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Jobless recoveries
no jobs for the unemployed, longer hours for workers?

Delmez, Françoise

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Françoise Delmez

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Supervisor
Professor Alain de Crombrugghe, University of Namur

Jury members
Doctor Grégory de Walque, National Bank of Belgium
Professor Mathias Hungerbühler, University of Namur
Professor Céline Poilly, University of Aix-Marseille
Professor Vincent Vandenberghe, UCLouvain

President
Professor Jean-Marie Baland, University of Namur

Rempart de la Vierge, 13
B - 5000 Namur (Belgique)

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Preface

Le chercheur en science humaine jouit d'une réputation de solitaire comparé à son collègue de science exacte. Et pourtant, derrière des articles signés par un ou deux auteurs, se cachent une myriade de petites et grande collaborations. En particulier, cette thèse est le résultat non seulement de collaborations formelles avec deux co-auteurs, Vincent Vandenberghe et Mathias Hungerbühler, mais aussi de nombreuses collaborations plus ou moins formelles, de soutien, de coups de pouce, d'aide ponctuelle (éventuellement récurrente), d'inspiration venant de nombreuses autres personnes, à Namur et ailleurs. En premier lieu, le rôle de promoteur a beau être formalisé sur papier, dans les faits il existe autant de surpervisions que de promoteurs. Ainsi mon promoteur, Alain de Crombrugghe, a été une pierre angulaire de ce travail de thèse tout en sachant me laisser une grande liberté de recherche, si chère aux académiques. C'est sur base d'une proposition de mémoire de sa part, portant sur les récessions dite en W, ou *double dip*, qu'est née la recherche qui a servi de base à la rédaction d'un projet financé par le FNRS et au premier chapitre de cette thèse. Malgré que mes recherches aient pris une direction autre, plus *labour* et moins *finance*, il est resté enthousiaste et prêt à discuter des résultats quels qu'ils soient, apportant son soutien à toutes mes initiatives. En dehors de la recherche, il m'a aussi donné l'occasion de faire mes armes dans l'enseignement en partageant avec moi la responsabilité de mener à bien le projet de classe inversée pour le cours d'introduction à l'économie.

Ma recherche a aussi certainement bénéficié des conseils avisés de mon jury dont je remercie chacun des membres, à commencer par le président Jean-Marie Baland, Grégory de Walque, Céline Poilly et mes deux co-auteurs sus-mentionnés. Au quotidien, ce sont surtout mes collègues qui ont été d'un soutien sans faille, toujours prêts aussi à célébrer une bonne nouvelle ou partager un gâteau. D'abord ceux (et surtout celles) avec qui j'ai eu la chancer de partager mon bureau: Isabelle, Anders, Marie-Sophie et Camille. Ensuite ceux et celles qui ont fait avant moi la démonstration qu'il existe autant de manières de faire une thèse que de doctorants: Ombeline, Elias, Isabelle, Joaquin, Alexandre, François, Wouter, Giulia, Elena, Nicolas, Astrid, Kelbesa, Jolan, Hélène, Olivier et Jérémie. Ceux aussi qui m'ont rappelé que faire une thèse était un choix parmi d'autres: Matteo, Caroline, Charlotte, Mathieu, Marie-Sophie. Ceux finalement qui ont suivi de près les hauts et les bas inhérents aux derniers mois de thèse: Camille, Modeste, Henri, Joey, Ludovic, Stéphanie, Rinchan et les derniers arrivés Marie, Pierre, Auguste, Luca et Paola ainsi que mes récents collègues néo-louvanistes. Une pensée partculière pour ceux qui souffrirent avec moi des déboires quotidiens de la SNCB. Un merci particulier à Pierrette pour sa disponibilité, son calme, et sa capacité à répondre inlassablement aux questions en tout genre quant au fameux parcours doctoral.

Enfin un gros kusje à mon entourage. Mes parents pour leur compréhension des méandres de l'université. Mes beaux-parents pour leur inlassables tentatives de comprendre en quoi consiste mon job. Et tout particulièrement

Robin qui y a toujours cru plus que moi, qui a mis la main à la pâte, ou plus précisément au code, à de multiples reprises et qui fait mine de comprendre que l'hétéroscédasticité et la non-stationnarité soient à même de générer des nuits sans sommeil.

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Chapter 1

Jobless recoveries after financial crises (and the key role of the extensive margin of employment)

Using a dynamic panel of 15 developed countries over the 1960-2010 period, this paper compares employment and hours recovery paths after financial vs. non-financial crises. We show that post financial crises recoveries display a stronger uplift of individual hours and a weaker one of the employment rate. The results are robust to controlling for the strength of the recovery in terms of GDP growth per capita, the depth of the preceeding recession, labour-market institutions differences potentially correlated with financial vs non-financial crises and for dynamic panel bias. In conclusion, we argue that considering both margins of employment, in particular the role of extended hours in coping with rising output, improves our understanding of financial crises as a source of jobless recoveries.

Keywords: *Financial crises, jobless recoveries, employment, working time.*

1.1 Introduction

Bad news regarding employment have received large and continuous media coverage ever since the recent recession episodes of 2008 and 2012. Reports of sluggish employment growth kept coming even when gross domestic product and other indicators, such as investments, displayed signs of recovery. This phenomenon where an economy GDP experiences growth while maintaining or decreasing its level of employment has been coined "jobless recovery" in the literature since it was first documented in the US the early 1990's. A jobless recovery is usually defined as a recovery displaying a slower growth of employment than would be predicted by historical data. Specifically, during jobless recoveries, the growth of the employment rate is delayed with respect to the growth of GDP, beyond the mere lag attributable to frictions on the labour market.

Economists still debate to determine whether (and why) recoveries in the US are more prone to joblessness than in the past (Graetz & Michaels, 2017). What motivates this paper is that there is international evidence of large variability in the paths of employment recovery after recession episodes. For example, Figure 1.1 presents the recovery path (growth rate since the trough) of the employment rate (share of people who declare holding a job among the 16-64 population) after each recession episode in the period from 1960 to 2010 for the US, Germany and Sweden. While some recoveries display a strong rebound of the employment rate, in other cases it keeps plummeting for many quarters after the GDP starts picking up. In this paper, the timing of the economic cycle always refers to the GDP growth rate per capita: peaks and troughs refer to the GDP such that the term "recovery" always refers to the period after the trough and before the next peak and the term "recession" refers to the period from after the peak until the through.

The determinants of the path of recovery of the employment rate have been studied by a broad literature in the past. In particular, the role of financial crises in determining the speed of recovery of employment relative to GDP has attracted a lot of attention. While some authors conclude that financial crises negatively impact the growth of employment, other reach the opposite conclusion. For instance, the direct dependance of employment on credit through the cost of opening a vacancy or the need for working capital is documented

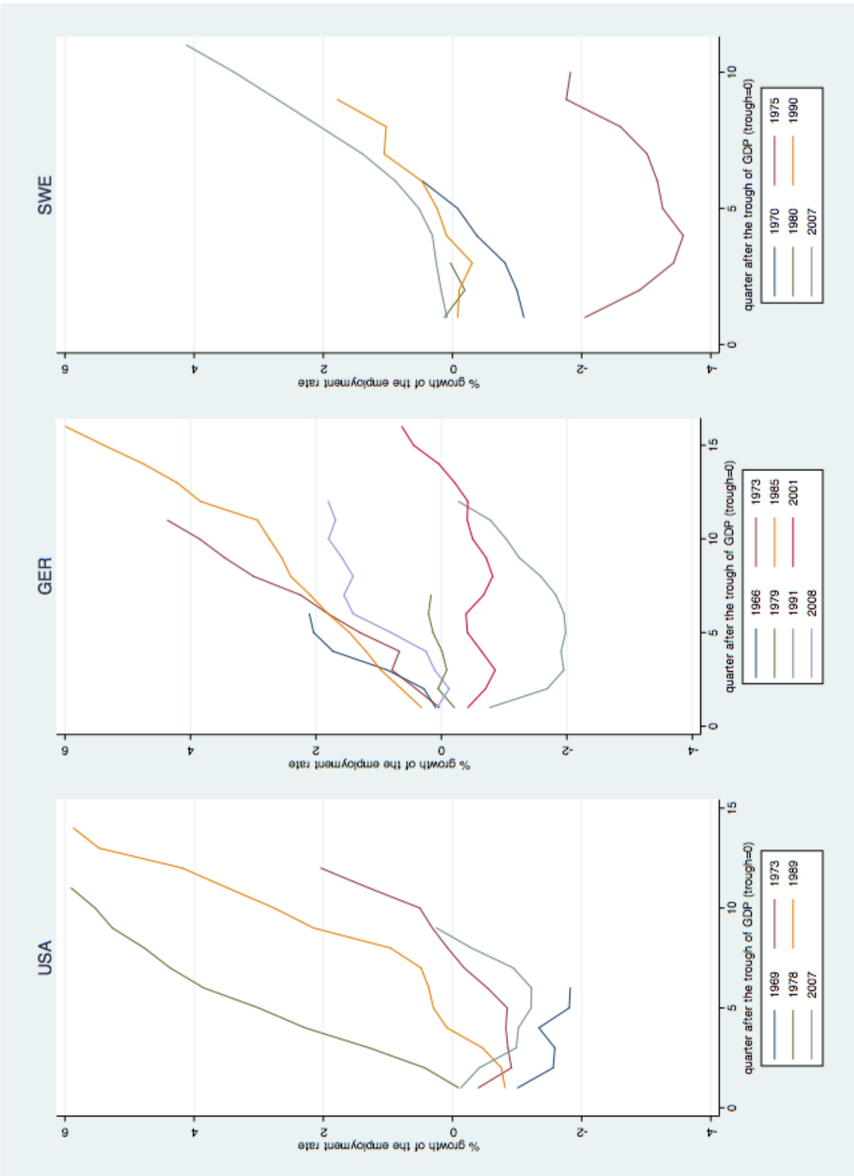

Figure 1.1: Joblessness in the data: growth rate of the employment rate in the quarters following a through, normalized to 0 at the through, for the USA, Germany and Sweden.

by Boustanifar (2014), Pagano & Pica (2012), Dromel *et al.* (2010), Wasmer & Weil (2004)). Amplification of labour market variations by agency costs on credit markets are documented by Petrosky-Nadeau (2014)) and the absence of collateral on employment is the cornerstone in Calvo *et al.*(2012). All these studies conclude to a negative impact of financial frictions on employment. On the opposite, Gali, Smets and Wouters (2007) conclude that financial crises do not cause total hours (the sum of individual hours) to grow significantly more slowly. They show that in the United States, total hours worked do not behave differently accross recoveries taking the usual control variables into account, especially output growth.

It can be noticed that all papers concluding that financial crises signficantly impact employment use an extensive margin definition (jobs created), whereas Gali, Smets and Wouters, who obtain opposite conclusions, use the total number of hours worked. The contribution of this paper is to study both margins in parallel. The option taken in this research is to simultaneoulsy explore the employment rate and the individual hours of work. The database of Ohanian and Raffo is well suited to this approach, as it comprises two separately estimated series for the employment rate and for individual hours of work (total hours worked are also available in their dataset and are computed by combining both the employment rate and individual hours). Importantly, the measure of individual hours is based on surveys and therefore allows to capture unpaid overtime. We suspect that financial crises do not impact the extensive and in the intensive margin of labour in the same way. In particular, we expect recessions caused by financial crises to translate into a lower propensity of firms to recruit and an overall tendency to raise hours. For instance, looking at two recessions taken in our dataset, we present in Figure 1.2 the recovery path of both the employment rate and individual hours for the USA in 1973 and Sweden in 1990. The relatively weak job recovery appears to be stronlgy compensated by a strong recovery in individual hours.

A careful disctinction between the behaviour of the employment rate of the labour force (extensive margin) and the behaviour of the individual hours of the workers (intensive margin) in a recovery generates two types of consequences. First, the existence of different types of recoveries has important welfare and policy implications for workers. Divergences in hours and employment across recoveries and across countries are likely to affect the distribution of income and as well as the activation of unemployment benefits and other social ex-

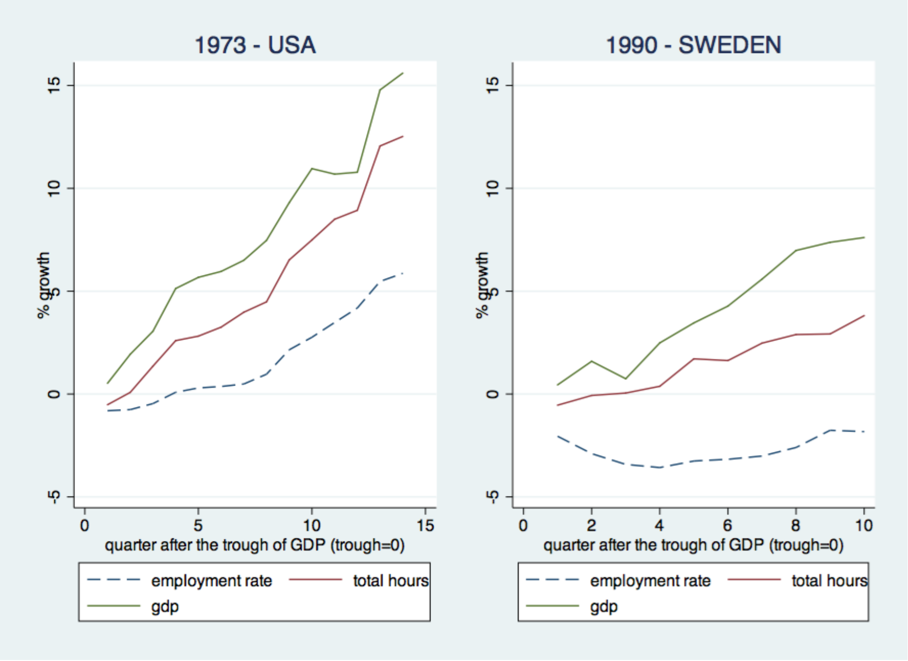

Figure 1.2: Joblessness in the data: growth rate of the employment rate and of individual hours of work in the quarters following the through, normalized to 0 at the through, for recession episodes in the USA-1973 and Sweden-1990.

penditure schemes. Second, empirically, this distinction creates room for a better understanding of the relation between output growth and labour inputs. Showing how hours diverge from employment helps solve the paradox of labour productivity differentials observed across recoveries. Previously, work by Petrosky-Nadeau (2013) and Berger (2012) pointed to productivity-enhancing restructuring during recoveries. Jobless recoveries, they point out, tend to display a higher level of productivity per worker. They argue that this is due to the less capable workers being fired, the less productive plants closing, or a higher productivity level needed to launch a new business. These mechanisms are able to explain (and link) the higher productivity and lower employment rate observed together in some jobless recoveries. We argue that besides those previously highlighted mechanisms, it could also be the case that more hours per worker, that can at least partially consist in unpaid overtime, raise the observed productivity per worker and at the same time generate joblessness, as more individual hours substitute in for hiring new workers. Evidences of a stronger individual effort during bad times have been measured at the firm level by Lazear *et al.* (2016). As our series on individual working time is based on surveys, we are confident that it will capture unpaid overtime that can be considered as effort put on by the worker to avoid loosing their job. Our measure of the intensive margin (individual hours of work) thus captures parlty worker-level productivity. We are also convinced that in the quarters following the trough of GDP, high unemployment rates maintain the incentive needed for the extra effort. In fact, during recoveries that display high unemployment and low job creation, the incentives to put on extra effort to avoid loosing one's job, as in Lazear's story, are still very high.

This paper thus adresses the question of whether financial crises are a significant determinant of the recovery of the employment rate and in parallel whether they have a similar impact on individual hours of work. Let us therefore call recoveries following financial crises "jobless" if they display a weaker growth of the employment rate than recoveries following non-financial crises. Specifically, this paper uses the comparison between financial and non-financial crises to assess the hypothesis that financial constraints, during the early stages of a recovery may lead firms to favour longer hours over recruitment; and thus explain why financial crises are followed by jobless recoveries. Obviously, financial crises are different from non-financial crises regarding many other aspects than the employment rate and individual hours of work. We develop different strategies to control for all other aspects of the economy (length, size and other characteristics of the recession, timing, strength and other characteristics of the recovery and structural characteristics (labour market institutions, . . .) of the economy). We present what we believe is a new stylized fact regarding jobless recoveries and financial crises: while we confirm previous findings that financial crises tend to delay the rebound of the employment rate, we also find that individual hours of work tend to grow at a stronger pace following financial crises. This new stylized fact is based on all economic cycles observed in 15 developed countries from 1960 to 2010.

The paper is then organized as follows. Section 1.2 presents the dataset. It describes the length and size of GDP cycles, the employment and hours data of Ohanian and Raffo (2012), financial vs. non-financial crises (relying on the data and classification of Reinhart and Rogoff (2009) and of Laeven and Valencia (2012)) and other determinants of labour market outcomes. Section 1.3 explains the empirical strategy, a dynamic panel estimation that takes into account the timing of the events within the cycle. Section 1.4 presents the estimation results of the behaviours of employment rate and individual hours of work during 140 episodes of economic recovery experienced by 15 advanced economies between 1960 and 2010. Section 1.5 concludes.

1.2 Data

Cycles and GDP The evidence presented in this paper is based on quarterly time series for 15 countries[1] over 50 years (1960 to 2010) leading to a total of 2462 observations (the dataset is mainly restricted by the availability of harmonized hours of work series) constituting 140 distinct cycles. Each cycle is made of a recession (or contraction) and of a recovery period that will form the focal point of this paper. For simplicity of exposure, we always refer to the period between peak and through as "the recession", even when the GDP growth rate only slows down and generates a mere "contraction" instead of a true "recession". Among the 140 cycles, 63 display a true recession (GDP (per capita) decreases from peak to trough) and 77 display a contraction (GDP (per capita) grows at a slower rate). Summary statistics on cycles are given in Tables 1.1 and 1.2 where the recession's length counts the number of quarters from peak to trough and the recession's depth measures the growth rate of GDP from peak to trough. Peaks and throughs dates are extracted from the cycle dating series of the OECD.

	mean	sd	min	max
Annual individual hours worked	1,876	290.5	1,314	2,845
Employment rate	63.53	15.33	55.6	83.11
GDP per capita peak to trough growth rate (recession size)	0.469	4.761	-14.54	23.01
Number of quarter from peak to trough (recession length)	7.828	3.905	2	19

Table 1.1: Descriptive statistics over all observations.

	1960's	1970's	1980's	1990's	2000-2005's	2006-2010's
Average recession depth	6%	1%	0.9%	0.6%	2,3%	-3%

Table 1.2: Average recession depth (peak to trough growth rate of GDP per capita) over time

[1] Australia, Austria, Canada, Finland, France, Germany, Ireland, Italy, Japan, Korea, Norway, Spain, Sweden, UK and USA

Employment and hours The employment rate measures the share of employed people (headcount of people reporting having worked during the quarter) among the population aged 16 to 64. As mentioned, the dataset uses the quarterly hours worked per worker series from the Ohanian and Raffo database. The hours worked series is composed of the number of hours worked by individual worker as reported in surveys and harmonized over time and countries for the period 1960-2010. It takes into account the number of days that are not worked (offical holidays, ...). The level of hours worked individually varies over time with a decreasing long-term trend but it especially varies a lot across countries, from an all-period average around 1500 annual hours in Norway and Sweden to above 2200 in Ireland, Japan and Korea. The rest of the data are standard country time series extracted from the OECD database and Bassanini & Duval (2009) database on labour market institutions as well as labour market characteristics data from the ICTWSS[2] that ranks countries each year on a scale from 1 (no wage coordination) to 5 (fully centralized wage-setting). All levels of wage coordination are well represented in the database as can be seen in Table 1.3. This measure of wage coordination will be our preferred control measure for labour market institutions. To our knowledge, other, more often used, measures of labour market institutions do not cover the whole period of interest in this paper[3] or do not vary overtime within some countries[4].

Wage coordination:	level 1	level 2	level 3	level 4	level 5
Share of all observations	17%	12%	22%	30%	20%

Table 1.3: Distribution observations regarding wage coordination

Financial crises They play a key role in our research. We use the fact that the observed recovery episode follows a financial crisis to infer the presence of financial restrictions affecting firms' men-hours tradeoff. We rely on the identification of financial crises made by Reinhart and Rogoff (2009) who identify 29 financial crises in our sample and define a financial crisis as:

"Bank runs that lead to the closure, merging, or takeover by the

[2]database on Institutional Characteristics of Trade Unions, Wage Setting, State Intervention and Social Pacts, 1960-2011

[3]For example the employment protection indicator (EPI) of the OECD starts in 1980/

[4]For example the strength of wage coordination from the ICTWSS does not vary overtime in some countries of our sample

> *pulic sector of one or more financial institutions; and if there are no runs, the closure, merging, takeover or large-scale governement assistance of an important financial institution (or group of institutions), that mark the start of a string of similar outcomes for other financial institutions." (Reinhart & Rogoff (2009))*

As a robustness check, we will use the alternative definition of financial crises by Laeven and Valencia (2012) who define financial crises as follows: *"A banking crisis is defined as systemic if two conditions are met: 1) Significant signs of financial distress in the banking system (as indicated by significant bank runs, losses in the banking system, and/or bank liquidations) 2) Significant banking policy intervention measures in response to significant losses in the banking system"*. The main difference with the definition by Reinhart and Rogoff is the necessary public intervention. As expected following many previous studies, the average output fall (measured as the sum of quarterly growth rate of GDP per capita from peak to trough) is higher in financial crises (-4,6%) than in non-financial crises (-2,56%). The length of crises (number of quarters from peak to trough) is not very different in financial crises and non-financial crises (6,15 versus 6,33 quarters). Also, financial recessions display significantly larger decline in the employment rate (in coherence with Calvo *et al*'s (2012) results regarding the unemployment rate)[5]. However, the presence of a financial crisis during the recession makes no strong difference for hours worked. More precisely, hours worked per worker are globally not strongly affected during recessions, even though this apparent absence of variation is an average and could hide large differences between jobs or sectors, with some workers reducing their paid hours and other working unpaid overtime for example. The dataset available does not allow to identify heterogeneity among workers.

Figure 1.3 shows the average recovery path, with and without financial crisis, of both the employment rate and the number of hours worked per worker over the years following a trough (in $t = 0$, all cumulative growth rate are thus equal to zero). The graphs correpond to an average, over all countries and cycles, of the recovery paths presented in Figure 1.1 and 1.2. The detailed computation methodology is presented in the next section. It clearly appears in Figure 1.3 that in the presence of a financial crisis, the employment rate is

[5]Calvo *et al.*, and other studies, often look at the unemployment rate. We prefer employment to unemployment measures because it carries more information, especially in the cases where discouraged job-seekers drop from unemployment statistics or when students defer their entry on the labour market waiting for more favourable conditions.

recovering more weakly and the opposite is true for hours worked per worker. The objective of the paper is to assess econometrically the magnitude and the statistical significativity of the difference on display on Figure 1.3.

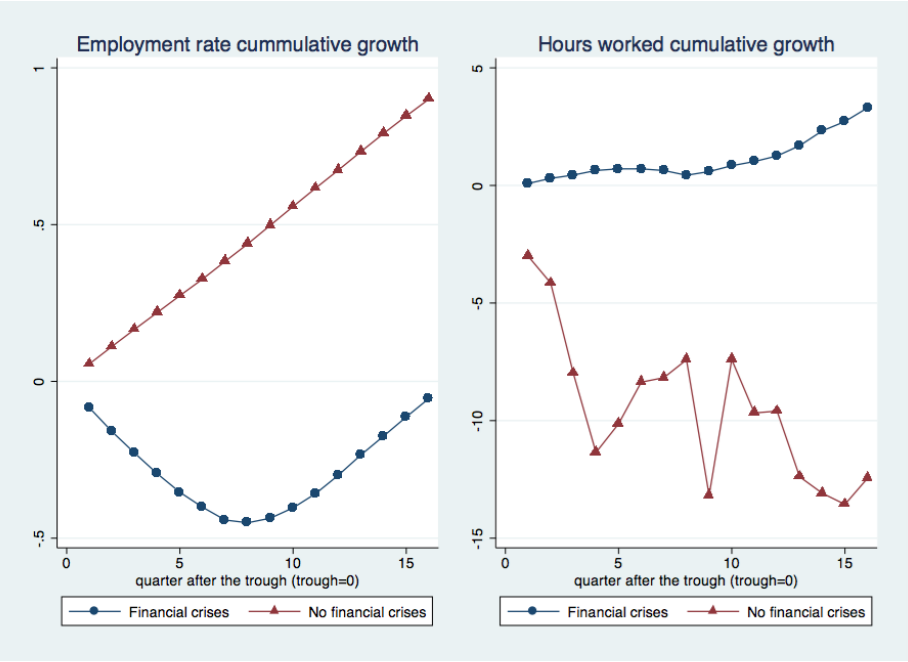

Figure 1.3: Average cumulative growth of employment rate and hours worked growth following the trough.

1.3 Empirical strategy

The objective is to determine, using non-financial crises as a reference, whether financial crises significantly affects the growth rate of the employment rate (and/or the growth rate of individual hours) during the recovery, that is to say in the period directly following a trough. At this point, it should be noted that three different time dimensions interfere with each other. First, an observation in our country-level panel data correspond to a country (c) and a quarter (t). For example, $t = 1980 - 1$ means that the observation was made during the first quarter of the year 1980. This first time dimension is thus an absolute one. The second time dimension, r, is relative: each observation belongs to one, and only one, cycle and we can measure the number of quarters, r, elapsed since the trough. For example, an observation that lies two quarters before the trough (during the recession phase thus) will have $r = -2$ and an observation lying 4 quarters after the trough will have $r = 4$. Each observation is thus associated to a unique value pair of values t and r. Finally, the third dimension (q) is the horizon over which the growth rate is computed. For example, it is possible to compute the growth rate of the employment rate over one quarter, generating the quarter-on-quarter growth rate. It is also possible to compute the growth rate over, for example, four quarters, which yields the year-on-year growth rate. For each unique observation, measured in t and located r quarters after the trough, we compute the cumulative growth since $t - q$. We do so over 16 different time horizons q, generating 16 new variables. For one of these we have the specific case where $r = q$, for example if an observation t is located 5 quarters after the trough ($r = 5$), then when $q = 5$, we compute precisely the cumulative growth rate since the trough. For the needs of the estimation of the model, we build a (dummy) variable Q that relates the horizon over which the growth rate is computed to the number of quarters elapsed since the trough. Formally, $Q_t^q = 0$ if $r \neq q$, $Q_t^q = 1$ if $r = q$; $q = 1, \ldots .16$.

The first step is thus to compute the cumulative growth rate of the variable of interest for horizons q, ranging from 1 to 16 quarters, for our two variables of interest, the employment rate and individual hours worked, denoted E and H. Ignoring the country dimension, the cumulative growth rate of the employment rate over the last q quarters at any time t is then given by $\Delta E_{t,q} = \frac{E_t - E_{t-q}}{E_{t-q}}$. Similarly, the cumulative growth rate of individual hours over the last q quarters at any time t is given by $\Delta H_{t,q} = \frac{H_t - H_{t-q}}{H_{t-q}}$. We compute these variables $\Delta E_{t,q}$ and $\Delta H_{t,q}$ for q going from 1 to 16, for all t (quarters from 1960 tp 2010).

