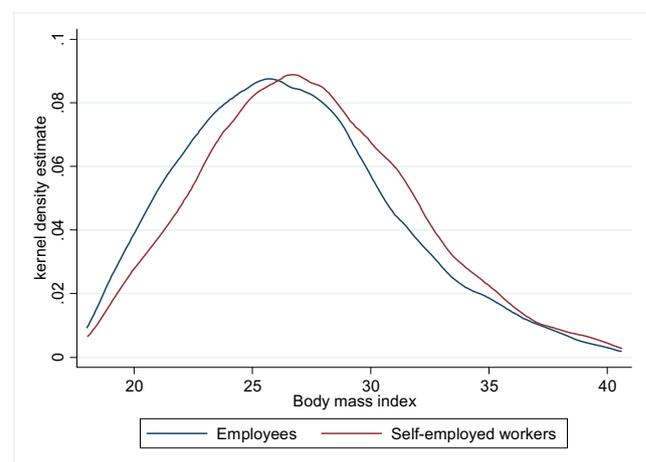
According to Moscoe et al. (2015), two main conditions must be tested and verified to establish a causal link between BMI categories and hourly income. First, the BMI variable must be continuous near the different thresholds (overweight, obesity). This condition is particularly important in the context of this

<sup>11</sup> The score varies from 0 to 6 from a low level to a high level of infrastructural development. It takes into account the presence (or absence) of public transportation, a health centre, a refuse collection service, a sewage system, a hydraulic system and hard roads in the municipality.

study insofar as the individual has some degree of control over his weight through diet and physical activity. The presence of weight manipulation is easily identifiable by a visual inspection of the BMI distribution. The presence of “bunching” on the left side of the cut-off (just before overweight or obesity statuses) would indicate that many individuals attempt to manipulate their weight. We check the potential presence of a manipulation bias using a histogram of the assignment variable (BMI). Second, treatment must be essentially randomly assigned around the cut-off. In other words, treated and untreated individuals on either side of the BMI categories must be comparable on the basis of observable and unobservable characteristics (excluding hourly income). This condition is only partially testable since some characteristics are not observable. Nevertheless, the independence of treated and untreated groups according to a comprehensive set of observed factors would be a good signal. Hence, we report covariate (control variables) balance tests between both groups.

