Underemployment and the Business Cycle

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Abstract

Recent years have seen a renewed interest in involuntary part-time employment. Despite its sizeable share in measures of resource underutilizaton in the labor market, our understanding of this phenomenon has remained limited. In this paper I analyze both household-level and aggregate data to characterize involuntary part-time employment in the US, and document its business cycle properties. I develop a tractable model of involuntary part-time employment, featuring search and matching frictions and partial substitutability between full-time and part-time workers in the production function, that successfully captures the dynamics of key labor market variables. In particular, the model is able to deliver the countercyclicality of involuntary part-time employment found in the data. The key mechanism to obtain this result is the relatively higher flexibility of part-time wages, a feature observed in the data, that makes it more profitable for the firm to reallocate workers from full-time to part-time contracts during recessions. Based on the model, I do policy analysis to evaluate the effect of changes in fringe benefits. In addition, I study the impact that organizational innovation may have had in changing the response over time of involuntary part-time employment to business cycle fluctuations.

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"[The] unemployment rate today probably does not fully capture the extent of slack in the labor market."

— Janet Yellen, *Providence Chamber of Commerce, May 2015*

1 Introduction

In recent years researchers and policymakers have shown a renewed interest in involuntary part-time employment as a crucial element to assess labor market health. The fact that individuals have part-time jobs even though they would be willing to work more hours is evidence that resources in the economy are not employed at full capacity. Data shows that, nowadays, this is a non-negligible group representing almost 40 percent of U6.[1] Given its sizeable share and its importance for policy-making, developing a better understanding of this phenomenon is needed, particularly nowadays that the unemployment rate does not seem to be able to fully capture the state of resource utilization in the labor market.

In this paper I address several questions regarding involuntary part-time employment. First, is involuntary part-time employment a different dimension of the labor market, relative to the standard extensive and intensive margins? Second, what factors could be influencing the choice of firms to have involuntary part-timers within its workforce? Third, are there policies that could be contributing to the existence of involuntary part-time employment in the economy? And, fourth, have there been any changes over time in the response of involuntary part-time employment to changes in aggregate economic conditions?

I analyze both household-level and aggregate data to characterize involuntary part-time employment in the US. Based on aggregate data, I compute business-cycle statistics for involuntary part-time employment and find that it is very volatile, nearly as volatile as unemployment, and strongly countercyclical. The same applies to underemployment, measured as U6.

From the household-level data I also extract two empirical observations. First, changes in involuntary part-time employment are mostly explained by reallocation of workers from full-time to part-time positions within the firm. Involuntary part-time employment works as an alternative mechanism of adjustment for firms that are looking for higher flexibility in the context of un-

[1] U6 is the measure of underemployment constructed and reported by the Bureau of Labor Statistics (BLS), which is made up of three components: unemployed individuals, part-time workers for economic reasons, and individuals marginally attached to the labor force. An individual is classified as part-time worker for economic reasons if she usually works less than 35 hours per week, and cites slack business conditions or inability to find a full-time job as the reason for not working full time. Marginally attached to the labor force are individuals not in the labor force who have been looking actively for a job within the last 12 months before the survey.

certain economic conditions, without necessarily changing effective headcounts and thus avoiding the potential costs associated to firing workers. Given the benefits and costs associated with this reallocation and the characteristics of the workers who are reallocated, this adjustment is more than a mere reduction in hours to existing workers, and thus part-time employment emerges as an alternative adjustment mechanism, different from the traditional intensive and extensive margins.

The second observation is that wages of involuntary part-time workers display a higher volatility and lower persistence than those of their full-time counterparts, thus indicating a higher degree of flexibility. This will turn out to be a key element in explaining the countercyclicality of involuntary part-time employment.

Based on this evidence, I build a business cycle model of involuntary part-time employment, featuring search and matching frictions, where the decision of whether a worker is full-timer or part-timer is entirely made by the firm. It is an augmented search and matching model of the labor market, which features full-time and part-time employment, and a production function that combines both types of workers. The model thus depicts individuals in three labor-market states: employment as full-timer, employment as part-timer and search unemployment. Individuals search and are hired as full-time employees. However, in a given period the firm may decide to reallocate part of the workforce towards part-time contracts in response to an aggregate shock that negatively affects its profits. When reallocated as part-timers, workers see their working hours reduced and stop receiving fringe benefits. If laid off, they receive unemployment benefits and face a probability less than one of finding a new job.

This model is able to deliver the countercyclicality of involuntary part-time employment found in the data. The key mechanism to obtain this result is the relatively higher flexibility of part-time wages, a feature from the data, that makes it more profitable for the firm to reallocate workers from full-time to part-time contracts during recessions. In addition, the model successfully captures the empirical dynamic comovements between output, unemployment and involuntary part-time employment.

Based on the model, I do policy analysis to evaluate the effect of changes in fringe benefits on involuntary part-time employment. The model predicts that an increase in mandatory fringe benefits to full-time workers, such that their share in average full-time wages goes up by 1 percentage point, leads to an increase of the steady state involuntary part-time ratio by 16 percent, from 4 percent to 4.65 percent. The increase in fringe benefits not only has a direct effect on the incentives of the firm to reallocate workers from full-time to part-time positions, but also has an indirect impact through its effect on vacancy posting. These results contribute to the discussion on the effects of the Employer Shared Responsibility provisions introduced by the Affordable Care Act.

Data shows that involuntary part-time employment has become more volatile and persistent than in the past. I study the role that organizational innovation may have had in changing the response over time of involuntary part-time employment to business cycle fluctuations. Organizational innovation and the adoption of workforce management technologies increase the degree of substitutability between full-time and involuntary part-time employment in the production process. Impulse response analysis from the model indicates that an increase in the degree of substitutability makes involuntary part-time employment more sensitive to aggregate productivity shocks. The response to the shock is stronger when the degree of substitutability is higher.

This paper is organized as follows. Section 2 provides a brief summary of the literature. Section 3 describes the model. Section 4 summarizes the calibration and the quantitative results. Section 6 presents results from sensibility analysis to key parameters. Section 7 analyzes how government policies may contribute to the existence of involuntary part-time employment. Section 8 studies the effect that organizational innovation may have had in changing the response of involuntary part-time employment to economic conditions over time. Section 9 concludes and discusses future lines of work.

2 Literature

Most of the existing literature on part-time work has focused on the supply side of the labor market resorting, in general, to individual or household survey data. The object of interest in this strand of the literature has been voluntary part-time work and its determinants. Some authors have studied the propensity of individuals to supply labor on a part-time basis rather than on a full-time basis. Bardasi and Gornick (2000) show that age, education, motherhood, and the level of the spouse's income in the household affect the decision to work part-time. In the same line, Venn and Wakefield (2005) find that this decision is associated to life-cycle events that affect the degree of involvement in the labor market.

Other studies have focused on the part-time wage penalty and its determinants. This literature is actually a branch of the gender wage gap literature, which decomposes individual wage data using Blinder-Oaxaca methods. Hirsch (2005) and Booth and Wood (2004) find that differences in worker-specific skills and job-related skills (i.e. productivity endowment) account for much of the part-time wage disadvantage. There are also papers analyzing the investment in human capital by part-time workers. Becker (1964) postulates that part-time workers have lower incentives to invest in their human capital, while Maximiano (2012) finds that workers' training probability increases with the number of contractual work hours.

The study of involuntary part-time employment in the US has remained limited until very recently. However, the substantial increase of part-time employment for economic reasons in the last years has generated a revived interest on this issue. Using data from CPS, some studies have documented the evolution of stocks and flows of involuntary part-time employment before, during and after the Great Recession. Canon et al. (2014) and Borowczyk-Martins and Lalé (2016c) characterize part-time employment for economic reasons along dimensions other than hours (observable characteristics of workers and wages) and find that involuntary part-time employment can be considered a separate labor market state, different from both full-time and voluntary part-time employment. In addition, both papers provide a detailed description of the transition probabilities to and from part-time employment for economic reasons, with particular focus on the period during and after the Great Recession. My own calculations of stock and flows from CPS data are consistent with the findings in these papers.

In terms of specific results from each paper, Borowczyk-Martins and Lalé (2016c) find that full-time employment accounts for most of the variation in involuntary part-time work and that, since the Great Recession, full-time workers have been at greater risk of working part-time involuntarily than being unemployed. Canon et al. (2014) conclude that changes in the transition probabilities to and from involuntary part-time work in the aftermath of the 2007-2009 recession only impact the composition of employment in terms of full-time and part-time shares, but not the distribution of individuals between employment and non-employment. So, according to the these authors, involuntary part-time employment might not be a mechanism to save jobs during recessions. This finding is at odds with the *variable labor utilization hypothesis* developed by Borowczyk-Martins and Lalé (2016a) based on the analysis of CPS data. According to this hypothesis, part-time employment is the mechanism used by firms to adjust and smooth out the pervasive consequences of adverse shocks. First, by reducing the number of hours worked the firm not only saves on labor costs, but also reduces potential hiring and training costs as well as the uncertainty of future matches. Second, in a context of uncertain demand prospects, the possibility of shortening the working schedule makes it possible for firms to keep jobs alive while saving the costs associated to full-time jobs, and to easily upgrade the number of hours worked once the demand conditions improve.

Other studies for the US, such as Cajner et al. (2014) and Valletta and Van Der List (2015), suggest that while the elevated level of involuntary part-time employment since the Great Recession reflects mainly cyclical factors, there is also an important structural component driven by changes in the composition of the population, in the wage structure and in the industrial composition of employment. Their main conclusion is that, if these structural factors persist, then involuntary part-time employment will remain at historically high levels even after a full recovery from the Great Recession.Valletta et al. (2016) find that market-level factors associated to demand and supply conditions, particularly changes in industry employment shares, are behind the increase in the incidence of involuntary part-time employment.

Based on the aforementioned empirical studies, a few recent papers have developed models featuring involuntary part-time employment. Borowczyk-Martins and Lalé (2016c) construct an incomplete-market search model and find that shorts spells of involuntary part-time work can have persistent negative effects on consumption through its impact on the household's saving behavior. This is a partial equilibrium model where the household decides to work full-time or part-time; in this sense, part-time employment is not strictly "involuntary" in this model. The higher risk of involuntary part-time employment is modeled as exogenous changes to the separation rate of part-time workers. But this paper abstracts from the decision of the firm and its response to standard shocks such as TFP or demand shocks.