We then apply a methodology borrowed from local projection methods (Jordà, 2005). The objective is to have a separate regression for each time horizon (q) over which we compute the growth rate. Local projections represent an now well-established alternative to VARs in empirical macroeconomic research. One of their great strengths is that they can be estimated by simple regression techniques and, what is more, that they impose almost no restrictions on the data due to a very flexible specification that consists of a series of dummies. We can then easily allow financial crises to have a different impact at different points in the recovery. The advantage of local projections over VARs is best understood by reading the words of Jordà:

> *"The central idea consists in estimating local projections at each period of interest rather than extrapolating into increasingly distant*

horizons from a given model, as it is done with vector autoregressions (VAR)". (Jordà, 2005)[6]

The consequence of using local projections instead of a single VAR is that we will have as many regressions as the number of horizons considered (horizons q over which we compute the growth rate of the employment rate and of the indvidual hours of work). In each regression, q is fixed to a value comprised between 1 and 16. The estimated models are the following, for the employment rate first, for $\{q = 1, 2, ...16\}$:

$$
\begin{aligned}
\frac{E_{t,c} - E_{t-q,c}}{E_{t-q,c}} = \Delta E_{t,q,c} = {} & \lambda_A^q (\textit{financial crisis dummy})_{t,c} && \text{(A)} \\
& + \lambda_B^q (\textit{dummy } Q_{t,c}^q \textit{ equal to 1 if } q{=}r)_{t,c} && \text{(B)} \\
& + \lambda_{AB}^q [(A) * (B)] \\
& + \lambda_C^q E_{t-q,c} \\
& + \lambda_D^q (\textit{GDP growth over the last q quarters})_{t-2,c} \\
& + \lambda_E^q (\textit{level of wage coordination})_{t,c} \\
& + \lambda_{F-J}^q (\textit{dummies: 1960, 1970, 1980, 1990, 2000, 2006})_{t,c} \\
& + \textit{constant}^q \\
& + u_c^q (\text{country fixed effect}) + \epsilon_{c,t}^q && (1.1)
\end{aligned}
$$

And then similarly for individual hours of work, for $\{q = 1, 2, ...16\}$:

[6] The equivalence between Local Projects (LP) and VARs is presented by Plagborg-Moller and Wolf (2019). In the case of infinite lags, any VAR can be re-written as a LP by using the appropriate control variables and any LP model can be written in the form of a VAR with the appropriate variable ordering. In cases whitout infinite lags, no method is proved to dominate the other under all circumstances and the choice of method amounts to a bias/variance arbitrage.

$$\begin{aligned}
\frac{H_{t,c} - H_{t-q,c}}{H_{t-q,c}} = \Delta H_{t,q,c} = \; & \mu_A^q (\textit{financial crisis dummy})_{t,c} && \text{(A)} \\
& + \mu_B^q (\textit{dummy } Q_{t,c}^q \textit{= 1 if q=r})_{t,c} && \text{(B)} \\
& + \mu_{AB}^q [(A) * (B)] \\
& + \mu_C^q H_{t-q,c} \\
& + \mu_D^q (\textit{GDP growth over the last q quarters})_{t-2,c} \\
& + \mu_E^q (\textit{level of wage coordination})_{t,c} \\
& + \mu_{F-J}^q (\textit{dummies: 1960, 1970, 1980, 1990, 2000, 2006})_{t,c} \\
& + \textit{constant}^q \\
& + u_c^q (\text{country fixed effect}) + \epsilon_{c,t}^q && (1.2)
\end{aligned}$$

Note that, in what follows, the above equations are estimated using only recovery quarters. Coefficients λ_A^q and μ_A^q measure the average outcome difference between financial vs non-financial crisis at any time of the recovery[7]. In fact, the dummy $(\textit{financial crisis})_{t,c}$ accounts for the presence of a financial crisis during the observed cycle. This financial crisis variable refers to the definition made by Reinhart and Rogoff and is equal to one if at least one quarter during the cycle is reported as a financial crisis episode. Coefficients λ_B^q and μ_B^q measure how much, in the case of a non-financial crisis, being q quarters after the trough makes a difference in terms of employment/hours compare to the other quarters of the recovery. Precisely, $Q_{t,c}^q$ is equal to 1 when $q = r$, that is to say when the time horizon considered for computing the growth rate (ie the dependent variable), q, is equal to the time elapsed since the last trough, r. For example, in the regression where $q = 3$, the dummy $(Q_{t,c}^q)$ is worth 1 for observations that lie exactly 3 quarters after the trough. In other words, observations associated to a value $r = 3$. Within each cycle, there is only one observation such that $q = r$. If we would only keep those observations for the regression analysis, the dummy (B) would always be equal to 1 and we would fall back to an event-study methodology. The results of running such an event study are presented as a robustness check in the appendix.[8] In such an event-study design, we loose many observations, reducing the precision of the

[7] except the quarter that is exactly q quarters after the trough

[8] Figure 1.3 is based on this event study methodology where we only keep the observations such that $q = r$. In other words, to compute the average growth rate of employment (resp. hours) $1(q)$ quarters after the trough, we only keep the observations that lie $1(r)$ quarter(s) after the trough. Technically, the difference between the two curves graphed in Figure 1.3 is thus measured in the event-study model.

estimates.

Coefficients λ^q_{AB} and μ^q_{AB} measure how much, in the case of a financial crisis, being q quarters after the trough makes a difference in terms of employment/hours compare to the other quarters of the (post-financial crisis) recovery. For example, in the regression where q is fixed to 4, the coefficients λ^q_{AB} and μ^q_{AB} measure the extent to which being 1 year after the trough makes a difference in terms of the degree of employment/hours recovery.

Our list of controls comprises: the base level of the dependent variable (with coefficients λ^q_C and μ^q_C), the growth of GDP over the same horizon (with coefficients λ^q_D and μ^q_D), the level of wage coordination (with coefficients λ^q_E and μ^q_E), the decade (dummy per 10-year period, with coefficient λ^q_F to λ^q_J and μ^q_F to μ^q_J) and a country fixed effect (u^q_c).

1.4 Results

1.4.1 Employment

Table 1.4 first line (λ^q_A), contains our estimates of the propensity of post-financial crises episodes to generate employment responses that deviate from those characterising standards recoveries. As exposed above, each column correspond to a different time horizon (of q quarters). We can see a very significant negative impact of the presence of a financial crisis during the cycle on the employment growth even after the growth of GDP, country fixed effects and the level of employment rate[9] are accounted for. In particular, the values presented in Table 1.4 reads as follow: considering the cumulative growth of the employment rate over 4 quarters (column (4)), the employment recovery handicap associated to financial crises is equal to 0.22 percentage point.

The second and third lines (λ^q_B; λ^q_{AB}) suggest that the precise quarter of the recovery calendar (except perhaps the first one) does not matter. Also as expected, the employment positively correlates with the growth of GDP (variable "GDP growth L2" which measure the growth rate of GDP over the same

[9] As expected, the higher the employment already is, the lower the growth rate, this being partly due to the way growth is computed, a two percentage point increase in employment represent less growth in percentage if the employment rate is higher. It also related to the intuition that the closer a country is to full employment, the less it can still increase its employment rate.

time horizon lagged two periods to mitigate the risk of reverse causality). In other words, the stronger the recovery of GDP, the stronger the recovery of employment. Variables measuring the labour market institutions also play an important role, especially the level at which wages are bargained. The more centralized the bargaining (high values of “coord”), the higher the employment growth. Finally, after controlling for all the above, there also seem to be factors that have increased employment growth over time compared to the 1960’s, as all time-period dummies capture positive significant effects.

1.4.2 Individual Hours

Regarding hours worked (results in Table 1.5), a significantly positive impact of a financial crisis is found on the growth of hours worked computed starting at 4 quarters of cumulated growth (line 1). This efffect is reinforced when considering longer growth horizons ($q > 4$) (line 5). Combined with those visible on the first line of Table 4, these results support the view that the intensive margin is used as a substitute to re-hiring during recoveries following financial crises. Turning to coefficient μ_B^q and μ_{AB}^q, we find no evidence that being exactly q quarters after the trough makes a differences at to the relative intensity of the recovery of hours. As for the employment rate, the higher the number of hours worked already is, the lower the growth rate of hours worked, probably both for computational and human capacity reasons. The GDP growth positively correlates to hours worked as expected.

Like with employment (Table 1.4), the wage coordination coefficient (μ_E^q) is statistically significant. But is has the opposite sign, suggesting that the more wage bargaining is centralized, the lower is the growth of hours per worker. These results are supportive of the idea that centralized wage bargaining might be a good thing for employment growth during recoveries.

	Employment rate growth over q quarters															
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
VARIABLES	1 quarter	2 quarters	3 quarters	4 quarters	5 quarters	6 quarters	7 quarters	8 quarters	9 quarters	10 quarters	11 quarters	12 quarters	13 quarters	14 quarters	15 quarters	16 quarters
fin crisis (λ_A^q)	-0.0876**	-0.128**	-0.140*	-0.222**	-0.316***	-0.399***	-0.473***	-0.602***	-0.663***	-0.694***	-0.740***	-0.735***	-0.741***	-0.750***	-0.762***	-0.752***
	(0.0377)	(0.0586)	(0.0736)	(0.0901)	(0.107)	(0.123)	(0.136)	(0.150)	(0.162)	(0.173)	(0.183)	(0.192)	(0.203)	(0.212)	(0.220)	(0.226)
Q^q (λ_B^q)	-0.244***	-0.0640	0.165*	0.0506	0.0589	0.0134	0.105	0.0663	0.133	0.149	0.287	0.510	0.404	0.387	0.245	0.495
	(0.0478)	(0.0760)	(0.0939)	(0.116)	(0.140)	(0.165)	(0.194)	(0.241)	(0.272)	(0.309)	(0.343)	(0.409)	(0.459)	(0.518)	(0.584)	(0.638)
Q^q * fin crisis (λ_{AB}^q)	-0.153	-0.133	-0.166	-0.00991	0.0942	0.223	0.284	0.603	1.035*	1.000	1.468*	1.062	1.599	1.790	2.132	2.853
	(0.0988)	(0.153)	(0.192)	(0.236)	(0.293)	(0.345)	(0.425)	(0.505)	(0.596)	(0.740)	(0.888)	(1.055)	(1.432)	(1.514)	(1.585)	(1.860)
GDP (λ_D^q)	0.0689***	0.201***	0.308***	0.354***	0.387***	0.415***	0.431***	0.435***	0.439***	0.435***	0.425***	0.413***	0.396***	0.373***	0.352***	0.336***
	(0.0117)	(0.0128)	(0.0119)	(0.0116)	(0.0118)	(0.0122)	(0.0125)	(0.0128)	(0.0131)	(0.0134)	(0.0135)	(0.0135)	(0.0137)	(0.0138)	(0.0137)	(0.0136)
coord (λ_E^q)	0.0407**	0.0762***	0.104***	0.136***	0.175***	0.211***	0.255***	0.298***	0.342***	0.396***	0.428***	0.461***	0.488***	0.517***	0.536***	0.569***
	(0.0162)	(0.0252)	(0.0316)	(0.0387)	(0.0462)	(0.0531)	(0.0593)	(0.0658)	(0.0716)	(0.0774)	(0.0826)	(0.0874)	(0.0926)	(0.0974)	(0.101)	(0.104)
Constant	0.300	0.288	-0.157	-0.0999	0.0840	0.546	1.305	2.407**	3.601***	5.158***	7.310***	9.460***	11.83***	14.42***	16.81***	18.21***
	(0.269)	(0.424)	(0.542)	(0.672)	(0.811)	(0.944)	(1.064)	(1.188)	(1.301)	(1.415)	(1.516)	(1.609)	(1.713)	(1.809)	(1.888)	(1.964)
Observations	1,663	1,650	1,637	1,627	1,619	1,609	1,600	1,591	1,579	1,565	1,552	1,540	1,530	1,520	1,510	1,499
R-squared	0.084	0.184	0.331	0.405	0.447	0.478	0.500	0.511	0.522	0.527	0.531	0.535	0.527	0.517	0.510	0.505
decade trend	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
base empl rate level	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
country FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
restrict to recoveries	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 1.4: Explaining the cumulative growth of the employment rate after the trough.

	Hours worked growth over q quarters															
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
VARIABLES	1 quarter	2 quarters	3 quarters	4 quarters	5 quarters	6 quarters	7 quarters	8 quarters	9 quarters	10 quarters	11 quarters	12 quarters	13 quarters	14 quarters	15 quarters	16 quarters
fin crisis (μ_A^q)	0.0154	0.0478	0.109	0.217**	0.202*	0.221*	0.282**	0.276**	0.330**	0.348***	0.297**	0.322**	0.249*	0.182	0.157	0.126
	(0.0905)	(0.0864)	(0.0924)	(0.106)	(0.106)	(0.115)	(0.120)	(0.128)	(0.129)	(0.134)	(0.139)	(0.139)	(0.147)	(0.148)	(0.151)	(0.159)
Q^q (μ_B^q)	0.0628	-0.0700	0.190*	0.0902	0.0956	0.106	-0.0891	0.116	0.433**	0.293	0.146	0.308	0.153	-0.100	0.659*	0.621
	(0.108)	(0.106)	(0.111)	(0.130)	(0.132)	(0.147)	(0.162)	(0.189)	(0.199)	(0.221)	(0.240)	(0.275)	(0.314)	(0.344)	(0.393)	(0.448)
Q^q * fin crisis (μ_{AB}^q)	-0.0250	-0.119	0.123	-0.126	0.467*	0.735**	0.740**	0.655	-0.0696	0.270	-0.164	-0.164	-0.534	0.00970	-1.154	-1.670
	(0.232)	(0.220)	(0.235)	(0.271)	(0.283)	(0.315)	(0.363)	(0.399)	(0.423)	(0.517)	(0.613)	(0.708)	(1.026)	(1.038)	(1.077)	(1.365)
GDP (μ_D^q)	0.0116	-0.0103	0.0235*	0.0383***	0.0402***	0.0407***	0.0408***	0.0376***	0.0402***	0.0400***	0.0376***	0.0369***	0.0370***	0.0331***	0.0287***	0.0278***
	(0.0263)	(0.0176)	(0.0138)	(0.0126)	(0.0108)	(0.0103)	(0.00993)	(0.00972)	(0.00915)	(0.00907)	(0.00892)	(0.00847)	(0.00860)	(0.00823)	(0.00809)	(0.00825)
coord (μ_E^q)	-0.0349	-0.0511	-0.0852**	-0.0931**	-0.107**	-0.121***	-0.148***	-0.172***	-0.183***	-0.192***	-0.183***	-0.207***	-0.226***	-0.206***	-0.182***	-0.158**
	(0.0363)	(0.0347)	(0.0370)	(0.0424)	(0.0426)	(0.0459)	(0.0483)	(0.0513)	(0.0518)	(0.0546)	(0.0569)	(0.0575)	(0.0612)	(0.0615)	(0.0633)	(0.0668)
Constant	3.660***	4.171***	5.096***	6.444***	6.868***	8.007***	8.478***	9.516***	10.16***	11.36***	12.14***	12.60***	13.93***	14.42***	15.08***	16.36***
	(0.772)	(0.738)	(0.790)	(0.909)	(0.913)	(0.983)	(1.037)	(1.098)	(1.105)	(1.163)	(1.211)	(1.223)	(1.299)	(1.304)	(1.343)	(1.426)
Observations	1,394	1,383	1,372	1,364	1,357	1,350	1,343	1,336	1,327	1,318	1,310	1,301	1,293	1,285	1,277	1,268
R-squared	0.021	0.037	0.057	0.071	0.097	0.118	0.129	0.146	0.174	0.192	0.199	0.220	0.228	0.248	0.259	0.270
decade trend	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
base hour level	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
country FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
restrict to recoveries	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 1.5: Explaining the cumulative growth of hours worked per worker after the trough.

1.4.3 Additional results and robustness analysis

First, we can detail the results obtained regarding the labour market institutions control variable. As exposed above, we find that a higher degree of centralizatio of the wage setting correlates to a stronger employment rate growth as well as a weaker growth of individual hours. Labour-market variables thus appear to play a key role in avoiding ascribing to financial crises an impact that has to do with labour-market institutions.

We then performed a series of robustness checks. First, we use an alternative definition of financial crises, using Laeven and Valencia database. The main difference with the database of Reinhart and Rogoff is that Laeven and Valencia require public intervention to define a financial crisis. This results in slightly less observations of financial crises. Results are presented in Table 1.6 and 1.7.

Second, we control for the size of the preceeding recession by using the (negative) growth of GDP per capital from peak to trough as well as this measure squared, to capture potential particularities of deep recessions. Results are presented in Tables 1.8 and 1.9. We find that deeper recessions, associated with a larger fall of GDP per capita, tend to generate less employment rate growth and stronger growth of individual hours. This effect is non-linear, as is captured by the squared term, meaning that very deep recession are associated with even less employment rate growth and even more individual hours growth. Nevertheless, we still find that financial crises (that tend to be associated with deeper recessions) still impacts negatively (resp. positively) the growth of the employment rate (respec. of individual hours), even if this impact is only visible for growth rate computed over longer horizons. We also present evidences of what happens to the employment rate growth and individual hours growth during the recession. We find that a financial crise depresses both growth rates, as does the fall in GDP (Tables 1.21 and 1.22).

Third, we present alternative control strategies for the GDP per capita. In Tables 1.10 and 1.11, we present results when the GDP per capita growth rate, used as a control variable, is not lagged. We also present, in Tables 1.12 and 1.13 the baseline model without the interact term.

Fourth, in Table 1.14, we present the results when using total hours of work instead of individual hours. Total hours of work are computed by Ohanian and

Raffo by simply multiplying individual hours by the number of workers. This series is the closest to the dataset used by Gali, Smets and Wouters (2012). We find contrasted results, with an average negative impact of financial crises that is counteracted by a positive impact when measuring the growth rate precisely since the trough, as is captured by the interaction term. The tentative conclusion is that in the first year that follows the trough, the negative impact of financial crises dominates, possibly because the low employment rate growth effect dominates. From 6 to 8 quarters after the trough, we find that the positive interaction term dominates, possibly indicating that the strong growth of individual hours dominates the low growth of the employment rate.

Fifth, the only robustness test that generated important discrepancies was to split the sample into 2 periods, before and after 1990. Our key results hold with statistical significance only for the post 1990 period. It is however the case that the period before 1990 was less prone to financial crises, such that the lack of significant effect is most probably due to the low number of observations displaying financial frictions in that period. Results are presented in Tables 1.15 to 1.18.

Finally, we present the results from and event-study exercise where one keeps only one observation per cycle (Tables 1.19 and 1.20). Precisely, we retain only observations recorded exactly q quarters after the trough. As we do not exploit the panel dimension of the data, we control for country fixed-effects using a dummy per country, with a reference country. This allows to uncover country-specific trend, mainly that the US, and more generally Anglosaxon countries, tend to experience less joblessness. Their recovery period tend to be more on the extensive margin (new jobs) than intensive (additional individual hours) than european and asian countries.

1.4.4 Typical dynamic panel issues and stationarity

As equations (1.1) and (1.2) contain among their predictors the base level of the dependant variable they can be said to be dynamic panel models. What is more, they contain country fixed effects. In principle, we should thus consider the possibility that our estimates are affected by the dynamic panel bias (also know as the Nickell bias in the econometric literature). But, in our case, the risk of a dynamic panel bias is greatly scaled down by the use of long time series (large T) as confirmed by Judson and Owen (1999) for the case of $T > 30$. In our case, all series cover at least 56 periods such that we are on the safe side regarding dynamic panel bias[10]. It should also be noted that clustering of the standard errors is not recommended for macro panels that typically do not display a large enough number of individuals (here 15 countries).

In fact, dynamic panel with long time series are not plagued by the dynamic panel bias but they may suffer from stationarity issues. In our case this issue is greatly limited as the dependend variables are both always expressed in growth rate. The only concern is with the independant variable controlling for the base level of, respectively, the employment rate and the level of individual hours of work. The employment rate is always comprised between 0 and 1 by definition, and is stable of time. Individual hours of work display a decreasing trend over time in all of the countries considered. Both series are stationary when taking into account a drift in the fisher-type tests. As a matter of completeness we present in the annexes the baseline regressions using linearly detrended series (Tables 1.23 and 1.24).

1.5 Conclusion

The key results of this paper are essentially twofold. First, since 1960 and across 15 advanced economies, financial crisis tend to be be followed by recoveries that are jobless. In comparison with recoveries taking place after non-financial crises, they are significantly less prone to employment growth. Second, the opposite results is found when focusing on the number of hours per worker. During the quarters after financial crisis, hours per worker tend to grow more. We posit that these results might be a confirmation of *i)* the key role of firm-level credit constraints in the wake of financial/banking crises, but also *ii)* of that of fixed labour costs in the way employers deal with the men vs. hours tradeoff. If fixed labour costs are financed via credit, restricted access to the

[10] General case:

$$y_{it} = \alpha y_{i,t-1} + \beta x_{i,t} + \mu_i + v_{i,t}$$

Where we have the following variables after fixed-effect transformation (within transformation) to remove unobserved μ_i:

$$y^*_{i,t-1} = y_{i,t-1} - \bar{y}_i$$
$$v^*_{i,t} = v_{i,t} - \bar{v}_i$$

Then the issues arises with the automatic correlation between $\bar{v}_i$ and $y_{i,t-1}$, where $y_{i,t-1}$ is also correlated to $y_{i,t}$ (presence of autocorrelation). However the correlation between $\bar{v}_i$ and $y_{i,t-1}$ is greatly reduced by a large T.

later should translate into less recruitment and extended hours of work.

Jobless recoveries have attracted a lot of interest from researchers in the past, with the aim of uncovering the reasons employment would not follow the recovery of the output, generating long-lasting, high unemployment levels. Different studies found different reasons for jobless recoveries, among them demographic changes (Stock & Watson (2012)) and lack of confidence in the sustainability of the recovery (Schreft *et al.*(2005), Schmitt-Grohé & Uribe (2012)). Some papers insisted on the role of productive recessions, either due to sectoral shifts, following the idea of Shumpeterian productive destruction (Jaimovich & Siu (2012), Burger & Schwartz (2014) and Srivastava & Theodore (2005) among others). Other papers focused on productivity-enhancing restructuring at the firm level (mainly Petrosky-Nadeau (2013) and Berger (2012)). Our conclusions are certainly in line with this last strand of the literature, as an increase in individual hours will lead to an apparent increase in individual productivity, measured in output per worker. This mechanism echoes most closely the lasting increase in individual effort observed by Lazear (2013) at the plant level.

Our results also align with those of Gali, Smets and Wouters (2012) who find no trace of joblessness in the US but use total hours of work as their measure of employment. We show that this result is not incompatible with joblessness in terms of the employment rate (the share of people who declare holding a job among the 16-64 years old population). In particular, we show how, when decomposing total hours of work into the intensive and the extensive margin of labour, individual hours and the employment rate react with opposite sign after a financial crisis.

In conclusion, our work highlights the importance of considering both the extensive and the intensive margins of employment when studying employment. In particular, what appears as just a jobless recovery might reveal a more complex story once both margins of employment are taken into account.

Appendix

	Employment rate growth over i quarters															
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
VARIABLES	1 quarter	2 quarters	3 quarters	4 quarters	5 quarters	6 quarters	7 quarters	8 quarters	9 quarters	10 quarters	11 quarters	12 quarters	13 quarters	14 quarters	15 quarters	16 quarters
fin crisis	-0.225***	-0.393***	-0.521***	-0.832***	-1.173***	-1.428***	-1.617***	-1.879***	-2.010***	-2.179***	-2.287***	-2.345***	-2.419***	-2.478***	-2.540***	-2.581***
	(0.0582)	(0.0961)	(0.122)	(0.151)	(0.180)	(0.209)	(0.228)	(0.250)	(0.266)	(0.284)	(0.298)	(0.310)	(0.324)	(0.337)	(0.347)	(0.353)
16 quarters after last trough	-0.281***	-0.107	0.1000	-0.00594	-0.0286	-0.0760	0.0702	0.154	0.301	0.312	0.373	0.541	0.493	0.500	0.435	0.667
	(0.0441)	(0.0727)	(0.0898)	(0.110)	(0.132)	(0.156)	(0.180)	(0.219)	(0.246)	(0.286)	(0.320)	(0.378)	(0.426)	(0.476)	(0.530)	(0.584)
1.trough_#1.fin_crisis_cycle_lv		-0.00175	0.0789	0.581*	1.150***	1.504***	2.006***	1.268	0.550	0.333						
		(0.222)	(0.278)	(0.337)	(0.421)	(0.499)	(0.771)	(1.030)	(2.142)	(2.294)						
GDP = L,	0.0706***	0.198***	0.301***	0.344***	0.374***	0.398***	0.413***	0.416***	0.420***	0.418***	0.411***	0.401***	0.386***	0.366***	0.347***	0.334***
	(0.0119)	(0.0132)	(0.0124)	(0.0122)	(0.0126)	(0.0131)	(0.0135)	(0.0139)	(0.0141)	(0.0143)	(0.0143)	(0.0142)	(0.0143)	(0.0142)	(0.0141)	(0.0140)
coord	0.0373**	0.0695***	0.0952***	0.125***	0.163***	0.202***	0.257***	0.309***	0.370***	0.446***	0.506***	0.574***	0.628***	0.680***	0.719***	0.762***
	(0.0169)	(0.0262)	(0.0330)	(0.0403)	(0.0479)	(0.0551)	(0.0615)	(0.0682)	(0.0741)	(0.0797)	(0.0849)	(0.0895)	(0.0945)	(0.0992)	(0.103)	(0.106)
Constant	0.250	0.159	-0.524	-0.736	-0.655	-0.332	0.417	1.495	2.396*	3.842**	5.796***	7.621***	9.741***	11.98***	13.91***	15.00***
	(0.292)	(0.462)	(0.597)	(0.741)	(0.894)	(1.041)	(1.175)	(1.316)	(1.442)	(1.562)	(1.669)	(1.765)	(1.876)	(1.983)	(2.071)	(2.142)
Observations	1,596	1,583	1,570	1,560	1,552	1,542	1,533	1,525	1,515	1,504	1,494	1,485	1,478	1,470	1,462	1,453
R-squared	0.090	0.197	0.342	0.421	0.467	0.500	0.524	0.534	0.546	0.552	0.558	0.563	0.557	0.548	0.542	0.539
decade trend	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
base empl rate level	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
country FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
restrict to recoveries	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 1.6: Explaining the cumulative growth of the employment rate after the trough using Laeven and Valencia's financial crisis definition

	Hours worked growth over i quarters															
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
VARIABLES	1 quarter	2 quarters	3 quarters	4 quarters	5 quarters	6 quarters	7 quarters	8 quarters	9 quarters	10 quarters	11 quarters	12 quarters	13 quarters	14 quarters	15 quarters	16 quarters
fin crisis	0.186	0.217	0.377***	0.448***	0.402**	0.450**	0.447**	0.375*	0.439**	0.485**	0.366*	0.457**	0.402*	0.359	0.364	0.310
	(0.140)	(0.133)	(0.143)	(0.167)	(0.168)	(0.184)	(0.189)	(0.200)	(0.200)	(0.211)	(0.217)	(0.216)	(0.228)	(0.227)	(0.231)	(0.241)
16 quarters after last trough	0.0772	-0.101	0.197*	0.0309	0.101	0.170	-0.0222	0.135	0.393**	0.289	0.118	0.289	0.0987	-0.102	0.502	0.429
	(0.105)	(0.102)	(0.106)	(0.123)	(0.125)	(0.139)	(0.151)	(0.172)	(0.181)	(0.207)	(0.228)	(0.260)	(0.299)	(0.324)	(0.366)	(0.424)
1.trough_#1.fin_crisis_cycle_lv	-0.148	-0.0250	0.266	0.351	1.015**	1.083**	1.716***	2.978***	1.999	2.915*						
	(0.338)	(0.317)	(0.335)	(0.385)	(0.395)	(0.441)	(0.643)	(0.867)	(1.470)	(1.548)						
GDP = L,	0.0121	-0.00966	0.0278*	0.0432***	0.0449***	0.0447***	0.0437***	0.0385***	0.0416***	0.0424***	0.0391***	0.0398***	0.0407***	0.0375***	0.0343***	0.0334***
	(0.0271)	(0.0180)	(0.0142)	(0.0132)	(0.0113)	(0.0110)	(0.0106)	(0.0105)	(0.00988)	(0.00979)	(0.00961)	(0.00905)	(0.00915)	(0.00870)	(0.00853)	(0.00865)
coord	-0.0350	-0.0495	-0.0816**	-0.0876**	-0.103**	-0.113**	-0.133***	-0.154***	-0.168***	-0.175***	-0.170***	-0.192***	-0.211***	-0.192***	-0.169***	-0.140**
	(0.0378)	(0.0358)	(0.0381)	(0.0438)	(0.0437)	(0.0470)	(0.0494)	(0.0526)	(0.0535)	(0.0565)	(0.0591)	(0.0595)	(0.0633)	(0.0635)	(0.0654)	(0.0689)
Constant	4.214***	4.859***	6.070***	7.736***	8.233***	9.422***	9.904***	11.04***	11.72***	13.05***	13.83***	14.21***	15.44***	15.92***	16.53***	17.80***
	(0.832)	(0.787)	(0.838)	(0.967)	(0.962)	(1.033)	(1.084)	(1.149)	(1.161)	(1.219)	(1.268)	(1.272)	(1.350)	(1.348)	(1.387)	(1.468)
Observations	1,340	1,329	1,318	1,310	1,303	1,296	1,289	1,282	1,274	1,267	1,261	1,254	1,248	1,242	1,236	1,229
R-squared	0.025	0.044	0.070	0.084	0.113	0.131	0.141	0.161	0.184	0.203	0.208	0.230	0.238	0.261	0.271	0.282
decade trend	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
base hour level	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
country FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
restrict to recoveries	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 1.7: Explaining the cumulative growth of hours worked per worker after the trough using Laeven and Valencia's financial crisis definition