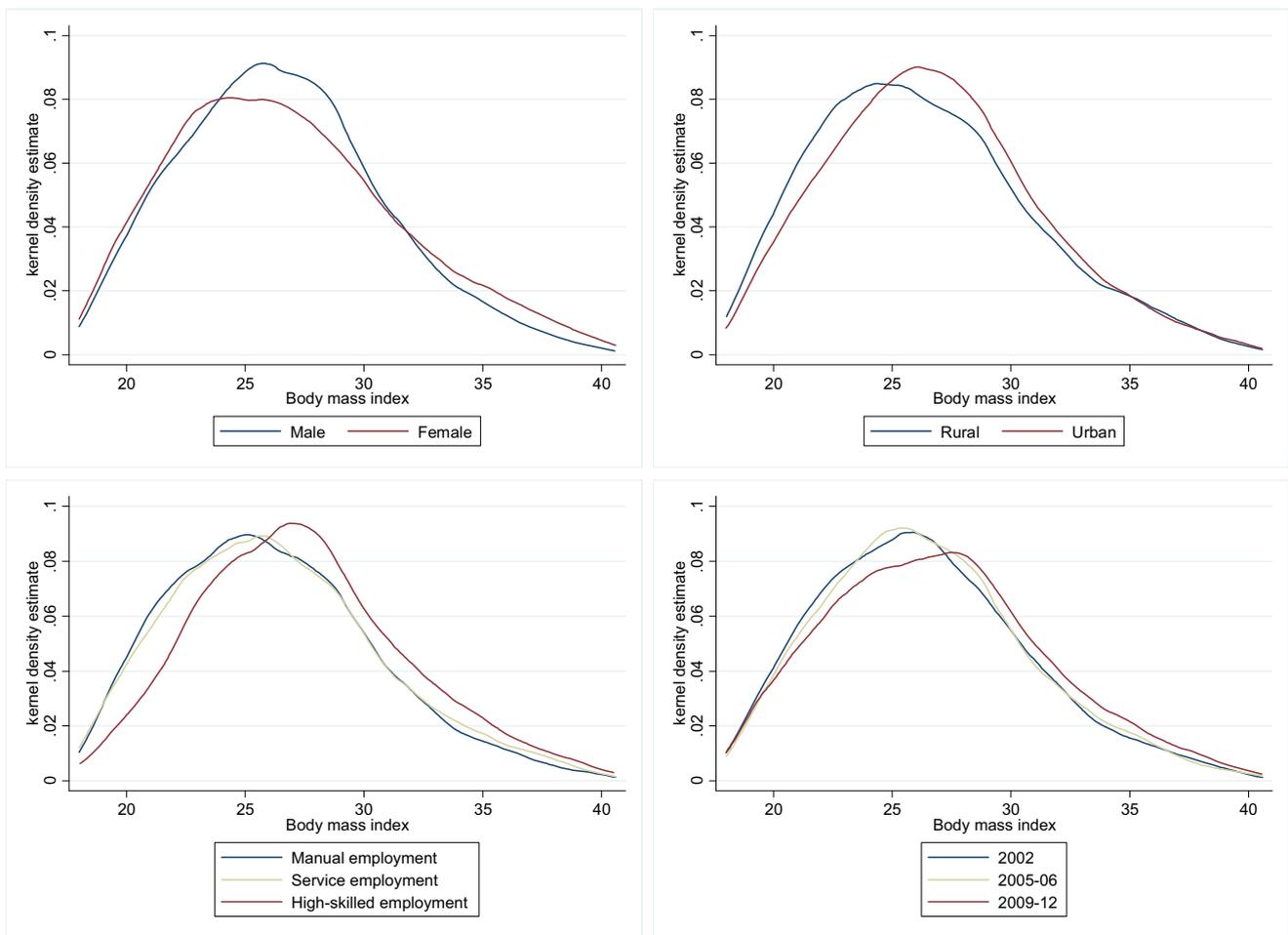
## Results

Figure 2 indicates that self-employed workers tend to have a higher BMI than employees: the BMI density function of employees is right-skewed. Figure 3 reports the distribution of BMI among employees across gender (male/female), living area (rural/urban), observation time (2002/2005–06/2009–12) and types of occupation (manual/service/high-skilled). Note that overweight (25–30 kg/m<sup>2</sup>) appears to be higher for males, while obesity (>30 kg/m<sup>2</sup>) is overrepresented for females. Besides, as discussed earlier, high-skilled employees are characterised by a larger body mass than service and manual employees. Furthermore, as expected, Fig. 3 suggests that time and urbanisation processes move the distribution of BMI towards the right.



Source: MxFLS (2002–2012).

Fig. 2 Distribution of BMI for employees and self-employed workers



Source: MxFLS (2002-2012).

**Fig. 3** Distribution of BMI for employees across gender, living area, observation time and type of occupation

Figure 4 shows the hourly income gap between employees and self-employed workers. The median salary is about 13.7 pesos per hour for employees, while half of self-employed workers accumulate 9.6 pesos for 1 h worked at most. Descriptive statistics presented in Table A.1 of the Appendix also outline that employees have better living conditions than self-employed workers, revealing better economic independence, education, health and access to public services (measured by the infrastructural development index). Moreover, it is interesting to note in Fig. 4 that hourly earnings tend to increase with the body mass category, for both employees and self-employed workers, at least up to the overweight status. Indeed, the hourly income gap between overweight and obese workers is not significant. The median hourly wages by BMI categories across gender, types of occupation, area and observation time are available in Fig. A.1 of the Appendix.

