Strategic bunching at eligibility notches : Evidence from the arts workers' UI scheme in France*

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Abstract

Notches are not compelling in various context though they figure prominently in many policies. In this paper, I analyze the notch defining the eligibility criteria of the French special Unemployment Insurance (UI) program for arts workers. To be entitled to this program, an art worker must have worked 507 hours over a 10-month period, which averages out at 13 hours a week. The program parameters have important implications on labor supply decisions and ultimately on public finances. I provide several pieces of evidence showing that arts workers respond to notches locating on the eligible side of the notch. I then show that this strategic behavior has real consequences on the unemployment rate (+27 percentage points) and on the UI deficit (-0.6 billion euros per year).

Keywords: bunching, notches, eligibility, unemployment insurance

JEL: J22, J65

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1 Introduction

The existence of an excess mass or "bunching" around kinks or notches provides compelling, visual evidence of a strategic behavior. Over the last decade, a growing literature has documented strategic behaviors in various settings; Kleven (2016) provides an overview of this literature. Yet, despite the ubiquity of kinks and notches, there is little empirical investigation of their consequences. Intuitively, strategic behavior around kinks and notches can be costly because they create a disconnection between private and social returns. In particular, for those located near a notch, a small change in behavior leads to a large private gain while the overall return is unclear. To the best of my knowledge, only Sallee and Slemrod have provided empirical evidences of the welfare consequences of this behavior. In the context of fuel economy policies, they find that notches are less efficient than a smooth tax would be, and they estimate that the local manipulation in response to notches has a net negative social impact.

The aim of this paper is to determine the welfare cost of strategic behavior in the context of the Unemployment Insurance (UI) eligibility. I focus on the very disputed arts workers' UI system in France. For decades, French people working in the arts and entertainment from circus clowns, choreographers, actors and musicians to camera operators and sound staff – hereafter called "arts workers" – have a special Unemployment Insurance system, designed to protect them in between jobs and offering them time for creativity. Arts workers can qualify for Unemployment Benefits (UB) if they work 507 hours over 10 months (roughly 13 hours a week), which is called *eligibility notch*. This special system almost doubles arts workers' monthly earnings: on average, UI eligible arts workers earn 2125 euros, of which 950 euros from the UI system and 1175 euros from work. Such a notch generates strong incentives for moving from a region below the cutoff to a point just above the cutoff. The eligibility notch distorts labor supply, increasing both revenue collections and UI expenditure. The aim of this paper is to estimate the welfare implications of this strategic bunching.

In this paper, I document that arts workers indeed respond to the eligibility notch. I begin the analysis by examining the distribution of arts workers' hours of work. There, I find evidence of strategic bunching: there is a higher proportion of arts workers on the eligible side of the notch point. At the same time, this strategic behavior produces a hole in the hours-of-work distribution on the non-eligible side of the notch point. This basic

descriptive evidence provides a compelling evidence of the causal effect of the arts workers' UI system on their labor supply. This result is confirmed by the fact that non-resident arts workers working in France, yet not eligible to UI, do not distort their labor supply. In particular, Belgian arts workers[1] do not respond to the eligibility notch while working in France.

Next, I develop a simple model to estimate hours-of-work elasticities using the bunching approach developed by Kleven and Waseem (2013). This approach relies on an estimate of the counterfactual distribution, i.e. what the distribution would have looked like in the absence of the notch. The standard approach to estimate the counterfactual distribution is to fit a flexible polynomial to the observed distribution, excluding data in a range around the cutoff. A requirement for this approach to work is that the distortions created by the notch are very local, so that the extrapolation of the fitted distribution is done over a relatively small range. Yet comparing the French and Belgian distributions, the behavioral response due to the notch is large. Thus this setting is not suitable for the standard approach. Instead I exploit the fact that Belgian arts workers are ineligible for the UI system, forming a natural control group. Comparing the French and the Belgian distributions, I find that French arts workers are very responsive to the scheme with a structural elasticity of 3.8 for artists and 4.3 for technicians, controlling for differences in individual characteristics. I also examine how the notch design might affect strategic bunching. I find that a one-percent increase in the replacement rate increases the behavioral response by around 0.4%. Likewise, a one-percent increase in the eligibility cutoff increases the behavioral response by 0.9%. These results contribute to the literature on the effect of UI design on unemployment inflows, that also shows that both the eligibility rules and the level of benefits have a significant impact on the inflow of unemployment (see Tatsiramos and Van Ours (2014) for a literature review).

Finally, I use my estimates to non-parametrically identify the impacts of strategic behavior on the unemployment rate and on the UI accounts. I find that the unemployment rate has increased by 17 percentage points for artists and 35 percentage points for technicians, i.e. 27 percentage points overall. As a result, the strategic bunching worsen the UI deficit by 0.6 billion euros per year. This implies that more than half of arts workers' UI negative balance is due to strategic behaviors. These results question the desirability of notches in

[1] In the rest of the paper, the term "Belgian arts workers" refers to arts workers residing in Belgium while working in France. I do not have information on their labor supply in Belgium.

the context of the UI[2] since notches are an inevitable feature of UI design. As Slemrod (2010) discusses, notches might be justified by benefits including administrative simplicity or enhance salience to workers. Moreover, in the field of policy, discrete classifications that separate employed workers from unemployed ones come more naturally.

The article is organized as follows. I begin in Section 2 by describing the institutional background in France and in Belgium. In section 3, I describe the data and document the existence of bunching in France and its non-existence in Belgium. In section 4, I turn to a theoretical model that incorporates the features of the arts workers' system. The empirical analysis begins in Section 5 with an analysis of the policy impacts of arts workers' strategic behavior. Section 6 concludes.

2 Institutional background

2.1 Historical context and recent debates

In the 1960s, the French employment system introduced a special UI system to cover workers in the sectors of performing art. This special system relies on the principle that these workers face a higher risk of repeated periods of unemployment associated with the completion of project-based contracts like films, television shows, or live performance. This special system is in some ways more advantageous than the regular UI system. Consequently, instead of functioning counter-cyclically like the regular UI system – where unemployment falls as employment rises – both are increasing on the case of the arts workers' UI system (Menger (2011)). Since 1980, the number of UI eligible arts workers has been multiplied by fifteen and the level of unemployment for this category of workers by three, rising from 14% in 1980 to 45% in 2015 (Figure 1).

[Figure 1]

In the early 2000s, the arts workers' UI system has been called into question in the context of the global UI debt that is exploding since 2002 (Figure 2). The 100,000 eligible

[2]The desirability of notches has been studied theoretically in the context of taxation. The seminal paper by Mirrlees (1971) shows that when the income tax schedule can be completely feasible, notches cannot be part of an optimal income tax system. Yet, in real-word tax system, there is a restricted set of tax instruments and in this context, notches may be optimal. This argument in favor of notches has been explored by Blinder and Rosen (1985) and more recently by Gillitzer and al. (2016).

arts workers, representing around 4% of job-seekers registered at the Employment Agency, are sometimes perceived as fully "responsible" for this deficit. In this context, the government scaled this special system down in 2003. Reforms sparked a wave of strikes and caused media sensation. Arts workers protesting against benefit cuts managed to shut down France's most prestigious theater festival at Avignon, plunge the major Aix-en-Provence arts festival into darkness, secure the sacking of the culture minister, and then threaten to pull the plug on the Cannes film festival. Yet, in July 2016, arts workers won their case: a new agreement has brought the rules back to how they were before 2003.

[Figure 2]

2.2 Arts workers' UI scheme

Arts workers' special UI scheme in France (2003-2016). The definition of arts workers follows the UI rules in terms of sectors, job category and contracts. First, arts workers must work in specific sectors: creative, arts and entertainment activities (Isic #90), motion pictures, video and television programme production, sound recording and music publishing activities (Isic #59) and programming and broadcasting activities (Isic #60). Second, arts workers must fit into one of the six hundred job categories specified in the UI agreement, from circus clowns, choreographers, actors and musicians to camera operators and sound staff. Last, arts workers must be hired on fixed-term contracts or paid on a fee-basis for their performing activities. According the UI rules, a fee amounts to 12 hours of work if the duration of the contract is lower than 5 days and 8 hours otherwise. The arts workers' UI system distinguishes performing artists from technicians. Table 1 displays the parameters of the system for these two categories of arts workers.

[Table 1]

Claiming arts workers must have worked 507 hours during a base period of 10 months before they can registrate at the Employment Agency. Thus, the *eligibility notch* is located at the 507-hour cutoff over 10-month periods. As soon as they have worked 507 hours in the past 10 months, they enter the unemployment registers. The level of benefits is calculated at the time of registration on the basis of reported hours and reported earnings during the 10-month base period (see formula in Table 1). If claimants are totally unemployed all along their claim and receive each month their UB, the potential duration of benefits is 8

months for all claiming arts workers. Claiming arts workers are allowed to work, including with their past employers. In this case, the level of partial UB depends on reported hours of work while on claim. For example, if the level of monthly benefits is 1000 euros, then 4.3 euros are deducted for each hour worked (5.8 for technicians). However, the reduction in benefits is not lost, it can be paid in a later month. The corresponding benefit transfers delay the potential benefit exhaustion date. At the exhaustion date, the eligibility condition is reassessed. If claimants have worked 507 hours over the 10-month period preceding the exhaustion date, they remain on the unemployment registers and so on and so forth.

Arts workers' special UI rules in Belgium (2005-2014). Belgian arts workers can claim unemployment benefits in Belgium on the basis of the hours worked in France. One would want to verify that Belgian arts workers' labor supply in France is not affected by their UI system. Actually, Belgium does not have any special UI system for arts workers since Belgian arts workers are subject to the same UI eligibility rules as regular workers. However, Belgian arts workers can benefit from advantageous special rules once registered at the Employment Agency. The definition of arts workers eligible for those rules includes artists and technicians in the sector of performing arts. Thanks to these rules, Belgian arts workers can avoid the UB degressivity that is applied to regular workers. To be entitled to this special status, arts workers have to be hired on a short duration job during the first year after their registration (since 2011, this condition has been raised to three short duration jobs). Then, they have access to a 12-month period without degressivity. To extend this status for another 12 months, they again have to be hired on a short-duration job before the end of the ongoing 12-month period (three short-duration jobs since 2011) and so on and so forth. This way, they can extend their status indefinitely if they manage to work a minimum of one day (three days since 2011) over 12-month periods. In Belgium, regular job-seekers also have UB without limitation in time. The only difference lies in the implementation of the degressivity rules. Contrary to what is observed in France, Belgian arts workers do not distort their hours worked in Belgium in order to qualify for UB (Figure 3). Therefore, it is unlikely that their hours worked in France are affected by the Belgian UI system.

[Figure 3]

3 Data and bunching evidence

3.1 Data description and summary statistics

The empirical analysis is based on administrative data sets on employment records (*Attestations Employeurs Mensuelles*) for the whole population of resident and non-resident arts workers in France. These data are collected by the French Public Employment Agency (Unédic and Pôle Emploi) since 2004. The data include basic demographic information (such as age, gender, place of residence) and detailed information about the start and end dates of labor contracts, occupation, hours of work, and earnings. Information about the place of residence allows me to isolate the control and treated groups. I complement these data with administrative data sets on unemployment spells (*Fichier National des Allocataires*) also collected by the French Public Employment Agency (Unédic and Pôle Emploi) since 1995. The data include detailed information about the start and end dates of unemployment spells, the level of UB, earnings and hours of work while on claim.