	Employment rate growth over i quarters															
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
VARIABLES	1 quarter	2 quarters	3 quarters	4 quarters	5 quarters	6 quarters	7 quarters	8 quarters	9 quarters	10 quarters	11 quarters	12 quarters	13 quarters	14 quarters	15 quarters	16 quarters
fin crisis	-0.0406	-0.0593	-0.0782	-0.147	-0.216**	-0.296**	-0.352***	-0.450***	-0.483***	-0.505***	-0.531***	-0.517***	-0.507***	-0.487**	-0.474**	-0.435**
	(0.0395)	(0.0605)	(0.0758)	(0.0918)	(0.108)	(0.122)	(0.134)	(0.145)	(0.156)	(0.165)	(0.174)	(0.182)	(0.192)	(0.201)	(0.208)	(0.214)
16 quarters after last trough	-0.243***	-0.0661	0.158*	0.0487	0.0521	0.0203	0.108	0.0839	0.151	0.177	0.252	0.452	0.391	0.348	0.178	0.443
	(0.0487)	(0.0768)	(0.0945)	(0.116)	(0.138)	(0.162)	(0.187)	(0.229)	(0.257)	(0.290)	(0.321)	(0.381)	(0.427)	(0.482)	(0.544)	(0.595)
1.trough_#1.fin_crisis_cycle	-0.137	-0.0974	-0.120	0.0532	0.126	0.243	0.248	0.617	0.763	0.816	1.080	0.581	1.013	1.207	1.554	2.015
	(0.0999)	(0.153)	(0.192)	(0.234)	(0.287)	(0.335)	(0.409)	(0.480)	(0.563)	(0.694)	(0.830)	(0.984)	(1.333)	(1.408)	(1.474)	(1.733)
GDP during recession	0.0173***	0.0283***	0.0325***	0.0428***	0.0523***	0.0532***	0.0583***	0.0752***	0.0790***	0.0880***	0.0932***	0.0960***	0.101***	0.110***	0.114***	0.122***
	(0.00400)	(0.00629)	(0.00808)	(0.0100)	(0.0122)	(0.0144)	(0.0164)	(0.0182)	(0.0198)	(0.0212)	(0.0223)	(0.0234)	(0.0246)	(0.0257)	(0.0265)	(0.0270)
GDP during recession, squared	-0.000857***	-0.00199***	-0.00335***	-0.00499***	-0.00711***	-0.00900***	-0.0108***	-0.0130***	-0.0147***	-0.0164***	-0.0178***	-0.0189***	-0.0200***	-0.0209***	-0.0217***	-0.0221***
	(0.000257)	(0.000393)	(0.000492)	(0.000595)	(0.000698)	(0.000793)	(0.000875)	(0.000954)	(0.00103)	(0.00110)	(0.00116)	(0.00122)	(0.00129)	(0.00135)	(0.00140)	(0.00146)
GDP = L,	0.0681***	0.200***	0.303***	0.346***	0.379***	0.410***	0.428***	0.430***	0.437***	0.433***	0.428***	0.419***	0.406***	0.385***	0.367***	0.351***
	(0.0125)	(0.0139)	(0.0132)	(0.0132)	(0.0138)	(0.0148)	(0.0156)	(0.0162)	(0.0167)	(0.0170)	(0.0172)	(0.0171)	(0.0173)	(0.0174)	(0.0173)	(0.0172)
coord	0.0312*	0.0658**	0.102***	0.139***	0.184***	0.231***	0.281***	0.324***	0.377***	0.440***	0.477***	0.510***	0.546***	0.577***	0.597***	0.624***
	(0.0173)	(0.0265)	(0.0332)	(0.0402)	(0.0473)	(0.0538)	(0.0593)	(0.0648)	(0.0696)	(0.0745)	(0.0789)	(0.0829)	(0.0874)	(0.0917)	(0.0952)	(0.0982)
Constant	0.524*	0.711	0.561	0.907	1.214	1.519	2.065*	2.961**	3.685***	4.827***	6.384***	7.927***	9.742***	11.87***	13.80***	15.05***
	(0.297)	(0.459)	(0.583)	(0.711)	(0.845)	(0.972)	(1.082)	(1.191)	(1.292)	(1.394)	(1.485)	(1.570)	(1.666)	(1.755)	(1.827)	(1.901)
Observations	1,559	1,557	1,555	1,553	1,551	1,547	1,544	1,542	1,537	1,530	1,523	1,517	1,512	1,506	1,500	1,492
R-squared	0.094	0.208	0.356	0.436	0.488	0.525	0.553	0.571	0.585	0.593	0.599	0.602	0.596	0.587	0.580	0.573
decade trend	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
base empl rate level	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
country FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
restrict to recoveries	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 1.8: Explaining the cumulative growth of the employment rate after the trough controlling for the growth of GDP and its square during the preceding recession

	Hours worked growth over i quarters															
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
VARIABLES	1 quarter	2 quarters	3 quarters	4 quarters	5 quarters	6 quarters	7 quarters	8 quarters	9 quarters	10 quarters	11 quarters	12 quarters	13 quarters	14 quarters	15 quarters	16 quarters
fin crisis	-0.0110	0.0254	0.0474	0.149	0.137	0.164	0.243**	0.259**	0.317**	0.347**	0.293**	0.319**	0.248*	0.195	0.182	0.161
	(0.0948)	(0.0895)	(0.0947)	(0.109)	(0.108)	(0.116)	(0.121)	(0.128)	(0.130)	(0.135)	(0.140)	(0.140)	(0.148)	(0.149)	(0.152)	(0.160)
16 quarters after last trough	0.0910	-0.0266	0.235**	0.125	0.121	0.130	-0.0663	0.143	0.454**	0.329	0.182	0.339	0.154	-0.0796	0.705*	0.655
	(0.110)	(0.107)	(0.111)	(0.130)	(0.131)	(0.146)	(0.161)	(0.188)	(0.199)	(0.220)	(0.239)	(0.273)	(0.313)	(0.344)	(0.392)	(0.448)
1.trough_#1.fin_crisis_cycle	-0.0449	-0.157	0.0736	-0.185	0.433	0.683**	0.703*	0.613	-0.0699	0.264	-0.143	-0.135	-0.422	0.122	-1.053	-1.534
	(0.233)	(0.220)	(0.234)	(0.271)	(0.280)	(0.312)	(0.360)	(0.396)	(0.421)	(0.513)	(0.610)	(0.706)	(1.026)	(1.038)	(1.076)	(1.364)
GDP during recession	-0.00799	-0.00909	-0.0236***	-0.0275***	-0.0285***	-0.0286**	-0.0227*	-0.0111	-0.00304	0.00524	0.00462	0.00819	0.0121	0.0262	0.0363**	0.0409**
	(0.00823)	(0.00801)	(0.00872)	(0.0103)	(0.0106)	(0.0119)	(0.0129)	(0.0140)	(0.0143)	(0.0151)	(0.0157)	(0.0158)	(0.0168)	(0.0168)	(0.0172)	(0.0180)
GDP during recession, squared	0.000580	0.00103**	0.00153***	0.00173***	0.00181***	0.00214***	0.00225***	0.00216***	0.00220***	0.00232***	0.00237***	0.00240***	0.00218**	0.00183**	0.00166*	0.00145
	(0.000542)	(0.000512)	(0.000543)	(0.000624)	(0.000620)	(0.000667)	(0.000700)	(0.000741)	(0.000747)	(0.000781)	(0.000813)	(0.000817)	(0.000869)	(0.000872)	(0.000893)	(0.000952)
GDP = L,	0.0252	0.000746	0.0399***	0.0554***	0.0567***	0.0563***	0.0534***	0.0431***	0.0396***	0.0346***	0.0319***	0.0286**	0.0271**	0.0172	0.00887	0.00712
	(0.0282)	(0.0191)	(0.0151)	(0.0142)	(0.0125)	(0.0126)	(0.0125)	(0.0126)	(0.0121)	(0.0120)	(0.0118)	(0.0112)	(0.0115)	(0.0110)	(0.0108)	(0.0110)
coord	-0.0394	-0.0620*	-0.0889**	-0.0946**	-0.109**	-0.124***	-0.162***	-0.194***	-0.200***	-0.214***	-0.206***	-0.228***	-0.247***	-0.222***	-0.195***	-0.172**
	(0.0387)	(0.0366)	(0.0387)	(0.0444)	(0.0441)	(0.0474)	(0.0497)	(0.0526)	(0.0530)	(0.0555)	(0.0577)	(0.0580)	(0.0618)	(0.0620)	(0.0635)	(0.0670)
Constant	4.176***	4.803***	5.815***	7.342***	7.672***	8.841***	9.476***	10.61***	10.99***	12.01***	12.69***	12.93***	14.18***	14.45***	14.91***	16.16***
	(0.852)	(0.801)	(0.845)	(0.970)	(0.961)	(1.029)	(1.079)	(1.137)	(1.143)	(1.194)	(1.240)	(1.247)	(1.324)	(1.326)	(1.360)	(1.442)
Observations	1,299	1,298	1,297	1,296	1,295	1,294	1,293	1,292	1,289	1,286	1,283	1,279	1,275	1,271	1,267	1,261
R-squared	0.027	0.048	0.077	0.093	0.120	0.142	0.156	0.172	0.196	0.215	0.219	0.238	0.241	0.258	0.269	0.277
decade trend	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
base hour level	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
country FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
restrict to recoveries	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 1.9: Explaining the cumulative growth of hours worked per worker after the trough controlling for the growth of GDP and its square during the preceding recession

	Employment rate growth over i quarters															
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
VARIABLES	1 quarter	2 quarters	3 quarters	4 quarters	5 quarters	6 quarters	7 quarters	8 quarters	9 quarters	10 quarters	11 quarters	12 quarters	13 quarters	14 quarters	15 quarters	16 quarters
fin crisis	-0.0807**	-0.125**	-0.175**	-0.251***	-0.344***	-0.481***	-0.633***	-0.730***	-0.785***	-0.799***	-0.821***	-0.798***	-0.774***	-0.756***	-0.739***	-0.728***
	(0.0378)	(0.0590)	(0.0764)	(0.0932)	(0.110)	(0.129)	(0.142)	(0.156)	(0.169)	(0.180)	(0.191)	(0.200)	(0.209)	(0.216)	(0.223)	(0.230)
16 quarters after last trough	-0.294***	-0.486***	-0.508***	-0.621***	-0.544***	-0.590***	-0.533***	-0.492*	-0.483*	-0.407	-0.403	-0.239	-0.182	-0.188	-0.268	-0.0600
	(0.0468)	(0.0731)	(0.0959)	(0.121)	(0.146)	(0.174)	(0.206)	(0.254)	(0.286)	(0.324)	(0.361)	(0.428)	(0.476)	(0.529)	(0.594)	(0.651)
1.trough_#1.fin_crisis_cycle	-0.181*	-0.168	-0.132	-0.0806	-0.167	0.141	0.390	0.529	1.093*	0.944	1.668*	1.283	1.584	2.076	1.935	3.128*
	(0.0990)	(0.154)	(0.200)	(0.244)	(0.302)	(0.361)	(0.447)	(0.529)	(0.622)	(0.771)	(0.923)	(1.097)	(1.475)	(1.539)	(1.605)	(1.888)
GDP	0.0788***	0.228***	0.340***	0.396***	0.426***	0.433***	0.433***	0.430***	0.429***	0.419***	0.404***	0.390***	0.375***	0.359***	0.341***	0.320***
	(0.0129)	(0.0155)	(0.0153)	(0.0144)	(0.0142)	(0.0144)	(0.0142)	(0.0142)	(0.0143)	(0.0144)	(0.0144)	(0.0143)	(0.0142)	(0.0139)	(0.0138)	(0.0137)
coord	0.0348**	0.0657***	0.0868***	0.114***	0.163***	0.203***	0.265***	0.313***	0.358***	0.403***	0.428***	0.472***	0.523***	0.564***	0.576***	0.601***
	(0.0162)	(0.0253)	(0.0327)	(0.0398)	(0.0475)	(0.0553)	(0.0620)	(0.0684)	(0.0741)	(0.0799)	(0.0852)	(0.0900)	(0.0948)	(0.0986)	(0.102)	(0.106)
Constant	0.0976	-0.463	-1.289**	-1.774**	-2.049**	-1.167	-0.111	1.378	2.990**	5.030***	7.415***	9.496***	11.56***	13.49***	15.49***	17.39***
	(0.267)	(0.428)	(0.566)	(0.701)	(0.852)	(1.003)	(1.132)	(1.256)	(1.364)	(1.469)	(1.564)	(1.660)	(1.754)	(1.829)	(1.904)	(1.985)
Observations	1,683	1,670	1,657	1,644	1,632	1,621	1,612	1,604	1,594	1,582	1,569	1,556	1,545	1,533	1,522	1,512
R-squared	0.084	0.169	0.273	0.360	0.406	0.424	0.445	0.460	0.476	0.482	0.488	0.493	0.494	0.498	0.494	0.487
decade trend	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
base empl rate level	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
country FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
restrict to recoveries	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 1.10: Explaining the cumulative growth of the employment rate after the trough controlling for the growth of GDP unlagged

	Hours worked growth over i quarters															
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
VARIABLES	1 quarter	2 quarters	3 quarters	4 quarters	5 quarters	6 quarters	7 quarters	8 quarters	9 quarters	10 quarters	11 quarters	12 quarters	13 quarters	14 quarters	15 quarters	16 quarters
fin crisis	0.0326	0.0871	0.143	0.270***	0.259**	0.284**	0.338***	0.337***	0.368***	0.399***	0.370***	0.401***	0.345**	0.292**	0.268*	0.230
	(0.0901)	(0.0860)	(0.0916)	(0.104)	(0.105)	(0.113)	(0.118)	(0.125)	(0.127)	(0.133)	(0.137)	(0.138)	(0.146)	(0.147)	(0.150)	(0.158)
16 quarters after last trough	0.0582	-0.0783	0.0991	-0.0454	-0.0267	-0.0254	-0.223	-0.0181	0.316	0.176	-0.00931	0.135	-0.0290	-0.295	0.469	0.425
	(0.105)	(0.101)	(0.109)	(0.128)	(0.131)	(0.146)	(0.162)	(0.189)	(0.200)	(0.221)	(0.239)	(0.274)	(0.313)	(0.343)	(0.391)	(0.448)
1.trough_#1.fin_crisis_cycle	-0.0178	-0.0947	0.156	-0.120	0.417	0.700**	0.744**	0.642	-0.0662	0.252	-0.166	-0.131	-0.490	0.0886	-1.141	-1.597
	(0.230)	(0.219)	(0.234)	(0.267)	(0.279)	(0.311)	(0.358)	(0.394)	(0.420)	(0.514)	(0.606)	(0.701)	(1.018)	(1.029)	(1.067)	(1.357)
GDP	0.0775***	0.0759***	0.0811***	0.0977***	0.0887***	0.0815***	0.0742***	0.0649***	0.0566***	0.0563***	0.0559***	0.0540***	0.0556***	0.0535***	0.0481***	0.0448***
	(0.0288)	(0.0210)	(0.0169)	(0.0148)	(0.0122)	(0.0114)	(0.0105)	(0.0101)	(0.00948)	(0.00926)	(0.00897)	(0.00848)	(0.00853)	(0.00811)	(0.00797)	(0.00808)
coord	-0.0406	-0.0590*	-0.0914**	-0.103**	-0.114***	-0.128***	-0.155***	-0.179***	-0.181***	-0.194***	-0.194***	-0.212***	-0.231***	-0.212***	-0.190***	-0.170**
	(0.0360)	(0.0343)	(0.0366)	(0.0416)	(0.0418)	(0.0450)	(0.0473)	(0.0503)	(0.0511)	(0.0538)	(0.0558)	(0.0564)	(0.0602)	(0.0606)	(0.0623)	(0.0661)
Constant	3.449***	3.832***	4.766***	5.880***	6.183***	7.336***	7.964***	9.175***	9.732***	10.79***	11.67***	12.10***	13.40***	13.85***	14.49***	15.91***
	(0.758)	(0.725)	(0.775)	(0.886)	(0.893)	(0.963)	(1.014)	(1.074)	(1.086)	(1.140)	(1.181)	(1.195)	(1.274)	(1.280)	(1.317)	(1.403)
Observations	1,414	1,403	1,392	1,381	1,370	1,362	1,355	1,348	1,340	1,333	1,325	1,315	1,306	1,297	1,289	1,281
R-squared	0.026	0.044	0.069	0.093	0.119	0.138	0.150	0.163	0.182	0.200	0.211	0.231	0.239	0.260	0.270	0.279
decade trend	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
base hour level	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
country FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
restrict to recoveries	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 1.11: Explaining the cumulative growth of hours worked per worker after the trough controlling for the growth of GDP unlagged

	Employment rate growth over i quarters															
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
VARIABLES	1 quarter	2 quarters	3 quarters	4 quarters	5 quarters	6 quarters	7 quarters	8 quarters	9 quarters	10 quarters	11 quarters	12 quarters	13 quarters	14 quarters	15 quarters	16 quarters
fin crisis	-0.104***	-0.143**	-0.159**	-0.224***	-0.306***	-0.378***	-0.451***	-0.565***	-0.607***	-0.654***	-0.695***	-0.710***	-0.715***	-0.721***	-0.729***	-0.717***
	(0.0361)	(0.0561)	(0.0705)	(0.0863)	(0.103)	(0.118)	(0.132)	(0.146)	(0.159)	(0.171)	(0.182)	(0.191)	(0.201)	(0.211)	(0.219)	(0.225)
16 quarters after last trough	-0.278***	-0.0933	0.126	0.0482	0.0805	0.0646	0.163	0.202	0.345	0.321	0.502	0.668*	0.567	0.596	0.533	0.826
	(0.0428)	(0.0681)	(0.0830)	(0.101)	(0.123)	(0.145)	(0.173)	(0.212)	(0.243)	(0.281)	(0.318)	(0.378)	(0.435)	(0.487)	(0.543)	(0.601)
GDP = L,	0.0699***	0.201***	0.308***	0.354***	0.387***	0.415***	0.431***	0.435***	0.439***	0.436***	0.425***	0.413***	0.396***	0.373***	0.351***	0.336***
	(0.0117)	(0.0128)	(0.0119)	(0.0116)	(0.0118)	(0.0122)	(0.0125)	(0.0128)	(0.0131)	(0.0134)	(0.0135)	(0.0135)	(0.0137)	(0.0138)	(0.0137)	(0.0136)
coord	0.0406**	0.0760***	0.104***	0.136***	0.175***	0.211***	0.255***	0.297***	0.341***	0.394***	0.429***	0.462***	0.488***	0.517***	0.537***	0.565***
	(0.0162)	(0.0252)	(0.0316)	(0.0387)	(0.0461)	(0.0531)	(0.0593)	(0.0658)	(0.0716)	(0.0774)	(0.0827)	(0.0874)	(0.0926)	(0.0974)	(0.101)	(0.104)
Constant	0.308	0.295	-0.146	-0.0995	0.0816	0.546	1.305	2.435**	3.582***	5.193***	7.334***	9.484***	11.90***	14.49***	16.88***	18.37***
	(0.269)	(0.424)	(0.542)	(0.671)	(0.811)	(0.944)	(1.064)	(1.188)	(1.302)	(1.415)	(1.517)	(1.609)	(1.712)	(1.808)	(1.888)	(1.962)
Observations	1,663	1,650	1,637	1,627	1,619	1,609	1,600	1,591	1,579	1,565	1,552	1,540	1,530	1,520	1,510	1,499
R-squared	0.083	0.184	0.331	0.405	0.447	0.478	0.500	0.510	0.521	0.526	0.530	0.535	0.527	0.517	0.509	0.504
decade trend	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
base empl rate level	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
country FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
restrict to recoveries	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 1.12: Explaining the cumulative growth of the employment rate after the trough by the presence of financial crises and controlling for the average recovery

Hours worked growth over i quarters

VARIABLES	(1) 1 quarter	(2) 2 quarters	(3) 3 quarters	(4) 4 quarters	(5) 5 quarters	(6) 6 quarters	(7) 7 quarters	(8) 8 quarters	(9) 9 quarters	(10) 10 quarters	(11) 11 quarters	(12) 12 quarters	(13) 13 quarters	(14) 14 quarters	(15) 15 quarters	(16) 16 quarters
fin crisis	0.0128	0.0350	0.122	0.204**	0.248**	0.289***	0.338***	0.322**	0.325***	0.360***	0.291**	0.318**	0.241	0.182	0.141	0.108
	(0.0870)	(0.0831)	(0.0889)	(0.102)	(0.103)	(0.111)	(0.117)	(0.125)	(0.126)	(0.132)	(0.137)	(0.138)	(0.147)	(0.147)	(0.150)	(0.158)
16 quarters after last trough	0.0577	-0.0947	0.216**	0.0615	0.197*	0.266**	0.0578	0.261	0.417**	0.342*	0.121	0.284	0.103	-0.0991	0.507	0.446
	(0.0975)	(0.0953)	(0.0988)	(0.114)	(0.117)	(0.130)	(0.146)	(0.167)	(0.176)	(0.200)	(0.221)	(0.254)	(0.299)	(0.325)	(0.366)	(0.425)
GDP = L,	0.0117	-0.0101	0.0234*	0.0383***	0.0402***	0.0411***	0.0412***	0.0380***	0.0402***	0.0401***	0.0376***	0.0369***	0.0370***	0.0331***	0.0288***	0.0278***
	(0.0263)	(0.0176)	(0.0138)	(0.0126)	(0.0108)	(0.0104)	(0.00993)	(0.00972)	(0.00915)	(0.00906)	(0.00892)	(0.00847)	(0.00860)	(0.00823)	(0.00809)	(0.00825)
coord	-0.0349	-0.0509	-0.0853**	-0.0930**	-0.107**	-0.121***	-0.149***	-0.172***	-0.183***	-0.192***	-0.184***	-0.207***	-0.227***	-0.206***	-0.184***	-0.157**
	(0.0363)	(0.0346)	(0.0370)	(0.0424)	(0.0426)	(0.0460)	(0.0484)	(0.0513)	(0.0517)	(0.0546)	(0.0569)	(0.0575)	(0.0611)	(0.0614)	(0.0633)	(0.0668)
Constant	3.660***	4.171***	5.094***	6.447***	6.844***	7.970***	8.432***	9.472***	10.16***	11.36***	12.14***	12.60***	13.93***	14.42***	15.07***	16.35***
	(0.772)	(0.738)	(0.790)	(0.908)	(0.913)	(0.984)	(1.038)	(1.099)	(1.105)	(1.163)	(1.211)	(1.223)	(1.299)	(1.304)	(1.343)	(1.426)
Observations	1,394	1,383	1,372	1,364	1,357	1,350	1,343	1,336	1,327	1,318	1,310	1,301	1,293	1,285	1,277	1,268
R-squared	0.021	0.037	0.057	0.071	0.095	0.114	0.126	0.144	0.174	0.192	0.199	0.220	0.227	0.248	0.258	0.269
decade trend	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
base hour level	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
country FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
restrict to recoveries	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 1.13: Explaining the cumulative growth of hours worked per worker after the trough by the presence of financial crises and controlling for the average recovery

	Total hours growth over i quarters															
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
VARIABLES	1 quarter	2 quarters	3 quarters	4 quarters	5 quarters	6 quarters	7 quarters	8 quarters	9 quarters	10 quarters	11 quarters	12 quarters	13 quarters	14 quarters	15 quarters	16 quarters
fin crisis	-0.128	-0.222**	-0.255**	-0.259*	-0.436***	-0.549***	-0.592***	-0.743***	-0.766***	-0.812***	-0.943***	-0.920***	-1.035***	-1.146***	-1.221***	-1.248***
	(0.100)	(0.109)	(0.123)	(0.148)	(0.160)	(0.177)	(0.191)	(0.207)	(0.214)	(0.224)	(0.236)	(0.242)	(0.258)	(0.268)	(0.278)	(0.289)
16 quarters after last trough	-0.175	-0.128	0.308**	0.0949	0.111	0.0825	-0.0832	0.149	0.530	0.280	0.312	0.741	0.621	0.720	0.877	1.350*
	(0.120)	(0.134)	(0.148)	(0.182)	(0.199)	(0.227)	(0.258)	(0.306)	(0.331)	(0.370)	(0.408)	(0.478)	(0.551)	(0.625)	(0.723)	(0.816)
1.trough_#1.fin_crisis_cycle	-0.101	-0.188	0.0525	-0.149	0.701	1.160**	1.246**	1.425**	0.750	1.280	1.158	0.641	-0.0654	0.254	-0.150	-0.525
	(0.257)	(0.279)	(0.313)	(0.379)	(0.427)	(0.486)	(0.578)	(0.647)	(0.703)	(0.864)	(1.043)	(1.234)	(1.801)	(1.885)	(1.984)	(2.484)
GDP = L,	0.0961***	0.216***	0.357***	0.422***	0.460***	0.493***	0.514***	0.523***	0.537***	0.542***	0.539***	0.537***	0.531***	0.510***	0.491***	0.479***
	(0.0292)	(0.0223)	(0.0184)	(0.0176)	(0.0163)	(0.0160)	(0.0158)	(0.0157)	(0.0152)	(0.0152)	(0.0152)	(0.0147)	(0.0151)	(0.0149)	(0.0149)	(0.0150)
coord	0.0567	0.109**	0.133***	0.187***	0.240***	0.283***	0.326***	0.378***	0.423***	0.488***	0.558***	0.596***	0.649***	0.759***	0.862***	0.966***
	(0.0401)	(0.0437)	(0.0492)	(0.0592)	(0.0643)	(0.0708)	(0.0768)	(0.0831)	(0.0860)	(0.0913)	(0.0968)	(0.100)	(0.107)	(0.112)	(0.116)	(0.121)
Constant	0.214	0.0876	-0.364	-0.828***	-1.332***	-1.910***	-2.513***	-3.112***	-3.696***	-4.278***	-4.759***	-5.292***	-5.772***	-6.210***	-6.638***	-7.096***
	(0.177)	(0.197)	(0.224)	(0.272)	(0.296)	(0.327)	(0.356)	(0.387)	(0.404)	(0.433)	(0.465)	(0.487)	(0.528)	(0.556)	(0.588)	(0.621)
Observations	1,394	1,383	1,372	1,364	1,357	1,350	1,343	1,336	1,327	1,318	1,310	1,301	1,293	1,285	1,277	1,268
R-squared	0.025	0.109	0.253	0.336	0.421	0.475	0.510	0.531	0.568	0.579	0.583	0.597	0.585	0.579	0.570	0.564
decade trend	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
base hour level	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
country FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
restrict to recoveries	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 1.14: Explaining the cumulative growth of the sum of hours worked

	Employment rate growth over i quarters															
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
VARIABLES	1 quarter	2 quarters	3 quarters	4 quarters	5 quarters	6 quarters	7 quarters	8 quarters	9 quarters	10 quarters	11 quarters	12 quarters	13 quarters	14 quarters	15 quarters	16 quarters
fin crisis	0.0494	0.158	0.345**	0.512***	0.669***	0.810***	0.954***	1.107***	1.221***	1.401***	1.593***	1.795***	1.974***	2.164***	2.338***	2.508***
	(0.0754)	(0.115)	(0.144)	(0.176)	(0.202)	(0.227)	(0.251)	(0.275)	(0.294)	(0.310)	(0.329)	(0.345)	(0.361)	(0.378)	(0.391)	(0.400)
16 quarters after last trough	-0.192***	-0.104	0.174	0.0781	0.186	0.113	0.0569	0.191	0.435	0.373	0.633	0.475	0.457	0.813	0.759	0.784
	(0.0580)	(0.0923)	(0.112)	(0.139)	(0.164)	(0.192)	(0.224)	(0.270)	(0.310)	(0.360)	(0.395)	(0.526)	(0.625)	(0.782)	(0.860)	(0.939)
1.trough_#1.fin_crisis_cycle	-0.106	-0.260	-0.709**	-0.576	-0.562	-0.361	-0.103	0.338	1.001	0.564	0.267	0.136	1.830	1.660	2.029	6.164**
	(0.180)	(0.276)	(0.344)	(0.422)	(0.487)	(0.549)	(0.612)	(0.716)	(0.820)	(1.041)	(1.105)	(1.351)	(1.712)	(1.842)	(1.930)	(2.686)
GDP = L,	0.0394***	0.124***	0.233***	0.273***	0.299***	0.322***	0.338***	0.339***	0.341***	0.335***	0.315***	0.299***	0.278***	0.251***	0.228***	0.214***
	(0.0139)	(0.0166)	(0.0161)	(0.0159)	(0.0157)	(0.0159)	(0.0166)	(0.0172)	(0.0176)	(0.0180)	(0.0184)	(0.0185)	(0.0185)	(0.0182)	(0.0178)	(0.0175)
coord	-0.0248	-0.0452	-0.0571	-0.0712	-0.0721	-0.0733	-0.0539	-0.0399	-0.0321	-0.0167	-0.0196	-0.0228	-0.0258	-0.0162	-0.0210	0.00823
	(0.0195)	(0.0299)	(0.0374)	(0.0459)	(0.0529)	(0.0595)	(0.0662)	(0.0731)	(0.0783)	(0.0839)	(0.0895)	(0.0948)	(0.0998)	(0.105)	(0.109)	(0.112)
Constant	0.604	0.960	0.538	1.172	1.886	2.925*	4.272**	6.148***	7.856***	9.870***	12.87***	16.34***	19.42***	22.60***	25.53***	26.32***
	(0.445)	(0.699)	(0.899)	(1.121)	(1.310)	(1.494)	(1.682)	(1.868)	(2.012)	(2.176)	(2.326)	(2.457)	(2.593)	(2.739)	(2.871)	(3.003)
Observations	855	843	831	822	815	807	799	791	781	769	758	747	738	729	720	710
R-squared	0.046	0.102	0.235	0.302	0.355	0.391	0.409	0.415	0.429	0.427	0.422	0.420	0.415	0.405	0.399	0.399
decade trend	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
base empl rate level	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
country FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
restrict to recoveries	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 1.15: Explaining the cumulative growth of the employment rate after the trough before 1990