An alternative modeling strategy is the one proposed by Tavares (2015). He develops a directed search model with heterogeneous workers and on-the-job search, in which jobs can be operated full-time or part-time. The model features two dimensions of heterogeneity. First, workers differ in their ex-ante productivity. Second, on-the-job productivity also varies from worker to worker to reflect the quality of the match. The main prediction of this model is that workers are involuntary part-timers either because their ex-ante productivity is low or because they are in a bad match. A decomposition of the two components indicates that the former is the one that dominates and, as a consequence, involuntary part-time employment is concentrated among the low productivity types. The key issue in this model is that a match is operated full-time or part-time if it maximizes the joint surplus of the match. Therefore, the reallocation decision is not just a firm decision. In fact, the reallocation can occur even if it is not profitable for the firm but it is profitable enough for the worker. However, if that is the case, a profit maximizing firm would rather fire the worker than reallocating her.

The paper most related to mine is Warren (2015). He also conceives involuntary part-time employment as a decision made exclusively by the firm. However, differently from my representative firm model with heterogeneous workforce, he constructs a model in which heterogeneous firms choose to allocate identical workers either into full- or part-time positions. With his model he is able to match the patterns of vacancies and new hires across the growth distribution of firms. In addition, he produces results for the cross-section of firms that employ part-time workers; however, given the lack of data availability on part-time employment at the firm level, the author cannot test these predictions. He also reports business cycle statistics obtained from the model that are able to capture the countercyclicality of involuntary part-time employment.

Finally, within the literature studying short-time work (STW) programs as the ones developed in Europe, particularly in Germany, a paper that is close to mine in terms of its setup is Balleer et al. (2013). These authors construct a search and matching model with endogenous separations to study the effect of STW on unemployment dynamics. Their main finding is that STW programs act as automatic stabilizers, saving jobs during recessions. The modeling strategy in this paper is based on defining two endogenous cutoffs associated to the decisions of firing a worker or of participating in the STW program. I adopt the idea of finding optimal cutoffs but implement it in a model with involuntary part-time employment that resembles more the US reality, where the development of STW programs is very limited, than the European reality.

3 Empirical Facts

3.1 Business Cycles

Table 1 presents empirical facts regarding underemployment in the U.S., with particular focus on involuntary part-time employment. Using data from the BLS, I compute business-cycle statistics for involuntary part-time employment, full-time employment, the involuntary part-time ratio[2], and underutilization measured as U6.

The results show that involuntary part-time employment is very volatile, nearly as volatile as unemployment, and strongly countercyclical. The opposite is true for full-time employment. Both series display a high degree of persistence. The broad measure of underutilization is also very

[2] The involuntary part-time ratio is defined as the ratio between involuntary part-time employment and full-time employment.

Table 1: Business Cycle Statistics for Selected Labor Market Variables

	IPT	FT	IPT Ratio	Unemployment	U6
Std. Dev.	0.102	0.014	0.115	0.113	0.102
Relative Std. Dev.	9.204	0.922	9.241	10.168	9.241
Autocorrelation	0.869	0.922	0.884	0.939	0.939
Correlation w/ Output	-0.890	0.837	-0.898	-0.918	-0.919

Notes: Author's own calculations based on data from BLS for the period 1994Q1-2016Q2. All variables are seasonally-adjusted and reported in logs as deviations from an HP trend with smoothing parameter 1600.

Table 2: Correlations with Leads and Lags of Output

	y_{t-4}	y_{t-3}	y_{t-2}	y_{t-1}	y_t	y_{t+1}	y_{t+2}	y_{t+3}	y_{t+4}
IPT	-0.38	-0.54	-0.69	-0.82	-0.90	-0.87	-0.73	-0.55	-0.37
FT	0.60	0.75	0.85	0.91	0.85	0.69	0.49	0.27	0.08
IPT Ratio	-0.41	-0.58	-0.72	-0.85	-0.91	-0.86	-0.71	-0.52	-0.34
Unemployment	-0.48	-0.65	-0.81	-0.91	-0.93	-0.84	-0.70	-0.53	-0.36
U6	-0.46	-0.64	-0.79	-0.89	-0.93	-0.85	-0.71	-0.54	-0.35

Notes: Author's own calculations based on data from BLS for the period 1994Q1-2016Q2. All variables are seasonally-adjusted and reported in logs as deviations from an HP trend with smoothing parameter 1600.

volatile and countercyclical, which does not come as a surprise given that its two main components, unemployment and involuntary part-time employment, also display these features.

Regarding the correlation with output, Table 2 shows that all variables display a strong contemporaneous correlation, but the relationship weakens when considering both leads and lags of output.

3.2 Micro Evidence

In this section I document two empirical observations that are going to be the key ingredients of the model described in the next section. First, changes in involuntary part-time employment are mostly explained by reallocation of workers from full-time to part-time positions within the firm; this is in line withe the findings of Borowczyk-Martins and Lalé (2016a) and Warren (2015). Second, wages of involuntary part-time workers seem to be more flexible than those of their full-time counterparts.

Stocks and Flows. The Current Population Survey (CPS) is the main source of data of part-time work in the US. I longitudinally link the monthly CPS files based on the methodology developed by Madrian and Lefgren (1999) and Nekarda (2009) to obtain employment stocks and gross flows for the period 1995-2015.[3],[4],[5] The resulting series are adjusted to remove seasonality, and also to correct time aggregation bias as done in Shimer (2012). For more details on the construction of the data see Appendix B.

I find evidence indicating that the increase in part-time employment during the most recent crisis was demand-driven. An analysis of the employment stocks computed from the CPS indicates that the key force behind the increase in part-time employment during recessions is the rise in part-time employment for economic reasons and, in particular, of part-time employment due to slack work or deteriorated business conditions (Figures 7 and 8). Involuntary part-time employment due to the inability of the individual to find a full-time job, which might be capturing supply forces driving involuntary part-time, represents a smaller share and is also less responsive to business cycle fluctuations. Finally, part-time employment for non-economic reasons, while sizeable, does not seem to respond to changes in economic conditions.

Shifting attention from the stocks to the flows, also computed from the CPS, provides additional insights on the dynamics of involuntary part-time employment. I identify three key facts.

The transition probability from full-time to involuntary part-time employment is countercyclical. In fact, during the Great Recession, this transition probability more than doubled, moving from about 1 percent to almost 2.2 percent at its peak during the crisis. The same behavior was observed during the 2001 recession, though the change in the transition probability was much smaller, explained by the differences in length and severity of both recessionary periods. In addition, the effect of recessions on p^{FI} is very persistent. The same pattern, though in the opposite direction, is observed in the case of the probability of transitioning from involuntary part-time employment back to full-time employment: it falls during recessions and takes a long time to recover back to pre-crisis levels (Figure 9).

Full-time employment is the most common origin and destination of involuntary part-time flows. Table 3 shows that, on average, more than a third of all involuntary part-timers were full-

[3]Each basic monthly CPS file starting from 1976 is publicly available through the NBER.

[4]In 1994 the CPS went through a major redesign that had an impact on the series of part-time employment for economic reasons. Prior to 1994, the survey did not ask part-time workers whether they wanted to or were available to work full-time. In addition, respondents were not asked about usual hours worked, only about actual hours worked, and questions referred to all jobs, without distinguishing between the primary job and other jobs. This calls for caution when constructing series of involuntary part-time employment that involve using data prior 1994. To avoid this issue, I limit the empirical analysis to the period 1995-2015.

[5]Even though the longitudinally linked data is now available through IPUMS, key variables such as usual hours worked, which are used to defined part-time employment, were not available when this project started.

Table 3: Transition Probabilities In and Out of Involuntary Part-Time Employment

Inflows (%)		Outflows (%)	
q^{FI}	31.65	p^{IF}	34.30
q^{XI}	29.33	p^{IX}	30.07
q^{UI}	16.97	p^{IU}	12.11
q^{NI}	4.14	p^{IN}	3.98

Notes: Transition probabilities computed based on CPS data over the period 1995m9-2015m11.

time workers in the previous month, and about the same proportion transitions to a full-time job in the following month. Data shows that transitions between involuntary part-time employment and other forms of employment – particularly voluntary part-time employment – are also frequent, though not as much as the ones between full-time and involuntary part-time employment.[6] Finally, transition probabilities between unemployment or non-participation and involuntary part-time employment are small.

The reallocation from full-time to involuntary part-time is a within-firm phenomenon. Job-to-job transitions conditional on reallocation have a probability of 11 percent in normal times and of 5 percent after the Great Recession; i.e. they are very infrequent. Most of the reallocation from full-time to part-time happens within the same firm. This is in line with the results reported by Borowczyk-Martins and Lalé (2016c). Warren (2015), resorting to data from the Survey of Income and Program Participants, also finds that 75 percent of all flows into or out of involuntary part-time employment are due to changes in hours within the job.

I interpret the above facts as evidence that the increase in the stock of involuntary part-time workers during recessions observed in the data is due to a reallocation of workers within firms. Involuntary part-time employment works as an alternative mechanism of adjustment for firms that are looking for higher flexibility in the context of uncertain economic conditions, without necessarily changing effective headcounts and thus avoiding the potential costs associated to firing workers. Given the benefits and costs associated to this reallocation and the characteristics of the workers who are reallocated[7], this adjustment is more than a mere reduction in hours to existing workers,

[6]The numbers reported in Table 3 may even overestimate the transition probabilities between involuntary part-time employment and other types of employment (excluding full-time jobs in the private sector) due to potential measurement error in transitions between involuntary and voluntary part-time work, as indicated by Borowczyk-Martins and Lalé (2016c).

[7]See Appendix B for descriptive statistics on the cross-sectional characteristics of involuntary part-time workers.

and thus part-time employment emerges as an alternative adjustment mechanism, different from the traditional intensive and extensive margins.

Another interesting observation is that involuntary part-timers separate more than full-timers, which does not come as a surprise since involuntary part-timers are more similar, in terms of their observable characteristics, to the unemployed than to the full-timers (see Appendix B for details). While the average of p^{IU} for the period 1995m9-2015m11 is 12.01 percent, the average of p^{FU} is only 1.55 percent, i.e. more than 7 times smaller. These findings are consistent with literature that finds that part-timers are more detached and less committed to the firm they work to, and thus more likely to separate; in addition, when facing shorter workweeks, an involuntary part-timer may have not only higher incentives but also more time for on-the-job search, thus increasing her chances of finding a job at another firm. The fact that involuntary part-timers have a higher separation rate than full-timers could deter firms from reallocating workers into part-time contracts.