[Table 2]

Panel A and B of Table 2 present summary statistics about French and Belgian arts workers. In the French population of arts workers, the average age is 38 years old, and about two thirds are females. Average monthly wage is 3430 euros while the median is 534 euros. The artistic labor market is characterized by a large income gap between the "superstars" and the rest of the arts workers. Belgian arts workers' earnings also feature a discrepancy between median and average monthly wages. Unsurprisingly, Belgian arts workers work on average fewer hours than French arts workers: the eligibility notch generates strong incentives to increase labor supply in order to locate above the cutoff. Panel C of Table 2 presents summary statistics of UI eligible arts workers who are by definition French residents. These descriptive statistics illustrate the favorable conditions provided by the arts workers' special system. UI eligible arts workers earn on average 2125 euros, of which 950 euros from the UI system and 1175 euros from work. The average monthly replacement rate is 1.6.

3.2 Bunching evidence

The existence of bunching at the eligibility notch for French arts workers is clearly evident, creating a hole in the distribution on the non-eligible side of the notch and excess bunching on the eligible side of the notch (Figure 4). It clearly demonstrates that arts workers increase

their hours of work in order to be eligible to UB, rising both revenue collections and UI expenditures. Thus, Figure 4 provides the motivation and starting point for the analysis carried out throughout the rest of the paper. In other words, this basic descriptive evidence provides a compelling evidence of the causal effect of UI eligibility rules on labor supply and accordingly on the unemployment rate and the UI expenditures, due to strategic behavior.

[Figure 4]

Besides, Figure 3 and Figure 4 interrogate the standard local approach. On the one hand, the absence of bunching for Belgian arts workers working in Belgium (Figure 3) suggests that workers do not react to small notches. On the other hand, the large bunching pattern observed in France (Figure 4) suggests the standard local approach is not compelling when workers do react. As pointed out by Kleven (2016) and Kosonen and Matikka (2017), the approach is not compelling in all context and a requirement for the approach to work is that the distortions created by the notch are very local. However, in the absence of a natural control group, it is difficult to assess whether the distortions are indeed local.

4 Model and Research Design

4.1 A Model of Behavioral Response to the arts workers' UI scheme

Setup. In this section, I develop a model that incorporates the dynamic aspects of the arts workers' system. The framework relies on Kleven and Waseem (2013). I consider an art worker hired on short-term contracts. In a month t, she works h_t. Hourly wage is w and UI contribution is τ. As a baseline, I start by considering an art worker who is not eligible to the UI system. Then her total earnings are $(1-\tau)h_t$. The wage is normalized to one so that h_t can also be interpreted as before-tax earnings in the model. The per-period utility is defined over consumption c_t and hours of work h_t. Following the typical approach, I assume a quasi-linear utility function (ruling out income effects) that depends on the individual ability n. Heterogeneity in ability is captured by a density function $f(n)$.

$$u(c_t, h_t) = c_t - (\frac{n}{1+1/e})(\frac{h_t}{n})^{1+1/e}$$

$$\text{such that } c_t = (1-\tau).h_t$$

In this case, the maximization of utility with respect to hours of work yields:

$$h_t = n(1-\tau)^e$$

where e is the parameter of interest : it captures the hours-of-work elasticity to the net-of-tax wage.

The art worker is eligible to UB as soon as she reaches 507 hours of work over a 10-month base period. At each date $t > 0$, the eligibility condition $H_t = \sum_{j=0}^{9} h_{t-j} > 507$ hours is reassessed. As soon as she has worked 507 hours in the previous 10 months, the art worker enters the unemployment registers. At the beginning of her claim, the eligible art worker has a total UB capital that equals to S^{max}. At each period that she is registered and does not work at all, the art worker receives an amount $B(h_t = 0) = B$ of unemployment benefits. Monthly benefits are deducted from this UB capital, so that S_t, the remaining entitlement at month t decreases over the spell. Total UB capital corresponds to 8 months of benefits ($S^{max} = 8B$). The art worker remains eligible to benefits as long as $St > 0$. When the remaining entitlement S_t of her current UB capital is not sufficiently large to pay by $B(h_t)$, either the art worker leaves the unemployment register if she has not worked 507 hours in the 10 months preceding the exhaustion date or recharges his UB capital by S^{max} otherwise. In this context, the art worker should work sufficiently so that the eligibility condition is met when her UB capital exhausts. When the art worker takes up a job of h_t hours at month t, she receives an amount $B(h_t) = B - \tau_b h_t$ of unemployment benefits, where $\tau_b.h_t$ is the reduction rate in benefits for working while on claim. When working while on claim, a smaller amount of benefits is deducted from the UB capital, so that S_t decreases at a lower pace over the spell[3]. The UB capital path can be defined as:

[3]In this case, the art worker can be registered for more than 8 months. However, if she works too much, the duration will last longer than 10 months and the first working hours will not count in the assessment of the eligibility condition. In this context, one may want to work exactly 507 hours over 10 months from the beginning of the spell. One complication may arise from the fact that the art worker may either have exhausted her benefits before the end the 10-month period or still be entitled to a positive UB capital $S_t > 0$ at the end of the 10 months. However, the rules are such that if the art worker works 507 hours over 10 months, the spell is going to last exactly 10 months, without remaining entitlement of her current UB capital $S_t = 0$ at the end of this 10-month period. This result comes from the definition of τ_b which is such that $8B \approx 10B - \tau_b \times 507$ hours. Therefore, one should work 507 hours over 10-month periods to fully consume the initial UB capital S^{max} and satisfy the eligibility condition.

$$S_{t+1} = \begin{cases} 0 & \text{if } 0 \leq S_t \leq B(h_t) \text{ and } H_t < H^* \\ S_t + S^{max} - B(h_t) & \text{if } 0 \leq S_t \leq B(h_t) \text{ and } H_t \geq H^* \\ S_t - B(h_t) & \text{if } S_t > B(h_t) \end{cases}$$

where H* is the eligibility cutoff.

Let me define individual preferences at time t when UB capital is S_t:

$$u(c_t, h_t) = (1-\tau).h_t + B(h_t).\mathbb{1}[S_t > 0] - (\frac{n}{1+1/e})(\frac{h_t}{n})^{1+1/e}$$

In the case of registered arts workers, the maximization utility with respect to hours yields (see appendix A.2 for computation details):

$$\beta(\frac{h_t}{n})^{1/e} = (\frac{h_{t-1}}{n})^{1/e} + (\beta - 1)(1 - \tau - \tau_b)$$

[Figure 5]

However, I consider the case of stationarity. In this case, $h_t = h_{t-1}$ implying that $H_t = 10h_t$. Thus in the stationary case, arts workers should work 50,7 hours per month in order to reach 507 over a 10-month base period. Figure 5 shows that such an assumption is relevant when studying the arts workers : bunching behavior is very stable over time and arts workers do work on average between 50 and 60 hours per month[4]. The maximization of utility with respect to hours of work yields a unique solution under the assumption of stationarity.

$$h_t = n(1 - \tau - \tau_b)^e$$

Under the assumption of stationarity, the notch is introduced at the cutoff h*=50.7 hours. The optimization problem boils down to:

$$u(h_t) = (1-\tau).h_t + B(h_t).\mathbb{1}[h_t \geq h^*] - (\frac{n}{1+1/e})(\frac{h_t}{n})^{1+1/e}$$

such that $h^* = H^*/10$

[Figure 6]

[4]Artists are usually paid on a fee-basis for their performing activities. According to the UI rules, a fee amounts to 12 hours of work if the duration of the contract is lower than 5 days and 8 hours otherwise. Therefore, the minimum number of hours that should target an artist paid on a fee-basis is 56 hours (7 fees $\times$ 8 hours) or 60 hours (5 fees $\times$ 12 hours).

Figure 6 illustrates the implications of a notch in a budget set diagram (Panel A) and a density distribution diagram (Panel B). There will be bunching at the notch point by all individuals who had hours in an interval $[h^*, h^* - \Delta h^*)$ before the introduction of the notch. The individual originally located at $h^* - \Delta h^*$, with ability $n^* - \Delta n^*$ is the marginal buncher: this person is exactly indifferent between the notch point h^* and the best interior solution $h^* - \Delta h^*$ after the introduction of the scheme. Theres is a hole in the post-notch density distribution since no individual is willing to locate between $h^* - \Delta h^*$ and h^*. The fundamental idea is that the response Δh^* of the marginal buncher is related to compensated elasticity e. The relationship between the two can be characterized using the indifference condition between the notch point h^* and the interior location $h^* - \Delta h^*$ so as to obtain (see appendix A.3 for computation details):

$$(1-\tau)(1-\Delta h^*/h^*) + e(1-\tau)(1-\Delta h^*/h^*)^{-1/e} - (1+e)(1-\tau-\tau_b+\frac{B}{h^*}) = 0$$

From the relationship $H^* = 10.h^*$:

$$(1-\tau)(1-\Delta H^*/H^*) + e(1-\tau)(1-\Delta H^*/H^*)^{-1/e} - (1+e)(1-\tau-\tau_b+\frac{10.B}{H^*}) = 0 \quad (1)$$

The determination of the structural elasticity e from equation (1) requires an estimate of the hours-of-work response ΔH^* since the other parameters are already known (Table 3).

[Table 3]

Sensitivity to the notch design. Applying the implicit function theorem (see appendix A.4 for computation details) to equation (1), I analyze the impact of the eligibility criteria H^*, the level of benefits B and the tax rate τ on the behavioral response ΔH^*.

$$\begin{aligned}
\frac{d\Delta H^*}{dB} &= -\frac{10(1+e)}{(1-\tau)[1-(1-\Delta H^*/H^*)^{-1-1/e}]} > 0 \\
\frac{d\Delta H^*}{d\tau_b} &= \frac{(1+e)H^*}{(1-\tau)[1-(1-\Delta H^*/H^*)^{-1-1/e}]} < 0 \\
\frac{d\Delta H^*}{dH^*} &= \Delta H^*/H^* + \frac{(1+e)\times(10B/H^*)}{(1-\tau)[1-(1-\Delta H^*/H^*)^{-1-1/e}]} > 0
\end{aligned} \quad (2)$$

As τ increases, ΔH^* decreases : with a higher tax rate, the arts workers have less incentives to target the notch point. Conversely, the level of benefits B is positively correlated to the response ΔH^*. As for the eligibility criteria, a higher cutoff H^* increases the behavioral response.