	Employment rate growth over i quarters															
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
VARIABLES	1 quarter	2 quarters	3 quarters	4 quarters	5 quarters	6 quarters	7 quarters	8 quarters	9 quarters	10 quarters	11 quarters	12 quarters	13 quarters	14 quarters	15 quarters	16 quarters
fin crisis	-0.143***	-0.222***	-0.340***	-0.477***	-0.615***	-0.693***	-0.746***	-0.917***	-0.969***	-1.075***	-1.082***	-1.069***	-1.023***	-0.989***	-0.918***	-0.889***
	(0.0513)	(0.0775)	(0.0947)	(0.111)	(0.132)	(0.150)	(0.162)	(0.175)	(0.189)	(0.200)	(0.208)	(0.215)	(0.224)	(0.233)	(0.237)	(0.241)
16 quarters after last trough	-0.289***	-0.0455	0.0964	0.0625	-0.0232	-0.0760	0.154	0.0991	0.0312	0.117	-0.0576	0.397	0.0637	-0.258	-0.682	-0.309
	(0.0768)	(0.116)	(0.142)	(0.170)	(0.201)	(0.228)	(0.261)	(0.330)	(0.354)	(0.384)	(0.424)	(0.448)	(0.480)	(0.509)	(0.569)	(0.616)
1.trough_#1.fin_crisis_cycle	-0.0842	0.0248	0.162	0.213	0.363	0.370	-0.00858	0.257	0.280	1.078	1.694*	0.888	0.146	0.687	1.292	1.014
	(0.126)	(0.190)	(0.233)	(0.275)	(0.341)	(0.396)	(0.489)	(0.583)	(0.676)	(0.809)	(1.023)	(1.165)	(1.665)	(1.730)	(1.769)	(1.810)
GDP = L,	0.104***	0.272***	0.368***	0.428***	0.479***	0.523***	0.546***	0.554***	0.561***	0.555***	0.555***	0.541***	0.531***	0.515***	0.509***	0.500***
	(0.0198)	(0.0191)	(0.0167)	(0.0160)	(0.0168)	(0.0176)	(0.0180)	(0.0187)	(0.0194)	(0.0200)	(0.0204)	(0.0203)	(0.0209)	(0.0212)	(0.0212)	(0.0215)
coord	0.0475	0.0764	0.0978	0.112	0.149	0.162	0.149	0.196	0.275*	0.390**	0.424**	0.424**	0.438**	0.438**	0.389*	0.342
	(0.0461)	(0.0692)	(0.0841)	(0.0979)	(0.116)	(0.131)	(0.143)	(0.155)	(0.167)	(0.178)	(0.185)	(0.191)	(0.201)	(0.209)	(0.212)	(0.217)
Constant	0.513	0.980	1.514	2.096*	2.856**	3.732**	5.061***	6.460***	7.216***	8.521***	10.18***	12.57***	15.17***	18.27***	20.13***	21.26***
	(0.523)	(0.795)	(0.983)	(1.167)	(1.415)	(1.627)	(1.789)	(1.978)	(2.158)	(2.334)	(2.455)	(2.547)	(2.672)	(2.759)	(2.794)	(2.864)
Observations	808	807	806	805	804	802	801	800	798	796	794	793	792	791	790	789
R-squared	0.121	0.271	0.442	0.548	0.597	0.641	0.677	0.694	0.708	0.716	0.729	0.736	0.733	0.729	0.730	0.727
decade trend	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
base empl rate level	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
country FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
restrict to recoveries	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 1.16: Explaining the cumulative growth of the employment rate after the trough after 1990

	Hours worked growth over i quarters															
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
VARIABLES	1 quarter	2 quarters	3 quarters	4 quarters	5 quarters	6 quarters	7 quarters	8 quarters	9 quarters	10 quarters	11 quarters	12 quarters	13 quarters	14 quarters	15 quarters	16 quarters
fin crisis	-0.0329	0.0139	0.0548	0.0752	0.101	0.0992	0.165	0.193	0.289	0.362	0.369	0.392	0.456*	0.525**	0.601**	0.662**
	(0.178)	(0.175)	(0.177)	(0.194)	(0.202)	(0.210)	(0.229)	(0.242)	(0.226)	(0.237)	(0.245)	(0.251)	(0.264)	(0.264)	(0.271)	(0.282)
16 quarters after last trough	-0.0981	-0.235*	0.0272	-0.120	-0.00295	0.00523	-0.0239	-0.0606	0.460**	0.247	0.0707	0.558	0.485	-0.133	1.387**	0.742
	(0.130)	(0.132)	(0.131)	(0.145)	(0.155)	(0.169)	(0.192)	(0.218)	(0.218)	(0.257)	(0.276)	(0.362)	(0.442)	(0.552)	(0.611)	(0.697)
1.trough_#1.fin_crisis_cycle	-0.0217	0.0377	0.183	0.354	0.343	0.396	0.173	0.366	0.00929	0.0287	0.309	-0.441	0.828	0.948	-0.983	
	(0.481)	(0.472)	(0.479)	(0.524)	(0.543)	(0.565)	(0.613)	(0.649)	(0.605)	(0.807)	(0.836)	(1.052)	(1.533)	(1.564)	(1.619)	
GDP = L,	-0.0241	-0.0168	0.0154	0.0258	0.0285*	0.0424***	0.0429***	0.0451***	0.0499***	0.0461***	0.0430***	0.0438***	0.0432***	0.0416***	0.0375***	0.0398***
	(0.0321)	(0.0242)	(0.0190)	(0.0167)	(0.0147)	(0.0137)	(0.0138)	(0.0136)	(0.0121)	(0.0124)	(0.0123)	(0.0120)	(0.0121)	(0.0114)	(0.0110)	(0.0110)
coord	-0.0170	-0.0239	-0.0425	-0.0432	-0.0555	-0.0503	-0.0526	-0.0594	-0.0672	-0.0736	-0.0721	-0.0671	-0.0892	-0.0908	-0.0621	-0.0381
	(0.0426)	(0.0419)	(0.0427)	(0.0467)	(0.0484)	(0.0503)	(0.0546)	(0.0576)	(0.0534)	(0.0572)	(0.0593)	(0.0613)	(0.0649)	(0.0650)	(0.0669)	(0.0697)
Constant	4.785***	4.806***	5.472***	6.533***	7.232***	8.488***	9.119***	10.74***	10.44***	12.55***	13.94***	15.10***	17.16***	17.87***	18.79***	20.25***
	(1.198)	(1.189)	(1.215)	(1.339)	(1.396)	(1.453)	(1.592)	(1.673)	(1.555)	(1.656)	(1.712)	(1.771)	(1.869)	(1.882)	(1.937)	(2.039)
Observations	752	741	730	722	715	708	701	694	686	678	671	663	656	649	642	634
R-squared	0.026	0.034	0.048	0.069	0.093	0.127	0.146	0.183	0.251	0.272	0.298	0.322	0.339	0.364	0.382	0.389
decade trend	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
base hour level	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
country FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
restrict to recoveries	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 1.17: Explaining the cumulative growth of hours worked per worker after the trough before 1990

	Hours worked growth over i quarters															
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
VARIABLES	1 quarter	2 quarters	3 quarters	4 quarters	5 quarters	6 quarters	7 quarters	8 quarters	9 quarters	10 quarters	11 quarters	12 quarters	13 quarters	14 quarters	15 quarters	16 quarters
fin crisis	-0.0103	0.0387	0.113	0.254*	0.247*	0.236	0.303**	0.354**	0.371**	0.441***	0.400**	0.428***	0.329*	0.247	0.200	0.133
	(0.119)	(0.109)	(0.118)	(0.139)	(0.134)	(0.147)	(0.147)	(0.155)	(0.160)	(0.162)	(0.166)	(0.161)	(0.171)	(0.169)	(0.172)	(0.183)
16 quarters after last trough	0.323*	0.179	0.408**	0.400*	0.179	0.0963	-0.361	0.221	0.139	0.0644	0.0830	0.133	0.133	0.322	0.718*	0.654
	(0.181)	(0.167)	(0.181)	(0.217)	(0.208)	(0.228)	(0.242)	(0.288)	(0.295)	(0.300)	(0.323)	(0.321)	(0.350)	(0.354)	(0.406)	(0.467)
1.trough_#1.fin_crisis_cycle	-0.115	-0.320	-0.0556	-0.509	0.353	0.686*	1.061**	0.422	-0.222	-0.164	-0.912	-0.435	-0.483	0.0205	-0.792	-0.613
	(0.291)	(0.266)	(0.291)	(0.344)	(0.343)	(0.383)	(0.430)	(0.481)	(0.519)	(0.586)	(0.725)	(0.773)	(1.112)	(1.100)	(1.129)	(1.209)
GDP = L,	0.127***	0.0320	0.0666***	0.0821***	0.0740***	0.0645***	0.0641***	0.0601***	0.0618***	0.0677***	0.0635***	0.0579***	0.0549***	0.0434***	0.0378***	0.0351***
	(0.0448)	(0.0263)	(0.0201)	(0.0189)	(0.0158)	(0.0155)	(0.0142)	(0.0139)	(0.0134)	(0.0128)	(0.0126)	(0.0115)	(0.0119)	(0.0114)	(0.0114)	(0.0121)
coord	0.0673	0.00352	-0.124	-0.0904	-0.142	-0.180	-0.287**	-0.332**	-0.305**	-0.312**	-0.221	-0.347**	-0.344**	-0.240	-0.203	-0.0953
	(0.112)	(0.103)	(0.112)	(0.130)	(0.126)	(0.137)	(0.138)	(0.146)	(0.150)	(0.153)	(0.157)	(0.154)	(0.165)	(0.163)	(0.166)	(0.178)
Constant	16.94***	16.99***	22.18***	28.44***	28.41***	32.49***	33.57***	36.11***	38.58***	40.85***	41.92***	40.23***	42.60***	42.36***	43.63***	46.64***
	(2.157)	(1.926)	(2.024)	(2.331)	(2.217)	(2.398)	(2.400)	(2.476)	(2.504)	(2.533)	(2.592)	(2.518)	(2.645)	(2.539)	(2.541)	(2.676)
Observations	642	642	642	642	642	642	642	642	641	640	639	638	637	636	635	634
R-squared	0.102	0.122	0.184	0.218	0.247	0.271	0.289	0.309	0.317	0.341	0.328	0.332	0.329	0.340	0.353	0.363
decade trend	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
base hour level	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
country FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
restrict to recoveries	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 1.18: Explaining the cumulative growth of hours worked per worker after the trough after 1990

	Employment rate growth over i quarters											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
VARIABLES	1 quarter	2 quarters	3 quarters	4 quarters	5 quarters	6 quarters	7 quarters	8 quarters	9 quarters	10 quarters	11 quarters	12 quarters
fin crisis	-0.194*	-0.313*	-0.456**	-0.455*	-0.435	-0.312	-0.328	-0.103	0.754	0.427	0.640	0.00409
	(0.117)	(0.174)	(0.219)	(0.268)	(0.345)	(0.373)	(0.479)	(0.636)	(0.626)	(0.847)	(1.035)	(1.759)
GDP = L,	0.132***	0.167***	0.234***	0.229***	0.270***	0.343***	0.441***	0.385***	0.399***	0.319***	0.290**	0.120
	(0.0353)	(0.0418)	(0.0500)	(0.0551)	(0.0600)	(0.0600)	(0.0770)	(0.0926)	(0.0873)	(0.0955)	(0.108)	(0.166)
coord	0.0922*	0.173**	0.217**	0.323**	0.328**	0.551***	0.430**	0.464	0.312	0.671	0.713	0.838
	(0.0549)	(0.0789)	(0.103)	(0.130)	(0.151)	(0.181)	(0.216)	(0.291)	(0.285)	(0.407)	(0.493)	(0.748)
Constant	-0.857	-1.753	-0.934	-0.747	-1.774	-3.320	-2.241	-3.425	-1.796	3.459	6.009	0.842
	(0.960)	(1.418)	(1.831)	(2.396)	(2.942)	(3.228)	(4.326)	(5.294)	(5.398)	(6.695)	(7.335)	(10.97)
Observations	164	163	159	150	142	133	115	92	82	70	62	48
R-squared	0.166	0.184	0.231	0.216	0.227	0.318	0.341	0.272	0.330	0.351	0.397	0.438
decade trend	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
base empl rate level	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
country FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
restrict to recoveries	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 1.19: Explaining the cumulative growth of the employment rate after the trough using one observation per cycle (event-study)

	Hours worked growth over i quarters														
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
VARIABLES	1 quarter	2 quarters	3 quarters	4 quarters	5 quarters	6 quarters	7 quarters	8 quarters	9 quarters	10 quarters	11 quarters	12 quarters	13 quarters	14 quarters	15 quarters
fin crisis	-0.110	-0.245	0.103	0.0426	0.398	0.636	0.802*	0.195	0.0133	-0.112	-0.395	-0.880	-2.629	-1.573	-1.745
	(0.239)	(0.267)	(0.298)	(0.281)	(0.337)	(0.382)	(0.442)	(0.609)	(0.423)	(0.577)	(0.759)	(1.354)	(2.233)	(2.973)	(4.845)
GDP = L,	-0.0506	-0.0787	-0.0412	-0.132**	-0.0957*	-0.0940	-0.0677	-0.147*	-0.109*	-0.133**	-0.0623	-0.0725	-0.141	-0.302	-0.250
	(0.0665)	(0.0594)	(0.0633)	(0.0516)	(0.0533)	(0.0567)	(0.0647)	(0.0873)	(0.0579)	(0.0652)	(0.0757)	(0.135)	(0.155)	(0.166)	(0.408)
coord	-0.0948	-0.0285	-0.0573	-0.0462	-0.0528	-0.231	-0.150	-0.442	-0.294	-0.288	-0.162	-0.400	-0.104	1.275	1.798
	(0.106)	(0.113)	(0.132)	(0.124)	(0.138)	(0.171)	(0.178)	(0.270)	(0.188)	(0.273)	(0.351)	(0.522)	(1.221)	(2.198)	(4.368)
Constant	4.284*	2.092	6.315**	5.424*	8.815**	11.32***	7.388*	16.09***	11.81***	11.02**	9.121	8.968	9.558	14.56	22.81
	(2.311)	(2.549)	(2.870)	(2.745)	(3.378)	(3.846)	(4.310)	(5.884)	(3.880)	(5.195)	(6.370)	(8.571)	(10.47)	(17.78)	(46.23)
Observations	138	137	134	125	118	109	95	80	72	61	54	41	33	28	23
R-squared	0.125	0.103	0.174	0.209	0.234	0.316	0.168	0.272	0.260	0.278	0.228	0.202	0.411	0.556	0.391
decade trend	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
base hour level	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
country FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
restrict to recoveries	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 1.20: Explaining the cumulative growth of hours worked per worker after the using one observation per cycle (event-study)

Employment rate growth during the recession	
	(1)
VARIABLES	peak to trough growth rate of the employment rate
fin crisis	-0.986***
	(0.109)
GDP during recession	0.392***
	(0.0106)
GDP during recession, squared	-0.0232***
	(0.000758)
coord	0.253***
	(0.0495)
Observations	2,896
R-squared	0.534
decade trend	yes
base empl rate level	yes
country FE	yes
restrict to recoveries	yes

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 1.21: Explaining the cumulative growth of the employment rate from peak to trough.

Hours worked growth during the recession	
	(1)
VARIABLES	peak to trough growth rate of hours worked
fin crisis	-0.219**
	(0.0922)
GDP during recession	0.0314***
	(0.00817)
GDP during recession, squared	-0.00238***
	(0.000563)
coord	-0.172***
	(0.0398)
Observations	2,473
R-squared	0.094
decade trend	yes
base hour level	yes
country FE	yes
restrict to recoveries	yes

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 1.22: Explaining the cumulative growth of hours worked per worker from peak to trough.

	Employment rate growth over q quarters											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
VARIABLES	1 quarter	2 quarters	3 quarters	4 quarters	5 quarters	6 quarters	7 quarters	8 quarters	9 quarters	10 quarters	11 quarters	12 quarters
fin crisis	-0.0202	-0.0205	-0.0177	-0.0528	-0.110	-0.181**	-0.246**	-0.331***	-0.392***	-0.427***	-0.480***	-0.488***
	(0.0243)	(0.0389)	(0.0506)	(0.0637)	(0.0753)	(0.0871)	(0.0976)	(0.108)	(0.118)	(0.126)	(0.134)	(0.141)
GDP = L,	0.0469***	0.132***	0.199***	0.229***	0.252***	0.269***	0.279***	0.282***	0.283***	0.280***	0.271***	0.262***
	(0.00726)	(0.00817)	(0.00784)	(0.00788)	(0.00799)	(0.00828)	(0.00856)	(0.00885)	(0.00905)	(0.00924)	(0.00942)	(0.00945)
coord	0.0300***	0.0552***	0.0738***	0.0948***	0.120***	0.140***	0.165***	0.191***	0.212***	0.243***	0.262***	0.285***
	(0.00990)	(0.0158)	(0.0207)	(0.0260)	(0.0309)	(0.0358)	(0.0404)	(0.0451)	(0.0491)	(0.0531)	(0.0570)	(0.0604)
1.trough_#1.fin_crisis_cycle	-0.0886	-0.115	-0.105	-0.0390	0.0635	0.150	0.312	0.472	0.716*	0.654	0.896	0.514
	(0.0640)	(0.102)	(0.133)	(0.168)	(0.207)	(0.247)	(0.303)	(0.351)	(0.407)	(0.505)	(0.607)	(0.726)
Observations	1,480	1,468	1,456	1,447	1,440	1,433	1,426	1,419	1,410	1,399	1,389	1,379
R-squared	0.088	0.201	0.340	0.403	0.449	0.477	0.495	0.504	0.517	0.521	0.522	0.524
decade trend	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
base empl rate level	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
country FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
restrict to recoveries	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 1.23: Explaining the cumulative growth of the employment rate after the trough using linearly detrended series

	Hours worked growth over q quarters											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
VARIABLES	1 quarter	2 quarters	3 quarters	4 quarters	5 quarters	6 quarters	7 quarters	8 quarters	9 quarters	10 quarters	11 quarters	12 quarters
fin crisis	0.251	0.556	1.646	3.419*	3.216*	3.917*	4.761**	4.675**	5.661**	5.752**	4.924*	5.197**
	(1.497)	(1.511)	(1.633)	(1.862)	(1.907)	(2.051)	(2.181)	(2.300)	(2.321)	(2.441)	(2.530)	(2.592)
GDP = L,	0.122	-0.0989	0.528**	0.786***	0.831***	0.845***	0.839***	0.788***	0.849***	0.844***	0.812***	0.789***
	(0.436)	(0.308)	(0.244)	(0.221)	(0.193)	(0.185)	(0.180)	(0.175)	(0.165)	(0.165)	(0.162)	(0.157)
coord	-0.536	-0.869	-1.470**	-1.588**	-1.834**	-2.063**	-2.530***	-2.921***	-3.170***	-3.313***	-3.195***	-3.593***
	(0.601)	(0.606)	(0.654)	(0.744)	(0.763)	(0.820)	(0.875)	(0.924)	(0.933)	(0.992)	(1.036)	(1.069)
1.trough_#1.fin_crisis_cycle	-1.069	-2.196	1.645	-2.312	8.965*	12.98**	14.65**	13.51*	-0.794	6.107	-0.837	-0.234
	(3.833)	(3.851)	(4.160)	(4.757)	(5.070)	(5.621)	(6.576)	(7.190)	(7.617)	(9.384)	(11.15)	(13.17)
Observations	1,394	1,383	1,372	1,364	1,357	1,350	1,343	1,336	1,327	1,318	1,310	1,301
R-squared	0.025	0.045	0.070	0.090	0.119	0.143	0.157	0.178	0.211	0.231	0.245	0.265
decade trend	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
base hour level	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
country FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
restrict to recoveries	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 1.24: Explaining the cumulative growth of hours worked per worker after the trough using linearly detrended series

Chapter 2

Long Working Hours Make Us Less Productive but Also Less Costly

Co-authored with Vincent Vandenberghe

This paper develops and assesses empirically a simple model of firms' optimal decision regarding working hours, where productivity varies with hours and where the firm faces quasi-fixed labour costs. Using Belgian firm-level data on production, labour costs, workers, and hours, and focusing on the estimation of elasticities along the isoquant and the isocost, we find evidence of not only declining productivity of hours but also of quasi-fixed labour costs in the range of 20 per cent of total labour costs. The tentative conclusion is that firms facing such costs are enticed to raise working hours, even if this results in lower productivity.

2.1 Introduction

A renewed interest in reducing working hours has recently been observed in many countries. In the wake of the 2008 crisis, it has been proposed to combat surging unemployment. It is also seen as a desirable corollary to longer careers (i.e. part-time/gradual retirement schemes) that governments promote in response to population ageing. The canonical model of labour supply states that a worker can flexibly choose his/her own work hours to maximize his or her utility at any given wage.[1] However, findings from several studies, reviewed by Kuroda and Yamamoto (2013), suggest that workers cannot choose work hours freely, or that a change of hours is conditional on a job change.[2] In this context, and following Pencavel's call (Pencavel, 2016) for more research on the demand of labour,[3] this paper focuses on the preferences of firms regarding the working hours of their employees.

In fact, once that intensive dimension of labour is introduced, firms must make a non-trivial decision on the number of workers hired as well as on the hours that are asked from them. A profit-maximizing firm will decide on the number of workers to hire and on working hours by comparing the productivity and cost of both workers and hours. Labour productivity, whether at the intensive or at the extensive margin, has already attracted a lot of interest in the past. A first, rather old, stream or the economic literature develops the idea that longer hours lead to counterproductive hardship. One of the first economists to discuss it was Karl Marx in the Capital Vo. 1, Ch XV, Section 3 (c). Later John Hicks (1932) stated that "probably it has never entered the heads of most employers . . . that hours could be shortened, and output maintained." A milder version of his story is that, as workers slave away for longer and longer, they lose energy, which makes them relatively less productive: in other words, the last hours of work still raise total output but at a declining rate. In contrast, Feldstein (1967) insists on the importance of 'slack' hours. He argues that many hours amount to setting-up time, refreshment breaks, time around lunch, and deliver no output. These paid-but-non-productive hours do not rise proportionately with the number of hours officially worked. An increase in the length of the official working day or week could therefore entail a more than proportionate increase in the number of effective hours of works. Our empirical work follows the conclusions by Leslie and Wise (1980), or more recently by Pencavel (2015) or Collewet and Sauermann (2017) that give credit

[1] Workers' preferences regarding hours have largely been studied in previous work (see, e.g., Barzel, 1973; Freeman and Gottschalk, 1998) and more recent one by Rogerson, Keane & Wallenius (2009, 2011).

[2] For example, in his survey on labour supply, Heckman (1993) concludes that most of the variability in labour supply can be explained by extensive margins (i.e. worker flows into and out of the labour market), whereas intensive margins (i.e. changes in hours worked) are extremely small. Using job-mover data, Altonji and Paxson (1986, 1988, 1992) or Senesky (2005) suggest that choices of wages and hours are available only as a 'package'; therefore, a worker is not able to change work hours flexibly unless he or she changes jobs.

[3] The relative importance of the demand for labour has also been highlighted by Bryan (2007) and Stier and Lewin-Epstein (2003).

to the hardship story, but it in its mild form: *average* productivity of hours is decreasing in the number of hours, due to the decreasing *marginal* productivity. This result is, however, only valid at the observed number of hours worked and does not contradict the presence of slack hours due to decreasing number of hours worked.

So, could it be that employers have it all wrong when they oppose reducing working hours even though it could boost productivity? Not necessarily if, as proposed by Oi (1962), Donaldson and Eaton (1984), Dixon and Freebairn (2009) or Kuroda and Yamamoto (2013), the existence of quasi-fixed labour costs is considered. The main contribution of this work is to shed light on the role of quasi-fixed labour costs in understanding firms' demand for hours. The notion deserves some clarification. Fixed costs of production already benefited from attentive scrutiny in the economic literature. They are usually understood as any financial cost — most often corresponding the cost of capital — not dependent on the level of goods or services produced. Less often explored, quasi-fixed labour costs are the focus of this paper and arise from the explicit modelling of both the intensive and the extensive margin of employment. Here, following Hamermesh's (1993) typology, quasi-fixed labour costs (F) reflect the propensity of a worker's compensation to be not strictly indexed on the hours of work delivered (H) (but rather on the number of workers N). That comprises not only the lump-sum part of pay, non-proportional taxes, or social security contributions, fixed insurance premia, indivisible perks like a company car but also recruitment/training or redundancy/firing costs.

Hamermesh distinguished two types of quasi-fixed labour costs. First, the 'recurring fixed costs' (R). These are the costs associated with non-wage remuneration and fringe benefits: the health insurance, leasing car, paid sickness leave (as well as any other type of leave where the worker remains paid while not delivering any hour). Second 'one-time fixed cost' (T). In Hamermesh's typology these are costs that are paid only once per worker. They typically consist of the cost of (externally or internally provided) training, the cost of operating an HR department, and dismissal costs. At the level of a firm, the one-time fixed costs will enter F pro rata the likelihood q of turnover $F = R+qT$. In contrast, variable labour costs are those that vary with the number of hours; and will typically correspond to the product of hours by an hourly wage rate ($w(H)H$). The total labour cost of a typical firm thus writes $C(N, H) = N(w(H)H + F)$. In the presence of significant labour quasi- fixed costs (F), raising the number of hours per worker will decrease the average cost and raise profitability ceteris paribus.

Evidence gathered in this paper, using firm-level data covering the whole Belgian private for-profit economy, suggests both a declining productivity of hours, and a declining average cost per additional hour worked. Using annual firm-level data over a 9-year period (2007–2015), we show that in the Belgian private economy firms operate around a level of hours per year that is synonymous with decreasing average productivity: thus, shorter hours could have a positive effect on labour productivity (value added per hour). But analysing the relationship between total labour cost and hours, we also find strong evidence of substantial quasi-fixed labour costs (around 20–23 per cent of total labour costs) suggesting that maximizing firms have an incentive to push hours beyond the point where labour productivity is maximal. To our knowledge, this paper is the first to quantify quasi-fixed labour costs using only econometric estimates of labour cost functions. So far, economists like Hart (1984), Ehrenberg (2016) or Martins (2004) have always resorted to an intrinsically more descriptive (and time-consuming) approach that consists of an in-depth analysis of accounting data, guided by a knowledge of institutional or contractual arrangements underpinning labour compensation. Finally, it is worth stressing that our paper goes beyond simply quantifying quasi-fixed labour costs. It also assesses their economic significance by looking at their impact on firms' actual labour decisions. Indeed, the paper reports evidence of substitution of hours for workers (i.e. longer hours, less workers) in response to rising quasi-fixed labour costs. This result aligns with those published by Cutler and Madrian (1998); Montgomery and Cosgrove (1993); Buchmueller (1999) or Dolfin (2006); who use descriptive estimation of quasi-fixed labour costs.

One of the tentative conclusions of the paper it that, akin so many other aspects of economic life, the decision of firms on working hours amounts to a trade-off: reducing working hours might improve labour productivity, but it could also raise average labour cost per hour. A better understanding of firms' or industries' incentives to reduce or raise working hours should help policy making. For example, to promote part-time employment for the older workers, policy makers should prioritize industries with low quasi-fixed labour costs or foster tax and compensation policies that ensure that employer costs are as proportional as possible to hours of work.

The rest of the paper is organized as follows. Section 2.2 exposes a model of the profit-maximizing firm that has all power to not only decide on the number of workers but also on the number of hours each worker must work. The model highlights the likely determinants of the demand for workers and working hours, the role of the productivity of hours, and that of quasi-fixed labour costs. It also suggests a way to identify econometrically the share of fixed labour costs as the workers/hours elasticity along the isocost. Section 2.3 presents and discusses the economic and institutional mechanisms that in the Belgian context generate quasi-fixed labour costs. Section 2.4 describes the panel of firm-level data that is used. Section 2.5 exposes our econometric analysis and results. We first present baseline estimates of the productivity of working hours and of the share of quasi-fixed labour costs in total labour costs. Second, we introduce an industry-by-industry analysis that shows that industries with larger quasi-fixed labour costs tend to have higher average working hours higher and make less use of part-time work. Section 2.6 presents further evidences about quasi-fixed labour costs at the worker-level and from an international perspective. Section 2.7 concludes.

2.2 Working hours as a firm-level decision

Consider a technology where effective labour consists of hours (H) and worker (N), where hours of presence (H) do not equal effective hours of labour $g(H)$. The production function is as follows:

$$Q(K;L) \leq f(K;L) \tag{2.1}$$

$$\text{where } L = Ng(H) \text{ and } g'(H) > 0 \tag{2.2}$$

Assuming that $g(H) = H$ for every possible value of H is probably unrealistic. Doubling hours per worker will not double the amount of effective hours/labour. As soon as one lifts the assumption of identity, the labour demand can no longer be simply considered as employers just choosing an optimal number of worker-hours (i.e. the product $N.H$ equal to L) (Hamermesh 1993) — with the level of H being essentially a matter of workers' preferences in terms of revenue versus leisure. In this model, we make the opposite assumption that employers are free to choose the number of hours worked per worker as well as the number of workers. It is worth noting that the specific form for $L(N,H)$

will lead to the absence of scale effect on firm's optimal number of hours per worker H^*: the latter is independent of the size of the firm (measured by N).

Following Cahuc et al. (2014), we assume firms face the following sequence of choices: first, firm choose between hours and workers by minimizing their labour cost, second they choose between labour (optimally composed of hours and workers) and capital. This sequential choice hypothesis implies that hours versus workers decisions are invariant to firm size and therefore separable from capital.[4] The employers' problem can then be viewed as one of mini- mizing total labour cost $C(N, H)$ subject to the technological constraint $Y \leq f(K, Ng(H))$. The optimum (H^*, N^*) is described by a series of FOC that lead after some manipulations to equating the ratio of marginal productivities to the ratio of marginal labour costs:

$$\frac{L_H}{L_N} = \frac{C_H}{C_N} \tag{2.3}$$

or equivalently using (2.2) and assuming that the true generating process for labour cost is:

$$C(N, H) = FF + N(w(H)H + F) \tag{2.4}$$

where $w(H)$ is the hourly wage ('variable labour costs') and rises with H ($w' > 0$) to reflect, among other, the legal obligation to pay more for extra hours. Modelling the overtime premium as a continuous increasing hourly wage function allows to compute elasticities that we will be able to estimate in the dataset. The alternative modelling option is to have an overtime premium paid per hour above a legal threshold, however, our data would not allow us to estimate the increase in remuneration at the threshold.
F denotes labour quasi-fixed costs (i.e. costs that are invariant to the number of hours per worker, but vary with the number of workers).
FF are firm-level fixed costs [i.e. costs that are invariant to the number of workers (human resources personnel, administrative procedures vis-a-vis insurers, public authorities)].