Wages. To compare wages of full-time and involuntary part-time workers I construct composition-bias corrected wage series using CPS data, based on the methodology developed by Haefke et al. (2013).[8] Differently from Haefke et al. (2013), my analysis focuses on incumbent workers, since I am interested in reallocations within the firm. Therefore, I exclude new hires either coming from unemployment or from out of the labor force, as well as those originating in job-to-job transitions.

Table 4 presents statistics for the volatility and persistence of various wage series. For comparison purposes the table reports aggregate wages computed by BLS, in the context of the Labor Productivity and Costs program, using firm-level rather than household data. Aggregate wages correspond to all workers, including new hires. Haefke et al. (2013) find that wages of new hires are more volatile than those of incumbent workers. Since my sample only comprises incumbent workers, it is not surprising that the volatility of average wages in my sample is smaller than the one of aggregate wages. Wages of full-time workers are slightly more volatile than wages for the whole sample, but in the same order of magnitude of aggregate wages. This stems from the fact that the majority of the workforce in the US is full-time, and thus they play an important role in shaping aggregate wages. All these wage series display a high degree of persistence, with

[8] While Haefke et al. (2013) develop this methodology to quantify wages of new hires, it is also appropriate in this case due to the particular design of the survey. The CPS has a 4-8-4 sampling scheme, but respondents are asked about their wages only when they are part of the Outgoing Rotation Groups, i.e. when they have been 4 or 8 months in the sample. As a consequence, for each respondent there are only two observed wages, with one year of difference between each other. Since involuntary part-time employment is a state with very fast dynamics, the annual change in the wage may not capture the changes in wages occurring at higher frequencies associated with the reallocation of workers within the firm.

Table 4: Wages at Business Cycle Frequencies

	Relative Std. Dev.	Autocorrelation
Aggregate wage	0.412	0.843
CPS – *all workers*	0.369	0.933
CPS – *FT workers*	0.479	0.912
CPS – *IPT workers*	1.101	0.845

Notes: The statistics correspond to the period 1995q1-2015q12. The aggregate wage corresponds to hourly compensation in the private non-farm business sector from the Labor Productivity and Costs program of the Bureau of Labor Statistics. Hourly wages from the CPS, for each of the groups considered, are composition-bias corrected averages for workers in the private non-farm business sector, between 25 and 60 years old, excluding supervisory workers. All series are in logs and filtered using a bandpass filter with periodicities between 6 and 32 quarters.

autocorrelation coefficients higher than 0.9.

The most relevant comparison for the purpose of this paper is between the volatility and persistence of full-time and involuntary part-time wages. The results show that wages of involuntary part-time workers are twice as volatile as those of their full-time counterparts. In addition, involuntary part-time wages display a lower degree of persistence. I take this as evidence that wages of involuntary part-timers are less rigid than those of full-timers.

Since involuntary part-time workers tend to have a lower educational achievement and to work in non-routine manual occupations that normally require low skills (Canon et al., 2014), their wages are lower than the wages of full-time workers. In the dataset I construct from CPS, average wages of involuntary part-time workers are 40 percent lower than average wages of full-time workers. In this context, one of the concerns around the flexibility of involuntary part-time wages is whether they are so low that they would get bounded by the minimum wage. If this is the case, then the involuntary part-time wage would be more rigid because the firms would not be able to reduce it beyond the minimum wage in times of economic distress. In order to assess this hypothesis, I consider all involuntary part-time workers in my sample and compute, for each of them, the difference between their hourly wage and the minimum hourly wage in place in the individual's state of residence. I calculate this gap for two points in time, for December 2006 and December 2009, to evaluate whether there are any differences between "normal" times and periods of economic distress.

Figure (10) shows that a very large fraction of involuntary part-time wages in 2006 were above the minimum wage. Only 5 percent of the individuals reported having an hourly wage equal or less than the minimum hourly wage. The median difference in 2006 was of about \$5, which is significant taking into account that the state with the highest minimum wage had an hourly minimum wage of \$7.63. This evidence is consistent with the survey results from Van Horn and Zukin (2015), who find that more than 60 percent of the involuntary part-time workers who were surveyed are paid above the minimum wage.

When I compare the distribution of the gap in 2006 to the one in 2009, its is clear that the distribution shifts to the left, implying that wages for involuntary part-timers declined in the context of the Great Recession. In 2009, there is a larger mass of individuals earning a wage at or below the minimum wage than the one in 2006. This is evidence that firms had scope to reduce wages, and that minimum wages were not imposing a bound on firms.

In this context, it is worth noting that more than 80 percent of involuntary part-time workers are paid by the hour, while the majority of full-time workers are salaried workers. There is also empirical evidence that salaries might be stickier than hourly wages (Barattieri et al., 2010). This would be suggestive of a lower degree of rigidity in part-time wages relative to full-time wages.

4 Model

4.1 Decentralized Economy

The model I present in this section is a real business cycle model that features search and matching frictions in the labor market, which impede transitions of individuals from search unemployment to employment. The distinctive feature of my model is that workers can have either full-time or part-time status, and production combines both types of workers. The model thus depicts individuals in three labor-market states: employment as full-timer, employment as part-timer and search unemployment. I abstract from labor force participation decisions on the part of households. They are assumed to supply work inelastically in the sense that all its unemployed members are sent to search for jobs each period.

In this paper I focus on part-time employment for economic reasons, i.e. workers who would like to work as full-timers but that actually work as part-timers due to slack business conditions.[9]

[9]The BLS definition of involuntary part-time employment also comprises individuals who work part-time because

Individuals search and are hired as full-time employees. However, in a given period the firm may decide to reallocate part of the workforce towards part-time contracts in response to a shock that negatively affects its profits.

4.1.1 Labor Market

The labor market is characterized by matching frictions. Unemployed workers search for full-time jobs at no cost and firms pay a cost to post vacancies. Matching between unemployed individuals and vacancies occurs randomly according to an aggregate matching function:

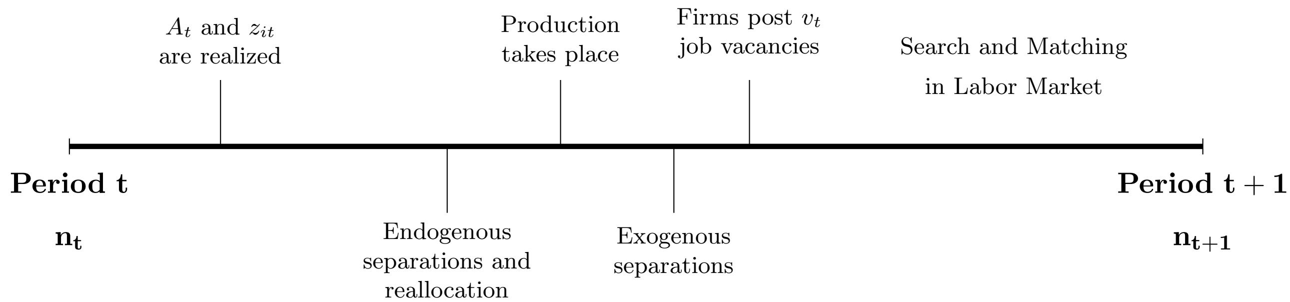
$$m(v_t, s_t) = \mu s_t^{\xi} v_t^{1-\xi}, \tag{1}$$

where s_t is the measure of workers searching for a job and v_t is the aggregate number of vacancies during period t. The parameter ξ denotes the elasticity of job matches with respect to search unemployment, and μ is the matching efficiency parameter. Finally, the labor market tightness, θ_t is defined as the vacancy-unemployment ratio, v_t/s_t. The probability that an unemployed individual is matched to an open vacancy at date t is denoted $p_t = m_t/s_t$. Similarly, the probability that any open vacancy is matched with a searching worker at date t is $q_t = m_t/s_t$. Households and firms take these probabilities as given. New hires, $m(v_t, s_t)$, begin working with a one-period delay.

Even though individuals search for full-time positions and are hired as full-time employees, when the jobs become operative in the following period the firm may choose to turn some full-time contracts into part-time contracts. This re allocation decision depends on the realization of the job-specific idiosyncratic productivity, z_{it}, that is drawn from a time-invariant distribution with c.d.f. $F(z)$, which has positive support and density $f(z)$. If the realization of the idiosyncratic productivity falls below $\tilde{z}_t$, then the job is destroyed and worker and firm separate. This leads to a job destruction rate $F(\tilde{z}_t)$. Alternatively, if the realization of the idiosyncratic productivity is higher than $\tilde{\tilde{z}}_t$, the individual remains as a full-time worker, i.e. under the conditions she was originally hired. Finally, if the realization of the idiosyncratic productivity falls between the two endogenously determined critical thresholds $\tilde{z}_t$ and $\tilde{\tilde{z}}_t$, it would be optimal for the firm to turn the full-time job into a part-time job. The resulting full-time/part-time reallocation rate is $F\left(\tilde{\tilde{z}}_t\right) - F\left(\tilde{z}_t\right)$. The optimal cutoffs are represented in Figure 11. Besides the previously described

they cannot find a full-time job. However, this component is much smaller, representing about a third of total involuntary part-timers, and less responsive to business cycle fluctuations than part-time employment due to slack business conditions. Therefore, I focus on the latter.

Figure 1: Timing of Events



endogenous separations, the model also features exogenous separations of full-time and part-time matches at rates ρ^F and ρ^P, respectively.

The initial stock of workers in period t is denoted by n_t. At the beginning of the period, after the aggregate state of the economy is revealed and the idiosyncratic productivity is realized, the firm makes its allocation decisions. A fraction $F(\tilde{z}_t)$ of employment relationships that were active in period $t-1$ is separated. In addition, after production takes place a fraction ρ^F of the full-time workers and a fraction ρ^P of the part-time workers are separated exogenously. All separated individuals immediately enter the period-t job-search process, together with the individuals who remained unmatched in period $t-1$. These two groups taken together constitute the measure of individuals searching for jobs in period t, s_t. Among total searchers, $p_t s_t$ individuals turn out to be successful in their job search and get matched to a job that starts operating in the following period. The new matches $m(v_t, s_t)$, together with the period-t workers who kept their jobs, constitute the initial workforce of period $t+1$, n_{t+1}.