4.2 Research design

Let $F(H|B(h))$ be the distribution of hours of work over 10-month base periods with the UI program $B(h)$. The objective is to estimate the behavioral response ΔH^*:

$$\widehat{\Delta H^*} = H^* - H_l$$
$$\text{where } H_l = \max\{H|F(H|B(h) = (B - \tau_b h).\mathbb{1}[h \geq h^*]) = F(H|B(h) = 0)\}$$

$\widehat{\Delta H^*}$ is difference between the cutoff H^* and the lower intersection between the French and the Belgian distributions, denoted H_l. Here, H_l represents the point of divergence between the French and the Belgian distributions: it is the last value of H such that the observed distribution of reported hours of work equals the counterfactual outcome without the arts workers' scheme. The standard approach to estimate the counterfactual distribution is to fit a flexible polynomial to the observed distribution, excluding data in a range around the cutoff. However, a requirement for this approach to work is that the distortions created by the notch are very local, so that the extrapolation of the fitted distribution is done over a relatively small range. In my setting where bunching responses are very large and the density is steep, this approach is not compelling. I take advantage of the fact that non-resident arts workers are not eligible to the UI special system. In particular, I focus on Belgian arts workers because Belgium is the closest country to France both geographically (Bruxelles is 1h30 far from Paris by train) and culturally (half of the population speak French). I use their observed hours-of-work distribution to obtain the counterfactual distribution for the French UI scheme, making the assumption that their behavior is identical to the behavior of people who do not perceive any benefits.

$$F^f(H|B(h) = 0) = F^b(H|B(h) = 0)$$

where the subscripts f and b stand for French and Belgian arts workers. This leads to the identification assumptions underlying the research design :

Assumption. Individuals' ability do not vary across place of residence.

$$f^f(n) = f^b(n) = f(n)$$

[Table 4]

This assumption can be tested by comparing the individual characteristics of Belgian and French arts workers (Table 4). Though significant, the differences are not very large quantitatively. To cut through the debate about differences in abilities, I will determine the behavioral response ΔH^*, controlling for the individual characteristics. In this setting, Belgian arts workers' labor supply in France can provide a satisfying approximation of the French arts workers' labor supply in the absence of the UI scheme, leading to the following feasible non-parametric estimate of the behavioral response :

$$\widehat{\Delta H^*} = H^* - H_l$$
$$\text{where } H_l = \max\{H | F^f(H|B(h) = (B - \tau_b h).\mathbb{1}[h_t \geq h^*]) = F^b(H|B(h) = 0)\}$$

In practice, I calculate for each individual the number of hours worked over all possible 10-month periods from 2005 and 2014. Then for each one-hour bin, denoted j, I examine the difference between the French and the Belgian distributions:

$$\text{Hours}_{ij} = \alpha + \beta \text{ French}_i + \gamma X_i + \epsilon \tag{3}$$

where the dummy Hours_{ij} takes the value 1 if the individual i has worked j hours and the dummy French_i takes the value 1 if the individual i lives in France and the value 0 if she lives in Belgium. The vector X is a vector of control variables (share of hours worked in Paris, gender, age, occupation). The coefficient β measures the difference between the French and the Belgian distributions for bin j. The lower intersection H_l corresponds to the first bin j where the measured difference between the French and the Belgian distributions β is at least 1% and statistically significant at the 1% level.

5 Elasticity Estimates and Policy Impacts

5.1 Elasticity estimates

Hours-of-work elasticities can be obtained by estimating the behavioral responses $\widehat{\Delta H^*}$ from specification (4) and then applying the parametric relationship (1). The estimates of $\widehat{\Delta H^*}$ are illustrated in Figure 7.

[Figure 7]

The results are presented in Panel A of Table 5. I find that French arts workers are very

responsive to the scheme with a structural elasticity of 3.8 for artists and 4.3 for technicians, controlling for differences in individual characteristics. Standard errors are calculated using a bootstrap procedure in which is generated a large number of distributions (and associated estimates of each variable) by random re-sampling of a subset of all possible 10-month base periods between 2005 and 2014 ($\sim$ 2600 different 10-month base periods). The standard error of each variable is defined as the standard deviation in the distribution of estimates of the given variable. Unsurprisingly, the elasticities are precisely estimated since the French distribution remains stationary over the period between 2005 and 2014 (Figure 3).

[Table 5]

Panel B of Table 5 presents the sensitivity of the behavioral responses to the notch design. As expected, the eligibility cutoff and the level of benefits have a positive impact on the behavioral response while the taxation rate has a negative impact.

5.2 Policy impacts of strategic behaviors

Impact on the Unemployment Rate. Excess bunching and missing mass are estimated as the difference between French and Belgium distributions in the relevant hours-of-work ranges. Let H_u be the upper intersection between French and Belgian distributions. By mathematical construction of two distributions summing to 100, the condition $\widehat{M} = \widehat{B}$ is always verified.

$$\widehat{M} = \sum_{j=H_l}^{H^*} (F_j^f - F_j^b)$$
$$\widehat{B} = \sum_{j>H^*}^{H_u} (F_j^f - F_j^b)$$

Excess bunching and missing mass provide a direct measure of the impact of strategic behavior on unemployment:

$$\widehat{\Delta U} = \widehat{M} = -\widehat{B} > 0$$

Having estimated the point of divergence H_l, I use this estimate to non-parametrically identify the impact of strategic behavior on the unemployment rate. The results are presented in Panel C of Table 5. The results are quantitatively very large: strategic behaviors have increased the level of unemployment by 17 percentage points for artists and 35 percentage points for technicians, i.e. 27 percentage points overall. Given that the unemployment

rate has risen from 14% in 1980 to 45% in 2015, this implies that strategic behaviors explain 87% of the increase in the arts workers' unemployment rate since the 1980s.

Impact on the UI accounts. The shift in labor supply generates financial gains through increased contributions, denoted $\widehat{G}$, while the excess number of eligible arts workers gives rise to additional UI expenditures, denoted $\widehat{E}$. The overall impact on the UI accounts, $\widehat{\Delta AC}$, depends on the relative magnitude of these two effects.

$$\widehat{G} = \text{Number of arts workers } \times \sum_{j=0}^{H^{max}} \tau w j (F_j^f - F_j^b)$$

$$\widehat{E} = \text{Number of arts workers } \times \sum_{j=H^*}^{H^{max}} (10B - \tau_b j)(F_j^f - F_j^b)$$

$$\widehat{\Delta AC} = \widehat{G} - \widehat{E}$$

Likewise, the impact on UI accounts is very large: the negative balance due to strategic behaviors amounts to 0.5 billion euros over 10 month periods, namely 0.6 billion euros over a year. Given that the negative balance of the arts workers' UI system comes to 1 billion euros, this implies that strategic behaviors represent 60% of the actual deficit of arts workers' special UI system.

6 Conclusion

Notches are widespread in tax and transfer systems around the world, but have not been systematically explored in empirical work. Because they can provide large incentives to distort labor supply, they may imply large strategic behavioral responses. In this paper I show that eligibility notches have real consequences. The most striking finding is perhaps the quantitatively large impact of strategic behavior on the unemployment rate (+27 percentage points) and ultimately on the UI deficit (-0.6 billion per year). I emphasize that these results should be viewed as illustrative. They are specific to this particular context as well as to the modeling choices I have made. Nonetheless, they highlight an important and broader point: strategic behavior has large welfare costs. Given that notches are an unavoidable feature of UI systems, the issue of their optimal design appears central.

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7 Tables and Figures

Table 1: The arts workers' UI parameters in France (2003-2016)

Panel A: Artists

Claimants	Performing artists
Eligibility	507 hours of work in the past 10.5 months (318 days)
Daily benefits	A + B + C where: $A = b_{min} \cdot \frac{0.4 \times \text{Earnings until 12000 €} + 0.05 \times (\text{Total earnings - 12000 €})}{\text{Total hours} \times \text{Hourly minimum wage}}$ $B = b_{min} \cdot \frac{0.3 \times \text{Hours until 600 €} + 0.1 \times (\text{Total hours - 600 €})}{\text{Total hours}}$ C=70% $\times$ b_{min} with b_{min}= 31.36€ in 2014
Monthly benefits	B = 30 $\times$ Daily benefits
Benefit Duration	8 months (243 days)
Working while on claim	Partial Unemployment Benefits = $B - \tau_b h_t$ where: $\tau_b = \frac{1.3}{10} \times B/30$

Panel B: Technicians

Claimants	Workers and technicians editing sound recording, film and audiovisual production, radio, broadcast and entertainment
Eligibility	507 hours of work in the past 10 months (309 days)
Daily benefits	A + B + C where: $A = b_{min} \frac{0.5 \times \text{Earnings until 12000 €} + 0.05 \times (\text{Total earnings - 12000 €})}{\text{Total hours} \times \text{Hourly minimum wage}}$ $B = b_{min} \cdot \frac{0.3 \times \text{Hours until 600 €} + 0.1 \times (\text{Total hours - 600 €})}{\text{Total hours}}$ C=40% $\times$ b_{min} with b_{min}= 31.36€ in 2014
Monthly benefits	B = 30 $\times$ Daily benefits
Benefit Duration	8 months (243 days)
Working while on claim	Partial Unemployment Benefits = $B - \tau_b h_t$ where: $\tau_b = \frac{1.4}{8} \times B/30$

Notes: The daily benefit formula was different from 2003 to 2005. See Menger (2011) for an historical summary of the rules.

Table 2: Descriptive statistics (2014)

Variable	N	Mean	Std	Median
French arts workers				
Share of artists (full-time)	265579	0.597	0.490	1.00
Share of technicians (full-time)	265579	0.336	0.472	0.00
Share of male	265498	0.642	0.480	1.00
Age	244052	38.21	12.51	36.74
Wage rate	263310	182.073	916.757	18.103
Monthly hours of work	263377	31.322	35.672	13.666
Monthly wage	263377	3429.65	10569.34	534.199
Belgian arts workers				
Share of artists (full-time)	448	0.786	0.412	1.00
Share of technicians (full-time)	448	0.214	0.412	0.00
Share of male	444	0.669	0.471	1.00
Age	437	36.57	11.74	34.54
Wage rate	448	100.37	374.00	18.88
Monthly hours of work	448	11.00	3.00	19.36
Monthly wage	448	573.16	1545.36	83.33
UI eligible arts workers				
Share of job-seekers compensated as performing artists	112756	0.4556	0.498	0.0
Share of male	112756	0.6564	0.475	1.0
Age	112756	39.586	9.861	38.743
Wage rate	108320	19.724	11.313	16.761
Monthly hours of work	112756	56.647	33.611	55.50
Monthly wage	112756	1175.93	1130.42	888.69
Monthly potential benefits (i.e. w/o working)	112705	1492.33	509.481	1564.78
Monthly benefits	112756	950.418	345.449	1014.25
Monthly replacement rate	111968	1.665	1.315	1.549

Sources : Data on French and Belgium arts workers are computed from an administrative database on arts workers' contracts (*Attestation Employeur Mensuelle*). Data on claiming arts workers are computed from an administrative database on unemployment spells (*Fichier National des Allocataires*). Notes: For each individual, monthly measures are determined as the total amount of the measure of interest over one year divided by 12.