[4] The sequence of choice has been documented before and it seems realistic to think that capital/ labour ratio decisions are subject to a different timing than hours/workers decisions. Would this assumption be lifted, the final signs of derivatives would be indeterminate and depend on capital, workers, and hours complementarity (Hart, 1984).

we get

$$\frac{L_H}{L_N} = \frac{Ng'(H)}{g(H)} = \frac{C_H}{C_N} = \frac{Nw'(H)H + w(H)N}{w(H)H + F} \tag{2.5}$$

One can also restate the equilibrium using the implicit function theorem,[5] where the ratio of marginal productivities L_H/L_N is equal to the slope of the isoquant:

$$-\frac{L_H}{L_N} = \frac{dN}{dH}_{|dL=0} \tag{2.6}$$

And multiplying by H/N leads to the elasticity along the isoquant $\sigma(H, N)$:

$$-\frac{H}{N}\frac{L_H}{L_N} = \frac{H}{N}\frac{dN}{dH}_{|dL=0} = -\sigma(H, N) \tag{2.7}$$

Similarly, the ratio of hours and men marginal labour cost C_H/C_N can be related to the elasticity of substitution along the isocost $\gamma(H, N)$:

$$-\frac{H}{N}\frac{C_H}{C_N} = \frac{H}{N}\frac{dN}{dH}_{|dC=0} = -\gamma(H, N) \tag{2.8}$$

Thus, as alternative to (2.3), the optimum N^*, H^* can be described as the equality of the slopes of the isoquant/isocost in the (N, H) space; or the equality of the elasticities of hours per worker along both the isoquant and isocost (Dixon et al., 2005):

$$\sigma(H, N) = \gamma(H, N) \tag{2.9}$$

or equivalently, given (2.2) and (2.4):

$$\sigma(H, N) = \frac{g'(H)}{\frac{g(H)}{H}} = \gamma(H, N) = \frac{1 + \epsilon}{1 + rF} \tag{2.10}$$

[5] $dL = 0 = L_H dH + L_N dN$

where: $\epsilon \equiv \frac{w'(H)}{\frac{w(H)}{H}}$ is the elasticity of hourly wage to working hours;[6]
$rF \equiv \frac{F}{w(H)H}$ the ratio of fixed to variable worker-level labour costs.

Note that (2.10) can be rewritten as $\gamma(H;N) = (1+\epsilon)w(H)H/(W(H)H+F)$ showing that $c(H,N)$ it is the upper bound ($e \geq 0$) of the share of variable costs in total labour costs. As a consequence, hereafter, $1-\gamma(H;N)$ will interpreted as a lower bound estimate of the share of quasi-fixed labour costs in total labour costs.

Equation (2.10)means that H^* is such that the ratio of its marginal to average productivity $\frac{g'(H)}{\frac{g(H)}{H}}$ equals $(1 + e(H)/1 + rF)$. The higher quasi-fixed costs relative to the sensitivity of wage rate to hours, the more likely $\gamma(H,N)$ will be less than 1 (in absolute value) (Figure 2.1, lower part). Simultaneously, if that is the case employers will push for longer hours; certainly, beyond the point where marginal productivity starts declining (presumably due to hardship, lassitude), and beyond the point where average productivity of hours reaches its maximum (Figure 2.1, upper part) i.e. $\sigma(H,N) < 1$.[7] Said differently, the only reason for firms to push working hours to the point where average productivity is declining, is that they are better able to spread fixed costs.

This finally leads to positing that the (conditional) labour demand for working hours looks like

$$H^* \equiv q(\overbrace{\sigma}^{-}) = m(\overbrace{\gamma}^{-}) = m(\overbrace{F}^{+}, \overbrace{\epsilon}^{-}) \tag{2.11}$$

with the last right-hand term reflecting the positive relationship between hours and quasi-fixed labour cost.

[6]Driven by overtime wage premia or a higher incidence of employer-paid sick leave when H rises.

[7]Mathematically, the sign of the slope (or derivative) of the average productivity is determined by the difference/ratio between the average productivity and the marginal productivity: $d(g(H)/H)/dH = g'(H)/Hg(H)/H^2) = [g'(H)g(H)/H]/H$. If $g'(H) < g(H)/H$ (i.e. if $r(H) < 1$) we necessarily have a negative slope for the average productivity, meaning that we are beyond its maxi- mum. And marginal productivity of hours is declining (Figure 2.1, upper part).

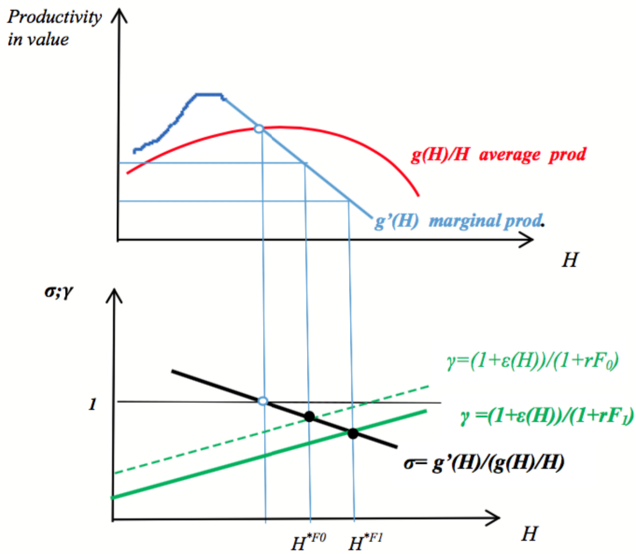

Figure 2.1: Optimal hours, ratio of marginal to average productivity of hours and quasi-fixed labour costs ($F_1 > F_0$).

2.3 The economic and institutional factors underpinning quasi-fixed labour costs in the Belgian context

As stressed in the introduction, one of the novelties of this paper is to quantify quasi-fixed costs using econometric estimates of the elasticities along firm's labour isocost and isoquant. What has been done on quasi-fixed costs in the existing empirical literature (Ehrenberg, 2016; Hart, 1984; Martins , 2004) consists of analysing accounting data, and identify the components that qualify as being (quasi)-fixed, based on relatively detailed and country-specific knowledge of institutional or contractual arrangements underpinning labour compensation. The advantage of our econometric approach — and of the algebra from which it derives, see Section 2.2 —, is that there is no need to invest time in scanning firms' financial reports or to develop an in-depth understanding of institutions. Our results simply derive from the estimation of the parameters of either a production function or a labour cost function comprising the duration of work and the number of workers. The challenge is more to estimate these functions correctly, and avoid statistical biases. This said, it is quite natural for the reader who discovers our results — quasi-fixed costs in the range of 20 per cent — to ask, in the context of Belgium, which might be the actual drivers and determinants of these fixed costs. The lines that follow try to answer that interrogation.

2.3.1 One-time fixed costs

A starting point is to discuss the presence 'one-time fixed costs': recruitment, firing/severance, and training costs (Hamermesh, 1993). These exist in Belgium. The singularity of Belgium probably is that its severance costs — particularly for white collars — are very high (i.e. in excess of one year of pay white-collar workers with seniority) — and may be a significant contributor to Belgium's overall level of quasi-fixed costs.[8]

2.3.2 Recurrent quasi-fixed labour costs

Things are trickier when it comes to 'recurrent' quasi-fixed labour costs; that labour economists traditionally associate to nonwage compensation (pension/ unemployment/ health insurance, paid sick or holiday leave, perks). In Belgium, not all of these amount to 'purely' quasi-fixed costs, as some are directly or indirectly indexed on hours. Only a cautious, case-by-case examination may lead to a definite judgement as to their degree of 'fixity'.

Strictly speaking in Belgium, all social security contributions (financing the health insurance, the unemployment insurance and legal pensions; i.e. the 1st pillar) are computed as a percentage of the gross remuneration, that is itself proportional to the number of hours worked. Therefore, these contributions do not a priori qualify as 'fixed'. Also, in principle, important mandatory benefits (end-of-year bonus, single and double holiday bonuses) are directly indexed on annual hours of work. For instance, if the worker has been absent during the year, the amount of her end-of-the-year bonus is reduced pro rata the number of days of absence. The same logic holds for occupational pensions (the so-called 2nd pillar of the pension system, paid by the employers to top-up legal pensions). Instalments are indexed on salaries, and thus on hours.

Belgium has many regimes of 'assimilation' i.e. days not worked but 'assimilated' to days of work and thus remunerated and/or qualifying for social security payments. The most important one is the regime of employer-paid sick

[8] Prorata the likelihood of dismissal/separation.

leave.[9] The list also comprises maternity/parental leave, educational/training leave, union leave. There is also a regime of 'economic unemployment'; i.e. situations of temporary economic recess where workers are sent home but are still paid by the employers. All these 'assimilated' days give rise to sizeable additional labour costs. But a priori, these are indexed on hours worked. Mathematically, if H_1 is the number of hours actually worked and H_2 is the number of 'assimilated' hours, the total labour cost writes $C = F + w(H_1 + H_2)$. If $H_2/H_1 = a$ is constant (ex: a probability of illness...), then the assimilated days are similar to variable costs i.e. $C = F + w(1 + a)H_1$. Simply, the effective wage rate writes $w(1 + a)$ and is inflated pro rata the share a of 'assimilated' hours. However, in practice, there are reasons to believe that $a = H_2/H_1$ is decreasing with H_1. Why? The most obvious case is that of temporary/economic unemployment. It typically intervenes during periods of overall reduction of the number hours worked (i.e. low H_1). Also, some 'assimilation' regimes (e.g. maternity leave) tend to work predominantly to the benefit of workers who work less hours (women). Similarly, one relatively unknown feature of Belgium's occupational pensions is the presence of 'social' contributions: extra payments by employers aimed at improving the pension capital of the lowest earners; that also often correspond to those working less hours.[10]

Then there is the case of perks and in-kind benefits. Mainly for fiscal reasons,[11] Belgian employers are prone to remunerate their employees in kind. The point is that many in-kinds are 'fixed'. The most significant one is the company car. It represents up to 20 per cent of a worker's gross remunera-

[9]Paid sickness leaves represent a large cost for firms. In fact, in the Belgian system, sickness leave is highly comparable to paid holiday in terms of cost for the firm. The first 30 days of each sick leave are paid for by the employer; and days of absence due to sickness still entitle workers to the associ- ated yearly premium, paid holidays, pension and health insurances. After 30 consecutive days, the replacement wage is paid for by the social security and the worker may lose some of the perks. On average in Belgium, 50 per cent of employees take at least 1 day of sick leave per year. Among those, sick leaves last on average 13 days but the average number of days paid by the firm is around 5 days. The percentage of workers taking at least one sick day is similar among blue and white collars, but the average leave length is quite different, 8 days for white collar (five paid for by the firm), 16 days for blue collar (seven paid for by the firm). The share of workers taking at least one day of sick leave also strongly increases with the size (number of workers) of the firm: from 32 per cent for firms of one to four workers up to 60 per cent for the largest firms (above 1,000 workers) Securex (2011).

[10]Formally, the consequences of H_2/H_1 being non-constant are that the average labour cost per hour becomes $C/H_1 = F/H_1 + w(1 + \alpha(H_1))$ and the derivative with respect to hours worked $d(C/H_1)/dH_1 = -F/H_1^2 + wd\alpha(H_1)/dH_1$. So if $d\alpha(H_1)/dH_1 < 0$, the deflating effect of longer hours of work H_1 is magnified.

[11]Belgium is characterized by a very large fiscal wedge on labour. One way for companies and workers to reduce payment is to resort to in-kind benefits.

tion and is very common in Belgium.[12] Other in- kinds comprise home/work travel allowances,[13] mobile phones, laptops and tablets. Also, employers must insure each employee against the risk of workplace and home-to-work commuting accident. Whatever the number of hours worked, employees benefit from mandatory, employer-paid, health checks performed in the workplace. All in all, in-kind benefits were estimated to be around 14 per cent of the labour cost for Belgian workers (Labour Cost Survey, SPF Economie, 2012).

Other sources of 'fixity' are worth mentioning. In Belgium, there are rules imposing that employers do not pay less than a certain amount, even if the number of hours actually worked is small. For part-timers, the Belgian legislation imposes that contracts (and the remuneration they generate) should be a least equivalent to a weekly minimum of one-third of the reference full time; with a daily minimum of 3 hours. Remuneration minima for night-shift workers (i.e. those who worker after 10 PM) are even stricter.[14] If, with some positive likelihood, the actual duration of work is inferior to these thresholds, then the hourly wage rises considerably. In that sense, these rules can lead to a caricature of the idea of quasi-fixed labour costs.

Finally — but this is not specific to Belgium, — compensation schemes for middle or top managers tend to amount to quasi lump-sum commitments. They receive an annual salary (+ in-kinds) for an indicative number of hours of service; that de facto fluctuates considerably, with no or little impact on the amount received. Ceteris paribus, the more prevalent these schemes, the more labour costs should appear a quasi fixed.

2.4 Data

The data we use in this paper essentially come from Bel-First (Tables 2.1–2.4, Figure 2.2),[15] that all for-profit firms located in Belgium must feed to comply with the legal prescriptions on income declaration. It consists of a large unbalanced panel of 115,337 firm-year observations corresponding to the situation of 14,544 firms with at least 20 employees, from all industries forming the

[12] 2015 figures suggest that 15 per cent of all employed workers in Belgium benefit from a com- pany car.

[13] Akin full-time workers, part-time workers are fully eligible.

[14] Min{6 hours, typical day-shift number of hours}

[15] http://www.bvdinfo.com/Products/Company-Information/National/Bel-First.aspx

for-profit Belgian private economy,[16] in the period 2007– 2015.[17] Our dataset comprises a large variety of firms. First along the firm size dimension, we include all data for firms from 20 workers (FTE) to very large firms (above 1,000 workers), corresponding to well-known international companies.[18] These firms are largely documented in terms of industry (NACE[19] or NAICS[20]), size (number of workers), capital used (total equity), total labour cost (more on this below) and productivity (value added).

Descriptive statistics on this large sample are reported in Tables 2.1–2.4. One of the originalities of this paper is to consider both the productivity and the labour cost of hours and workers. Table 2.2 contains descriptive statistics on productivity (Q/N where Q is value added) and average labour costs (C/N). The latter is logically inferior to productivity.

	Number of firms
2007	11944
2008	12213
2009	12369
2010	12698
2011	12949
2012	13272
2013	13365
2014	13370
2015	13157
Total	115337
N	115337

Source: Bel-first(2016)

Table 2.1: Descriptive statistics, number of firms

In this paper, labour costs are measured as a firm-level aggregate independently from production. They include the value of all wage and non-wage compensations paid to or on behalf of the total labour force (both full- and

[16] We remove the primary sector (agriculture and mining) as well as the public/non-profit industry (NACE 1-digit codes 'A', 'B', 'O', 'P', 'T', 'U').

[17] The analysis has also been performed on 2005–2014 data without any impact on the conclusions.

[18] Such as Volvo, Arcelor, Audi, GSK, Electrabel, Colruyt, Delhaize, Carrefour, AIB-Vinçotte and 10 large interim firms (Randstad, Adecco, Start People, T-Groep, Tempo Team, Daoust, Manpower).

[19] European industrial activity classification (Nomenclature scientifique des Activité économiques dans la Communauté Européenne).

[20] North American Industry Classification System

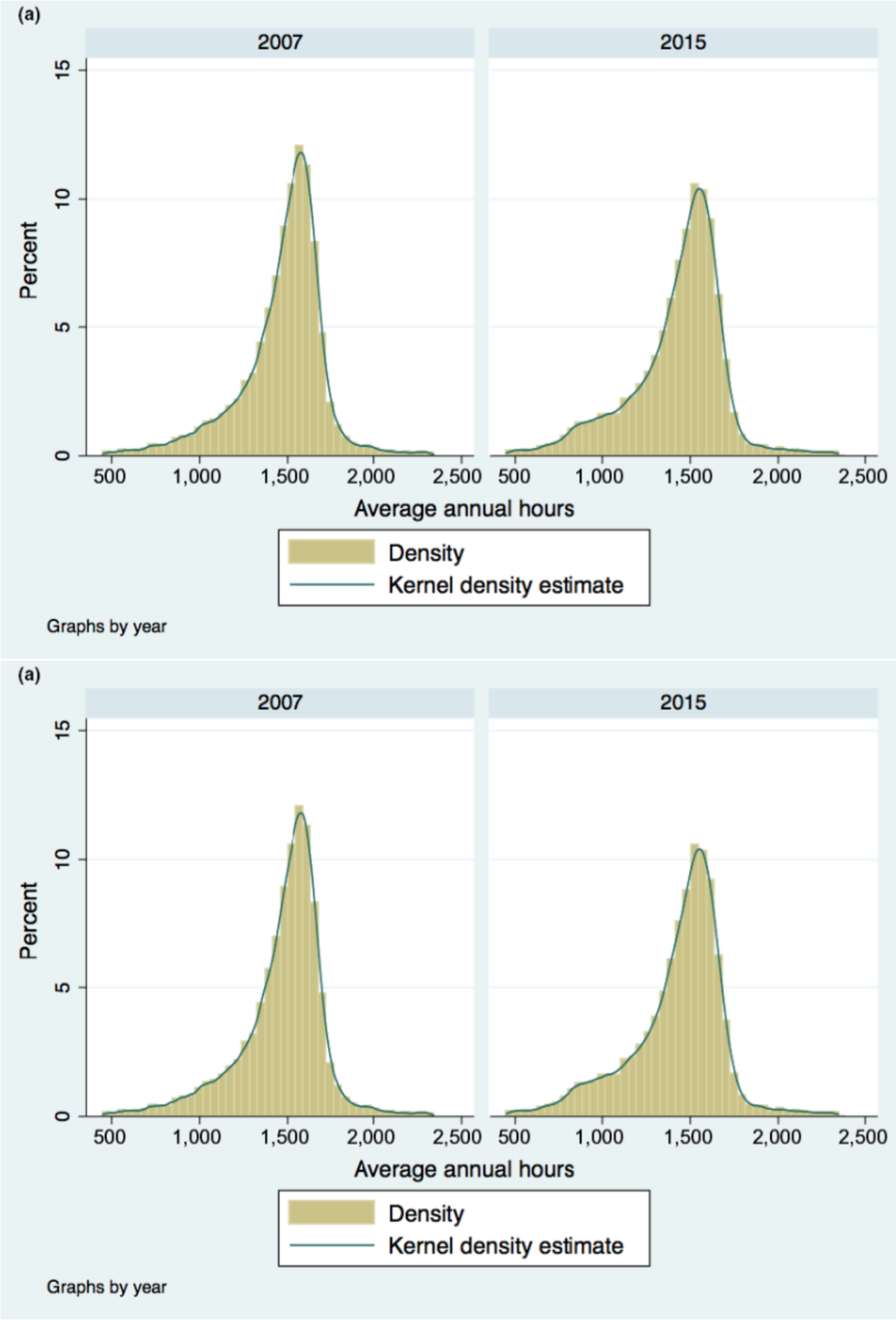

Figure 2.2: Annual average working hours per worker: (a) full-time and part-time and (b) full-time only. Distribution across firms. Belgium private economy 2007–2015.

	Value added per empl. [EUR]	Labour cost per empl. [EUR]	Capital per empl. [EUR]	Hours per empl. [annual]	Workers full time	Workers part time	Workers interim
2007	77,133.03	43,237.04	325,163.3	1,472.4	80.38	24.78	14.57
2008	78,996.69	44,680.06	413,030.7	1,472.4	80.77	24.83	12.98
2009	73,856.15	45,153.60	426,619.2	1,428.4	76.80	24.97	11.51
2010	76,494.41	45,898.61	322,024.1	1,433.2	74.66	25.57	12.59
2011	79,430.76	47,709.65	610,067.9	1,437.2	76.33	27.14	12.28
2012	76,136.48	49,003.94	639,064.7	1,427.9	75.78	28.02	12.57
2013	76,403.06	49,705.03	485,220.0	1,422.4	75.44	29.02	12.81
2014	77,347.08	50,599.59	462,562.8	1,427.7	90.82	36.38	12.37
2015	79,568.47	50,779.37	329,668.3	1,430.1	75.33	37.95	13.67
Total	77,269.98	47,517.51	447,715.7	1,438.5	78.49	28.87	12.81
N	115337						

Source: Bel-first(2016)

Table 2.2: Descriptive statistics, main variables

part-time plus interim/temporary workers) on an annual basis. Labour costs comprise: annual gross wage (including end-of-the year bonuses, paid holiday/sickness/maternity leave), employees' social contributions (representing 13.07 per cent of gross wage), employers' contributions to social security (38 per cent of the gross wage), employers' contributions to extra-legal insurances and pensions, stocks, and other (taxable) perks like 'meal vouchers', company car, mobile phone. Most of the costs of externally provided training are included in the firms' total labour cost used here.[21] And so are Belgium's notoriously high severance payments including the special regimes applicable to older workers.[22],[23]

All in all, the firm-level aggregate that we use is thus likely to capture most of the 'recurrent' and 'one-time' quasi-fixed costs mentioned in the introduction. Still there is a need of an in-depth analysis of which of these items can be considered as genuinely 'fixed'. By contrast, our aggregate does not comprise the costs for externally-provided search/recruitment and training. These appear in the books as intermediates. Also, internal training costs, as well as those of

[21] Account 648 'Other Personnel Expenses'.

[22] By contrast, the cost of workers in a pre-retirement scheme is not counted anymore when fully retired. If partially retired ('aménagement de fin de carrière'), they count as part-time workers; and the worker replacing them for the other part-time is counted.

[23] Unemployment with complement paid by the former employer ('complément d'entreprise'); account 624 Retirement and survival pensions.

	Number of empl.	Av. hours [full-time w.]	Av. hours [part-time w.]	Av. hours [interim w.]	Share of full-time w.	Share of part-time w.	Share of interim w.
p25	27.00	1,464.92	857.25	1,634.33	0.68	0.06	0.00
p50	40.00	1,581.86	1,044.60	1,883.59	0.83	0.12	0.00
p75	74.00	1,666.90	1,201.75	2,004.15	0.92	0.27	0.03
N	115337						

Source: Bel-first(2016)

Table 2.3: Descriptive statistics, workers hours

	Number of workers (n)	Working time(wkt)	Working time FT(wkt_ft)
Std-error	823.32	337.12	280.08
Std_error(between)	454.15	281.62	207.00
Std_error(within)	686.73	185.31	188.67
Within share of total var.	0.696	0.302	0.454

t statistics in parentheses
Source: Bel-first

Table 2.4: Focus on within firm variation

HR departments involved in search and recruitment are unlikely to appear in our data as fixed labour costs. This is because they essentially take the form of wages paid to specialized workers (who also deliver a certain number of hours just like any other employee of the firms). In our data, there is no way to isolate their labour cost.

Of crucial importance in this paper is the distinction between the number of workers (N) and the number of hours (H) (Table 2.2 right-hand columns, Table 2.3). The former is simply the headcount, or more precisely the average over the year of the headcount at the end of each month. The latter corresponds to the number of worked and paid hours over the year.[24] It does not consider unpaid overtime, holidays, sick leaves, short-term absences, and hours lost due to strikes or for any other reasons.

The average hours worked varies strongly in our sample; even among full-time workers (Figure 2.2). The standard deviation of hours worked (overall or for full-time workers only) within firm is only slightly smaller than between firms (Table 2.4). Generally, we observe non-negligible variation of both hours

[24] Unlike hours found in the social security database, Belfirst data on hours do not suffer from the ‘assimilation’ bias: i.e. hours that are assimilated to worked hours in the definition of social (e.g. pension) rights. The only serious issue with Bel-first is thus the underestimation of worked hours due to unpaid overtime (something this seems to be common among white-collar workers).

and workers within firm, over time representing more than 30 per cent of total variation.[25] This observation of large within-firm variations is important to allow for meaningful firm-level fixed effect regressions in the subsequent econometric analysis. In the extension of the main econometric analysis (Section 2.6) we also use individual-level international data from PIAAC.[26]

2.5 Econometric analysis of firm-level data

In this section, using firm-level panel data, we estimate both production and labour cost functions[27] with the aim of assessing the productivity of working hours and the (relative) importance of quasi-fixed labour costs. The advantage of firm-level data is that workers and hours can be analysed simultaneously. And as the data consist of panels, they can be used to control for firm-level unobserved heterogeneity as well as for the risk of simultaneity bias (both being synonymous with endogeneity). What is more, the dataset is sufficiently large to allow for: (i) the identification of cross-industry differences (in terms of $\sigma(H;N)$; $\gamma(H,N)$) and (ii) an econometric analysis of these differences' impact in terms of duration of hours or the incidence of part-time work (Section 2.5.2).

2.5.1 Identification strategy

The simple model, spelled out in Section 2.2, suggests that hours worked per worker are determined at the firm level by the equality of the elasticity along the workers–hours isoquant curve $\sigma(H;N)$ to the elasticity along the isocost curve $\gamma(H,N)$, assuming firms operate at their cost-minimization optimum.

We use Belgian annual firm-level data on total labour cost (wages, contributions to social security and paid holidays, annual bonuses) alongside information about annual hours and number of workers in each of the firms present in the dataset. As we do not observe fixed costs F and the elasticity of unit wage to hours worked ϵ, there is no way we can directly compute $\gamma(H,N)$ as specified in (2.10). The same applies for $\sigma(H;N)$. But these elasticities can be retrieved by estimating n^{th} order polynomial approximations of (the log of) $C(H,N)$) and $Q(K,H,N)$, respectively. In the case of second-order approximations (i.e.

[25] Even after removing outliers: i.e. firms declaring hours per worker to be, on average over all workers, below 100 or above 3,000 annual hours, mostly due to encoding errors.

[26] The Programme for the International Assessment of Adult Competencies (PIAAC).

[27] Not to be confounded with the traditional [production] cost function i.e. a function of input prices and output quantity.

translog specification) we have

$$c_{it} \approx A + \theta n_{it} + \lambda h_{it} + \frac{1}{2}\chi_1 h_{it}^2 + \frac{1}{2}\chi_2 n_{it}^2 + \chi_3 h_{it} n_{it} + T_t + \nu_{it} \quad (2.12)$$

$$q_{it} \approx B + \alpha k_{it} \beta n_{it} + \pi h_{it} + \frac{1}{2}\psi_1 h_{it}^2 + \frac{1}{2}\psi_2 n_{it}^2 + \psi_3 h_{it} n_{it} + T_t + \mu_{it} \quad (2.13)$$

where lower case *c, q, h, n* correspond to the log of *C, Q, H, N,* respectively, T_t are time dummies, and ν_{it}, μ_{it} the residuals.

The derivatives of these translogs vis-a-vis n and h are equal [ignoring firm and time indices] to:

$$\frac{\partial c}{\partial n} = \frac{\partial lnC}{\partial lnN} = \frac{C_N}{C/N} \approx \theta + \chi_2 n + \chi_3 h \quad (2.14)$$

$$\frac{\partial c}{\partial h} = \frac{\partial lnC}{\partial lnH} = \frac{C_H}{C/H} \approx \lambda + \chi_1 h + \chi_3 n \quad (2.15)$$

$$\frac{\partial q}{\partial n} = \frac{\partial lnQ}{\partial lnN} = \frac{Q_N}{Q/N} \approx \beta + \psi_2 n + \psi_3 h \quad (2.16)$$

$$\frac{\partial q}{\partial h} = \frac{\partial lnQ}{\partial lnH} = \frac{Q_H}{Q/H} \approx \pi + \psi_1 h + \psi_3 n \quad (2.17)$$

and thus following (2.7), (2.8) the elasticities along the isocost/isoquant can be approximated using the estimated parameters of (2.12), (2.13):

$$\gamma(H,N) \equiv \frac{H}{N}\frac{C_H}{C_N} \approx \frac{\lambda + \chi_1 h + \chi_3 n}{\theta + \chi_2 n + \chi_3 h} \quad (2.18)$$

$$\sigma(H,N) \equiv \frac{H}{N}\frac{Q_H}{Q_N} \approx \frac{\pi + \psi_1 h + \psi_3 n}{\beta + \psi_2 n + \psi_3 h} \quad (2.19)$$

In particular, with a true cost function (2.4) $C(N,H) = FF + N(wH + F)$ and using (2.10)

$$\gamma(H,N) \equiv \frac{H}{N}\frac{C_H}{C_N} = \frac{\lambda + \chi_1 h + \chi_3 n}{\theta + \chi_2 n + \chi_3 h} \equiv \frac{1+\epsilon}{1+rF} \quad (2.20)$$

or equivalently, if unit wages do not vary with hours (i.e. $\epsilon = 0$) we get and estimation for the share of fixed costs in total labour cost of an employee as:

$$1 - \gamma(H, N) = \frac{F}{F + w(H)H} \equiv \frac{\lambda + \chi_1 h + \chi_3 n}{\theta + \chi_2 n + \chi_3 h} \tag{2.21}$$

Note that expressions (2.18), (2.19) boil down to [respectively] λ/θ [π/β] when χ's [ψ's] are null (i.e. first-order polynomial approximation also equivalent to the Cobb–Douglas specification). Note finally that all our estimates allow for firm-level unobserved heterogeneity (i.e. residuals $\mu_{it} = \omega_{it} + \rho_{it}$; (and similarly for the residual of the cost function), with ω_{it} being a time-invariant firm-level unobserved term potentially correlated with outcome variables and labour ones. In subsequent developments we also allow for simultaneity bias; i.e. $\mu_{it} = \omega_{it} + \rho_{it}$ with ω_{it} being a time-variant unobserved term (corresponding, e.g., to partially anticipated demand chocks) also potentially correlated simultaneously to output and labour decisions (Ackerberg et al., 2015; Levinsohn and Petrin, 2003).