Therefore, employment in this economy evolves according to the following equation:

$$n_{t+1} = n_t \left(1 - F\left(\tilde{z}_t\right) - \rho^P \left[F\left(\tilde{\tilde{z}}_t\right) - F\left(\tilde{z}_t\right)\right] - \rho^F \left[1 - F\left(\tilde{\tilde{z}}_t\right)\right]\right) + m(v_t, s_t). \tag{2}$$

Figure 1 summarizes the timing of the model.

4.1.2 Firms

On the production side of the economy there is a measure one of identical firms, which can thus be considered a representative firm. The representative firm is "large" in the sense that it operates many jobs and consequently has many individual workers attached to it through those jobs. There are two types of work arrangements: part-time and full-time. Workers devote all their available time (normalized to 1) to full-time jobs, while part-time jobs involve only $\bar{h} < 1$ hours. Each job i produces $A_t z_{it}$ units of output if it is full-time and $A_t z_{it} \bar{h}$ units of output if it is part-time, where A_t denotes aggregate productivity and z_{it} denotes job-specific idiosyncratic productivity.

Total output is the aggregation of full-time and part-time output by means of a Constant Elasticity of Substitution (CES) aggregator:

$$\begin{aligned} Y_t &= \left[\alpha \left(Y_t^F\right)^{\varepsilon} + (1-\alpha)\left(Y_t^P\right)^{\varepsilon}\right]^{1/\varepsilon} \\ &= \left[\alpha \left(A_t n_t \int_{\tilde{\tilde{z}}_t}^{\infty} z f(z) dz\right)^{\varepsilon} + (1-\alpha)\left(A_t n_t \bar{h} \int_{\tilde{z}_t}^{\tilde{\tilde{z}}_t} z f(z) dz\right)^{\varepsilon}\right]^{1/\varepsilon} \end{aligned} \quad (3)$$

where $x \equiv 1/(1-\varepsilon)$ is the elasticity of substitution between full-time and part-time workers that captures the extent to which the work of a full-time employee can be performed by one or more part-time employees.[10]. There are some economic sectors, particularly those that require a high level of on-the-job training or that require job-specific skills, in which the tasks cannot be split among different workers, making it harder to substitute between full-time and part-time workers. The use of this production function aims at capturing these realities.

The firm begins period t with an employment stock n_t.[11] After the aggregate state of the economy is realized, it makes its reallocation and firing decisions, and produces with the non-separated workers. The total real wage bill of the firm, W_t, is the sum of wages paid to all its full-time employees and of wages paid to all its part-time employees. In addition, the firm posts vacancies v_t, at a cost $g(v_t)$, for next period's production. With probability q_t, taken as given by the firm, a vacancy is matched with an individual searching for a job. The firm also pays fringe benefits (e.g. health insurance) to full-time workers for a fixed amount ζ per worker; I assume that part-time workers do not receive non-wage benefits. Furthermore, when firing workers, the firm pays a fixed cost per worker denoted by ϕ.[12,13]. Firing costs are associated only with endogenous

[10]It can be proved that when $\varepsilon \to -\infty$ the CES functions corresponds to a Leontief function, which implies perfect complementarity between full-time and part-time output. If $\varepsilon = 0$, the CES function corresponds to a Cobb-Douglas function, with a more limited degree of complementarity between full-time and part-time output, though still requiring both as inputs. And, finally, $\varepsilon \to 1$ corresponds to the case of perfect substitutability.

[11]Period-t employment stock is comprised by period-$t-1$ full-time and part-time employees who did not separate, as well as by the new matches generated in period $t-1$ that start working in period t.

[12]A fixed firing cost is just a reduced form representation of several costs, both direct and indirect, associated with firing a worker, such as expenses related to exit interviews, severance payments and higher unemployment tax rates (experience rating). Firing costs could be also capturing losses in productivity due to reduced morale among the remaining employees, or due to a required reorganization of work until the vacant position is filled.

[13]The US has traditionally been considered a country with very low firing costs, especially when compared to Europe. However, several case studies in different industries indicate that turnover costs can be sizable, particularly when taking into account the productivity losses associated with firing a worker (Boushey and Glynn, 2012).

separations; exogenous separations, which can be thought as quits, do not involve any cost. Finally, firms take the wage-setting protocol as given.

For $t = 0, 1, ...$, the representative firm chooses state-contingent decision rules for vacancies v_t, employment n_{t+1}, reallocation threshold $\tilde{\tilde{z}}_t$ and firing threshold $\tilde{z}_t$, to maximize the sum of discounted profits:

$$E_0 \sum_{t=0}^{\infty} \Xi_{t|0} \left\{ Y_t - W_t - g(v_t) - \phi n_t F\left(\tilde{z}_t\right) - \zeta n_t \left[1 - F\left(\tilde{\tilde{z}}\right)\right] \right\}, \tag{4}$$

subject to the sequence of perceived laws of motion for its employment level

$$n_{t+1} = n_t \left(1 - F\left(\tilde{z}_t\right) - \rho^P \left[F\left(\tilde{\tilde{z}}_t\right) - F\left(\tilde{z}_t\right)\right] - \rho^F \left[1 - F\left(\tilde{\tilde{z}}_t\right)\right]\right) + q_t v_t, \tag{5}$$

where aggregate output Y_t is defined as in equation (3), the total wage bill W_t is given by

$$W_t = n_t \int_{\tilde{\tilde{z}}_t}^{\infty} w_t^F(z) dF(z) + \bar{h} n_t \int_{\tilde{z}_t}^{\tilde{\tilde{z}}_t} w_t^P(z) dF(z), \tag{6}$$

and the measure of workers searching for a job is defined as

$$s_t = 1 - n_t + n_t \left(F\left(\tilde{z}_t\right) + \rho^P \left[F\left(\tilde{\tilde{z}}_t\right) - F\left(\tilde{z}_t\right)\right] + \rho^F \left[1 - F\left(\tilde{\tilde{z}}_t\right)\right]\right). \tag{7}$$

$\Xi_{t|0}$ denotes the period-0 value to the representative household of period-t goods, which the firm uses to discount profit flows because households are the ultimate owners of firms.

The derivation of the firm's optimality conditions is presented in Appendix C; here I simply intuitively describe the outcomes. The firm's first-order conditions with respect to v_t, n_{t+1}, $\tilde{z}_t$ and $\tilde{\tilde{z}}_t$ yield three optimality conditions:

$$\begin{aligned} \frac{g'\left(v_t\right)}{q_t} = E_t \Bigg\{ \Xi_{t+1|t} \Bigg[& \frac{Y_{t+1}}{n_{t+1}} - \frac{W_{t+1}}{n_{t+1}} - \phi F\left(\tilde{z}\right)t+1) - \zeta \left[1 - F\left(\tilde{\tilde{z}}_{t+1}\right)\right] + \\ & + \frac{g'\left(v_{t+1}\right)}{q_{t+1}} \left(1 - F\left(\tilde{z}_{t+1}\right) - \rho^P \left[F\left(\tilde{\tilde{z}}_{t+1}\right) - F\left(\tilde{z}_{t+1}\right)\right] - \rho^F \left[1 - F\left(\tilde{\tilde{z}}_{t+1}\right)\right]\right)\Bigg]\Bigg\}, \end{aligned} \tag{8}$$

$$(1-\alpha)\frac{Y_t}{n_t}\left(\frac{Y_t^P}{Y_t}\right)^{\varepsilon} \frac{\tilde{z}_t}{\int_{\tilde{z}_t}^{\tilde{\tilde{z}}_t} z dF(z)} - w_t^P\left(\tilde{z}_t\right)\bar{h} + \left(1-\rho^P\right)\frac{g'\left(v_t\right)}{q_t} = -\phi, \tag{9}$$

and

$$(1-\alpha)\frac{Y_t}{n_t}\left(\frac{Y_t^P}{Y_t}\right)^{\varepsilon}\frac{\tilde{\tilde{z}}_t}{\int_{\tilde{z}_t}^{\tilde{\tilde{z}}_t} zdF(z)} - w_t^P\left(\tilde{\tilde{z}}_t\right)\bar{h} + \left(1-\rho^P\right)\frac{g'\left(v_t\right)}{q_t} =$$

$$= \alpha\frac{Y_t}{n_t}\left(\frac{Y_t^F}{Y_t}\right)^{\varepsilon}\frac{\tilde{\tilde{z}}_t}{\int_{\tilde{\tilde{z}}_t}^{\infty} zdF(z)} - w_t^F\left(\tilde{\tilde{z}}_t\right) - \zeta + \left(1-\rho^F\right)\frac{g'\left(v_t\right)}{q_t}. \tag{10}$$

Equation (8) is an augmented job creation condition for a problem with part-time employment. It states that, at the optimal choice, the vacancy-creation cost incurred by the firm is equated to the discounted expected value of a matched worker. The expected value of a new worker before the realization of the idiosyncratic productivity in $t+1$ comprises the expected future (net) marginal profit from the match as well as the asset value of having a pre-existing relationship with a firm in period $t+1$.

Equations (9) and (10) define the critical thresholds for firing and reallocation decisions, respectively. The former states that the net benefit of firing the marginal worker (ϕ), should equal the opportunity cost of firing him, which is given by the profit the firm would have earned had it kept this worker as a part-timer. Similarly, the reallocation equation (10) equates the marginal benefit of reallocating a worker from a full-time to a part-time position, to the marginal cost, which in this case corresponds to the profit the firm would have made had it kept the worker as a full-timer.

4.1.3 Households

There is a measure one of individuals in the economy. Each individual, regardless of her personal labor-market status, has full consumption insurance, which is modeled by assuming that all individuals belong to a representative household that pools income and shares consumption. This "large household" assumption is a tractable way of modeling perfect consumption-risk insurance, and has been standard in the literature since Andolfatto (1996) and Merz (1995).