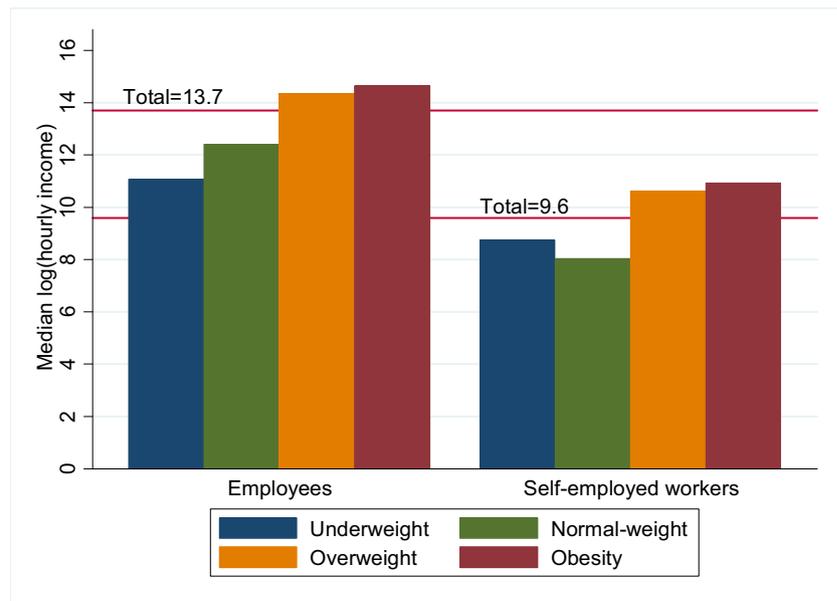
Despite the apparent presence of a link between individual BMI categories and hourly earnings, it would be premature to conclude on a direct and positive causal relationship between both factors. We speculate that other dimensions can influence and alter the relationship, hence the importance of implementing an RDD strategy.

### RDD validity

As expected, the first requirement is respected: absence of treatment manipulation by individuals themselves. Indeed, in Fig. A.2 of the Appendix, we do not detect any break in the BMI distribution just before (or after) the underweight, normal-weight, overweight and obesity statuses. The BMI variable is continuously distributed and follows a normal distribution (normal BMI is around 27–28 kg/m<sup>2</sup>).

The second requirement that an RDD must respect is also tested: absence of a selection bias due to heterogeneity that simultaneously affects treatment and hourly income within the considered bandwidth  $H$ . As presented in Tables A.2 and A.3 of the Appendix, most of the observed characteristics are not significantly correlated with the treatment (obesity) for different BMI bandwidths  $H$  ( $h = 1.5$  to  $h = 3$ ). In other words, we can assume that individuals are quasi-randomly distributed on either side of the obesity cut-off and that obese and non-obese workers are *locally* comparable. However, in the employee sample, both gender and living area significantly affect obesity risks (Table A.2 of the Appendix). This justifies our choice

**Fig. 4** Median hourly income by body mass category



Source: MxFLS (2002-2012).

to split this sample in order to explore gender- and area-specific heterogeneity. For self-employed workers (Table A.3 of the Appendix), both gender and cognitive abilities significantly influence obesity risks, but only beyond a certain bandwidth (from  $h = 2.5\text{--}3 \text{ kg/m}^2$ ). Although it would be interesting to implement a gender-specific analysis, we voluntarily choose not to disaggregate the self-employed worker sample, which is already relatively small. Tables A.4 and A.5 of the Appendix repeat the same tests, but this time when the treatment distinguishes the overweight status ( $25 \text{ kg/m}^2$ ). We observe a notable heterogeneity between treated and untreated workers, especially according to age. Therefore, it seems necessary to control for this heterogeneity taking into account a comprehensive set of observable characteristics.

### Local average effect of overweight and obesity on hourly income

Figures 5 and 6 explicitly illustrate the presence (or the absence) of hourly income discontinuities between BMI categories (overweight and obesity) among employees and self-employed workers, respectively. In the same way, Tables 1 and 2 transcribe local average estimates of overweight and obesity on log-hourly income for different BMI bandwidths  $H$  ( $h = 1.5$  to  $h = 3$ ). Let us recall that the larger the bandwidth is, the more precise the estimates, but the more sensitive the results to the presence of heterogeneity. The last columns of Tables 1 and 2 show RDD estimates when we control for a comprehensive set of observed characteristics and the bandwidth  $H = 6$  ( $h = 3$ ). Note that both model specifications display similar results. This indicates that the empirical strategy implemented in this study seems to be robust to the presence

of heterogeneity and allows the local effects of overweight and obesity on hourly income to be established (LATE).