2.5.2 Results

All industries pooled

A first set of key results are presented in Tables 2.5 and 2.6. Estimated coefficients using firm-level mean-centred variables — not only corresponding to equations (2.12), (2.13) but also order 1 simplifications or order 3 generalizations — are reported in the upper part of the table, whereas the implied elasticities $\gamma(H_{it}, N_{it})$ (2.18) $\sigma(H_{it}, N_{it})$ (2.19) along (respectively) the isoquant and the isocost are reported in the lower part of the table. Focusing on the latter, we can see that they are systematically (and statistically significantly) less than 1. For instance, the model delivers a value of $\sigma = 0.80$, in line with results of the literature on the elasticity of output to hours (Anxo and Bigsten, 1989; Cahuc et al., 2014; Cette et al., 2015; Leslie and Wise, 1980). The FE effects model using first-differenced data are presented in the Table 2.6 deliver estimates that are qualitatively similar, suggesting an absence of a serious problem with serial correlation of the residuals in our panel data.[28]

[28] Although both mean-centering (Table 2.5) and first-differencing (FD) (Table 2.6) aim at the same thing (remove a fixed effect) they do not necessarily generate the same results. The main difference stems from the way they transform the OLS residuals and a problem known in the literature on panels as 'serial correlation' (i.e. the fact luck in 1 year might correlate (or not) with luck in other years). Both mean-centering and FD rely on some assumptions. In short, FD is more appropriate when there is serial correlation, while mean-centering is more appropriate (in the sense that it is more effective at removing the time-invariant fixed effect) in the absence of serial correlation. This justifies implementing both methods, even if it is to observe that they generate similar results.

	1st order approximation		2nd order approximation		3rd order approximation	
	Productivity	Labour cost	Productivity	Labour cost	Productivity	Labour cost
$k_{it} \equiv ln(K_{it})$	0.0878***		0.0864***		0.0853***	
	(0.001)		(0.001)		(0.001)	
$n_{it} \equiv ln(N_{it})$	0.779***	0.926***	0.788***	0.930***	0.800***	0.933***
	(0.002)	(0.001)	(0.002)	(0.001)	(0.003)	(0.002)
$h_{it} \equiv ln(H_{it})$	0.627***	0.711***	0.672***	0.746***	0.687***	0.759***
	(0.004)	(0.003)	(0.005)	(0.003)	(0.005)	(0.003)
n_{it}^2			-0.00159	-0.00973***	-0.00421*	-0.00150
			(0.001)	(0.001)	(0.002)	(0.001)
h_{it}^2			0.0830***	0.0699***	-0.0388***	-0.0678***
			(0.003)	(0.002)	(0.005)	(0.003)
$n_{it}h_{it}$			0.0908***	0.0805***	-0.0344***	-0.0367***
			(0.003)	(0.002)	(0.006)	(0.004)
n_{it}^3					-0.00444***	0.00159***
					(0.001)	(0.000)
h_{it}^3					-0.0270***	-0.0307***
					(0.001)	(0.001)
$n_{it}^2 h_{it}$					-0.0189***	-0.00997***
					(0.002)	(0.001)
$n_{it} h_{it}^2$					-0.0422***	-0.0412***
					(0.002)	(0.001)
Controls	year, province, join commission and industry(NAICS 4-digit)					
R^2	.83	.92	.83	.92	.83	.92
Implied elasticities along the effective labour isocost/isoquant+ test of alignment						
σ;γ	0.80	0.77	0.67	0.75	0.68	0.76
Prob = 1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Prob $\sigma = \gamma$	0.0105		0.0000		0.0000	

Standard errors in parentheses

Source: Bel-first

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 2.5: Econometric estimation of the productivity of hours and of the (relative) importance of quasi-fixed labour costs — Fixed effect as mean centering

	1st order approximation		2nd order approximation		3rd order approximation	
	Productivity	Labour cost	Productivity	Labour cost	Productivity	Labour cost
$k_{it} \equiv ln(K_{it})$	0.0913***		0.0903***		0.0881***	
	(0.002)		(0.002)		(0.002)	
$n_{it} \equiv ln(N_{it})$	0.661***	0.843***	0.643***	0.815***	0.702***	0.850***
	(0.003)	(0.002)	(0.004)	(0.002)	(0.004)	(0.003)
$h_{it} \equiv ln(H_{it})$	0.542***	0.650***	0.537***	0.642***	0.630***	0.720***
	(0.005)	(0.003)	(0.005)	(0.003)	(0.005)	(0.004)
n_{it}^2			0.0252***	0.0392***	0.0217***	0.0259***
			(0.002)	(0.001)	(0.002)	(0.001)
h_{it}^2			0.00215	-0.00771***	-0.00954***	-0.00651***
			(0.002)	(0.001)	(0.002)	(0.001)
$n_{it}h_{it}$			0.0304***	0.0326***	0.0110***	0.0176***
			(0.002)	(0.002)	(0.003)	(0.002)
n_{it}^3					-0.00625***	0.00128***
					(0.001)	(0.000)
h_{it}^3					-0.0128***	-0.0131***
					(0.000)	(0.000)
$n_{it}^2 h_{it}$					-0.00302**	0.00955***
					(0.001)	(0.001)
$n_{it}h_{it}^2$					-0.0103***	-0.00633***
					(0.001)	(0.001)
Controls	year, province, join commission and industry(NAICS 4-digit)					
R^2	.35	.6	.36	.6	.37	.62
Implied elasticities along the effective labour isocost/isoquant+ test of alignment						
$\sigma;\gamma$	0.82	0.77	0.54	0.64	0.63	0.72
$Prob = 1$	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
$Prob\sigma = \gamma$	0.0566		0.0000		0.0000	

Standard errors in parentheses

Source: Bel-first

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 2.6: Econometric estimation of the productivity of hours and of the (relative) importance of quasi-fixed labour costs — Fixed effect as first difference

In Table 2.7, we exploit the fact that our data permit replicating the labour cost analysis (using FE-first differences) for three types of employment contracts: full-time (forming the largest part of the total), part-time, and interim/temporary.[29] Two interesting results emerge. First, all types of contracts are associated with quasi-fixed labour costs as all estimated c are statistically less than 1. Fixed costs appear significantly higher for full-time employees[30] : at least 34 per cent compared to 15.4 per cent and 5.4 per cent for part-timers and interims, respectively. This result is in line with the model's prediction that job positions that are associated with higher quasi-fixed costs should be filled with full-time workers, whereas part-timers should only be hired when quasi-fixed costs are relatively low. Results regarding temporary workers should be interpreted with caution, as the data for such workers is much weaker: only a small proportion of firms report the presence of temporary workers and the reporting is based on hours invoiced by the interim company.

In Table 2.8, we explore the varying importance of quasi-fixed labour costs across broadly defined (NACE1) and contrasted industries: manufacturing, retail, and accommodation/ restaurants. The analysis is done separately for the three industries, using FE-first differences. Conditional on hourly wage elasticity (ϵ) to be uniformly distributed, fixed costs appear to be significantly higher in manufacturing (at least 40 per cent) compared to retail and accommodation/restaurants (26 per cent and 21 per cent, respectively). These differences can reflect differences in the labour cost structure between sectors due to, e.g., historically different institutional arrangements of the type listed in Section 2.3. For further results on industry-by-industry results, see Section 2.5.2 below.

In Table 2.9, we present the results when endogeneity stems both from fixed effects (unobserved time-invariant firm heterogeneity) and simultaneity (unobserved, final demand-related, short-run shocks that can affect simultaneously outcomes variables and the level of labour inputs).[31] To control for that risk we

[29]Interims are workers who, from a legal point of view, are employed by interim agencies and 'sold' to the firm where we observe them, for short periods of time (hence, the fact that they are also referred to as 'temporary' workers) and the accomplishment of a speccialized task.

[30]And this in spite of the fact that wage elasticity (ϵ) — which leads to an underestimation of the share quasi-fixed labour costs Equation (2.10) — could be higher for full-timers due to overtime premia.

[31]For instance, the simultaneity of a negative shock (due to the loss of a major contract) and a reduction in hours worked, causing reverse causality: from productivity drop to hours contraction. Alternatively, focusing on the estimation of the labour cost function, the simultaneity between a positive shock (e.g. the landing of a big contract, triggering an overall rise of wages) and a rise of the number of hours worked, also causing a reverse causality problem

	All types of workers	Full-time workers	Part-time workers	Interim workers
n_{it}	0.815***	0.862***	0.938***	0.974***
	(0.002)	(0.003)	(0.003)	(0.002)
h_{it}	0.642***	0.657***	0.845***	0.946***
	(0.003)	(0.004)	(0.004)	(0.005)
n_{it}^2	0.0392***	0.0308***	0.00744***	0.00388*
	(0.001)	(0.002)	(0.002)	(0.002)
h_{it}^2	-0.00771***	0.00261*	-0.0147***	0.00112
	(0.001)	(0.001)	(0.001)	(0.004)
$n_{it}h_{it}$	0.0326***	0.0378***	-0.00553	-0.00274
	(0.002)	(0.002)	(0.003)	(0.005)
Observations	98961	98224	88936	31205
R^2	0.603	0.558	0.560	0.859
Control		year and firm fixed effects		
γ	0.64	0.66	0.85	0.95
$prob = 1$	0.0000	0.0000	0.0000	0.0000

Standard errors in parentheses

Source: Bel-first

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 2.7: Econometric estimation of the (relative) importance of quasi-fixed labour costs. Breakdown by type of contract (full-time, part-time, and interim). Note that only large firms are required to report information on temporary workers' hours and cost separately (large firms are firms with more than 100 workers, or firms exceeding two of the following thresholds: 50 FTE workers, €7,300,000 turnover, €3,650,000 total balance sheet)

implement the more structural approach developed by Levinsohn and Petrin (2003) and more recently by Ackerberg et al. (2015) (ACF hereafter), which primarily consists of using intermediate inputs (materials and other supplies) to proxy short-term shocks. Results are qualitatively very similar to the ones reported in previous tables where we control only for fixed effects. Even though this suggests c that simultaneity is a relatively benign problem in our data, coefficients in Table 2.9 are our most robust and thus preferred ones. Referring to Table 2.9's ACF results,[32] the tentative conclusion would be that quasi-fixed labour costs account for at least 23 per cent of total labour costs. As far as we know, this has never been estimated econometrically so far.

More generally, it should be noted for all tables that our contribution resides principally in the correct estimation of elasticities along the isoquant (σ) and the isocost (γ) to be both significantly lower than one. Estimations along the isoquant are not new and should be understood as the demonstration that

[in particular a shock-driven rise of hourly wage elasticity (ϵ) that may translate into γ being underestimated].

[32] See Vandenberghe (2017) for a full presentation of the LP and ACF proxy-variable idea, and (Vandenberghe et al., 2013) for how it can be combined with fixed effects.

	All industries	Manufacturing	Wholesale and Retail	Accommodation and Restaurants
n_{it}	0.815***	0.775***	0.841***	0.822***
	(0.002)	(0.005)	(0.005)	(0.007)
h_{it}	0.642***	0.594***	0.732***	0.780***
	(0.003)	(0.006)	(0.007)	(0.009)
n_{it}^2	0.0392***	0.0568***	0.0456***	0.0185***
	(0.001)	(0.002)	(0.003)	(0.003)
h_{it}^2	-0.00771***	-0.00730***	0.0169***	-0.00947
	(0.001)	(0.002)	(0.002)	(0.007)
$n_{it}h_{it}$	0.0326***	0.0548***	0.0644***	0.00862
	(0.002)	(0.003)	(0.003)	(0.007)
R^2	0.603	0.637	0.529	0.787
	Control: year and firm fixed effects			
γ	0.64	0.60	0.74	0.78
$prob = 1$	0.0000	0.0000	0.0000	0.0000

Standard errors in parentheses

Source: Bel-first

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 2.8: Econometric estimation of the (relative) importance of quasi-fixed labour costs. Breakdown by broadly defined industries (Manufacturing, Wholesale and Retail, and Accommodation and Restaurants)

our database yields results aligned with the existing empirical literature. On the other hand, results regarding the isocost have not been shown before and represent an important contribution to the literature on labour demand.

Industry-level analysis and the impact of quasi-fixed costs on the demand for hours

In this section, we derive distinct estimates of $\gamma(N, H)$ and $\sigma(N, H)$ for each of the NACE 3-digit industries in our dataset with the aim of assessing equation (2.11); namely of a positive relationship between (estimated) quasi-fixed labour costs and the demand for hours. The latter will be proxied by the firm-level number of hours and the share of workers on a part-time contract. We first estimate our productivity and labour cost equations separately for each industry.[33] Results are reported in Table 2.11 (Appendix) and can be visualized on Figure 2.3. The latter suggests that the two estimates are strongly correlated but not necessarily perfectly aligned. Values of $\hat{\sigma}, \hat{\gamma} < 1$ hint at the presence of quasi-fixed labour costs whose effect dominates those of longer hours on unit wage ($\epsilon \geq 0$). Note that most of the large industries (representing more firms and revealed by the size of the circles on Figure 2.3) display elasticities that are significantly less than 1; an indication of the relative importance of quasi-fixed labour costs.

[33] Using second-order polynomial approximations, fixed effect as first differences.

	LP[a]		ACF[b]	
	Productivity	Cost	Productivity	Cost
n_{it}	0.645***	0.684***		
	(0.004)	(0.004)		
h_{it}	0.475***	0.464***		
	(0.008)	(0.008)		
n_{it}			0.756***	0.914***
			(0.006)	(0.008)
h_{it}			0.564***	0.701***
			(0.063)	(0.052)
Control: year and firm fixed effects [and (log of) capital in productivity equation]				
$\sigma;\gamma$	0.74	0.77	0.74	0.75
prob= 1	0.0000	0.0000	0.0017	0.0000
prob $\sigma=\gamma$	0.409		0.776	

Standard errors in parentheses.
Source: Bel-first.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.
[a]Levinsohn-Petrin, [b] Ackerberg, Caves & Frazer.
Cobb–Douglas specification of $Q(N, H)$ and $C(N, H)$.

Table 2.9: Econometric estimation of the productivity of hours and of the (relative) importance of quasi-fixed labour costs. Fixed effect as mean centring + accounting for simultaneity bias

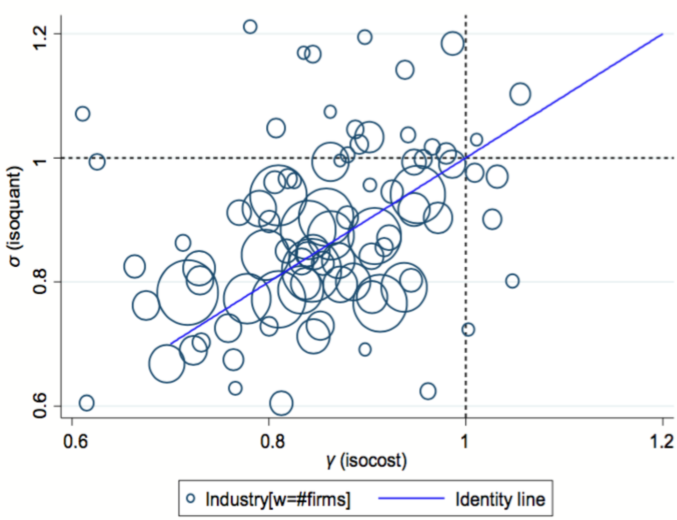

Figure 2.3: Industry-by-industry estimation of σ and γ. Second-order polynomial specification of $Q(N, H)$ and $C(N, H)$.

	Productivity		Labour costs	
	Working hours	Share part-time contracts	Working hours	Share part-time contracts
$\hat{\sigma}^j; \hat{\gamma}^j$	-0.163***	0.0848***	-0.115***	0.00512***
	(0.001)	(0.001)	(0.001)	(0.001)
Controls	Year fixed effect, output (log)			

Standard errors in parentheses
Source: Bel-first
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 2.10: Econometric results: impact of industry-level elasticity on working hours and prevalence (share) of part-time work contract; using industry-by-industry estimated $\hat{\sigma}^j$; $\hat{\gamma}^j$ [FE (first diff.) and second-order polynomial specification of $Q(N, H)$ and $C(N, H)$]

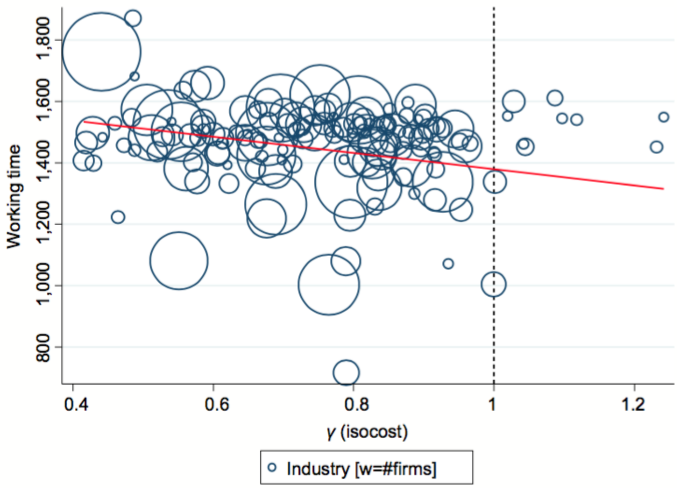

Figure 2.4: Working hours in 2015 as a function of industry-level estimated isocost elasticity ($\hat{\gamma}^j$).

More related to the point at the core of this paper, using these estimates $\hat{\gamma}$ and$\hat{\sigma}$ as predictors of (conditional) labour demand equation (2.11) yields the theoretically expected results (see Table 2.10, left part). The higher $\hat{\gamma}$ is (i.e. the lower the estimated share of quasi-fixed costs), the lower the average annual number of hours is (Table 2.10, col. 3 and Figure 2.4), and also the higher the share of workers with a part-time contract (Table 2.10, col. 4 and Figure 2.5).

About the alignment of isoquant $\hat{\sigma}$ and isocost $\hat{\gamma}$ elasticities

One of the originalities of the paper is the conjoint study of the relationship between hours, productivity, and labour costs. Given this, it is important to

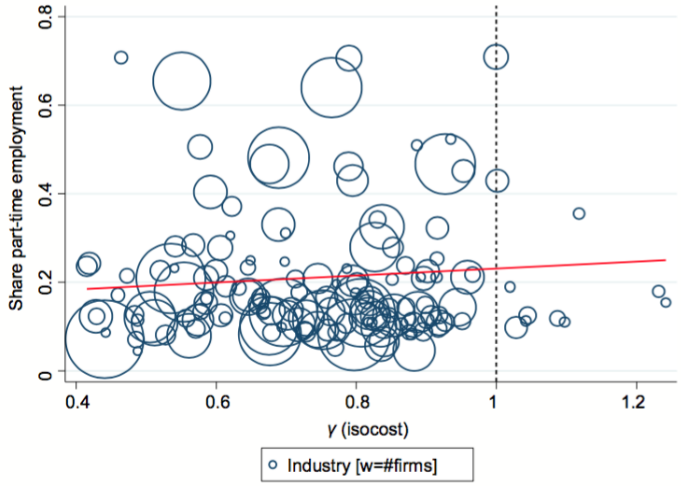

Figure 2.5: Share of part-time work in 2015 as of industry-level estimated isocost elasticity ($\hat{\gamma}^j$).

spend some time discussing the alignment of σ and γ. Theoretical developments exposed in Section 2.2 suggest that firms should choose working hours (and the number of workers) such that these two elasticities are equal). As is visible at the bottom of Tables 2.5-2.8, we do not verify alignment systematically. This said, some of our results are synonymous with alignment.

First, it is the case of our LP-ACF estimates (Table 2.9) as the hypothesis that $\hat{\gamma} = \hat{\sigma}$ is accepted with a probability of, respectively, 0.41 and 0.78. The main econometric challenge is probably to come up with a robust estimation of the production function (and thus of what happens along this isoquant as captured by estimated σ). The estimation of the labour cost function is not trivial but intrinsically less complicated, at it is less prone to biases (in particular to short-run endogeneity/simultaneity biases). Hence, it probably not by chance that we get the alignment with LP, and even more with ACF as these are methods that have been designed to overcome the limitations of OLS or fixed-effect methods.

Second, if we consider our industry-by-industry estimates (Figure 2.3), they are not aligned on a one-by-one case, but are strongly and significantly correlated. Thus, statistically, an industry by a lower/higher σ is very likely to have a lower/higher γ. The absence of a perfect alignment could reflect data or estimation limitations (particularly of σ as suggested above), or could point at a functioning of firms/industries that is synonymous with (partial) short-sightedness and/or tâtonnement.

Third, also in Table 2.2, one should note that industry-by-industry estimated σ and γ have a very similar predictive capacity as to the share of part-time work and the duration of work. In other words, industries with lower/higher σ *tend to be those* with lower/higher γ but also lower/higher share of part-time worker or higher/lower duration of work.

2.6 Further evidence about quasi-fixed labour costs

2.6.1 Econometric analysis of worker-level wage data to estimate labour costs

In this section, we use PIAAC 2012 data[34] on average gross wage per hour (GWH) and hours of work per week (H) from the individuals who work as employees in the private, for-profit segment of the economy. By definition, PIAAC aims at delivering comparable international data. It is analysed here with the aim of assessing how Belgian quasi-fixed labour costs compare with the situation in other countries. PIAAC contains only individual-level data so there is no way one can replicate the productivity & labour cost analysis of the previous sections. And as in the above sections, the objective is to infer the presence (and the importance) of quasi-fixed labour costs F from the parameters of an econometric models regressing labour cost on hours.

As in Section 2.5.1 we assume that $GWH(H) = (wH + F)/H = w + F/H$. We do not observe unit wage w or fixed labour cost F. But elasticities can be retrieved by the estimation of a linear[35] approximation of the log of $GWH(H)$ i.e.:

$$gwh_{ik} \equiv A_k + \phi_k h_{ik} + \lambda_k F_{ik} + \nu_{ik} \tag{2.22}$$

where gwh_{ik} is the (log of) the average gross wage per hour reported by

[34]The OECD led Programme for the International Assessment of Adult Competencies (PIAAC).

[35]The estimation was conducted using quadratic and cubic approximations. Results were qualitatively similar to that reported hereafter.

worker i in country k and h_{ik} the (log) of number of hours per week the worker declares. Assuming the actual process generating wages is $GWH = w + F/H$; [ignoring individual and country indices] we have that

$$\frac{\partial ghw}{\partial h} = \frac{\partial ln(GHW)}{\partial ln(H)} = \frac{-\frac{F}{H^2} + w'(H)}{\frac{F}{H^2} + \frac{w(H)}{H}} \approx \phi \tag{2.23}$$

which is negative (i.e. gross wage per hour goes down with hours) if $F > 0$ and if $w'(H)$ is relatively small or null. In the particular case where $w'(H) \approx 0$ [i.e. no or little rise of the wage rate with hours] it is immediate to show that $\partial gwh/\partial h = F/(F + wH) \approx \phi$. This means that the estimation of 2.22 delivers coefficients that can be used to estimate the share of quasi-fixed labour costs. Indeed, — ϕ is a lower bound proxy of the importance of quasi-fixed costs.

Of course, the level of hourly gross wage of an individual worker reflects many things that have little to do with the number of working hours. As PIAAC is not a panel, there is no way to resort to fixed effects (FE) to account for unobserved heterogeneity. What we do is to specify pik as a vector of controls comprising many of the determinants of wage: educational attainment, gender, labour market experience, labour market experience squared, occupation (ISCO 2008 2-digit), and industry (ISIC 2-digit). We also include the respondent's average test score in literacy, numeracy, and problem solving. The hope is that this rather rich set of controls allows for a proper identification of actual gross wage/hours elasticity ϕ, and thus of the (relative) importance of quasi-fixed labour costs.

Results (Appendix, Table 2.12) clearly hint at the presence of quasi-fixed labour costs. With an estimated $\phi = -0.18$ for Belgium, we may conclude that fixed costs are at least equal to 18 per cent of total gross wage of a typical private- and for-profit economy employee. This is slightly below the 20–23 per cent that we found using firm-level data. But remember that PIAAC is only about gross wages, whereas Bel-first, firm-level data used in previous section is about total payroll cost, with the possibility that some of elements constituting the difference (e.g. severance payments, in-kinds) drive fixed costs' share upwards.

2.6.2 International descriptive/accounting evidence about the share of quasi-fixed labour cost, and their impact on the demand for hours

Another assessment of our econometric estimates of the share of quasi-fixed labour costs coming from the comparison with *direct* estimates of that share, based on accounting/descriptive data from other countries than Belgium. In general, authors consider both 'one-time' fixed costs (i.e. recruitment, training, severance) and 'recurrent' fixed labour costs i.e. employer-funded unemployment, medical insurance or retirement plans (social security), remuneration of non-worked days (annual holiday, sick or maternity leave), and other in-kind employee benefits (stocks, cars, phones).

Hart (1984) suggests that for both the United States and the United Kingdom it is reasonable to put quasi-fixed labour costs at roughly 20 per cent of total cost. For Ehrenberg (2016), the [US] data suggest that around 19 per cent of total compensation (about 60 per cent of nonwage costs) is quasi fixed. Martins (2004), in a study for Portugal, estimates quasi-fixed costs at 25 per cent of labour costs, with social security payments being the dominant quasi-fixed cost item. Of course, the actual sources of quasi-fixed costs in the above countries could differ from those underpinning the Belgian result. For instance, health care insurance contributions by firms seem to be a key source of 'fixity' in the US. Less so in Belgium, where severance payments, assimilated days or in-kinds/perks probably play a greater role. Yet, it is still worth underlying that the overall estimates published by these authors is surprisingly close to our estimate for Belgium, at about 20 per cent.

Finally, there is a small literature that used descriptive estimates of quasi-fixed labour costs as predictor of firms' demand for hours (paralleling what we do in Section 2.5.2). Cutler and Madrian (1998) find that increases in health insurance costs during the 1980s increased the hours worked by covered workers. Montgomery and Cosgrove (1993) and Buchmueller (1999) show that a smaller proportion of hours are worked by part-time employees in firms offering more generous fringe benefits to full-time workers. Finally, Dolfin (2006) uses US data on the cost of recruiting, search, hiring, training, and firing; and shows that, ceteris paribus, the higher that cost the higher the average number of hours. The results of these studies are consistent with our results in Section 2.5.2. based on inferred/econometric measures of quasi-fixed labour costs.

More generally, they accord with the idea of substitution of hours for workers in response to rising quasi-fixed labour costs, as predicted by a theory of labour demand.

2.7 Concluding remarks

Hours worked tend to not only vary across individuals but also — on average — across firms, and even within firm over time. Why? Over the past decades, most economists have privileged the idea that shorter versus longer hours (leaving labour market regulations aside) had primarily to do with the preferences of individuals. In this work, echoing Pencavel (2016)'s question of 'Whose Preferences Are Revealed in Hours of Works?', we explore the role of employers' preferences for working time; and in particular the role of quasi-fixed labour costs. By quasi-fixed labour costs, we mean any expense that is assoc ated with employing a worker but is independent of his/her hours of work (such as the costs of in-kind benefits, hiring and training new workers, firing workers,[36] taxes, or insurance payments that are not proportional to the duration of work).

We consider a setup where firms decide simultaneously on working hours and the number of workers. We find that despite an obvious productivity gain from reducing working hours, firms facing large quasi-fixed labour costs choose a higher level of hours to cover such quasi-fixed labour costs.

We estimate that increasing hours by 1 per cent would only increase output (value added) by 0.8 per cent, thus in line with the hypothesis of decreasing marginal return to working hours, and that of imperfect substitutability between hours and workers in the production process. What is more — and to our knowledge this is a novelty — we were able to retrieve the relative share of quasi-fixed labour costs: 20–23 per cent of a worker's cost could be independent from hours. These econometric results suggest that the typical for-profit firm located in Belgium faces financial incentives to raise hours beyond the point where the average labour productivity starts declining. These explain why ceteris paribus some industries (i.e. those with higher quasi-fixed labour costs) are characterized by longer hours and a lower propensity to employ people on a part-time basis. We also find evidence that quasi-fixed labour costs are more

[36] Recruitment, training or firing costs typically intervene as fixed labour costs *pro rata* firms' turnover rate.

important among people with a full-time contract than among those with a part-time or interim contract. Again, this could explain employers' reluctance to let the former reduce their working hours, even when they accept a strictly proportional reduction of their wage.[37]

In short, when it comes to working time policies — often presented as crucial to accommodate the varying needs and desires of contemporary individuals — policymakers should not overlook firms' preferences and their determinants. For instance, in the context of pension reforms aimed at extending people's careers, they should check that the quasi-fixed costs of employing older workers are limited. If not, employers might be reluctant to endorse part-time/flexitime work arrangements most older individuals aspire to (Harris Interactive & Dychtwald, 2005).

[37]And do not demand that the hourly wage gets revised upwards to preserve total remuneration.