For periods $t = 0, 1, ...$, the representative household chooses state-contingent decision rules for consumption c_t and bond holdings b_t to maximize expected lifetime discounted utility

$$E_0\sum_{t=0}^{\infty}\beta^t u(c_t) \tag{11}$$

subject to a sequence of flow budget constraints

$$c_t + b_t = (1 - \tau^n) W_t + [1 - n_t + n_t F(\tilde{z}_t)] \chi + R_t b_{t-1} + d_t. \tag{12}$$

The subjective discount factor is β, and the function $u(\cdot)$ is a standard strictly-increasing and strictly-concave utility function over consumption. There is no labor force participation decision in this problem. Since the reallocation and firing decision are only made by the firm, the workers have no control over their employment status and take as given the reallocation and firing thresholds, $\tilde{\tilde{z}}_t$ and $\tilde{z}_t$.

The total pre-tax wage income is W_t, defined as in equation (6), and $(1 - \tau^n) W_t$ corresponds to the after-tax wage income. The household also takes the wage-setting protocol as given. Unemployed individuals receive unemployment benefits, denoted as χ, that are time-invariant.[14] Due to firms' sunk resource and time costs of finding employees, firms earn positive flows of economic profits. These profits are transferred to the household at the end of each period in a lump-sum fashion: d_t is the household's receipt of firms' flow profits. Finally, the household's holdings of a state-contingent one-period real government bond at the end of period $t-1$ are b_{t-1}, each of which has gross state-contingent payoff R_t at the beginning of period t.

The optimality condition arising from household optimization is the standard consumption-savings condition:

$$u'(c_t) = E_t \left\{ \beta u'(c_{t+1}) R_{t+1} \right\}. \tag{13}$$

As usual, this condition defines the one-period-ahead stochastic discount factor, $\Xi_{t+1|t} = \beta u'(c_{t+1}) / u'(c_t)$, with which firms, in equilibrium, discount profit flows.

4.1.4 Wage Bargaining

The baseline wage-determination mechanism is Nash bargaining. Specifically, wages are set in period-by-period Nash negotiations, where the threat point of worker and firm is the termination of the match. Negotiations take place after the employment status is determined, i.e. after the reallocation and firing decisions are made. Full-time and part-time workers negotiate different wages.

[14] This is a simplifying assumption. Recent literature has shown that the opportunity cost of employment, which includes not only unemployment benefits but also the value of non-working time, might be procyclical (Chodorow-Reich and Karabarbounis, 2016).

In Section 3 I present evidence that part-time wages are more flexible than full-time wages. In order to capture this with the model, I assume that full-time wages are sticky by introducing a partially smoothed wage of the following form:

$$w_t^F = \omega w_t^{F,NB} + (1-\omega)\, w_{ss}^{F,NB}, \tag{14}$$

where $w_t^{F,NB}$ is the full-time Nash-bargaining wage negotiated in period-t, $w_{ss}^{F,NB}$ is the full-time Nash-bargaining wage in the deterministic steady state, and $\omega \in (0,1)$ measures the degree of stickiness. The smaller is ω, the stickier are full-time wages.

Part-time workers are just paid the Nash-bargaining wage negotiated in period-t, i.e.

$$w_t^P = w_t^{P,NB}. \tag{15}$$

The derivation of the Nash bargaining wages is presented in Appendix D. In what follows I just present the bargaining outcomes. Assuming that $\eta^F \in (0,1)$ is a full-time worker's bargaining power and $\eta^P \in (0,1)$ a part-time worker's bargaining power, the outcome of the negotiations for full-time and part-time wages is given by

$$\begin{aligned} w_t^{F,NB} = \eta^F \Bigg[& \alpha \frac{Y_t}{n_t} \left(\frac{Y_t^F}{Y_t}\right)^{\varepsilon} \frac{z_t}{\displaystyle\int_{\tilde{z}_t}^{\infty} z f(z) dz} - \zeta + \left(1-\rho^F\right)\theta_t g'(v_t) - \\ & - \left(1-\rho^F\right)\left(1-\theta_t q_t\right) E_t \left\{\Xi_{t+1|t} \phi F\left(\tilde{z}_{t+1}\right)\right\} \Bigg] + \left(1-\eta^F\right) \frac{\chi}{1-\tau^n}, \end{aligned} \tag{16}$$

and

$$\begin{aligned} w_t^{P,NB} = & \frac{\eta^P}{\bar{h}} \Bigg[(1-\alpha) \frac{Y_t}{n_t} \left(\frac{Y_t^P}{Y_t}\right)^{\varepsilon} \frac{z_t}{\displaystyle\int_{\tilde{z}_t}^{\tilde{\tilde{z}}_t} z f(z) dz} + \\ & + \left(1-\rho^P\right)\theta_t g'(v_t) - \left(1-\rho^P\right)\left(1-\theta_t q_t\right) E_t \left\{\Xi_{t+1|t} \phi F\left(\tilde{z}_{t+1}\right)\right\} \Bigg] + \frac{1-\eta^P}{\bar{h}} \frac{\chi}{1-\tau^n}. \end{aligned} \tag{17}$$

The negotiated wages in equations (16) and (17) depend on both aggregate and idiosyncratic conditions. They are increasing in labor market tightness, as well as on aggregate and idiosyncratic productivity. It should be noted that a fraction of the fringe benefits is passed onto the full-time workers through lower wages. The same holds for the firing costs, which are passed into the wages of both part-timers and full-timers given the possibility that in the future worker with whom the wage is negotiated might have a low realization of her idiosyncratic productive and might be fired.

4.1.5 Government

Unemployment benefits are provided by the government. The government runs a balanced budget and finances the unemployment insurance system by collecting labor income taxes and issuing real state-contingent debt. The period-t government budget constraint is thus

$$[1 - n_t + n_t F(\tilde{z}_t)]\,\chi + R_t b_{t-1} = \tau^n W_t + b_t, \tag{18}$$

where W_t is defined as in equation (6).

4.1.6 Equilibrium

The equilibrium in this economy is made up of endogenous processes $\{c_t, v_t, n_{t+1}, \tilde{z}_t, \tilde{\tilde{z}}_t, w_t^F, w_t^P, R_t, b_t\}_{t=0}^{\infty}$ that, given the stochastic processes $\{z_t, A_t\}_{t=0}^{\infty}$ and the initial stock of workers n_0, satisfy:

1. The household's consumption-saving optimality condition (13).

2. The firm's optimality conditions (8), (9) and (10).

3. The wage equations (16) and (17).

4. The law of motion for the aggregate stock of employment (2).

5. The government budget constraint (18).

6. The aggregate resource constraint of the economy:

$$c_t + g(v_t) + \Phi\left(n_t, \tilde{z}_t, \tilde{\tilde{z}}_t\right) + \zeta n_t\left[1 - F\left(\tilde{\tilde{z}}_t\right)\right] = Y_t \tag{19}$$

   where Y_t is defined as in (3).[15]

4.1.7 Nesting the Standard Search and Matching Model

The framework considered so far nests the standard search and matching labor market model. In this section I am going to show under what conditions this is true.

[15] Total costs of posting vacancies $g(v_t)$ and of firing workers, as well as the total fringe benefits paid by the firm, are all resource costs for the economy.

First of all, moving to the standard model requires discarding part-time employment, which occurs as long as $\tilde{\tilde{z}}_t = \tilde{z}_t = \hat{z}_t$. When the firing and reallocation thresholds are the same, total output is just given by

$$Y_t = \alpha^{1/\varepsilon} A_t n_t \int_{\hat{z}_t}^{\infty} z f(z) dz, \tag{20}$$

which implies that the contribution of the marginal worker to output is $\alpha^{1/\varepsilon} A_t z_t$.

The two critical thresholds for reallocation and firing defined by equations (9) and (10) are the same as long as the following condition holds:

$$\alpha^{1/\varepsilon} A_t \hat{z}_t - w_t^F(\hat{z}_t) - \zeta + \left(1-\rho^F\right) \frac{g'(v_t)}{q_t} = -\phi.$$

Given the full-time wage in equation (14), and assuming complete flexibility (i.e. $\omega = 1$), this expression defines the reallocation threshold under which $\tilde{\tilde{z}}_t$ equals $\tilde{z}_t$

$$\begin{aligned} \hat{z}_t =& \frac{1}{\left(1-\eta^F\right)\alpha^{1/\varepsilon} A_t}\Bigg[\left(1-\eta^F\right)\zeta - \phi + \left(1-\eta^F\right)\frac{\chi}{1-\tau^n} - \\ & - \left(1-\rho^F\right)\left(\frac{g'(v_t)}{q_t} - \eta^F g'(v_t)\theta_t - \eta^F\left(1-\theta_t q_t\right) E_t\left\{\Xi_{t+1|t}\phi F\left(\tilde{z}_{t+1}\right)\right\}\right)\Bigg]. \end{aligned} \tag{21}$$

In addition, for $\alpha = 1$, $\zeta = 0$, $\phi = 0$ and $\tau^n = 0$, the critical threshold becomes

$$\hat{z}_t = \frac{1}{A_t}\left[\chi - \frac{1-\rho^F}{1-\eta^F}\left(\frac{g'(v_t)}{q_t} - \eta^F g'(v_t)\theta_t\right)\right], \tag{22}$$

which is the condition for endogenous separation of the standard search and matching model. Notice that, under this parameterization, equation (8) also becomes the standard job creation condition.