Table 3: Parameters

Parameters	Notation	Artists	Technicians
Notch point	H^*	507	
Monthly benefits	$B = q \times w \times 30$	48	
UI contributions	τ	0.09	
Taxation when working while on claim	τ_b	0.2	0.3

Table 4: Individual Characteristics for Belgium and French arts workers (2005-2014)

	Panel A : Artists		
	French artists	Belgium artists	
Individual Characteristics	Level	Level	Difference
Share of hours worked in Paris	0.592	0.472	0.120^{***}
			(0.0119)
Male	0.592	0.643	-0.051^{***}
			(0.0126)
Young	0.241	0.120	0.121^{***}
			(0.0111)
Primeage	0.549	0.689	-0.139^{***}
			(0.0129)
Senior	0.209	0.192	-0.018^{*}
			(0.0105)
Musicians	0.200	0.296	-0.096^{***}
			(0.0102)
Walk-on actors	0.043	0.009	0.034^{***}
			(0.0052)
Artists	0.128	0.352	-0.224^{***}
			(0.0085)
Comedians	0.067	0.096	-0.287^{***}
			(0.0064)
Actors	0.410	0.101	0.309^{***}
			(0.0125)
Dancers	0.032	0.038	-0.006
			(0.0045)
Other professions	0.108	0.171	0.012
			(0.0083)
Number of observations	580761	1544	

Source: Data on French and Belgium arts workers are computed from an administrative database on arts workers' contracts (*Attestation Employeur Mensuelle*).

	Panel B : Technicians		
	French artists	Belgium artists	
Individual Characteristics	Level	Level	Difference
Share of hours in Paris	0.618	0.789	-0.171^{***}
			(0.0244)
Male	0.669	0.555	0.114^{***}
			(0.0253)
Young	0.192	0.154	0.038^{*}
			(0.0214)
Primeage	0.671	0.672	0.001
			(0.0255)
Senior	0.138	0.175	-0.037^{**}
			(0.0187)
Assistants	0.088	0.034	0.054^{***}
			(0.0152)
Speakers	0.030	0.178	-0.148^{***}
			(0.0041)
Professions in realization	0.055	0.060	-0.005
			(0.0122)
Managers	0.086	0.049	0.038^{**}
			(0.0150)
Technicians	0.259	0.057	0.202^{***}
			(0.0235)
Other professions	0.479	0.619	-0.140^{***}
			(0.0267)

Source: Data on French and Belgium arts workers are computed from an administrative database on arts workers' contracts (*Attestation Employeur Mensuelle*).

Table 5: Results

Panel A: Estimated elasticities

		Artists		Technicians	
Elasticities	Notation	(1)	(2)	(1)	(2)
Hours of work response	ΔH^*	493^{***}	495^{***}	499^{**}	499^{**}
		(5.060)	(3.795)	(3.615)	(3.440)
Structural Elasticity	e	2.913^{***}	3.781^{***}	4.297^{***}	4.297^{***}
		(0.366)	(0.2745)	(0.4144)	(0.3832)

Panel B: Sensitivity of the behavioral responses to the notch design

		Artists		Technicians	
Sensitivity to...	Notation	(1)	(2)	(1)	(2)
...the eligibility cutoff	$\frac{d\Delta H^*}{dH^*}$	0.856^{***}	0.914^{***}	0.937^{***}	0.937^{***}
		(0.0246)	(0.0184)	(0.0201)	(0.0189)
...to the level of UB	$\frac{d\Delta H^*}{dB}$	0.726^{***}	0.466^{***}	0.352^{***}	0.352^{***}
		(0.1097)	(0.0823)	(0.0975)	(0.0917)
...to the taxation rate	$\frac{d\Delta H^*}{d\tau_b}$	-36.832^{***}	-23.636^{***}	-17.84^{***}	-17.84^{***}
		(5.564)	(4.172)	(4.938)	(4.649)

Panel C: Policy Impacts

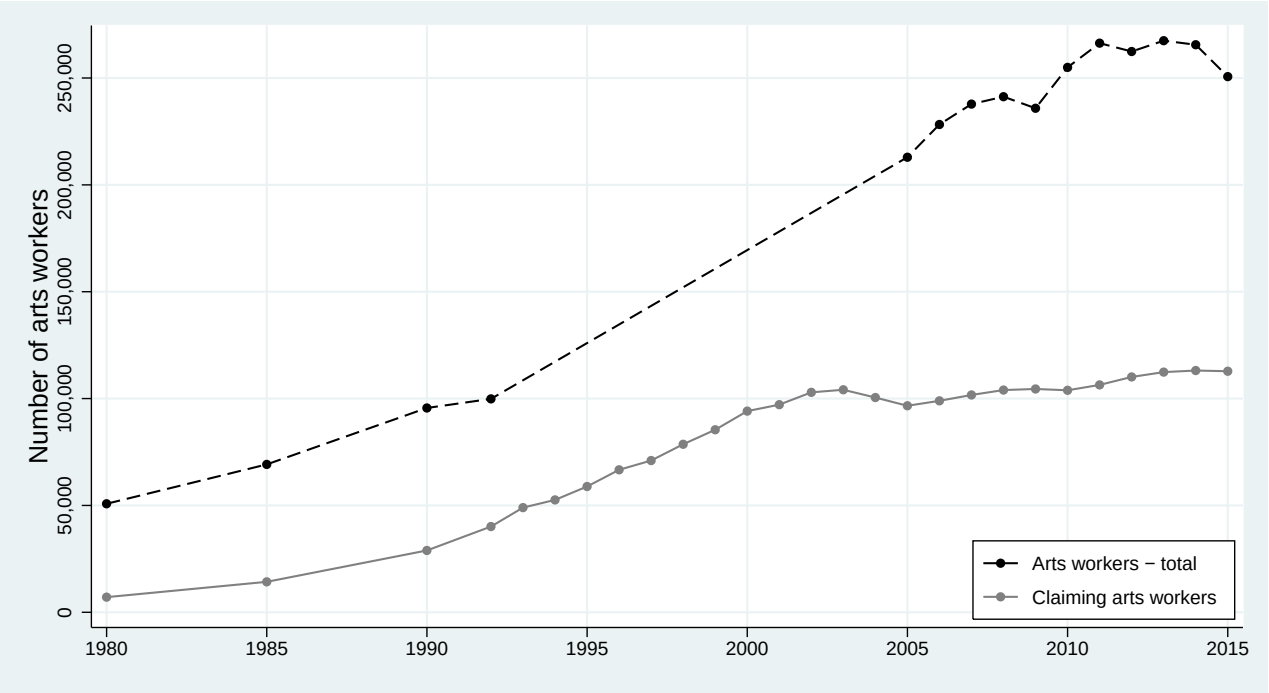
		Artists		Technicians	
Change in...	Notation	(1)	(2)	(1)	(2)
...Unemployment	$\widehat{\Delta U}$	$+15.76^{***}$	$+17.22^{***}$	$+35.24^{***}$	$+35.24^{***}$
		(0.6144)	(0.4608)	(0.9268)	(0.7585)
...UI accounts	$\widehat{\Delta AC}$	$-2.13.10^{8***}$	$-2.13.10^{8***}$	$-2.49.10^{8***}$	$-2.49.10^{8***}$
		$(2.75.10^5)$	$(2.75.10^5)$	$(6.44.10^5)$	$(6.44.10^5)$

Source: Data are computed from an administrative database on arts workers' contracts (*Attestation Employeur Mensuelle*).

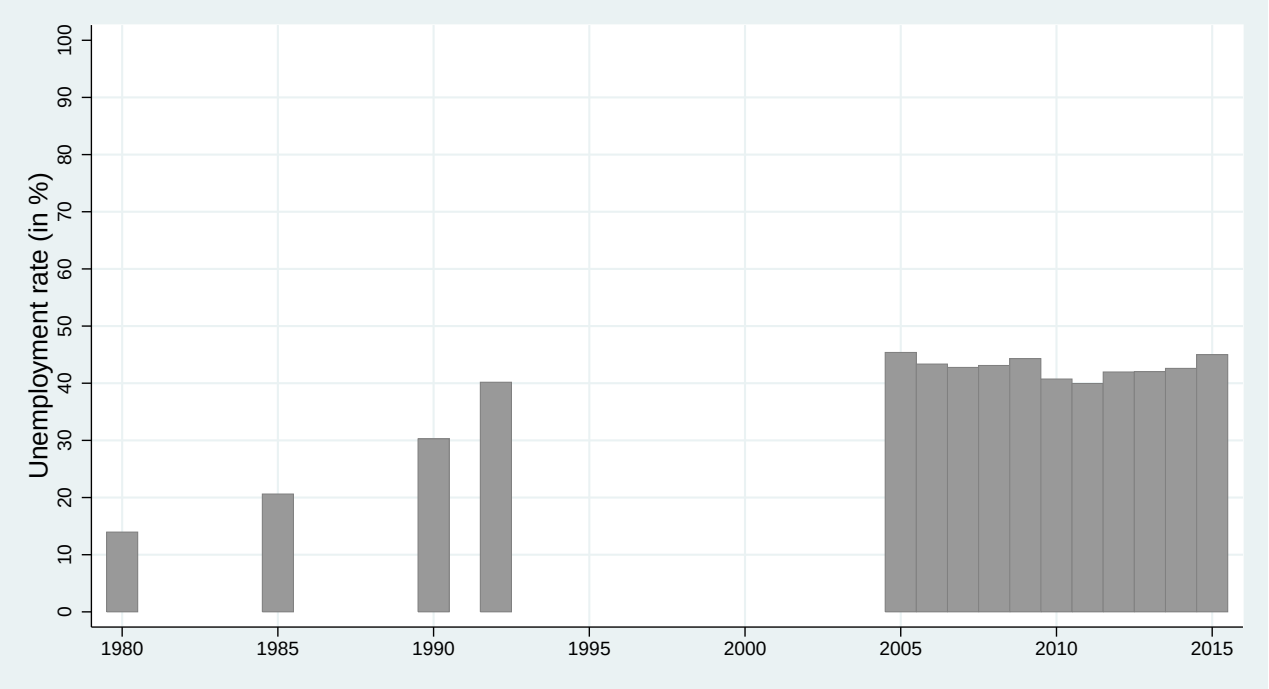
Notes : The table presents estimates of the elasticities (Panel A), the sensitivity of the behavioral responses to the notch design (Panel B) and the policy impacts (Panel C). The lower intersection between the French and the Belgian distribution is determined without any controls in column (1) and with controls on individual characteristics in column (2).