Appendix

Table 2.11: Estimation of elasticities, by industry (NACE 3)

NACE 3-digit	**Nobs**	γ^j	**Prob** $\gamma^j = 1$	σ^j	**Prob** $\sigma^j = 1$
101_Processing and preserving of meat and production of meat products	864	0,65	0,0000	0,44	0,0000
103_Processing and preserving of fruit and vegetables	330	1,03	0,0000	1,08	0,0000
105_Manufacture of dairy products	261	0,52	0,0000	0,76	0,0000
106_Manufacture of grain mill products, starches and starch products	135	0,85	0,0000	0,92	0,1221
108_Manufacture of other food products	916	0,95	0,0000	0,74	0,0000
109_Manufacture of prepared animal feeds	211	0,48	0,0000	0,89	0,4920
110_Manufacture of beverages	357	0,71	0,0000	0,82	0,0000
120_Manufacture of tobacco products	79	0,91	0,0000	0,47	0,0001
131_Preparation and spinning of textile fibres	207	0,87	0,0000	1,00	0,8482
132_Weaving of textiles	257	0,66	0,0000	0,70	0,0000
139_Manufacture of other textiles	544	0,82	0,0000	0,73	0,0000
141_Manufacture of wearing apparel, except fur apparel	312	0,92	0,0000	0,91	0,0000
161_Sawmilling and planing of wood	189	0,73	0,0000	0,53	0,0000
162_Manufacture of products of wood, cork, straw and plaiting materials	566	0,83	0,0000	0,80	0,0000
171_Manufacture of pulp, paper and paperboard	193	0,95	0,0080	0,83	0,0000
172_Manufacture of articles of paper and paperboard	394	0,88	0,0000	0,90	0,0000
181_Printing and service activities related to printing	986	0,82	0,0000	0,64	0,0000
201_Manufacture of basic chemicals, fertilisers and nitrogen compounds, plastics and synthetic rubber in primary forms	821	0,73	0,0000	0,65	0,0000
				0,55	0,0000
204_Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations	195	0,90	0,0000	0,66	0,0000
205_Manufacture of other chemical products	345	0,58	0,0000	0,61	0,0000
211_Manufacture of basic pharmaceutical products	72	0,82	0,0000	1,43	0,0000
212_Manufacture of pharmaceutical preparations	294	0,61	0,0000	0,75	0,0000
222_Manufacture of plastics products	1169	0,85	0,0000	0,81	0,0000

NACE 3-digit	Nobs	γ^j	Prob $\gamma^j = 1$	σ^j	Prob $\sigma^j = 1$
233_Manufacture of clay building materials	105	0,86	0,0000	0,74	0,0041
236_Manufacture of articles of concrete, cement and plaster	853	0,74	0,0000	0,65	0,0000
				0,43	0,0000
241_Manufacture of basic iron and steel and of ferro-alloys	212	0,77	0,0000	0,84	0,0036
244_Manufacture of basic precious and other non-ferrous metals	225	0,90	0,1087	0,56	0,0000
245_Casting of metals	235	0,57	0,0000	1,12	0,0004
251_Manufacture of structural metal products	1352	0,51	0,0000	0,63	0,0000
252_Manufacture of tanks, reservoirs and containers of metal	192	0,92	0,0000	0,87	0,0000
255_Forging, pressing, stamping and roll-forming of metal; powder metallurgy	207	0,68	0,0000	0,99	0,4761
256_Treatment and coating of metals; machining	1007	0,84	0,0000	0,68	0,0000
257_Manufacture of cutlery, tools and general hardware	121	0,67	0,0000	0,83	0,0545
259_Manufacture of other fabricated metal products	714	0,43	0,0000	0,41	0,0000
261_Manufacture of electronic components and boards	162	0,66	0,0000	0,89	0,3448
262_Manufacture of computers and peripheral equipment	44	0,77	0,0083	0,90	0,8064
263_Manufacture of communication equipment	137	0,82	0,0570	1,00	0,9506
265_Manufacture of instruments and appliances for measuring, testing and navigation; watches and clocks	178	0,72	0,0000	0,78	0,0000
271_Manufacture of electric motors, generators, transformers and electricidistribution and control apparatus	232	0,93	0,0000	1,07	0,0000
				0,53	0,0093
279_Manufacture of other electrical equipment	139	0,63	0,0000	1,17	0,0000
281_Manufacture of general – purpose machinery	268	0,91	0,0000	0,93	0,0236
282_Manufacture of other general-purpose machinery	736	0,72	0,0000	0,72	0,0000
283_Manufacture of agricultural and forestry machinery	152	0,88	0,0000	0,93	0,4027
289_Manufacture of other special-purpose machinery	430	0,92	0,0000	1,19	0,0000

NACE 3-digit	Nobs	γ^j	Prob $\gamma^j = 1$	σ^j	Prob $\sigma^j = 1$
291_Manufacture of motor vehicles	90	0,61	0,0550	0,69	0,0475
293_Manufacture of parts and accessories for motor vehicles	332	0,61	0,0000	0,68	0,0000
321_Manufacture of jewellery, bijouterie and related articles	71	0,70	0,0000	0,49	0,0000
325_Manufacture of medical and dental instruments and supplies	334	0,60	0,0000	0,41	0,0000
331_Repair of fabricated metal products, machinery and equipment	391	0,84	0,0000	0,92	0,0000
332_Installation of industrial machinery and equipment	172	0,90	0,0000	0,76	0,0000
370_Sewerage	95	0,88	0,0000	0,81	0,0000
381_Waste collection	106	0,81	0,0000	0,70	0,0000
382_Waste treatment and disposal	310	0,76	0,0000	0,55	0,0000
				0,62	0,0000
411_Development of building projects	205	0,71	0,0000	0,51	0,0000
412_Construction of residential and non-residential buildings	3368	0,80	0,0000	0,72	0,0000
421_Construction of roads and railways	1127	0,88	0,0000	0,90	0,0000
422_Construction of utility projects	645	0,84	0,0000	1,05	0,0000
429_Construction of other civil engineering projects	196	0,77	0,0000	1,16	0,0554
431_Demolition and site preparation	566	0,84	0,0000	0,75	0,0000
432_Electrical, plumbing and other construction installation activities	2580	0,68	0,0000	0,61	0,0000
433_Building completion and finishing	2232	0,68	0,0000	0,54	0,0000
439_Other specialised construction activities	1252	0,56	0,0000	0,56	0,0000
				0,56	0,0000
452_Maintenance and repair of motor vehicles	659	0,57	0,0000	0,54	0,0000
453_Sale of motor vehicle parts and accessories	581	0,70	0,0000	0,55	0,0000
461_Wholesale on a fee or contract basis	359	0,90	0,0000	0,71	0,0000
462_Wholesale of agricultural raw materials and live animals	392	0,59	0,0000	0,53	0,0000
463_Wholesale of food, beverages and tobacco	2314	0,55	0,0000	0,47	0,0000
465_Wholesale of information and communication equipment	519	0,76	0,0000	0,45	0,0000
466_Wholesale of other machinery, equipment and supplies	2996	0,81	0,0000	0,68	0,0000
467_Other specialised wholesale	3004	0,70	0,0000	0,80	0,0000
469_Non-specialised wholesale trade	328	0,76	0,0000	0,68	0,0000

NACE 3-digit	Nobs	γ^j	Prob $\gamma^j = 1$	σ^j	Prob $\sigma^j = 1$
471_Retail sale in non-specialised stores	2442	0,69	0,0000	0,77	0,0000
472_Retail sale of food, beverages and tobacco in specialised stores	641	0,80	0,0000	0,60	0,0000
474_Retail sale of information and communication equipment in specialised stores	255	0,85	0,0000	0,45	0,0000
475_Retail sale of other household equipment in specialised stores	1571	0,83	0,0000	0,61	0,0000
476_Retail sale of cultural and recreation goods in specialised stores	254	0,62	0,0000	0,69	0,0000
477_Retail sale of other goods in specialised stores	2339	0,93	0,0000	0,74	0,0000
494_Freight transport by road and removal services	3955	0,44	0,0000	0,41	0,0000
521_Warehousing and storage	966	0,82	0,0000	0,93	0,0000
551_Hotels and similar accommodation	1262	0,84	0,0000	0,79	0,0000
552_Holiday and other short-stay accommodation	73	0,94	0,0000	0,66	0,0000
561_Restaurants and mobile food service activities	2401	0,76	0,0000	0,70	0,0000
562_Event catering and other food service activities	531	0,79	0,0000	0,86	0,0000
591_Motion picture, video and television programme activities	318	0,42	0,0000	0,87	0,0000
602_Television programming and broadcasting activities	72	1,02	0,2280	1,38	0,0825
612_Wireless telecommunications activities	153	1,09	0,0000	0,75	0,0000
620_Computer programming, consultancy and related activities	2317	0,75	0,0000	0,74	0,0000
631_Data processing, hosting and related activities; web portals	156	0,65	0,0000	1,05	0,0271
642_Activities of holding companies	609	0,65	0,0000	0,80	0,0000
661_Activities auxiliary to financial services, except insurance and pension funding	700	0,69	0,0000	0,72	0,0000
662_Activities auxiliary to insurance and pension funding	293	0,54	0,0000	0,47	0,0000
682_Renting and operating of own or leased real estate	633	0,80	0,0000	0,77	0,0000
683_Real estate activities on a fee or contract basis	158	0,97	0,0000	0,70	0,0000
691_Legal activities	334	0,57	0,0000	0,46	0,0000
692_Accounting, bookkeeping and auditing activities; tax consultancy	342	0,90	0,0000	0,91	0,0000

NACE 3-digit	Nobs	γ^j	Prob $\gamma^j = 1$	σ^j	Prob $\sigma^j = 1$
701_Activities of head offices	528	0,68	0,0000	0,42	0,0000
702_Management consultancy activities	996	0,80	0,0000	0,89	0,0000
711_Architectural and engineering activities and related technical consultancy	1096	0,89	0,0000	0,78	0,0000
				0,55	0,0000
731_Advertising	575	0,75	0,0000	0,82	0,0000
732_Market research and public opinion polling	271	0,80	0,0000	0,55	0,0000
741_Specialised design activities	79	1,12	0,0000	1,00	0,9483
743_Translation and interpretation activities	52	1,24	0,0004	0,95	0,4670
749_Other professional, scientific and technical activities n.e.c.	53	0,79	0,0695	0,47	0,0480
771_Renting and leasing of motor vehicles	210	0,56	0,0000	0,45	0,0000
772_Renting and leasing of personal and household goods	98	0,85	0,0000	0,56	0,0000
773_Renting and leasing of other machinery, equipment and tangible goods	323	0,81	0,0000	0,61	0,0000
781_Activities of employment placement agencies	403	0,58	0,0000	0,56	0,0000
782_Temporary employment agency activities	713	0,59	0,0000	0,58	0,0000
783_Other human resources provision	110	0,46	0,0000	1,11	0,0003
791_Travel agency and tour operator activities	268	0,85	0,0000	0,47	0,0000
801_Private security activities	267	0,42	0,0000	0,42	0,0000
802_Security systems service activities	67	0,80	0,3075	0,86	0,5561
811_Combined facilities support activities	119	0,92	0,0000	0,81	0,0000
				0,50	0,0000
813_Landscape service activities	248	0,73	0,0000	1,01	0,7703
829_Business support service activities n.e.c.	713	0,96	0,0036	0,62	0,0000
				0,73	0,0000
869_Other human health activities	334	1,00	0,8865	0,54	0,0000
				0,74	0,0000
872_Residential care activities for mental retardation, mental health and substance abuse	77	0,89	0,0000	1,16	0,3031
873_Residential care activities for the elderly and disabled	2150	0,55	0,0000	0,41	0,0000

NACE 3-digit	**Nobs**	γ^j	**Prob** $\gamma^j = 1$	σ^j	**Prob** $\sigma^j = 1$
889_Other social work activities without accommodation	388	1,00	0,9982	1,05	0,0000
931_Sports activities	334	0,95	0,0000	0,66	0,0000
932_Amusement and recreation activities	188	0,83	0,0000	0,94	0,0003
952_Repair of personal and household goods	98	1,23	0,0000	0,66	0,0000
960_Other personal service activities	979	0,68	0,0000	0,64	0,0000

Table 2.12: Econometric Results-Worker-level (cross-sectional) analysis. Conditional impact of (log of) hours on (log of) average hourly gross wage (computed as the ratio [weekly] gross wage/hours). Belgium (Flanders)

	BEL
h	-0.180***
	(0.024)
Experience	0.027***
	(0.002)
Experience^2	-0.000***
	(0.000)
Schooling years	0.034***
	(0.004)
Score (log of)$	0.179**
	(0.059)
Female	-0.095***
	(0.020)
Other controls	Occup (ISCO 2008 2-digit) indus(ISIC 2-digit) fixed effects
Estimates of the wage/hours elasticity	
$\partial gwh/\partial h = -F/(F + wH) \approx \phi$ if $W'(H) = 0$	-0.180***
Prob $\phi = 0$	0.000

Source: PIAAC-OECD 2012

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

$ The respondent's average test score in literacy, numeracy and problem solving.

Chapter 3

Effort optimal reaction to firing threat in a fair-wage model

Co-authored with Mathias Hungerbühler

The empirical literature has documented that in the presence of a firing threat, workers tend to undertake more effort in their job. However, the theoretical literature on effort lacks a framework that takes this feature into account, as a basic fair wage model would predict that during bad times, if wages fall down, effort will follow in the same direction. We develop a model where workers internalize the impact of their individual effort on the risk of being dismissed during bad times. We implement this mechanism within a simple general equilibrium model with efficiency wages and show that workers optimally increase their effort level following a negative shock. This result could help understand previously documented evidences of productive recessions.

3.1 Introduction

The recent recessions of 2008 and 2012 have caused a sharp increase in the unemployment rate in most developed countries. Many countries are still affected by high levels of unemployment, along with an otherwise recovering economy. The joblessness of the recovery has been attributed, at least partially, to an increase in individual productivity. Evidences on jobless recoveries as episodes that tend to display a relatively higher productivity level than other, standard, recoveries have been presented by Berger (2012) and Burger & Schwartz (2015) among others. It is however not clear what drives the increase in productivity: in Berger, firms fire the less productive workers, whereas in Burger & Schwartz, less productive firms or sectors shut down. Another possibility is that workers undertake a greater effort: evidence of this at the firm level is presented by Lazear (2016). In previous work, we also documented macroeconomic evidences of an increase in individual hours of work during jobless recoveries (Delmez (2019)). In fact, when productivity is measured per worker, additional individual hours will contribute to an increase in the measured productivity. For all of what follows, we interpret effort as anything that increases the measured productivity per worker, without increasing its contractual wage (for example unpaid overtime hours, education, more focus, less on-the-job leisure, . . .). In the past, effort has usually been included in general equilibrium models through the mechanism of efficiency (or fair) wage, which implies that workers offered wages above their outside option will reciprocate with a more intense effort. With this baseline mechanism, we should observe that the effort level declines during bad times (or stays stable due to downward wage rigidity). In this paper, we argue that the baseline efficiency wage model should be supplemented to accomodate for an increase in individual effort and productivity in the absence of an increase in wages, as has been documented in the literature and summarized above. To understand what sorts of mechanism might be at play, we summarize below the main findings on the drivers of individual effort for a given wage level.

Previous research highlighted the contribution of different factors to changes in the effort provided by workers for a given wage level. In particular, a drop in income (Anderson & Frantz (1984)) and unexpected events in general (Abeler *et al.* (2011)) as well as rewards (Goswami & Urminsky (2017)) and higher relative wages in an unequal wage structure (Pfeifer (2010)) tend to increase effort for a given hourly wage. Similarly, a higher minimum wage (Brandts &

Charness (2004)) and a high income target (Abeler *et al.* (2011)) also tend to increase effort at a given wage level. Finally, Lazear (2016) and Corgnet *et al.* (2015) present empirical evidences on the importance of firing threat to explain the observed hike in individual effort. In particular, Lazear observes within a large firm that effort varies over the business cycle, with an increase of around 5% during the recession, of which at least 85% is attributable to an increase in individual effort, the remaining being due to a change in composition of the workforce at the firm level. In the context of economic recessions, firing threats appear as a strong potential candidate to explain a rise in effort and will be the focus of our contribution.

The firing threat is not unknown in the litterature. It has been largely studied empirically by researchers from different fields: economics, management but also psychology. As mentioned above, Corgnet *et al.* (2015) find, in a virtual workplace experiment, that firing threats decrease shirking and increase production and that this effect disapears with the removal of the threat. In particular, they show that in the presence of a firing threat, individual of all ability levels wish to signal themselves as non-shirking workers. This outcome is corroborated by Kopanyi-Peuker, Offerman & Sloof (2018) who also find that when the employer can fire a worker, even with a cost, the worker's productivity rises. Their result is robust to the introduction of noise between effort and productivity. One important finding is that the firm has to be able to commit to retain some workers, that is it cannot strategically fire all its workers in each period in the hope a a higher productivity. In fact, in recent work, Kuvalekar & Lipnowski (2018) find that job insecurity leads to lower effort when the commitment of the firm is not credible. Finally, Brandts *et al.* (2018) have pointed out that hours of work can be used as a proxy by employer to evaluate effort, with the same positive effect on productivity in presence of firing threat. In this last case, the firing threat will lead to an increase in individual hours.

The macroeconomic consequences of the firing threat have however, to our knowledge, not yet been modelled in a fair-wage setting, which is the usually standard method of introducing effort in the production function[1]. We develop a fair-wage model where workers internalize the effect of their effort level on their probability to be fired. Our model is aimed at describing the macroeconomic consequences, in terms of employment, wages and output level, of a

[1] The closest experiment is the work by Golosov & Menzio (2015) who use strategic firing threat to generate effort in a search-and-match context. They find that the resulting variation in workers' effort is able to give rise to business cycle fluctuations.

temporary shock to aggregate productivity. In particular, we will assume for simplicity that there are no matching frictions. This hypothesis is singularly less strong in a recession context where the pool of unemployed is so large that firms can immediately find a new worker if they wish to hire (in line with the findings of Michailliat (2012))[2]. The model is thus fairly simple and the main steps follow. In the beginning of each period, workers previously hired, firms and job-seekers observe the shock. At that point, firms set the wage (unilaterally but anticipating the workers' reaction) and, immediately after, workers decide on their optimal level of effort, based on the wage they were offered and taking into account that in case of negative shock, the less productive workers will be fired. At the end of each period, firms decide on the optimal number of workers for the next period and hire or fire employees to reach that number. In case of firing, it is the less productive workers who are laid down. This raises the question of the observation of the individual productivity, here entirely determined by individual effort. In our case, given the homogenity of the workers, they will all turn up to accomplish the same level of effort and the firm therefore simply randomizes the firing decision.

Altough the model appears to be extremly simple, the new mechanism of fear of firing introduce several technical complexities. First, the mutliple interdependances between aggregate productivity, wages, effort and employment trigger non-linearities that hamper explicit solutions. In particular, the optimal effort is now a compound reaction to both the wage level and the probability to be fired, which itself depends on the state of the world (good or bad shock). Furthermore, in case of positive aggregate shock, no one gets fired and the effort decision can be reduced to the simple fair wage case. On the contrary, when the aggregate shock is negative, workers anticipate firing at the end of the period and effort thus optimally increases at any given wage level. This askew reaction of workers to aggregate shocks generates a kink around the steady state for the optimal effort, which results in asymmetries around the steady state. The non-linearities issued from the multiple interdependances combined to the instrinsic assymetry of effort generates substantial mathematical complexity to simulate the model. To our knowledge, no previous model allows to take into account business cycle variations with non-linear and non-symmetric reactions of agents. In this project, we present different potential solution methods and discuss them.

[2]Future work should include matching frictions to be able to extend the conclusions to a broader set of economic scenarii.

Beyond supplying a theoretical fair wage framework that supports the empirical evidences on individual hours of work at the worker and firm level, this research contributes to previous macroeconomic findings regarding the inclusion of both an extensive and an intensive margin of labour. In particular, seminal work in this field has been performed by Rogerson and co-authors who present a basic framework for policy analysis with search frictions in single worker firms (Fang & Rogerson (2009)). They show how the inclusions of both an intensive and an extensive margin can reconcile micro and macro labour supply elasticity estimates (Keane & Rogerson (2012)) and how these elasticities play an important role in the presence of taxes (Rogerson & Wallenius (2009)). Chetty *et al.* (2011) also revisit evidences on micro and macro elasticities in a framework with both an intensive and an extensive margin. Finally, Dominguez *et al.* (2011) also developed a basic framework for individual hours of work where a decrease in working time increases the employment rate through an increasing participation rate, at a fixed wage rate.

Section 3.2 lays down the model and calibration choices. Thereafter, section 3.3 discusses the methods used to present simulations of the model. Section 3.4 concludes.

3.2 Model

3.2.1 Timing

At the beginning of each period t, the aggreagate productivity level A is revealed to all agents: workers and job-seekers maximizing their utility level and identical, profit-maximizing firms. Workers and job-seekers are perfectly homogenous and only differ by their employment status. At the outset, firms set the wage rate, anticipating the reaction of effort. As is the case in usual fair wage models, firms set a wage above the (here exogenous) outside options of workers in order to generate a higher level of effort. Next, workers optimally set their effort taking into account the wage rate (reciprocity) and the impact of their effort on the probability to be fired (fear of firing). Job-seekers find a job with a probability that is independant from their behaviour and therefore they do not make any specific choice. In fact, participation in the labour market is not modelled here and all agents are supposed to be active on the labour market. Finally firms set the optimal number of workers for the next period $(t+1)$ to maximize their expected profit. This optimal number of workers is implemented through either firing or hiring some workers at the end of the period. For now, we do not consider any hiring of firing costs or frictions, such that the firm can perfectly implement its optimal number of workers. Employment is however predetermined, based on the expectations made for next period, and in particular firms do not anticipate that a new shock will hit the economy. This specific timing of the shock, wage setting and then effort setting at the beginning of the period, followed by the labour setting at the end of the period is necessary to prevent the model from several caveat. First, if the employment decision would happen before the effort is set, there would be no room for a increase in effort to reduce one's own firing probability. In other words, there would be no fear of firing, on the contrary: workers would know in advance that they are fired and should optimally provide zero effort. Labour decision must thus come after the effort is exerted, thus at the end of the period. Second, effort is decided before it is accomplished, thus at the beginning of the period. Third, wage is used to incentivize a higher effort since we have a reciprocity dimension, therefore, wage has to be set before effort. Otherwise, wage could always be set to the outside option of the worker. To sum up, labour must be set after effort is exerted, thus at the end of the period and wage has to be set before effort.

3.2.2 Workers

In our model, all agents are active labour market participants, either working or unemployed. The worker derives utility (U_t) from his wage (w_t), diminished by the cost of his effort ($c(e_t) = \frac{e^2}{2}$). He also enjoys utility from reciprocity in the labour relation: he happily provides a higher effort if the difference between his wage level (w_t) and his outside option (b, exogenous) is large. This outside option is equal to the income he perceives when unemployed, in our case derived from home production as there is no formal governement providing benefits. The (discounted) continuation value of the worker depends on whether he remains employed (with probability $(1 - \delta_t(e))$) or gets fired (with probability $\delta_t(e)$) at the end of the period. The probability to be fired decreases with the level of effort he provides.

$$U_t = w_t - \beta\frac{e_t^2}{2} + \theta(w_t - b)^\gamma e_t + \mu\left[(1 - \delta_t(e_t))U_{t+1} + \delta_t(e_t)B_{t+1}\right] \tag{3.1}$$

The worker's optimization problem is simply to determine his effort level. Maximizing his utility with respect to effort yields an optimal level of effort that is implicitely defined in equation 3.2. The explicit form of effort is presented in the Appendix.

$$e_t = \frac{\theta}{\beta}(w_t - b)^\gamma - \frac{\mu}{\beta}\delta'_e(U_{t+1} - B_{t+1}) \tag{3.2}$$

The optimal level of effort depends on the probability to be fired ($\delta_t(e)$), that is defined very simply as the proportion of workers who will be fired at the end of the period (f_t) out of the firm's current labour force (l_{t-1}) multiplied by a factor that measures the relative size of the worker's effort (e_t) compared to the average effort ($\bar{e}$) (equation (3.3)). By definition, the number of fired workers corresponds to the difference between the current number of workers (l_t) and the optimal number of workers the firm wants to have in the next period (l_{t+1}). At the optimum, following the absence of worker heterogenity, they all achieve the same level of effort such that their individual effort is always equal to the mean effort ($\bar{e} = e^*$). We thus have the following probability to be fired:

$$\delta_t = \frac{f_t}{l_t}\frac{\bar{e}}{e_t} \tag{3.3}$$

$$\text{Where : } f_t = \begin{cases} l_{t-1} - l_t & \text{if } l_{t-1} - l_t \geq 0 \\ 0 & \text{else.} \end{cases} \tag{3.4}$$

It should be noted from this definition that the number of fired workers cannot be negative. If the firm grows, the number of fired workers is equal to zero and the number of hired workers will be positive. This distinction between firing and hiring, instead of using an aggregate turnover number, is central to our model's main mechanism which implies that workers react differently to positive and negative aggregate shocks. The number of fired workers as a function of the number of workers is thus kinked at zero, which is also the steady state value. One can also note that the number of fired workers cannot be higher that the total number of workers, as the firm cannot choose a negative optimal number of workers. The minimum number of workers will be zero ($l_t = 0$), in which case the firms fires all its workers ($f_t = l_{t-1}$). Combined with the non-negativity of the number of fired workers, this ensures that the probability to be fired is always comprised between 0 and 1, by construction.

3.2.3 Job-seekers

The unemployed agents derive a utility level denoted B from an income b that should be understood as home production, in our context without formal unemployment benefits. The continuation value depends on the probability that the job-seeker is hired at the end of the period (ξ_t), to begin working in the following period. As mentionned above, the job-seeker cannot influence this probability and there is no participation decision in our model. He thus does not solve any optimization problem in our model.

$$B_t = b + \mu\left[\xi_t U_{t+1} + (1 - \xi_t)B_{t+1}\right] \tag{3.5}$$

The probability to be hired at the end of the period (ξ_t) depends both on the current number of job-seekers (V_t), in other words the size of the pool of unemployed, and on the aggregate number of hirings (H_t) to be made by firms at the end of the period. Individually, each firm hires h workers, downward bounded at zero. The number of firms (n) is a parameter calibrated to normalize total employment at 0.95 at the steady state ($n * l^{ss} = 0.95$), out of a total population of 1. Since there is no participation decision, the number of unemployed workers is simply equal to one minus total employement ($V_t = 1 - L_t$, with $L_t = n * l_t$).

$$\xi_t = \frac{H_t}{V_t} \tag{3.6}$$

$$\text{Where :} \quad h_t = \begin{cases} l_t - l_{t-1} & \text{if } l_t - l_{t-1} \geq 0 \\ 0 & \text{else.} \end{cases} \tag{3.7}$$

$$H_t = nh_t \tag{3.8}$$

3.2.4 Firms

The production is totally standard in a fair wage context. Firms produce using a combination of labour and effort, decide on the size of their labour force and set the wage, anticipating their effect on the effort provided by workers. There is no capital in the model. Aggregate productivity (A) experiences unexpected shocks ϵ_A that have a zero mean and a standard deviation of σ, and autocorrelation over time of A measured by the parameter ρ. Our focus is on negative productivity shocks.

$$y_t = exp(A_t)(e_t l_{t-1})^\alpha \tag{3.9}$$

$$\text{Where :} \quad A_t = \rho_A A_{t-1} - \epsilon_A \tag{3.10}$$

Firms observe the shock, then set the wage and choose the optimal number of workers for next period by maximizing their profit π_t with respect to w_t and l_{t+1}. To simplify the reading of the Dynare code in parallel of the model, we adopted the same timing convention as imposed by the software, namely that a variable decided in period t is indexed t. In our case, l_t is thus the employment level decided today, that will be productive next period. Hiring or firing decisions are implicitely made when the firm decides to increase its labour force compared to the current situation (hiring), or decrease it (firing).

$$\pi_t = exp(A_t)(e_t l_{t-1})^\alpha - w_t l_{t-1} \tag{3.11}$$

Profit maximization yields, implicitely, the optimum wage level (equation

3.12) and number of workers (equation 3.14) of the representative firm. The detail computations for e'_w can be found in the appendix.

Wages:

$$\frac{\partial \pi}{\partial w} = 0$$

$$l_t = (exp(A_t)\alpha e_t^{\alpha-1} e'_w)^{\frac{1}{1-\alpha}} \tag{3.12}$$

$$\text{where } \; e'_w = \frac{\partial e}{\partial w} = \frac{\gamma\theta(w_t - b)^{\gamma-1}}{2\beta} \tag{3.13}$$

$$+ \left[\frac{\theta^2}{2\beta^2}(w_t - b)^{2\gamma} + 2\frac{\mu}{\beta}\frac{f_t}{l_{t-1}}(U_{t+1} - B_{t+1})\right]^{-1/2} \frac{\theta^2}{\beta^2}\gamma(w_t - b)^{2\gamma-1}$$

Employment:

$$E(\pi_{t+1|t}) = exp(E(A_{t+1|t})(e_{t+1|t} l_{t+1|t})^{\alpha} - w_{t+1|t} l_t$$

$$\frac{\partial E(\pi_{t+1|t})}{\partial l_t} = 0$$

$$w_{t+1|t} = exp(\rho_A A_t)\alpha e_{t+1|t}^{\alpha} l_t^{\alpha-1} \tag{3.14}$$

For what follows, the reader should consider that all variables indexed $t+1$ are taken in expectation, given t. It should be noted that with a more “usual” timing where employment and wages are decided simultaneously in t, for the period t, we could easily combine first order conditions (3.14) and (3.12) to get the following general results: $w_t = \frac{e_t}{e'_w}$.

3.2.5 Aggregate outcomes

Since there is perfect homogeneity in firms and in workers and job-seekers, aggregate outcomes are fairly simple to get. We normalize full employment to the size of the population (itself normalized to 1) and calibrate the number of firms n to match a steady state aggregate employment level equal to 95%. As there is not participation decision in the model, the unemployment level is simply the size of the population from which we substract total employment.

$$\text{Aggregate employment: } \; L_t = n l_{t-1} \tag{3.15}$$

$$\text{Aggregate unemployment: } \; V_t = 1 - L_t \tag{3.16}$$

$$\text{Aggregate production: } \; Y_t = n y_t \tag{3.17}$$

3.2.6 Steady state

At the steady state of the model, by definition, employment remains constant ($l_t = l_{t-1}$). This simplifies greatly the model, as the probability to be either fired or hired is null. This also implies that we do not need to worry about satisfying the non-negativity constraints imposed on the number of workers fired and hired.