5 Wage Stickiness and the Reallocation Decision

To illustrate some properties of the model consider the case of perfect substitutability between full-time and part-time employment, i.e. $\varepsilon = 1$. The reallocation and firing conditions (9) and (10), combined with the wage equations in (14) and (15), give simplified expressions for the firing and reallocation cutoffs:

$$\tilde{z}_t = \frac{1}{\left(1-\eta^P\right)(1-\alpha)A_t}\Bigg[-\left(1-\rho^P\right)g'(v_t)\left(\frac{1}{q_t}-\eta^P\theta_t\right)- \\ -\phi\Bigg(1+\eta^P\left(1-\rho^P\right)\left(1-\theta_t q_t\right)E_t\left\{\Xi_{t+1|t}F\left(\tilde{z}_{t+1}\right)\right\}\Bigg)+\left(1-\eta^P\right)\frac{\chi}{1-\tau^n}\Bigg] \tag{23}$$

and

$$\tilde{\tilde{z}}_t = \frac{1}{\left[\left(1-\omega\eta^F\right)\alpha-\left(1-\eta^P\right)(1-\alpha)\right]A_t-(1-\omega)\eta^F\alpha}\Bigg[\left(1-\eta^F\right)\zeta-\left(\eta^F-\eta^P\right)\frac{\chi}{1-\tau^n}- \\ -\left(1-\rho^F\right)\left[\frac{g'(v_t)}{q_t}-\omega\eta^F g'(v_t)\theta_t-(1-\omega)\eta^F g'\left(v_{ss}\right)\theta_{ss}\right]+\left(1-\rho^P\right)\left[\frac{g'(v_t)}{q_t}-\eta^P g'(v_t)\theta_t\right]- \\ -\eta^F\left(1-\rho^F\right)\left[\omega\left(1-\theta_t q_t\right)E_t\left\{\Xi_{t+1|t}\phi F\left(\tilde{z}_{t+1}\right)\right\}+(1-\omega)\left(1-\theta_{ss}q_{ss}\right)\beta\phi F\left(\tilde{z}_{ss}\right)\right]+ \\ +\eta^P\left(1-\rho^P\right)\left(1-\theta_t q_t\right)E_t\left\{\Xi_{t+1|t}\phi F\left(\tilde{z}_{t+1}\right)\right\}\Bigg]. \tag{24}$$

As expected, the firing threshold is inversely related to aggregate productivity: less productive matches survive when production is more profitable due to higher aggregate productivity. The effect of market tightness is ambiguous, as it depends on the relative magnitude of two effects. On the one hand, a higher θ_t increases the wage, making marginal jobs less productive. On the other hand, a tighter labor market increases hiring costs, creating incentives to preserve matches in order to avoid rehiring. If η^P, the parameter ruling the bargaining power of a part-time worker, is small then the effect of θ on the firing threshold is more likely to be negative.[16] Higher unemployment benefits, which lead to a higher wage, require a higher idiosyncratic productivity for the match to survive, thus increasing the threshold. Finally, higher firing costs reduce the threshold via two mechanisms: first, higher firing costs are partially paid by the worker through lower wages, thus requiring a lower idiosyncratic productivity to make the match as profitable as without firing costs; second, higher firing costs lower the gains of firing a worker, which implies that the idiosyncratic productivity required for the match to survive is not as high.

Regarding the reallocation threshold, it also depends inversely on aggregate productivity as long as $\alpha > {}^{\left(1-\rho^P\right)}/_{\left(2-\omega\eta^F-\eta^P\right)}$. The parameter α rules the effect of A_t on the marginal productivity of full-time and part-time workers. For high values of α, full-time matches become relatively more profitable than part-time matches when A_t increases, thus lowering the threshold. Higher fringe

[16] The strategy of introducing wage stickiness through the bargaining power parameter was suggested by Hagedorn and Manovskii (2008).

benefits, i.e. higher ζ, make full-time positions less profitable for the firm relative to part-time positions, thus inducing more reallocation. Since $\rho^P > \rho^F$, the effects of market tightness on the reallocation threshold are equivalent to those described for the firing threshold.

To analyze the role of wage stickiness in shaping the reallocation decision, I am going to simplify equation (24) by setting firing costs to zero, $\phi = 0$, and by assuming that vacancy posting costs are linear, $g'(v_t) = \gamma_v$. In addition, I am going to assume that the bargaining power and the exogenous separation rate of part-time workers are the same as those of full-time workers ($\eta^P = \eta^F = \eta$ and $\rho^P = \rho^F = \rho$). Under these assumptions, the reallocation threshold in equation (24) can be rewritten as

$$\tilde{\tilde{z}}_t = \frac{(1-\eta)\,\zeta - (1-\rho)\,(1-\omega)\,\gamma_v\,(\theta_t - \theta_{ss})}{B}, \tag{25}$$

where $B = [(1-\omega\eta)\,\alpha - (1-\eta)\,(1-\alpha)]\,A_t - (1-\omega)\,\eta\alpha$.

Around the deterministic steady state, the elasticity of the reallocation cutoff with respect to aggregate productivity is

$$\eta_{\tilde{\tilde{z}},A} = \frac{\partial ln\left(\tilde{\tilde{z}}\right)}{\partial ln\,(A)} = -A\left[\frac{\partial B}{\partial A} + \frac{(1-\rho)\,(1-\omega)\,\gamma_v}{(1-\eta)\,\zeta}\frac{\partial \theta}{\partial A}\right]. \tag{26}$$

For reasonable parameterizations, $B > 0$ and $\partial B/\partial A > 0$.[17] In addition, the business cycle statistics reported in section 3 show that $\partial\theta/\partial A > 0$. This implies that $\eta_{\tilde{\tilde{z}},A} < 0$.

To evaluate whether the reallocation cutoff is more responsive to changes in aggregate productivity depending on the degree of stickiness of full-time wages, I compute the derivative of the absolute value of the elasticity in (26) with respect to ω:

$$\frac{\partial|\eta_{\tilde{\tilde{z}},A}|}{\partial\omega} = A\left[-\eta\alpha + \frac{(1-\rho)\,(1-\omega)\,\gamma_v}{(1-\eta)\,\zeta}\frac{\partial\theta}{\partial A\partial\omega}\right]. \tag{27}$$

In the literature on wage stickiness in search an matching models with Nash bargaining that emerged following Shimer (2005), sticky wages are introduced in the model in order to prevent wages to absorb al changes in aggregate productivity, thus leading to stronger responses of the labor market tightness and of the other labor market variables, particularly unemployment. Based on this, I would expect that $\partial\theta/\partial A\partial\omega < 0$. This means that the response of market tightness to changes in aggregate productivity are stronger for smaller values of omega, i.e. for stickier full-time

[17] On the one hand, $B > 0$ as long as $\alpha > 1/2$. On the other hand, if $\omega = 1$, the conditions $\partial B/\partial A > 0$ is also equivalent to $\alpha > 1/2$; this lower bound for α is even smaller if $\omega < 1$. In my quantitative exercise, α is calibrated to be 0.75 and, given the values of the rest of the parameters of the model, both conditions are satisfied.

wages. If this is the case, then $\partial|\eta_{\tilde{z},A}|/\partial\omega$ is unambiguously negative. In other words, the magnitude of the elasticity of the reallocation cutoff with respect to aggregate productivity is larger when full-time wages are more sticky. This implies that, when full-time wages are stickier, a higher reallocation towards part-time would take place than in the case of complete flexibility of wages.

This result is indicative of the relevance of wage stickiness in shaping the reallocation decision. However, in my model there are other elements in place – e.g. structural differences between full-timers and part-timers – that might be affecting the benefits and costs of reallocating workers within the firm when facing a negative shock. This will be taken into account in the quantitative exercise presented in the next section.

6 Quantitative Results

The deterministic steady-state equilibrium is computed using a nonlinear numerical solution. To study dynamics, I compute a first-order log-linear approximation of the equilibrium conditions around the deterministic steady-state. Using the first-order decision rules, I simulate the economy in the face of an aggregate productivity shock, which is drawn according to the parameters described below. I conduct 1000 simulations, each 200 periods long. For each simulation, I compute first and second moments and report the medians of these moments across the simulations.

6.1 Calibration

For this exercise I assume quadratic vacancy-posting costs of the following form:

$$g(v_t) = \gamma_v \left(v_t + \frac{1}{2} v_t^2 \right).$$

Regarding preferences, I assume a standard functional form:

$$u(c_t) = ln\, c_t.$$

Table 5 lists the baseline parameter settings.

The model is quarterly, so I set a subjective discount factor $\beta = 0.99$, which implies a steady-state real interest rate of about four percent. The intertemporal elasticity of substitution is 1 in line with the literature.

Regarding the production function, in the baseline scenario I assume partial substitutability of full-time and part-time workers and set $\varepsilon = 0.75$. This assumption is relaxed later to capture the effect of different degrees of substitutability on involuntary part-time; the results of these experiments are reported in Section 6.2.3. Hours worked by part-timers, $\bar{h}$, are computed as the ratio between 25 and 42, which are the average hours worked by part-time and full-time workers, respectively, in the CPS.

Shifting attention to the labor market, the matching function is assumed to be Cobb-Douglas, $m(v_t, u_t) = \mu s_t^{\xi} v_t^{1-\xi}$, with $\xi = 0.4$, as typically assumed in the literature.

The exogenous separation rate for part-time workers, ρ^P, is not directly observed in the data. An analysis of the flows form CPS indicates that part-time workers are almost six times more likely to separate from their jobs than their full-time counterparts.[18] But it is not possible to disentangle what is the share of exogenous separations of each group in total exogenous separations. Due to this lack of direct evidence, I just assume that $\rho^P = 1.2 \times \rho^F$, and then analyze the sensibility of the results to this assumption.

I set the part-timers' bargaining power, η^P, at an intermediate value of 0.5, and then choose the full-timers' bargaining power so that the average compensation – including wages and benefits – of part-timers is 60 percent of the average compensation of full-timers[19]; the resulting value is $\eta^F = 0.75$. The fringe benefits paid to full-time workers, set at $\zeta = 0.1507$, are calibrated to be 20 percent of full-time wages, in line with the Employer Costs for Employee Compensation statistics reported by the BLS.[20] Similarly, the unemployment benefits are chosen to be $\chi = 4$ in order to match a replacement rate of 40 percent, which is consistent with the average replacement rate for the period 1997-2016 published in the UI Replacement Rate Reports made available by the Employment and Training Administration within the US Department of Labor.

The labor income tax rate is calibrated based on the empirical measure developed by Arseneau and Chugh (2012). According to their calculations, the mean labor income tax rate over the period 1947Q1-2009Q4 is about 20 percent. Therefore, τ^n is set at 0.20.

The parameters α, ρ^F, μ, γ_v, and ϕ are chosen so as to match five steady state targets. First,

[18] The average transition rates from part-time and full-time employment to unemployment in the period 1994-2014 were 6.6. percent and 1.2 percent, respectively. However, it could be the case that most of the separations of part-timers captured in the CPS flows are due to endogenous separations rather than exogenous quits, and thus the numbers reported previously might be overestimating the exogenous separations of involuntary part-timers.

[19] The Employer Costs for Employee Compensation statistics reported by the BLS show that the ratio of part-time over full-time compensation averaged 50 percent during the period 2004-2016. However, this statistics correspond to total part-timers, both voluntary and involuntary, and not only to involuntary part-timers, which is what I am capturing with my model. Nevertheless, these number is indicative of the magnitude.