Figure 1: Employment and unemployment trends

Panel A: Number of arts workers

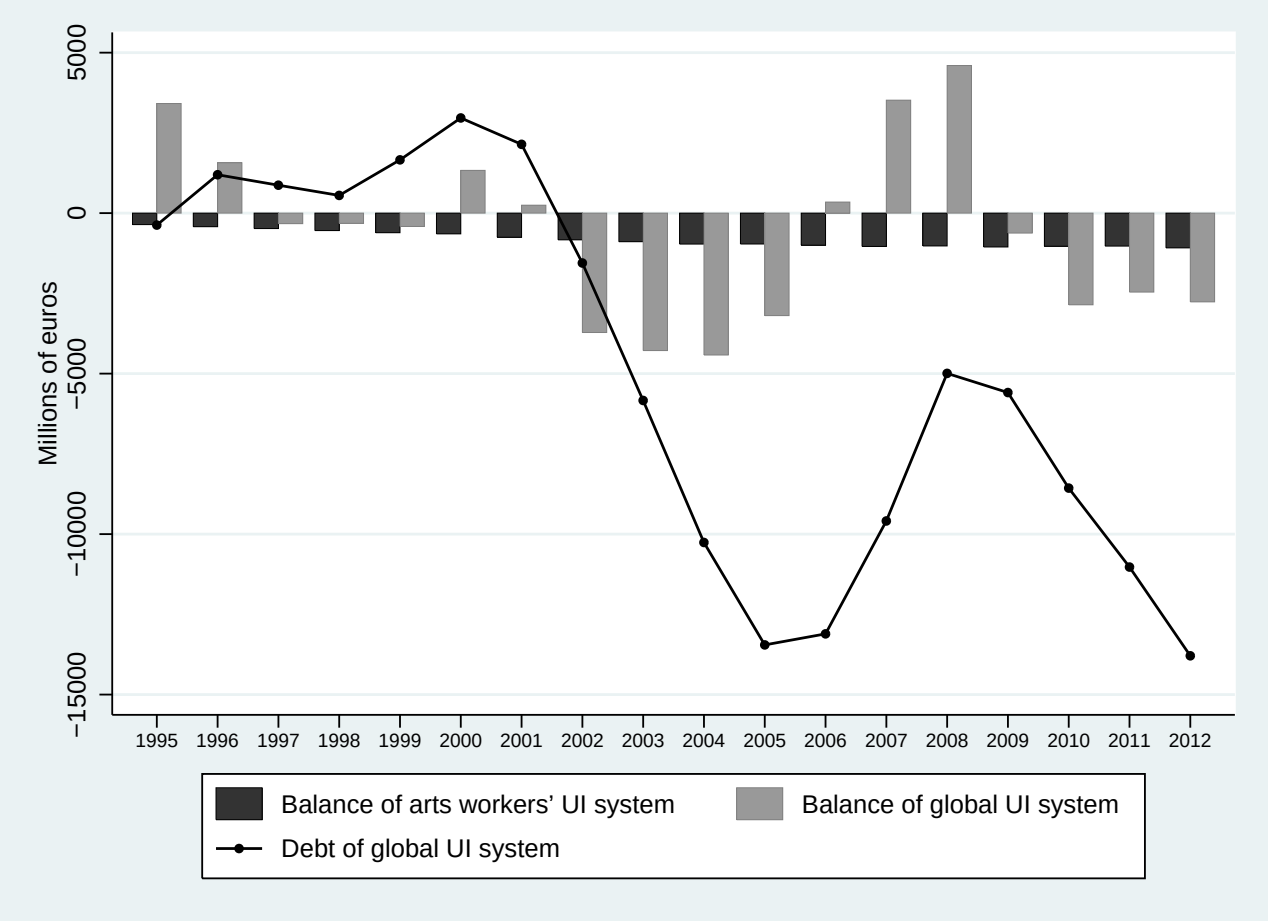


Panel B: Unemployment rate



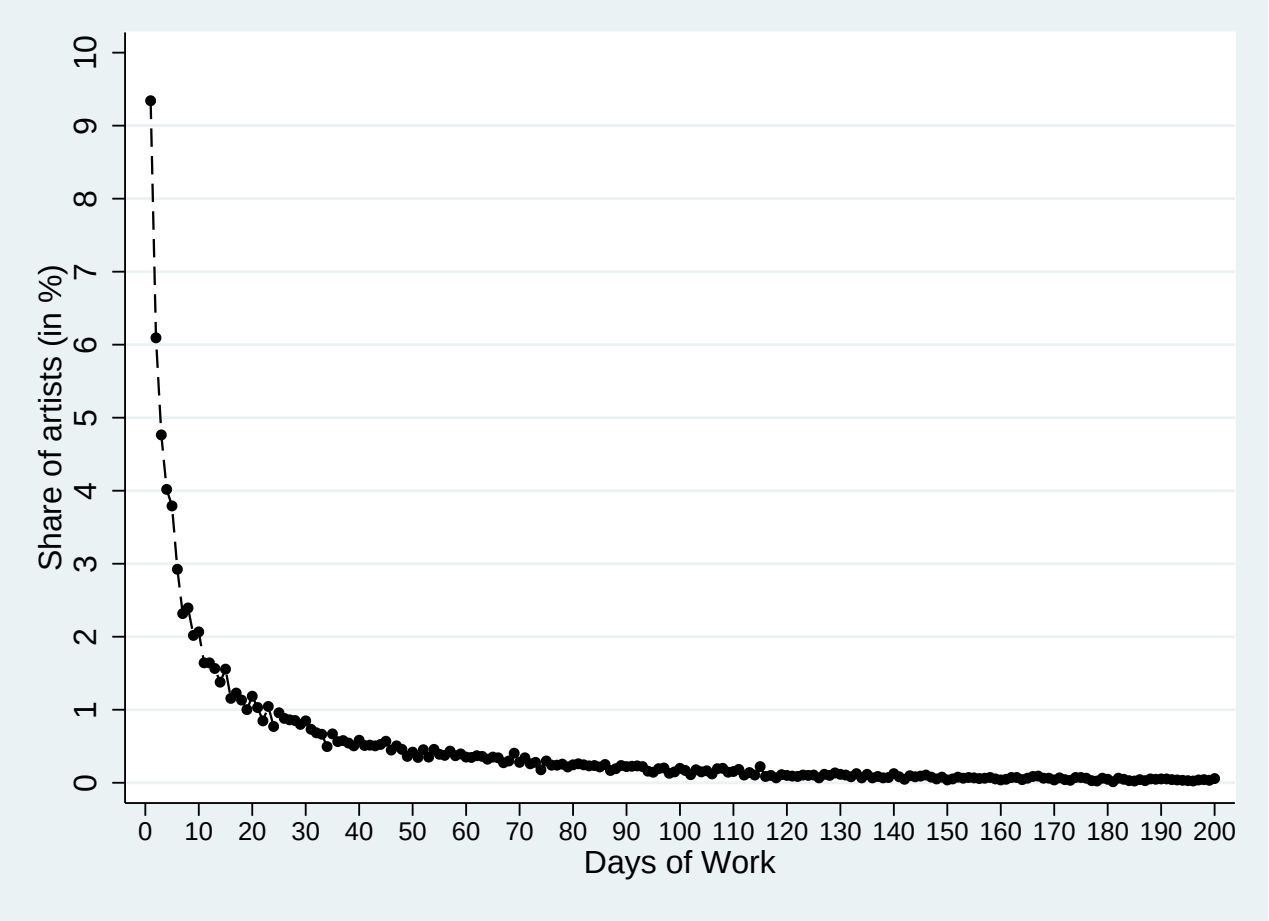
Sources : Data on claimants and non claimants over the 1980-1992 period stem from Menger and Gurgand (2011). Data on the total number of arts workers over the 2005-2015 period are computed from an administrative database on arts workers' contracts (*Attestation Employeur Mensuelle*). Data on claiming arts workers over the 1993-2015 period are computed from an administrative database on unemployment spells (*Fichier National des Allocataires*).
Notes: The unemployment rate is the ratio of the number of claiming arts workers over the total number of arts workers

Figure 2: UI accounts



Sources : Data on the debt and balance of the global UI system stem from Unédic (2016). Data on the balance of arts workers' UI system come from Cour des comptes (2007, 2012)

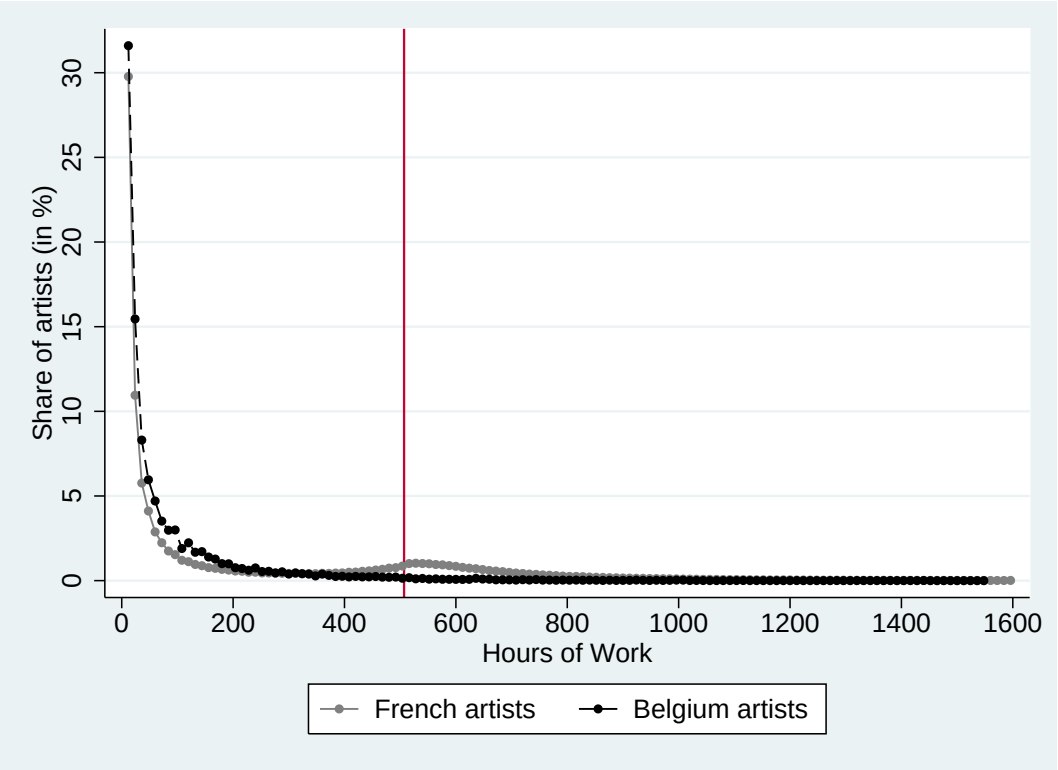
Figure 3: Absence of bunching for Belgian arts workers working in Belgium



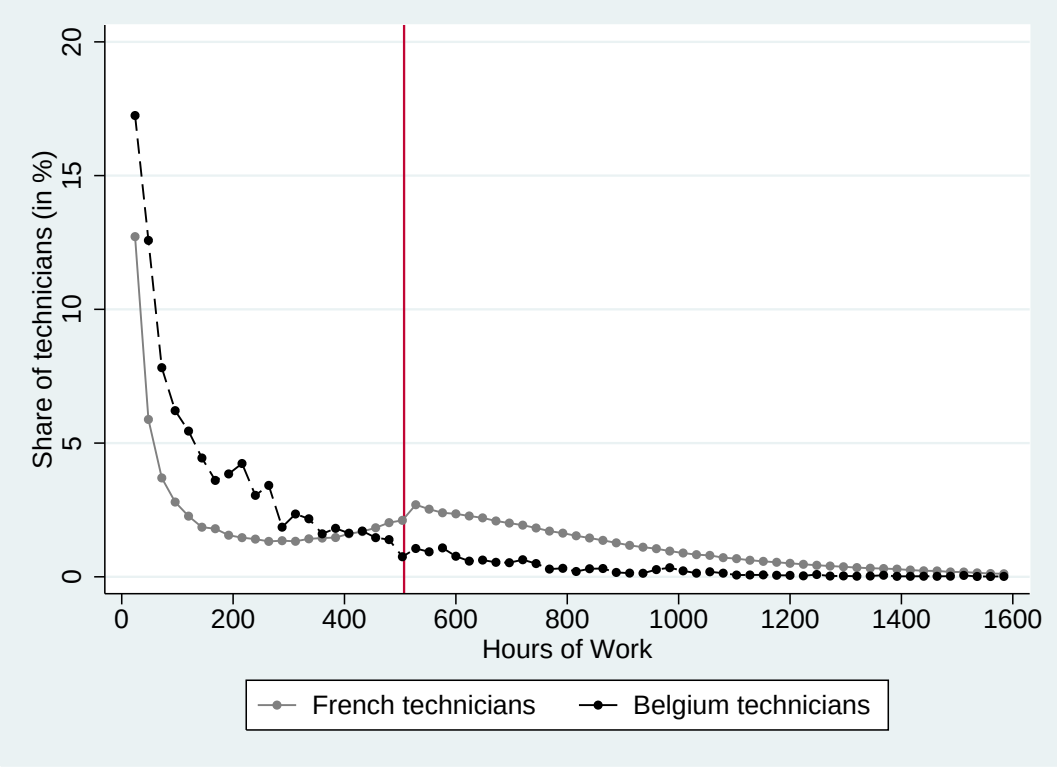
Source : Aggregated data on artists from the Belgian National Social Security Office.
Notes: According to the Belgian National Social Security Office, one day of work is equivalent to 7.6 hours of work.