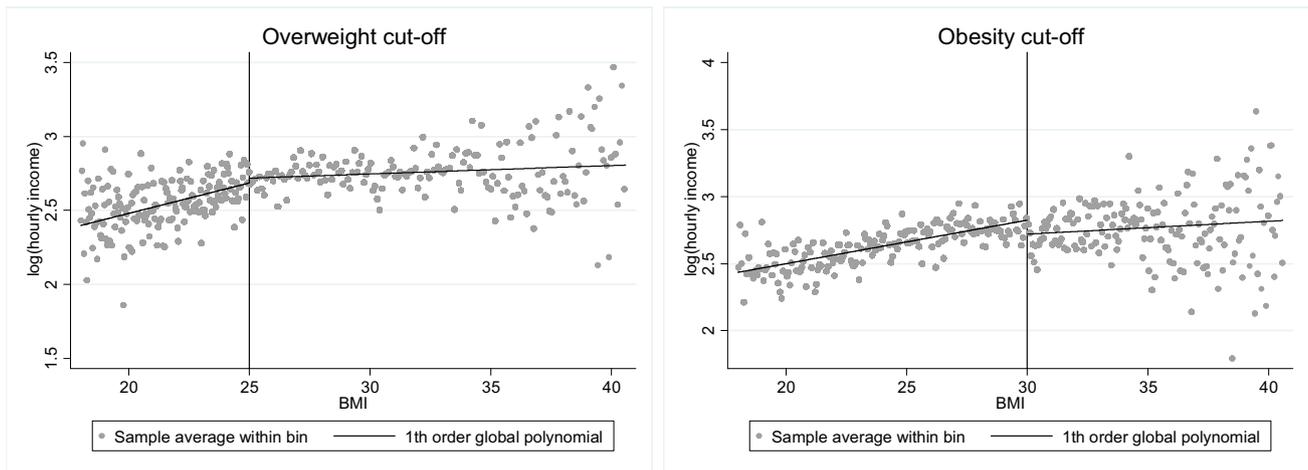
Among employees, Fig. 5 shows an apparent hourly income gap between overweight and obesity statuses. According to Table 1, this discontinuity is significant and negative, independent of the considered bandwidth. Around the obesity cut-off, individuals classified as obese earn between 12 and 17% less than individuals classified as overweight. By contrast, we do not observe any local wage gap between normal-weight and overweight workers around the overweight cut-off (Fig. 5). We also implement placebo tests in Table A.6 of the Appendix that check for possible wage gaps at other BMI cut-offs. These tests show that the obesity status ( $30 \text{ kg/m}^2$ ) is the unique cut-off leading to wage penalties for employees.

For self-employed workers, Fig. 6 shows a local positive income gap from normal to overweight. According to Table 2, this positive local effect is only significant when the set of control variables is included in the RDD, despite a relatively high rate of error (significant at the 10% level). Although the overweight status is a bit rewarded in self-employment (a 17% hourly income gap), we do not detect any income difference between the overweight and obesity statuses (Fig. 6 and Table 2).

### Heterogeneity within the employee sample

The main purpose of this article is to identify the presence of heterogeneity in the local effect of obesity on hourly wages.<sup>12</sup> Particularly, we investigate the potential influence of gender,

<sup>12</sup> Since we did not observe any local effect of overweight on hourly wage, only local effects of obesity are presented in this part of the study. Remember that only the employee sample is segmented into different sub-samples.



Note: Each point represents the mean log(hourly income) for a number of bins determined by a spacing estimator (mimicking variance evenly-space method). Fitted values (lines) are estimated from a first degree polynomial regression on each side of the discontinuity.