[20] The average ratio of health insurance and other legally required benefits over full-time wages during the period 2004Q1-2016Q2 is 23.52 percent.

the quarterly total job-separation rate in steady state is set at 0.1, a standard value in search and matching models and in line with the evidence in Davis et al. (2006). Second, based on Ramey et al. (2000), the quarterly exogenous separation rate is assumed to be 0.068. Third, the steady state part-time ratio is set at 4 percent to match the pre-recessionary average observed in the BLS data. Fourth, the steady state quarterly job filling rate is targeted at 70 percent as in Ramey et al. (2000). Finally, the steady state unemployment rate is set to 6 percent, in line the pre-recessionary historical unemployment rate reported by BLS.

The degree of wage stickiness is chosen to be $\omega = 0.54$ in order to match the volatility of average wages observed in the data and reported in Section 3.

I assume that idiosyncratic productivity z_t is $i.i.d$ is distributed log-logistic with location parameter $\alpha_z = 1$. The shape parameter, β_z is set so as to match the correlation between involuntary part-time employment and output observed in the data; the resulting value is approximately 2. This delivers a distribution that features a hump shape and is skewed towards zero. Under this parameterization, high idiosyncratic productivity realizations are relatively less likely. This can be considered an appropriate representation of industries that resort more intensively to part-time work, in which unskilled workers are relatively more abundant.

The only shock in this economy is an aggregate (log) TFP shock. Aggregate productivity is assumed to follow an AR(1) process with a persistence parameter of 0.95 and standard deviation of 0.0048, as standard in RBC models.

6.2 Results

6.2.1 Business Cycle Statistics

Table 6 present simulation results for the model under the baseline calibration. The results indicate that the model is able to deliver the high volatility and strong countercyclicality of involuntary part-time employment found in the data. It also correctly captures the much less volatile and procyclical dynamics of full-time employment. As a result, it does a good job in characterizing the dynamics of the involuntary part-time ratio.

To assess the ability of the model to account for the business cycle comovements observed in the data and not targeted in the calibration, I compute the covariogram for output, unemployment and involuntary part-time. While for the calibration I use data for the period 1994-2016, for

Table 5: Baseline Calibration

Structural Parameters	Value	Source / Target
Subjective Discount Factor	$\beta = 0.99$	
Intertemporal Elasticity of Substitution	$\sigma = 1$	
Elasticity of Matches wrt Searchers	$\xi = 0.4$	
Bargaining Power PT	$\eta^P = 0.5$	
Substitutability FT-IPT	$\varepsilon = 0.75$	
Idiosyncratic Productivity (Location)	$\alpha_z = 1$	
TFP Process	$\rho_A = 0.95$	
	$\sigma_A^2 = 0.0048$	
Hours PT	$\bar{h} = 25/42$	CPS
PT Exogenous Separation	$\frac{\rho^P}{\rho^F} = 1.2$	CPS flows: $\rho^P > \rho^F$
Bargaining Power FT	$\eta^F = 0.75$	$\frac{\bar{w}^P}{(\bar{w}^F+\zeta)} = 0.6$
Unemployment Benefit	$\chi = 4$	Replacement ratio = 0.42
Health Insurance Cost	$\zeta = 0.1507$	BLS/ECEC: Benefits = 20% FT Wage
FT Exogenous Separation	$\rho^F = 0.0697$	IPT ratio = 0.04
Matching Efficiency	$\mu = 0.7274$	Job filling rate = 0.7
Share FT Production	$\alpha = 0.6408$	Total job destruction rate = 0.1
Firing Cost	$\phi = 0.1135$	Exogenous job destruction rate = 0.068
Vacancy Posting Cost	$\gamma_v = 0.0606$	Unemployment rate = 0.06
Degree of Wage Stickiness	$\omega = 0.54$	Volatility of Average Wages
Idiosyncratic Productivity (Shape)	$\beta_z = 2$	Correlation of IPT and Output

Table 6: Business Cycle Statistics

	IPT	FT	PT Ratio	Unempl.	U6	Avg. Wage
			Data			
Std. Dev.	0.102	0.014	0.115	0.113	0.102	0.007
Relative Std. Dev.	9.204	0.922	9.241	10.168	9.241	0.412
Autocorrelation	0.869	0.922	0.884	0.939	0.939	0.843
Correlation w/ Output	-0.890	0.837	-0.898	-0.918	-0.919	0.080
			Model			
Std. Dev.	0.080	0.012	0.091	0.062	0.063	0.005
Relative Std. Dev.	6.680	1.004	7.589	5.198	5.318	0.403
Autocorrelation	0.704	0.883	0.738	0.888	0.882	0.740
Correlation w/ Output	-0.899	0.999	-0.924	-0.985	-0.999	0.925

Notes: Author's own calculations based on data from BLS for the period 1994Q1-2016Q2. Model results are obtained from simulating the model with a stochastic TFP shock. All variables are reported in logs as deviations from an HP trend with smoothing parameter 1600.

this exercise I consider longer series, starting in 1955.[21] The red solid lines in Figure 2 represent the auto-covariances among these variables predicted by the model, and the black ones are those obtained from the data. The dotted lines correspond to 95 percent confidence intervals for the data moments. The confidence bands are obtained by bootstrapping from an unrestricted VAR(4) estimated on the filtered data. Taking into account that most of these moments were not targeted in the calibration, except for the contemporaneous correlation between involuntary part-time employment and output, the model is successful in capturing the business cycle comovements between these variables.

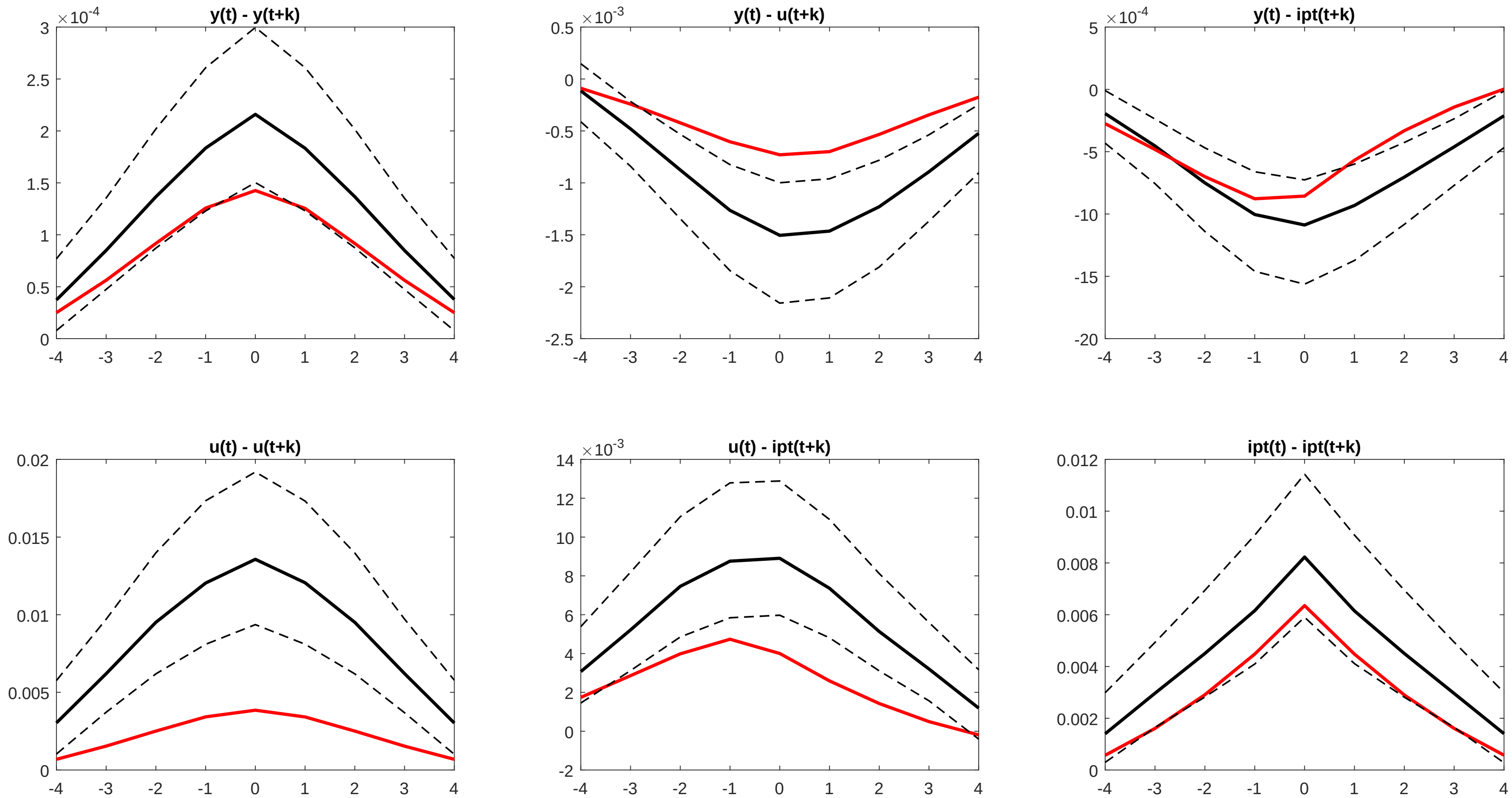
The dimensions in which the model falls short is in matching the volatility of unemployment, which is not surprising taking into account that this is a limitation of all search and matching models, as well as the comovement between average wages and output, which is much higher than the one observed in the data.

6.2.2 Impulse Response Analysis

Figure 3 displays the impulse response functions to a 1 S.D. negative shock to aggregate productivity.

[21] See Section 8 for a description on how consistent long series are constructed, accounting for methodological breaks in the data.

Figure 2: Business Cycle Comovements in the Data and in the Model



Notes: The red solid lines represent the auto-covariances among output, unemployment and involuntary part-time employment predicted by the model, and the black ones are those obtained from the data. The dotted lines correspond to 95 percent confidence intervals for the data moments, which are obtained by bootstrapping from an unrestricted VAR(4) estimated on the filtered data.

As detailed in Section 5, both the firing and reallocation cutoffs are inversely related to aggregate productivity. Less productive matches are destroyed when production is less profitable due to worse aggregate conditions, leading to an increase in the firing threshold. Given the parameterization of α, which rules the effect of A_t on the marginal productivity of full-time and part-time workers, part-time matches become relatively more profitable than full-time matches when A_t falls, thus rising the reallocation threshold.