Figure 4: Bunching for French arts workers vs. non-bunching for Belgian arts workers

Panel A: Artists



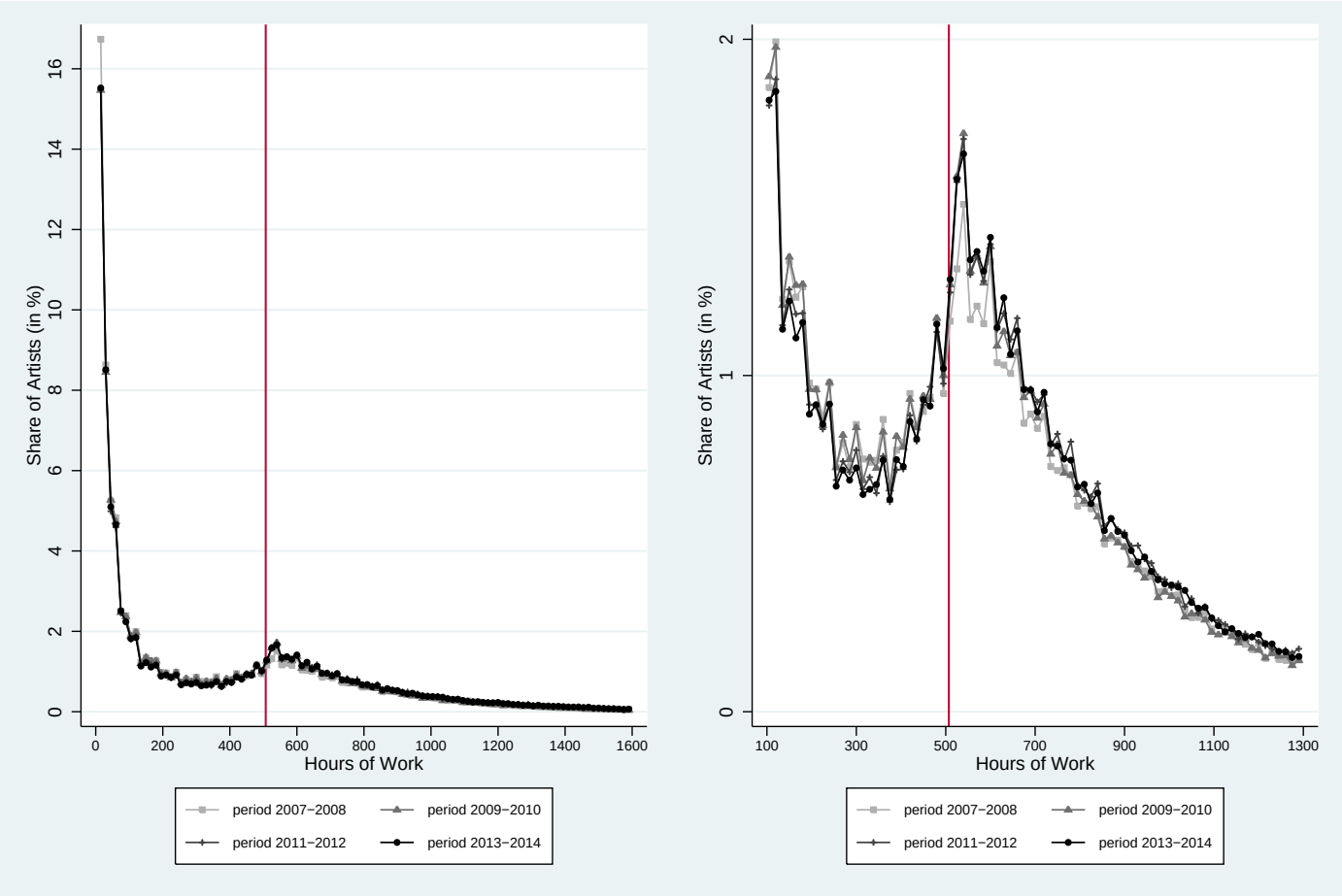
Panel B: Technicians



Source: Data on French and Belgium arts workers are computed from an administrative database on arts workers' contracts (*Attestation Employeur Mensuelle*).
Note: The vertical line indicates the 507-hour cutoff.

Figure 5: Stationary setting

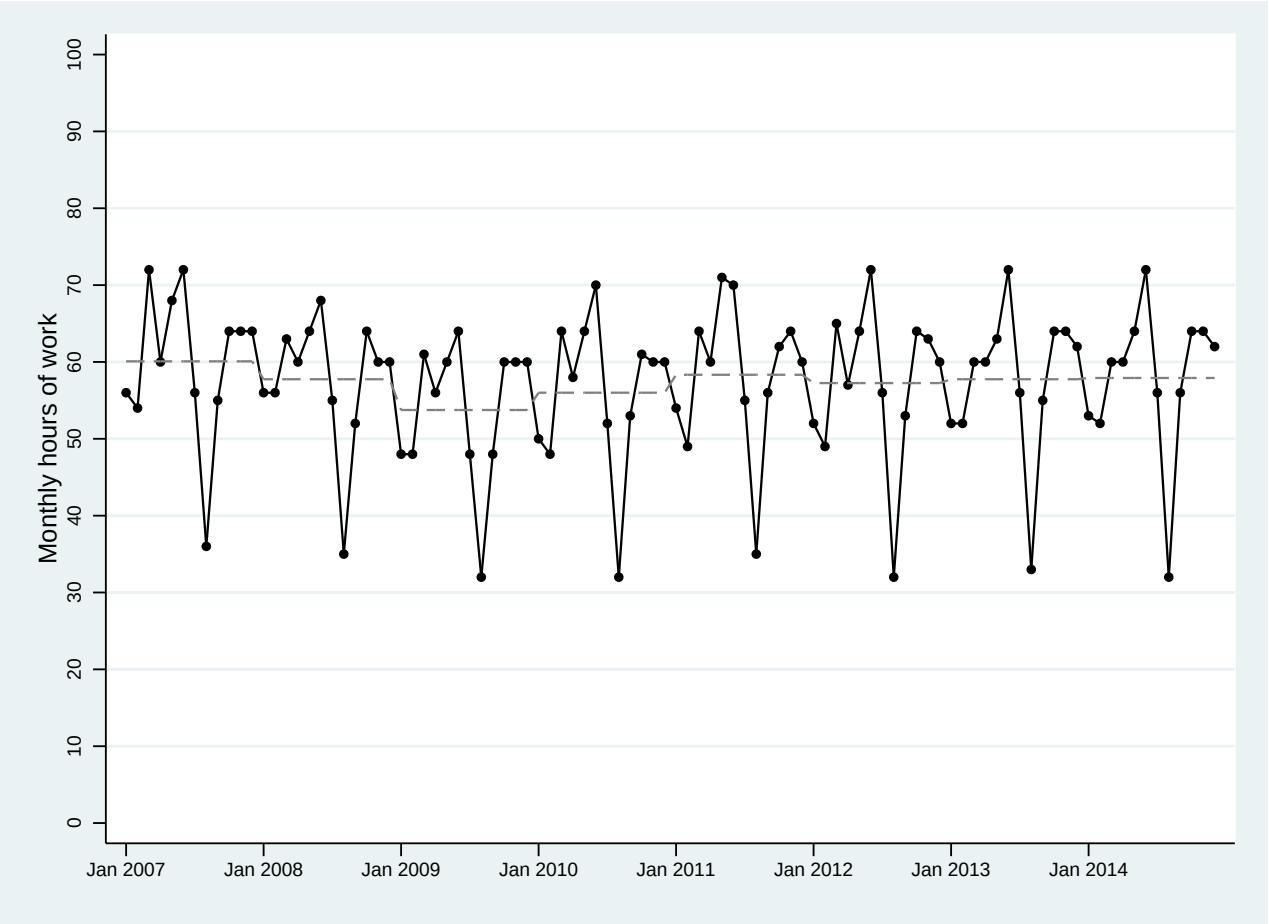
Panel A: Stationarity of bunching



Source: Data on French arts workers are computed from an administrative database on arts workers' contracts (*Attestation Employeur Mensuelle*).

Notes : The figures show the empirical distributions of worked hours for French arts workers (both artists and technicians) over all possible 10-month periods in 2007-2008, 2009-2010, 2011-2012 and 2013-2014. Bins are 12 hours. The notch point H^* is marked by a vertical solid line.