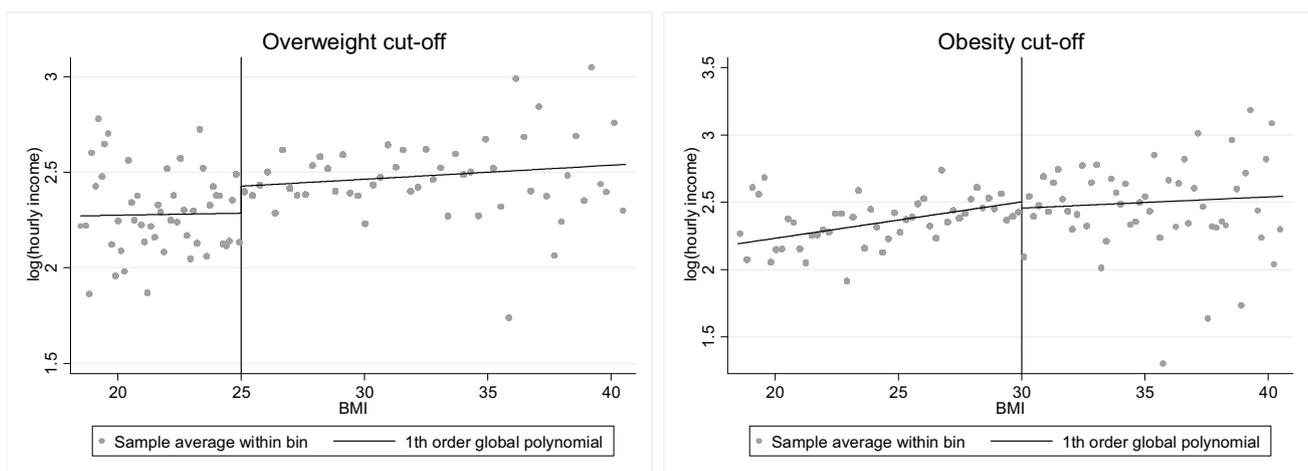
Source: MxFLS (2002-2012).

**Fig. 5** Regression discontinuity between BMI categories and hourly income for employees

types of occupation, living area and observation time. Table 3 presents estimates from these specific sub-samples using the same RDD as previously. In these estimates, note that omitted factors tend to overestimate the negative effect of obesity on wages since the inclusion of control variables decreases the coefficients' amplitude (except for certain sub-samples where the opposite occurs). Hence, we base the following interpretations on the results from column 2 of Table 3.

First, the local effect of obesity on hourly wages is stronger for women than for men. While obesity reduces men's hourly wages by 10%, obese women earn 15% less than non-obese women. Second, wage penalties induced by obesity are more pronounced in urban (−15%, significant at the

1% level) than in rural areas (non-significant). Third, the negative impact of obesity on earnings increases over time. The amplitude and significance of coefficients increase from 2002 (around −6%, non-significant) to 2012 (−17%, significant at the 5% level). Finally, Table 3 shows an important occupational heterogeneity. Indeed, the negative effect of obesity on hourly wages is the highest for service-sector employees (−26%, significant at the 1% level). However, obesity does not lead to wage penalties in high-skilled occupations. In the case of manual occupations of the primary and secondary sectors, we observe a slight negative effect of obesity on hourly wages (−15%, significant at the 10% level).



Note: Each point represents the mean log(hourly income) for a number of bins determined by a spacing estimator (mimicking variance evenly-space method). Fitted values (lines) are estimated from a first degree polynomial regression on each side of the discontinuity.

Source: MxFLS (2002-2012).

**Fig. 6** Regression discontinuity between BMI categories and hourly income for self-employed workers

**Table 1** Local average effect of overweight and obesity on employees' hourly income

	Without control variables $\Phi$				Including control variables $\Psi$
	1.5	2	2.5	3	3
Overweight	-0.048 (-0.70)	0.002 (0.04)	-0.033 (-0.61)	-0.060 (-1.21)	-0.059 (-1.61)
Observations	3903	5139	6294	7503	5442
Obesity	-0.156* (-1.69)	-0.159** (-1.99)	-0.172** (-2.42)	-0.145** (-2.24)	-0.121** (-2.48)
Observations	2652	3526	4512	5372	3670

Notes: (1)  $\Phi$ : z-statistics (in parentheses) are corrected using the method of Calonico, Cattaneo and Titiunik (2014)

(2)  $\Psi$ : t-statistics (in parentheses) are clustered at the household level

(3) Significance levels of coefficients: \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$

Source: MxFLS (2002–2012)

## Discussion

This study aimed to explore the presence of heterogeneity with respect to the impacts of overweight and obesity on labour income in Mexico. Using panel data from the MxFLS (2002–2012), we compared the effects of the BMI on earnings between employees and self-employed workers. Moreover, we analyse potential wage penalty differences related to gender (female vs. male), type of occupation (manual vs. service vs. high-skilled), living area (rural vs. urban) and observation time (2002 vs. 2005–06 vs. 2009–12). Based on an original conceptual framework, we implemented an RDD strategy to assess the local effects of BMI categories on hourly earnings. The use of an RDD approach appears to be particularly relevant in the context of this study and, more generally, in the literature that aims to assess the BMI's impacts. For the purpose of establishing a causal inference, this strategy is a good alternative to the instrumental variable models. Indeed, this procedure allows the income gaps between international body mass categories to be visually and clearly inspected and compared with other countries. Furthermore, the simplicity of this method enables a sensitive analysis of weight perception heterogeneity within a given society.