Formally, we immediately can write the steady state equations for the number of workers fired (f^{ss}), the probability to be fired (δ^{ss}), the number of workers hired at the firm level (h^{ss}) and at the aggregate level (H^{ss}) and the probability for a job-seeker to find a job (ξ^{ss}).

$$f^{ss} = 0$$
$$\delta^{ss} = 0$$
$$H^{ss} = 0$$
$$\xi^{ss} = 0$$

We can then use the above results in the optimal effort, wage and employment (equations (3.2), (3.12) and (3.14)). We get the following steady state equations:

$$e^{ss} = \frac{\theta}{\beta}(w-b)^{\gamma} \tag{3.18}$$
$$w^{ss} = \frac{b}{1-\gamma} \tag{3.19}$$
$$l^{ss} = \frac{(w-b)^{\frac{\gamma-1}{1-\alpha}}}{e}(exp(A)\alpha\gamma\theta)^{\frac{1}{1-\alpha}} \tag{3.20}$$

As can be seen immediately, the steady state wage is a function of parameters only. It depends positively on the outside option of the worker (b). It also increases if workers derive a higher utility from the reciprocity between wages and effort (ie γ is higher). From equation (3.19), we can easily find an expression for steady state effort and then labour as functions of parameters only.

Finally, the steady state equations for the utility level of workers (U^{ss}), of job-seekers (B^{ss}) as well as steady state (aggregate) production and profit follow immediately from the previous steady state results. We have:

$$U^{ss} = \frac{w^{ss} - \beta\frac{e^{ss2}}{2} + \theta(w^{ss} - b)^{\gamma} e^{ss}}{1-\mu}$$
$$B^{ss} = b$$
$$y^{ss} = (e^{ss} l^{ss})^{\alpha}$$
$$\pi^{ss} = (e^{ss} l^{ss})^{\alpha} - w^{ss} l^{ss}$$
$$Y^{ss} = n y^{ss}$$
$$A^{ss} = 0$$

The steady state level of aggregate employment L^{ss} is calibrated to be 0.95, out of a population of 1. Since there is not participation decision, the steady state unemployment level V^{ss} is 0.05.

3.2.7 Calibration

We present here the calibration choices made for the parameters of the model. It should be noted that the parameter that measure the average effort, $\bar{e}$, is specific to our model's mechanism and might raise questions about its calibration. However, from the homogenity of workers, we can set it to the steady state value of effort. In fact, the parameter $\bar{e}$ does not impact the simulation exercise. Also, as mentionned above, the number of firms is calibrated to reach a steady state level of aggregate employment ($L^{ss} = n * l^{ss}$) equal to 95% of the total population. The total population is the sum of workers (L) and job seekers (V) and is normalized to 1, such that the levels (of employment or unemployment) are equal to the rates (of employment or unemployment). Finally, the outside option of the worker is calibrated to 50% of the steady state wage. Table 3.1 presents the calibration choices.

Parameter	Value	Interpretation
α	2/3	Cobb-Douglas parameter on labour in production function.
β	1	Share of effort cost in utility function, neutral.
γ	0.3	Reciprocity strength.
θ	0.5	Share of gift exchange in utility function.
μ	0.99	Discount factor
ρ_A	0.9	Persistence of shock.
σ	$0.007/\alpha$	standard deviation of the exogenous shock.
b	0.6	Replacement wage, represent 50% of wage level at steady state.
$\bar{e}$	e^{ss}	Reference effort set to the effort level at steady state.
n	34.9920	Number of firms, calibrated to get $L^{SS} = 0.95$

Table 3.1: Parameter calibration value and interpretation

3.3 Simulation exercise and methodological discussion

The dependance of the firing probability on the effort provided by the worker generates non-linearities in the optimal effort, wage and employment levels, that are therefore only implicitely defined by the first order conditions presented in the previous section. In particular, the impossibility to derive policy functions prevents us from the possibility to present comparative statics. The natural way to put forward the output of our model is thus to simulate an aggregate shock and present the impulse response functions. To simulate our model, we use the Dynare sofware.

3.3.1 Non-symmetry around the steady state

One of the consequences of the mechanism of fear of firing is that the reaction of agents is not symmetric around the steady state. In particular, there is no analogous mechanism to the fear of firing regarding the probability to be hired. Therefore, we cannot summarize the change in employment using a global turnover variable that could take negative (net firing) or positive (net hiring) values. In fact, in the model, we presented two separate variables measuring respectively the number of workers fired (f_t) and the number of workers hired (h_t) and we imposed that each of these variable must always be non-negative. This non-negativity constraint generates kinks located precisely at the steady state. Those kinks are illustrated in figure 3.1 below.

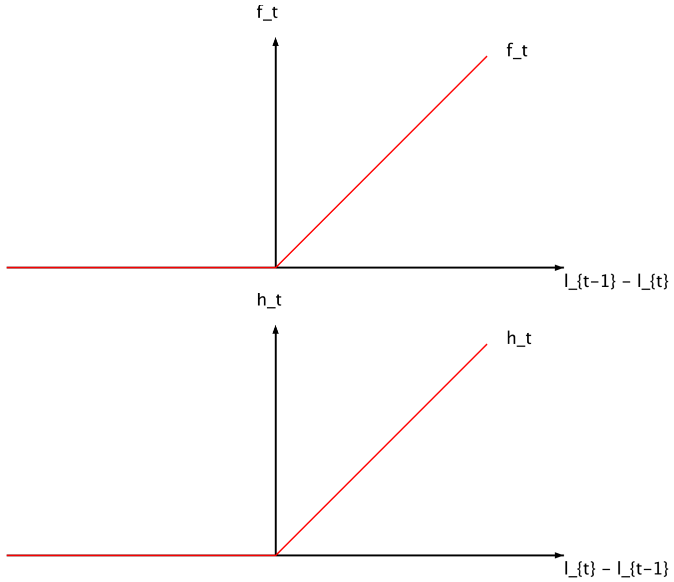

Figure 3.1: Firing and hiring functions

This feature of the model raises challenges for the simulation exercise. In fact, the standard methodology to generate impulse response functions in models similar to ours (dynamic, stochastic, general equilibrium models) in Dynare is to use the perturbation approach. In this approach, the software approximates the policy functions around the steady state. The approximation are made using a technique similar to Taylor expansions and Dynare accomodates computations up to the third order. As in any Taylor expansions, Dynare needs to compute the first (and second and third for expansion of order two and three) order derivatives around the steady state. Therefore, the software does not allow functionnal forms that are not differenciable, such as *max* or *binary* operators. This restriction is in immediate conflict with the non-negativity constraints imposed on the variables measuring hiring and firing. In fact, this constraint generates kinks that are obviously non-differentiable. Morevover, the kink is located precisely at the steady state. Would the kink be located elsewhere, it would not have represented an issue. In short, it is not possible to, as would seem natural algebraically, re-write the number of workers fired as $f_t = max(0; l_{t-1} - l_t)$ due to Dynare's restrictions[3].

[3] Even though it is possible to force Dynare to run with a binary operators worth 1 when the condition $l_{t-1} - l_t \geq 0$ is verified and 0 else, this does not yield interesting results as Dynare evaluates the operator only one time, that is at the initial values (in our case, the steady state).

In what follows, we explore two options to simulate the model given the constraints. In the first option, we build on our anticipation of the solution. In particular, we can anticipate if and when the non-negativity constraints will be binding. In the second option, we change the model to introduce exogenous turnover at the steady state to ensure both non-negativity constraints are never hit. In the appendix, we present two additional methods: smoothing the kink and the use of a deterministic setting.

3.3.2 Anticipating on the solution

We can easily anticipate when and for how long the constraints will be binding. In fact, our two constraints will always be verified, with equality, at the steady state where by definition hiring and firing are null. If a negative aggregate shock hits the economy, firms will always fire workers in the first period, such that in this initial period, the non-negative firing constraint is not binding, whereas the non-negative hiring constraint is binding. Then, starting in period 2, and because the model does not display any frictions, firms will slowly hire until the economy is back to steady state. We can thus conclude that for period 2 and all following periods the non-negative hiring constraint is non-binding, whereas the non-negative firing constraint is binding. This outcome can be exploited to build an ad-hoc computational solution to simulate the model. The knowledge we have of the solution, in terms of when the constraints will be binding or not, is also the reason for not using the RISE toolkit. In fact, RISE is based on the modelling of the endogenous probabilities to switch from binding to non-binding states each period, following a markov-switching approach. Those probabilities to hit constraints are then internalized by the agents. In our case, we know with certainty when the constraints are hit. Another toolkit exists to deal with occasionally binding constraints, namely the OccBin toolkit for Dynare, developed by Guerrieri & Iacoviello in 2015. However, one of the condition for the proper use of the toolkit is that agents should not be able to anticipate if and when the constraints will be hit. This is not true in our case. A summary of the techniques to take care of occasionally binding constraints (OBC) has been written by Binning & Maih (2017), who also developed the toolkit RISE.

Based on our anticipation of when the constaints shall be binding or not, we build an ad-hoc variable (x) worth 1 in period 1, then 0 for all remaining periods. Thereby, we bypass Dynare's built-in solution for binary variables.

The new variable (x_t) is the ratio of the random shock (ϵ_A) over the standard deviation of the shock (σ). By construction, our new variable is thus worth 1 in period 1, when the shock happens, and 0 for all the remaining periods when there is no shock[4]. We append the variables measuring the number of fired workers, f_t and the number of hired workers h_t. The new expressions are as follows:

$$f_t = (l_{t-1} - l_t)x_t$$
$$h_t = (l_t - l_{t-1})(1 - x_t)$$

By construction, f_t and h_t now always satisfy the non-negativity constraints. However, this artificial binary variables generates obvious computation issues within Dynare. Actually, even though the solution is now accepted by the software, it still generates a discontinuity when the ad-hoc variable x switches from zero to one and then to zero again. Even though we are able to generate impulse response functions, there remain issues. In particular, in the presence of a negative aggregate shock, part of the decrease of the number of workers at the firm level is correctly attributed to a increase in firing, but a substantial part of the negative turnover is incorrectly picked up by undue negative hirings. This generates a negative probability to be hired that distorts most of the results (the impulse response function computed and plotted by Dynare), with some quantitative non-sense, for example the increase of the utility level of workers (U) after a negative shock. In fact, when the number of hirings becomes negative, the probability to be hired also becomes negative. Then, the continuation value in the utility of the job-seeker (B) is impacted since we have that, suddenly, a higher future level of utility (U_{t+1}) negatively impacts the current utility of job-seekers. In turns, this distorted B_t generates incoherence in the continutation value of the utility of workers. When the utility of workers is wrongly defined, the optimal effort that follows utility maximization is also distorted. Finally the wage level, that anticipates on the optimal effort also suffers from the initial undue negative hirings. Also, even though negative shock seems to be able to generate the expected hike in the effort provided, it is hard to disentangle the effect of our new mechanism from the effect of fair wage, since we also observe in increase in wage, and from the distortion induced by the negative hirings. The IRF's are displayed in Figure 3.2 and the steady state values are given in Table 3.2. It can be noted that

[4]This follows from the fact that we ask Dynare to simulate a shock worth precisely one standard deviation.

starting in period two, the hirings seem to be correctly picked up in the IRF's computed by Dynare, whereas the firings suffer from some slight deviation from zero.

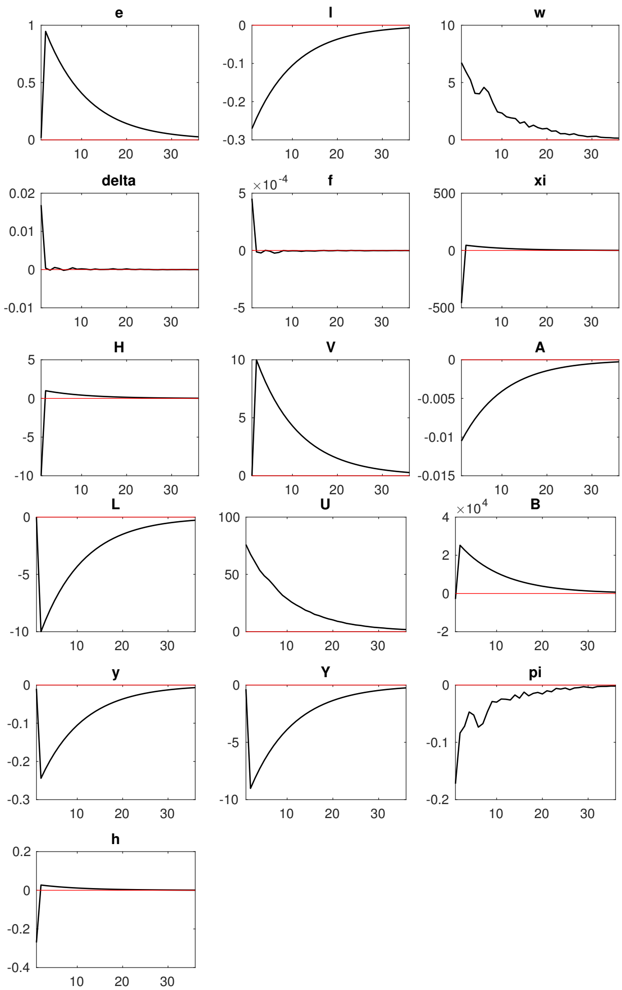

Figure 3.2: IRF with ad-hoc binary variable

3.3.3 Avoiding the kink altogether

Given the failure of the above mentioned techniques to provide meaningful impulse response functions, a remaining option is to modify the model in order for the equilibrium to fall in a never-binding case regarding the non-negativity constraints. The obvious way to do this is to have a positive equilibrium turnover. In a model with positive steady state turnover, the number of fired worked and

Variable	Steady-state value
e	0.387298
w	1.2
l	0.0257202
U	127.5
B	60
y	0.0462963
Y	1.71
π	0.0154321

Table 3.2: Steady state values with ad-hoc binary variable

of hired workers are defined in equations 3.21 and 3.22. A proportion λ of the work force is fired and hired in each period. This ensures, with λ high enough, that f_t and h_t are always positive. The rest of the model remains unchanged.

$$f_t = (1+\lambda)l_{t-1} - l_t \tag{3.21}$$

$$h_t = l_t - (1-\lambda)l_{t-1} \tag{3.22}$$

In this context however, the steady state cannot be computed by hand anymore, due to the fact that hiring and firing probabilities are strictly non-null at steady state, which is now defined by the equality of the number of hired and fired workers. The new steady state values of the number of fired workers (f^{ss}), the number of hired workers at the level of the firm (h^{ss}) and at the aggregate level (H^{ss}) and the firing and hiring probabilities (δ^{ss} and ξ^{ss}) are the following:

$$f^{ss} = \lambda l^{ss}$$
$$h^{ss} = \lambda l^{ss}$$
$$H^{ss} = n\lambda l^{ss}$$
$$\delta^{ss} = \lambda$$
$$\xi^{ss} = \frac{n\lambda l^{ss}}{V^{ss}}$$

We can plug these values in the optimal effort to get the new steady state level of effort, which is implicitely given by equation 3.23. Using the quadratic solver and imposing non-negative effort at the steady state, we can get equation

3.24.

$$e^{ss} = \frac{\theta}{\beta}(w^{ss} - b)^{\gamma} + \frac{\lambda}{e^{ss}\beta}(U^{ss} - B^{ss}) \tag{3.23}$$

$$e^{ss} = \frac{\frac{\theta}{\beta}(w^{ss} - b)^{\gamma} + \sqrt{(\frac{\theta}{\beta})^2(w^{ss} - b)^{2\gamma} + 4\frac{\lambda}{\beta}(U^{ss} - B^{ss})}}{2} \tag{3.24}$$

As is immediately observed, the steady state effort now depends not only on the steady state wage, as before (without equilibrium turnover), but also on the steady state utility level of workers and job-seekers. The same complexity appears in the steady state level of all other variables.

In particular, we now have:

$$\begin{aligned} e_w^{'ss} = & \frac{\gamma\theta(w^{ss} - b)^{\gamma-1}}{2\beta} \\ & + \frac{1}{2\beta}\left[\theta^2(w^{ss} - b)^{2\gamma} + 4\beta\mu\lambda(U^{ss} - B^{ss}\right]^{-1/2}\theta^2\gamma(w^{ss} - b)^{2\gamma-1} \end{aligned}$$

Which allows to compute optimal wages at steady state, implicitely given by:

$$l^{ss1-\alpha} = \alpha e^{ss\alpha-1} e_w^{'ss} \tag{3.25}$$

In turn, optimal labour at steady state is given by the following expression:

$$l^{ss} = \frac{w^{ss}}{\alpha e^{ss\alpha}} \tag{3.26}$$

We can combine equations 3.25 and 3.26 to get the following results (which is a general results in fair wage models):

$$w^{ss} = \frac{e^{ss}}{e_w^{'ss}}$$

We must then turn to a numerical algorithm to solve the steady state values of the model. The details are shown in the appendix. Using a calibration of parameters identical to the one proposed in Table 3.1, except for n which is now calibrated to 133.516 to keep matching a steady state employment of 0.95. The resulting steady state values are given in Table 3.3. In particular, we can see that steady state effort is higher with equilibrium turnover, as was already visible from the algebra (equations 3.18 and 3.24). The next step is to implement this steady state in a Dynare simulation of the model with equilibrium turnover.

Variable	Steady-state value
e	0.56
w	2.3548
l	0.0071
e'_w	0.2378
U	233.0426
B	231.222
y	0.0251
Y	3.3556
π	0.0084

Table 3.3: Steady state values with equilibrium turnover

3.4 Conclusion

Firing threats have been covered by empirical research, leading to the conclusion that in the presence of such a threat, wokers tend to carry out more effort in their work. This effort can be manifested in different manners, for example working longer hours. Whether this effort is remunerated or not does not hinder the main consequence of this phenomenon: individual productivity increases. This increase in individual productivity has been documented by several authors who studied jobless recoveries such as Berger (2012) and Burger & Schwartz (2015).

To our knowledge, the fair wage model had not yet been extended to allow for the fear of firing. In this project, we develop an extension of the fair wage model where we allow workers to exert a higher effort in order to reduce their risk of being fired following a negative aggregate shock. Importantly, the mechanism does not a have counterpart in case of positive aggregate shock. Therefore, the model does not yield symmetric reaction of agents around the steady state. We account for this non-symmetry by measuring separately the number of firings and the number of hirings at each period, instead of using a net turnover variable taht aggregates firings and hirings.

Beyond the specific mechanism of fear of firing, this project thus looks into the simulation techniques for models with non-linear and non-symmetric optimal reaction of agents to shocks. Beyond the interest in the model itself to understand the mechanisms behind jobless recoveries, we hope that the early stages completed in this research represent an excellent base for technical developments that could serve a broader agenda of model developments in macroeconomics and business cycles.

Appendix

Optimal effort

From the first order condition for optimal effort (equation 3.2) and the definition of δ (equation 3.3) and f (equation 3.4), we can isolate optimal effort and take its derivative with respect to wage.

$$
\begin{aligned}
e_t &= \frac{\theta}{\beta}(w_t - b)^{\gamma} - \frac{\mu}{\beta}\delta'_e(U_{t+1} - B_{t+1}) \\
\delta_t &= \frac{f_t}{l_t}\frac{\bar{e}}{e_t} \\
&\text{Where}: \ f_t = \begin{cases} l_{t-1} - l_t & \text{if } l_{t-1} - l_t \geq 0 \\ 0 & \text{else.} \end{cases}
\end{aligned}
$$

We also have that $\delta'_e = -\frac{f_t}{l_{t-1}}\frac{\bar{e}}{e^2}$. First, we plug the expression for δ'_e in optimal effort to get:

$$
e_t = \frac{\theta}{\beta}(w_t - b)^{\gamma} - \frac{\mu}{\beta}\frac{f_t}{l_{t-1}}\frac{1}{e_t}(U_{t+1} - B_{t+1})
$$

We then solve for e using the quadratic solver and constraining e to be non-negative:

$$
e_t = \frac{\theta}{2\beta}(w_t - b)^{\gamma} + \frac{1}{2}\sqrt{(\frac{\theta}{2\beta})^2(w_t - b)^{2\gamma} + 4\frac{\mu}{\beta}\frac{f_t}{l_{t-1}}(U_{t+1} - B_{t+1})}
$$

And finally take the derivative of the optimal effort with respect to wage.

The baseline fair wage case

The objective of this project is to explore how the fear of firing can impact the economic outcomes (unemployment, production, . . .) in case of negative shock, in presence of reciprocity. It is thus informative to understand what happens in a basic model without the fear of firing. In such a case, the main difference with the model presented above, is that the probability to be laid off does not depend on the effort provided by the worker. The model then simplifies greatly and the impulse response function to a negative aggregate shock are presented in figure 3.3.

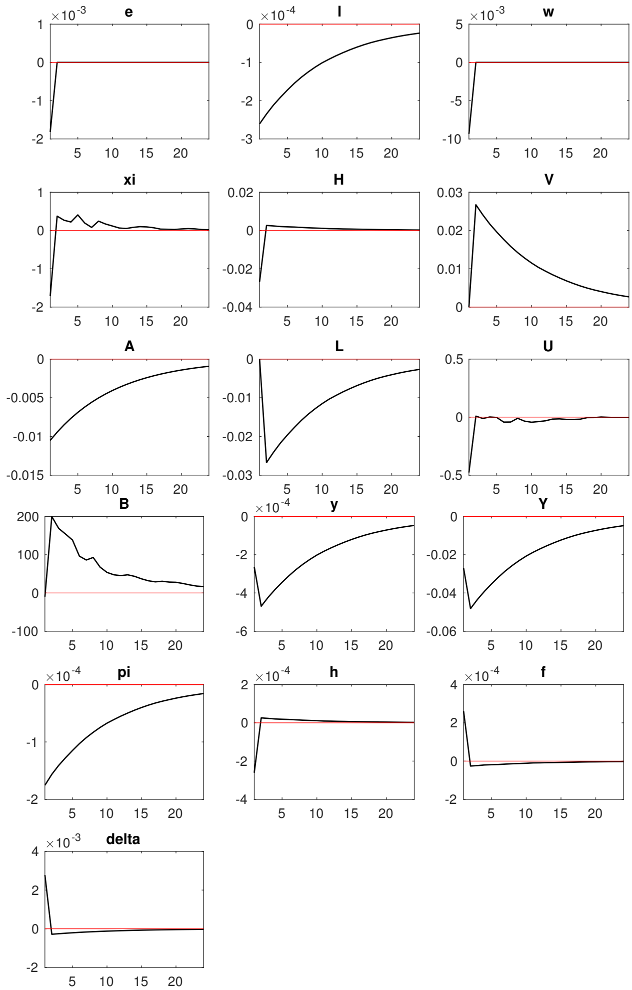

Figure 3.3: IRF without fear of firing

As can be seen, following a 1% deviation from the steady state of the aggregate productivity level, we observe that the effort level decreases at the time of the shock, reciprocating to the decrease in wage at the same period. Total employment is pre-determined and thus reacts with a lag of one period. In fact, at the time of the shock the firm cannot immediately adapt its employment level, such that the shock is entirely absorbed by the wage. Then, starting in the following period, the firm can pick its optimal employment level. From there on, the lower aggregate productivity (lower than at steady state) is entirely

Variable	Steady-state value
e	0.232379
w	1.2
l	0.00925926
U	122.7
B	60
y	0.0166667
Y	1.71
π	0.00555556

Table 3.4: Steady state values without fear of firing

absorbed by employment. This happens because in the presence of reciprocity, the firm should maintain its wages high to generate a high effort from its workers. The goal of our research is to generate more effort for a given wage reaction after a negative shock. As can also be seen, this simulation suffers from the same issues as the one presented in the main section: part of the firing is picked up by negative hirings, distorting the probabilities to be hired and fired.

If one wants to simplify the model further, we can get rid of the transitions on the labour market. Then a worker never gets laid off and probabilities to transition in and out of unemployment are null. In this case, the utility of the job-seeker is a constant.

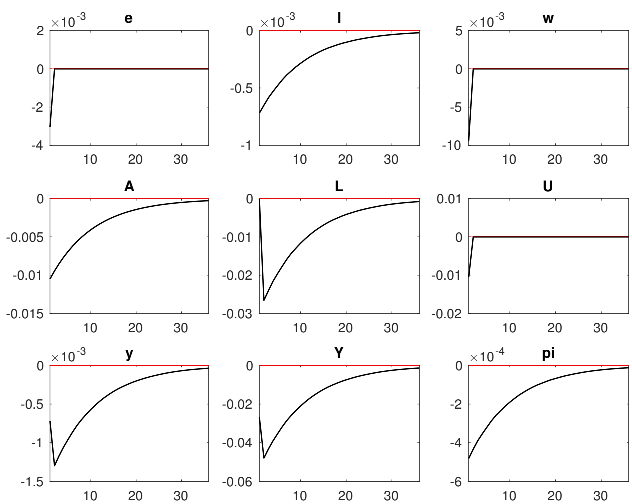

Figure 3.4: IRF without transitions

Variable	Steady-state value
e	0.232379
w	1.2
l	0.00925926
U	122.7
B	60
y	0.0166667
Y	1.71
π	0.00555556

Table 3.5: Steady state values without transitions on the labour market

Smoothing the function around the steady state

Looking at figure 3.1, the first solution that jumps out is to smooth the function around the steady state. This can be done using the polyfit tool of Matlab by providing a grid of points and requiring Matlab to compute the polynomial function that minimizes the distance between the function and the given coordinates. The method is illustrated in figure 3.5.

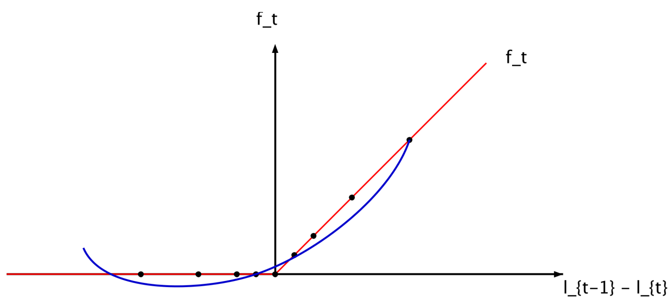

Figure 3.5: Polyfit smoothing

As is imperfectly represented on the picture, the grid of points is centered around the steady state, on a domain that extends from -10 to +10 percentage deviation from the steady state. This domain restriction allows to reduce the size of the remaining numerical error but requires that the simulated value for the number of fired (respectively hired) workers does not fall outside of the interval. In our case, the interval covers values from -0.0026 to 0.0026. By imposing a higher density of points in the grid as we get closer to 0, we give more weight to the steady state point in the error minimization. The best polynomial function generated yields a numerical error equal to 0.0001 at the steady state.

This numerical error is however still too high with regards to the consequences on the rest of the model. In fact, the error is multiplied to reach a probability to be fired equal to 0.3% at the steady state, which compromises the rest of the results.

Using a deterministic setting

The last option considered to simulte the given model is to avoid the need for differentiable functional forms. In fact, Dynare offers an alternative method to the perturbation approach. This alternative is most often used in context deemed "deterministic" and uses a very different technique to generate impulse response function. In this case, Dynare uses the provided steady state as initial value and then solves, using different possible algorithm, the model at each period, until the model converges to the provided end-values, in our case the steady state. This method circumvent the need for differentiability, each period being solved independently. However, this does not provide the researcher with policy functions, but only with a numerical time series for each variable. Impulse response functions then need to be computed by hand, by simulating the model many times and aggregating the results to obtain average reactions after the shock. For reasons yet to be elucidated, we cannot introduce in Dynare the stochastic variable needed and this research is still ongoing.

Steady state with equilibrium turnover

The system to be solve is the following, all variables taken at steady state:

$$e = \frac{\frac{\theta}{\beta}(w-b)^{\gamma} + \sqrt{(\frac{\theta}{\beta})^2(w-b)^{2\gamma} + 4\frac{\lambda}{\beta}(U-B)}}{2} \tag{A}$$

$$e'_w = \frac{\gamma\theta(w-b)^{\gamma-1}}{2\beta} + \frac{1}{2\beta}\left[\theta^2(w-b)^{2\gamma} + 4\beta\mu\lambda(U-B\right]^{-1/2}\theta^2\gamma(w-b)^{2\gamma-1} \tag{B}$$

$$U = \frac{w - \beta\frac{e^2}{2} + \theta(w-b)^{\gamma}e + \mu\lambda B}{1-\mu+\mu\lambda} \tag{C}$$

$$B = \frac{b + \mu\frac{n\lambda l}{1-nl}U}{1-\mu+\frac{\mu n\lambda l}{1-nl}} \tag{D}$$

$$l^{1-\alpha} = \alpha e^{\alpha-1}e'_w \tag{E}$$

$$l = \frac{w}{\alpha e^{\alpha}} \tag{F}$$

$$n = \frac{L}{l} \tag{G}$$

We can combine equations E and F to get the following results (which is a general results in fair wage models):

$$w^{ss} = \frac{e^{ss}}{e'^{ss}_w} \tag{H}$$

We can also plug G in D and B (replace n with its calibration value, where $L^{ss} = 0.95$). Then, we can plug D in C to get:

$$U = \frac{w - \beta\frac{e^2}{2} + \theta(w-b)^{\gamma}e + mu\lambda\left[\frac{b+\frac{\mu\lambda L}{1-L}U}{1-\mu+\frac{\mu\lambda L}{1-L}}\right]}{1-\mu+\mu\lambda} \tag{I}$$

We then use the *fsolve* function in Matlab to solve the system of 4 equations (H, A, B, I) and 4 variables (w, e, e'_w and U). The reason for reducing the dimensionality of the system to only 4 equations is to help *fsolve* to converge to a solution.

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