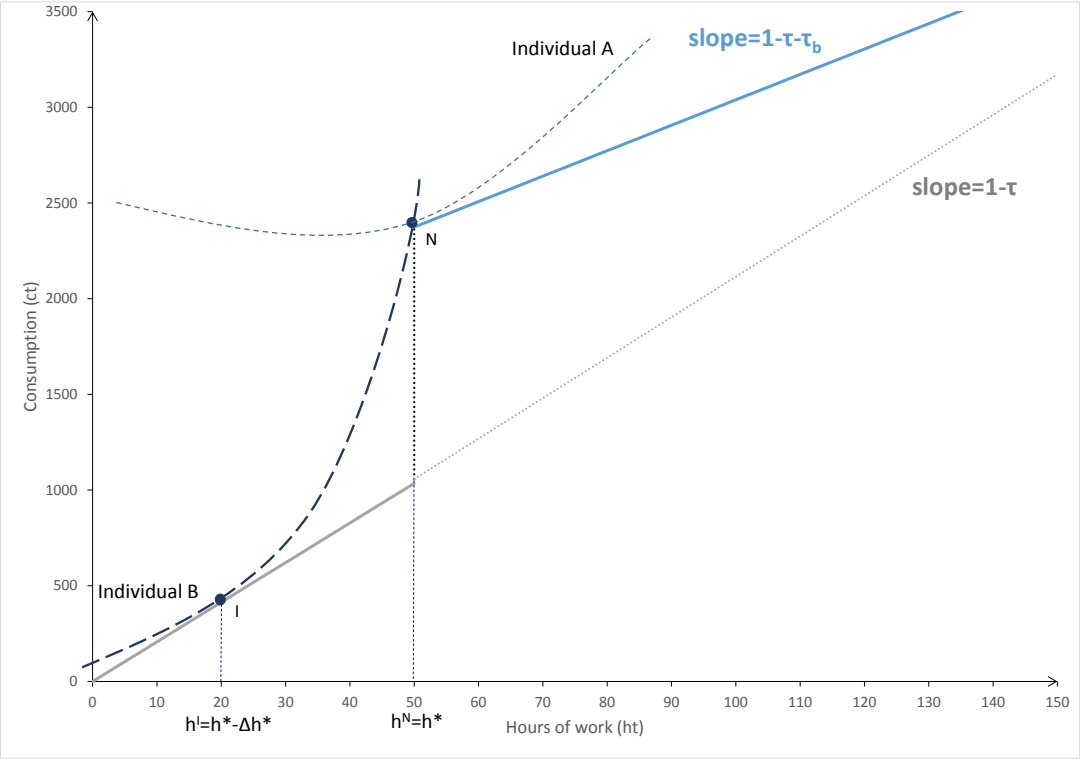
Panel B: Stationarity of hours of work



Source: Data on French arts workers are computed from an administrative database on arts workers' contracts (*Attestation Employeur Mensuelle*).
Notes : The figure shows the monthly and annual medians of hours worked for French arts workers (both artists and technicians)
.

Figure 6: Behavioral responses to an Eligibility Notch

Panel A: Budget set Diagram



Panel B: Density Distribution Diagram

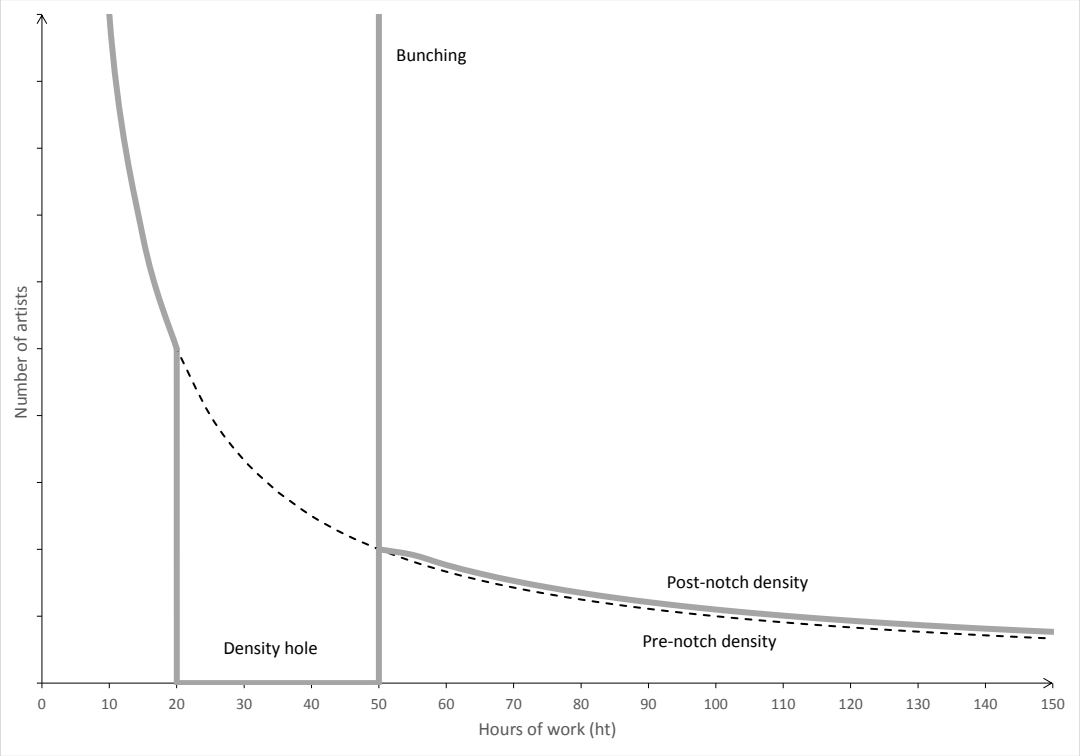
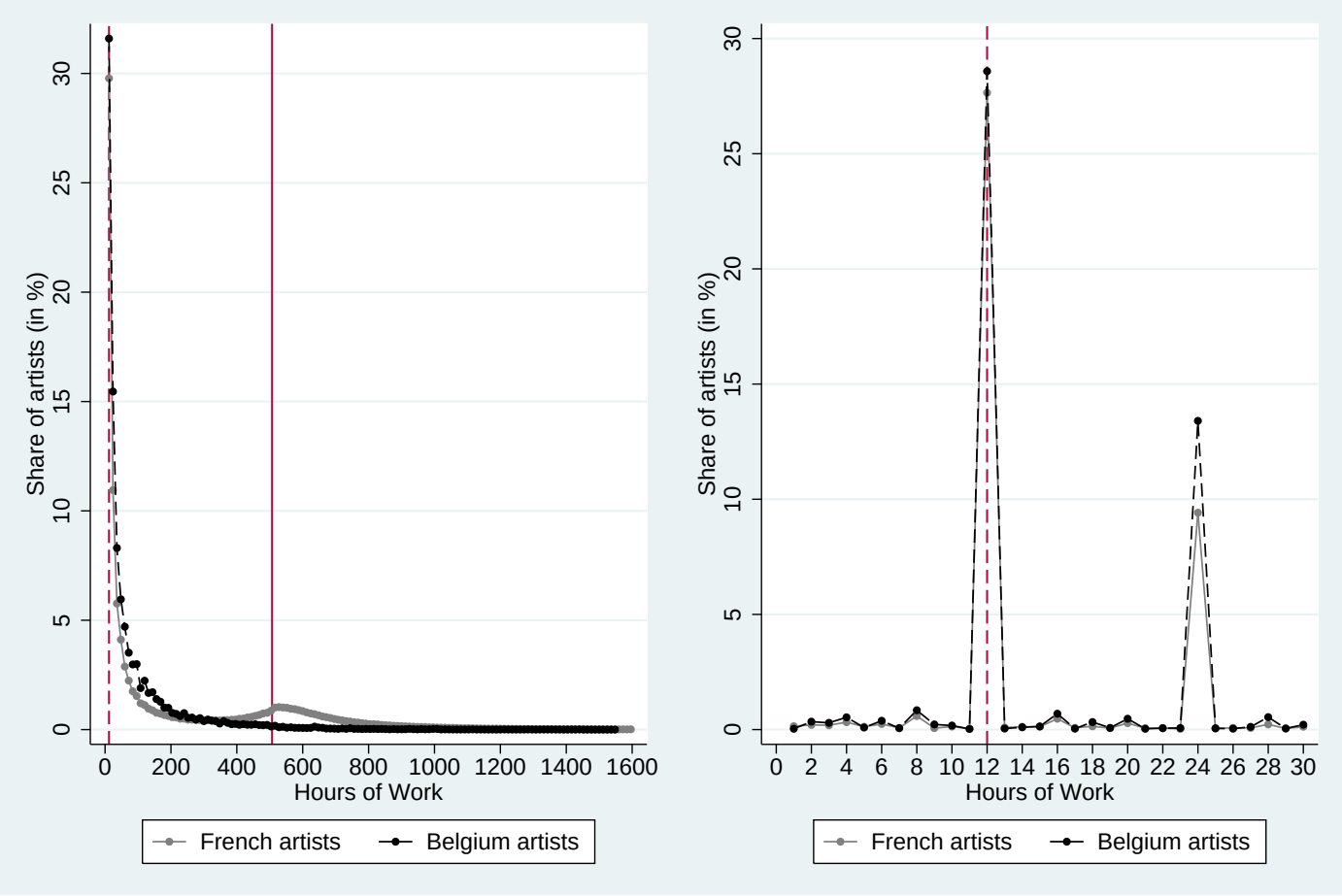


Figure 7: Determination of $\widehat{\Delta H^*}$

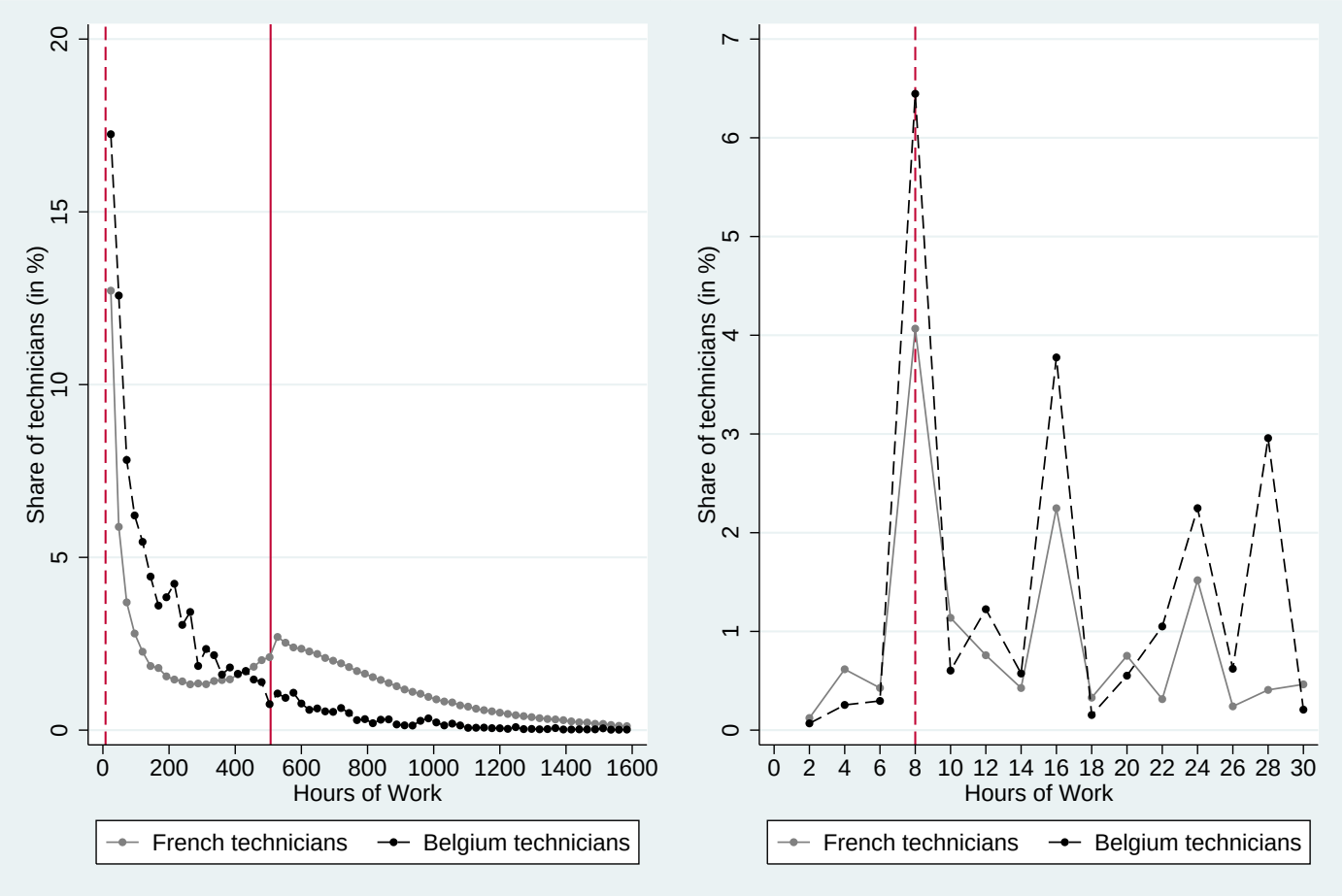
Panel A: Artists



Source: Data on French and Belgium arts workers are computed from an administrative database on arts workers' contracts (*Attestation Employeur Mensuelle*).