This article makes several contributions in terms of findings. Obese employees earn about 15% less per hour than their overweight counterparts, but we do not note any local effect of the overweight status on employees' earnings. By contrast, the RDD estimates suggest a slight positive local effect of the overweight status on labour income in self-employment. Moreover, the obesity status does not lead to income penalties for self-employed workers. These results remind us of the case of coalminers in India (Dinda et al. 2006) and Guinean self-employed workers (Glick and Sahn 1998).

These results have various possible explanations. First, given that two-thirds of Mexican adults are overweight, it is not impossible that this nutritional status is gradually becoming the social norm in Mexico. Such a social acceptance of overweight would explain why the local impact of overweight on labour income is non-negative for self-employed and salaried workers in Mexico (*phenomenon 3*). However, wage penalties induced by the obesity status in the employee sample highlight the presence of *phenomenon 2* in Mexico: a progressive adoption of thinness ideals through the globalisation process.

Note that different outcomes between employees and self-employed workers may be explained by different exposures to weight discrimination. Contrary to employees, self-employed

**Table 2** Local average effect of overweight and obesity on self-employed workers' hourly income

	Without control variables $\Phi$				Including control variables $\Psi$
	1.5	2	2.5	3	3
Overweight	0.012 (0.06)	0.176 (0.99)	0.120 (0.75)	0.151 (1.04)	0.169* (1.71)
Observations	741	947	1172	1391	1007
Obesity	-0.196 (-0.91)	-0.255 (-1.33)	-0.147 (-0.83)	-0.078 (-0.48)	0.018 (0.16)
Observations	646	857	1059	1262	894

Notes: (1)  $\Phi$ : z-statistics (in parentheses) are corrected using the method of Calonico, Cattaneo and Titiunik (2014)

(2)  $\Psi$ : t-statistics (in parentheses) are clustered at the household level

(3) Significance levels of coefficients: \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$

Source: MxFLS (2002–2012)

**Table 3** Local average effect of obesity on hourly wages according to gender, living area, observation time and type of occupation

		Without control variable $\Phi$ (h = 3) BMI = (27–33)	Including control variables $\blacklozenge$ (h = 3) BMI = (27–33)
Gender	Male	-0.098 (-1.26) N = 3781	-0.108* (-1.86) N = 2515
	Female	-0.24* (-1.94) N = 1691	-0.147* (-1.70) N = 1155
Living area	Rural	-0.058 (-0.53) N = 1779	-0.077 (-0.87) N = 1204
	Urban	-0.200*** (-2.55) N = 3593	-0.149*** (-2.56) N = 2466
Observation time	2002	-0.094 (-0.67) N = 1399	-0.064 (-0.76) N = 1265
	2005–06	-0.117 (-1.05) N = 1795	-0.119 (-1.21) N = 1013
	2009–12	-0.200** (-2.08) N = 2178	-0.166** (-2.25) N = 1392
Type of occupation	Manual	-0.023 (-0.25) N = 2174	-0.146* (-1.91) N = 1489
	Service	-0.462*** (-3.80) N = 1295	-0.255*** (-2.64) N = 908
	High-skilled	-0.057 (-0.377) N = 853	0.01 (0.09) N = 586

Notes: (1)  $\Phi$ : z-statistics (in parentheses) are corrected using the method of Calonic, Cattaneo and Titiunik (2014)  
 (2)  $\blacklozenge$ : t-statistics (in parentheses) are clustered at the household level  
 (3) Significance levels of coefficients: \*\*\*p < 0.01, \*\*p < 0.05, \*p < 0.1  
 Source: MxFLS (2002–2012)

workers are not exposed to discriminatory behaviours from the employer and co-workers. Moreover, considering that the vast majority of self-employed workers are uneducated and vulnerable individuals who work informally (Gong et al. 2004), we can speculate that overweight is still considered (by the client and/or the individual himself) as an asset, allowing physical and manual tasks to be better managed for instance. According to Guendelman et al. (2011), this popular belief (still widespread in the poorest social categories) would be the result of past nutritional deprivations that many Mexicans suffered a few decades ago (*phenomenon 1*). Cawley (2004) observes the same type of sociocultural heterogeneity in the US: Hispanic and African-American women are not significantly threatened by wage penalties.

In line with the literature, the negative effect of obesity on hourly wages appears to be significantly stronger for women than for men (Cawley 2004). Indeed, women are more likely to be exposed to weight and auto-discrimination. In Mexico, Mancilla-Díaz et al. (2012) report an increasing social pressure on women’s bodies, leading them to match Western ideals of beauty (*phenomenon 2*).

In addition, the effect of obesity on hourly wages depends on the type of occupation. As noted by DeBeaumont (2009) and Caliendo and Gehrsitz (2016) in rich economies and

Huang et al. (2016) in China, obesity leads to high wage penalties in service employment in Mexico. Since individuals that work in this type of occupation are relatively thin (Fig. 1), the risk of discrimination and self-discrimination is potentially higher (*phenomenon 2*). Concerning manual employees from primary and secondary sectors, obesity also negatively affects hourly earnings, but with lower amplitude than for service workers. In the manual and physical occupations, we cannot determine whether the effect comes from the *weight stigmatisation* process or from a *productivity loss* due to obesity-related comorbidities. Further studies are needed to quantify the importance of both pathways. Finally, obesity does not alter the hourly wages of high-skilled employees in Mexico. A possible explanation is because physical appearance does not matter in high-skilled employment. Obese high-skilled employees are not stigmatised by others because they are decision-makers and have the highest positions in the labour market. Besides, this occupational category is characterised by the highest rates of overweight and obesity (Fig. 1). Therefore, one can assume that the generalisation of overweight and obesity in high-skilled employment, resulting from chronic stress, lack of free time and sedentary activities (Levasseur 2015), leads to a social acceptance of excess weight (Classen 2017). The expression of such a sociocultural

mechanism would also explain the absence of weight stigmatisation in high-skilled employment (*phenomenon 3*).

According to our findings, the negative impact of obesity on wages is becoming stronger over time (between 2002 and 2012) and appears to be higher in urban than rural areas. These results emphasise the increasing adoption of Western beauty ideals diffused by the media and other cultural goods in Mexico, generally more available in cities (*phenomenon 2*). This temporal and geographical dynamic once again highlights the importance of the *weight stigmatisation* pathway (Huang et al. 2016).

### Limitations

Our results potentially reflect the two channels through which weight and wage are related (i.e. the productivity channel and the stigma channel). However, worker productivity is partially controlled for since the dependent variable is expressed in hours (thus controlling for time-related productivity) and important determinants of productivity (e.g. age, education) are included in the models as control variables. As a consequence, our RDD estimates particularly identify income gaps due to a *weight-related stigma*. Further studies are needed to capture the *weight-related productivity loss*.

The main limitation of the RDD lies in establishing a local average treatment effect (LATE). In this study, we only identify the presence of a significant wage gap along the BMI distribution but we do not determine the global functional form that relates the BMI to the hourly income. Hence, an RDD should be only used as a complement to parametric and semi-parametric methods based on an instrumental variable strategy (see a *MPRA paper* of Levasseur for an application based on Mexico, 2017).

### Conclusion

To summarise, the nature of the causal relationship between BMI and labour income is closely linked to *weight-related social norms* that change over regions and time, but also over socio-professional groups. The use of an income gap analysis represents a good quantitative approach to explore weight-related sociocultural transformations. In the current context of emerging countries such as Mexico, where obesity reaches an endemic level, our findings suggest that two concomitant, but paradoxical, processes are occurring: (1) a social acceptance of overweight (pro-fat social norms) due to past nutritional deprivations (*phenomenon 1*) and the growing normalisation of obesity (*phenomenon 3*) and (2) a social rejection of obesity (anti-fat social norms) due to the large diffusion and adoption of thinness ideals from Western culture (*phenomenon 2*).

### Compliance with ethical standards

The author declares that he has no financial and non-financial conflict of interest. No ethical approval is required to use the Mexican Family Life Survey. This database is anonymous and does not contain personal information. Please see the website for more information about the data: [www.enmvih-mxfls.org](http://www.enmvih-mxfls.org). The author is responsible for all remaining errors.

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