Notes : The figures show the empirical distributions of worked hours over all possible 10-month periods between 2005 and 2014 for French arts workers (solid gray graph) and Belgian arts workers (dashed black graph). The left-hand side figure plots the whole distribution with 12-hour bins while the right-hand side figure focuses on hours lower than 30 with bins of one hour. The notch point H^* is marked by a vertical solid line, lower intersection between the two distributions is marked by a vertical dashed line.

Panel B: Technicians



Source: Data on French and Belgium arts workers are computed from an administrative database on arts workers' contracts (*Attestation Employeur Mensuelle*).
Notes : The figures show the empirical distributions of worked hours over all possible 10-month periods between 2005 and 2014 for French arts workers (solid gray graph) and Belgian arts workers (dashed black graph). The left-hand side figure plots the whole distribution with 24-hour bins while the right-hand side figure focuses on hours lower than 30 with 2-hour bins. The notch point H^* is marked by a vertical solid line, lower intersection between the two distributions is marked by a vertical dashed line.

A - Model Solution

A.1 - Setup

Setup without the notch.

$$u(c_t, h_t) = c_t - (\frac{n}{1+1/e})(\frac{h_t}{n})^{1+1/e}$$

where c_t is consumption during month t, h_t are hours worked during month t, n is an ability parameter and e is the elasticity of labor supply with respect to wages.

$$c_t = z_t = (w - \tau).h_t = (1 - \tau).h_t$$

where z_t is after-tax earnings in month t, τ is the UI contribution rate and w is the hourly wage normalized to one.

Setup with the notch.

$$u(c_t, h_t) = c_t + B(h_t).\mathbb{1}[S_t > 0] - (\frac{n}{1+1/e})(\frac{h_t}{n})^{1+1/e}$$

$$c_t = \begin{cases} z_t + B(h_t) & \text{if } S_t > 0 \\ z_t & \text{otherwise} \end{cases}$$

$$B(h_t) = B - \tau_b.h_t$$

where B are unemployment benefits and $-\tau_b.h_t$ is the taxation of work while on claim.

$$S_{t+1} = \begin{cases} 0 & \text{if } 0 \leq S_t \leq B(h_t) \text{ and } H_t < H^* \\ S_t + S^{max} - B(h_t) & \text{if } 0 \leq S_t \leq B(h_t) \text{ and } H_t \geq H^* \\ S_t - B(h_t) & \text{if } S_t > B(h_t) \end{cases}$$

$$H_t = \sum_{\tau=0}^{9} h_{t-\tau} \text{ and } H^* = 507 \text{ hours of work}$$

where $S^{max} = 8.B$ is the initial UB capital, S_t is the remaining UB entitlements and $H_t = \sum_{j=0}^{9} h_{t-j}$ is the sum of hours of work in the past 10 months.

A.2 - Stationary solution

Stationary solution without the notch.

$$\max_{(c_t,h_t)} \sum_{t=0}^{\infty} \beta^t u(c_t, h_t)$$

$$\text{s.c. } c_t = (1-\tau).h_t$$

$$\max_{h_t} \sum_{t=0}^{\infty} \beta^t [(1-\tau).h_t - \frac{n}{1+1/e}(\frac{h_t}{n})^{1+1/e}]$$

$$(1-\tau) - (\frac{h_t}{n})^{1/e} = 0$$

$$h_t = n(1-\tau)^e \text{ or equivalently } H_t = 10.n(1-\tau)^e$$

Stationary solution with the notch.

$$\max_{(c_t,h_t)} \sum_{t=0}^{\infty} \beta^t u(c_t, h_t)$$

$$c_t = (1-\tau).h_t + B - \tau_b.h_t$$

$$S_{t+1} = S_t - B + \tau_b.h_t$$

$$L = \sum_{t=0}^{\infty} \{\beta^t [(1-\tau).h_t + B - \tau_b.h_t - \frac{n}{1+1/e}(\frac{h_t}{n})^{1+1/e}] + \lambda_t [S_t - B + \tau_b.h_t - S_{t+1}]\}$$

$$\frac{\partial L}{\partial h_t} = \beta^t [(1-\tau) - \tau_b - (\frac{h_t}{n})^{1/e}] + \lambda_t \frac{b_w}{n} = 0$$

$$\frac{\partial L}{\partial S_t} = \lambda_t - \lambda_{t-1} = 0$$

$$\lambda_t = \lambda_{t-1} \text{ implies that: } \beta(\frac{h_t}{n})^{1/e} = (\frac{h_{t-1}}{n})^{1/e} + (\beta - 1)(1 - \tau - \tau_b)$$

$$\text{If } h_t = h_{t-1} \text{ then: } h_t = n(1-\tau-\tau_b)^e \text{ and } H_t = 10.h_t$$

$$h_t = n(1-\tau-\tau_b)^e \text{ or equivalently } H_t = 10.n(1-\tau-\tau_b)^e$$

A.3 - Determination of the elasticity e

At the notch point $h^N = h^*$:

$$u_t^N = (1 - \tau - \tau_b).h^* + B - \frac{n^* - \Delta n^*}{1 + 1/e}(\frac{h^*}{n^* - \Delta n^*})^{1+1/e}$$

At the pre-notch location $h^I = h^* - \Delta h^*$:

$$\text{FOC: } h^I = h^* - \Delta h^* = (n^* - \Delta n^*)(1 - \tau)^e$$

$$u_t^I = (1 - \tau).h^I - \frac{n^* - \Delta n^*}{1 + 1/e}(\frac{h^I}{n^* - \Delta n^*})^{1+1/e}$$

$$u_t^I = (1 - \tau).h^I - \frac{n^* - \Delta n^*}{1 + 1/e}(1 - \tau).^{1+e} = (1 - \tau).h^I - \frac{1}{1 + 1/e}(1 - \tau).h^I = (1 - \tau).h^I \frac{1}{1 + e}$$

This individual is indifferent between the notch point and his pre-notch location :

$$u_t^N = u_t^I$$

$$(1 - \tau - \tau_b).h^* + B - \frac{1}{1 + 1/e}(h^* - \Delta h^*)\frac{1}{(1 - \tau)^e}(\frac{(1 - \tau)^e h^*}{h^* - \Delta h^*})^{1+1/e} = (1 - \tau)(h^* - \Delta h^*)\frac{1}{1 + e}$$

$$(1 - \tau - \tau_b).h^* + B - \frac{(1 - \tau).h^*}{1 + 1/e}(\frac{h^*}{h^* - \Delta h^*})^{1/e} = (1 - \tau)(h^* - \Delta h^*)\frac{1}{1 + e}$$

$$(1 - \tau - \tau_b) + \frac{B}{h^*} - \frac{(1 - \tau)}{1 + 1/e}(\frac{1}{1 - \Delta h^*/h^*})^{1/e} = (1 - \tau)(1 - \Delta h^*/h^*)\frac{1}{1 + e}$$

I can rearrange terms so as to obtain :

$$(1 - \tau)(1 - \Delta h^*/h^*) + e(1 - \tau)(1 - \Delta h^*/h^*)^{-1/e} - (1 + e)(1 - \tau - \tau_b + \frac{B}{h^*}) = 0$$

From the relationship $H^* = 10.h^*$:

$$(1 - \tau)(1 - \Delta H^*/H^*) + e(1 - \tau)(1 - \Delta H^*/H^*)^{-1/e} - (1 + e)(1 - \tau - \tau_b + \frac{10.B}{H^*}) = 0$$

A.4 - Comparative statistics

In this appendix, I analyse the impact of the elegibility criteria H^*, the level of benefits B and the taxation rate when woriking while on claim τ_b on the behavioral response, captured by ΔH^*. To investigate the impact of these parameters, let us apply the implicit function theorem to equation (1) determining the elasticity e :

$$f(\Delta H, B, H, \tau) = (1-\tau)(1-\Delta H^*/H^*)+e(1-\tau)(1-\Delta H^*/H^*)^{-1/e}-(1+e)(1-\tau-\tau_b+\frac{10.B}{H^*}) = 0$$

$$\begin{aligned}
\frac{d\Delta H}{dB} &= -\frac{\frac{\partial f}{\partial B}}{\frac{\partial f}{\partial \Delta H}} \\
&= -\frac{-(1+e)\times 10/H}{-(1-\tau)/H + e(1-\tau)\times(-1/H)\times(-1/e)\times(1-\Delta H/H)^{-1-1/e}} \\
&= -\frac{-(1+e)\times 10/H}{-(1-\tau)/H + (1-\tau)/H\times(1-\Delta H/H)^{-1-1/e}} \\
&= -\frac{10(1+e)}{(1-\tau)-(1-\tau)(1-\Delta H/H)^{-1-1/e}} \\
&= -\frac{10(1+e)}{(1-\tau)[1-(1-\Delta H/H)^{-1-1/e}]}
\end{aligned}$$

$$\begin{aligned}
\frac{d\Delta H}{d\tau_b} &= -\frac{\frac{\partial f}{\partial \tau_b}}{\frac{\partial f}{\partial \Delta H}} \\
&= \frac{(1+e)H}{(1-\tau)[1-(1-\Delta H/H)^{-1-1/e}]}
\end{aligned}$$

$$\begin{aligned}
\frac{d\Delta H}{dH} &= -\frac{\frac{\partial f}{\partial H}}{\frac{\partial f}{\partial \Delta H}} \\
&= -\frac{(1-\tau)\Delta H/H^2 + e(1-\tau)\times(-1/e)\times(\Delta H/H^2)(1-\Delta H/H)^{-1/e-1} - (1+e)\times(-10B/H^2)}{-(1-\tau)/H + e(1-\tau)(-1/e)\times(-1/H)(1-\Delta H/H)^{-1-1/e}} \\
&= \frac{(1-\tau)\Delta H/H[1-(1-\Delta H/H)^{-1-1/e}] + (1+e)\times(10B/H)}{(1-\tau)[1-(1-\Delta H/H)^{-1-1/e}]}
\end{aligned}$$