Both endogenous cutoffs rise following the shock, but the change in the reallocation cutoff is larger than the one of the firing cutoff, leading to a increase in involuntary part-time employment and a reduction in full-time employment. As a result, the involuntary part-time ratio rises. The higher responsiveness of the reallocation cutoff to aggregate productivity is driven by two factors. First, the higher rigidity of full-time wages relative to part-time wages contributes to a higher sensitivity of the reallocation threshold to changes in aggregate conditions since part-time workers become cheaper in recessions relative to normal times. Second, the shape of the distribution that is skewed towards the origin, which makes high productive matches relatively scarce. Given this shape, both thresholds are in a region of the distribution in which the probability density is declining, which implies that the reallocation threshold must move more aggressively to adjust the desired mass of workers.

The negative shock leads to a decline in output, which is driven by a fall in full-time output, since part-time output increase relative to the steady state because of the increase in part-time employment.

Higher endogenous separations due to the increase in the firing cutoff, combined with the exogenous separations that also increase because there are more part-time workers who separate exogenously at a higher rate, lead to a fall in employment and a rise in unemployment. Underemployment, which in the model is measured by the sum of unemployment and involuntary part-time employment, also increases on impact.

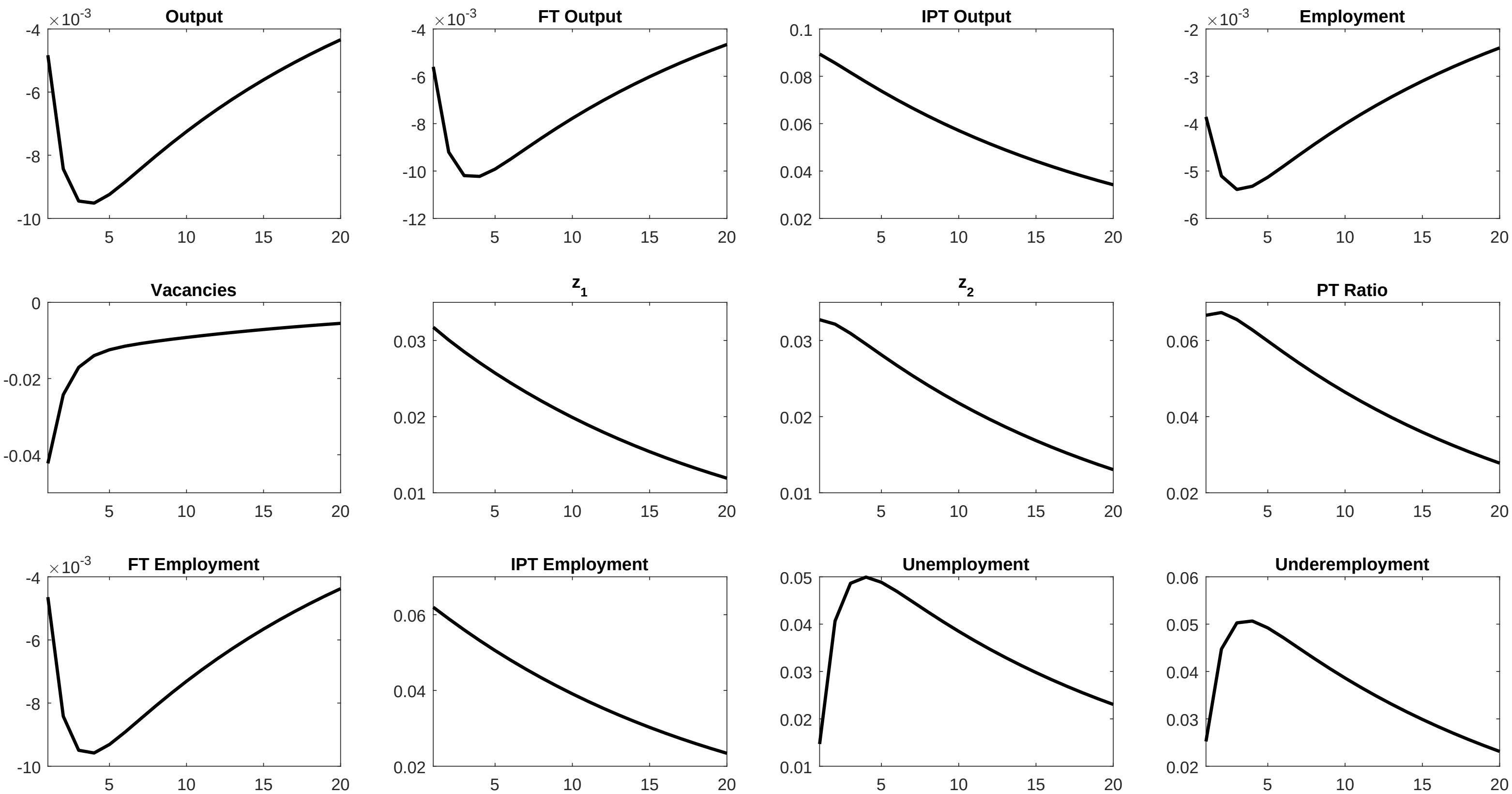
All variables display a high degree of persistence due to the persistence of the shock.

6.2.3 Sensitivity Analysis

In this section I analyze the sensitivity of my results to changes in key parameters.

First I consider different degrees of full-time wage stickiness, captured by the parameter ω. Figure 4 shows the impulse responses for the baseline scenario, as well as for higher and lower degrees of stickiness. The results show that for stickier full-time wages, the responses are amplified,

Figure 3: Impulse Response Functions to a 1 S.D. Negative Aggregate Productivity Shock



Notes: All figures represent log deviations from the steady state.

while the opposite is true when full-time wages are more flexible. These results are in line with the literature that has emerged since Shimer (2005) that has incorporated wage stickiness to search and matching models of the labor market as a way to deliver higher volatility of labor market variables.

In the baseline scenario I assumed that the exogenous separation rate of part-time workers is 20 percent higher than the one of full-time workers. In this section I analyze the impact of relaxing this assumption. I consider exogenous separations rates of part-time workers that are higher and lower than in the baseline. As shown in Figure 5, the results do not change substantially. Differences in exogenous separation rates between part-timers and full-timers do not seems to matter for the cyclicality of part-time employment. A possible reason for this is the fact that in my model idiosyncratic productivity is *iid*, which implies that the long-lasting relationship with the worker is less valuable because in the following period she may have a low realization of her idiosyncratic productivity and be fired.

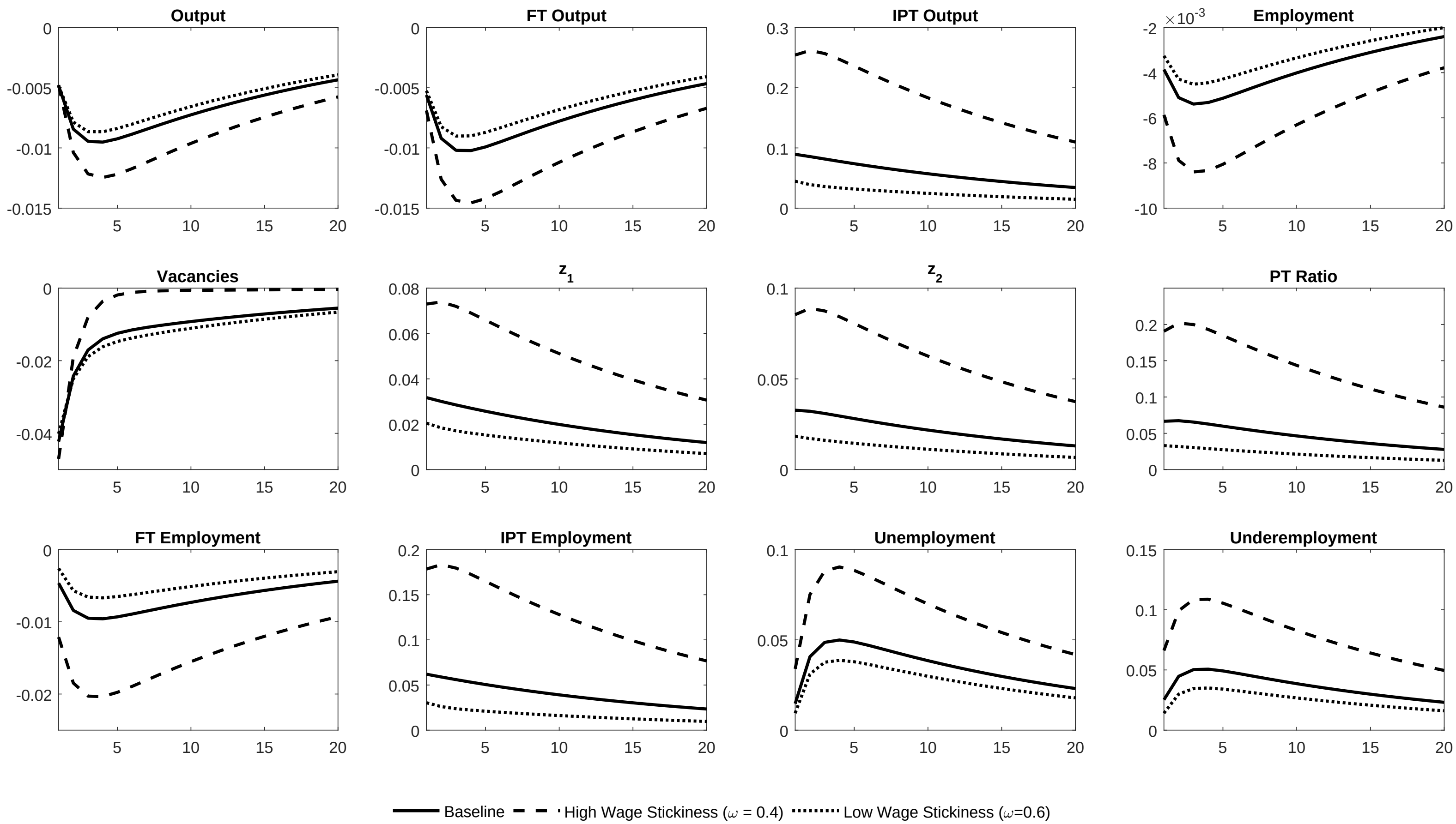
7 Policy Analysis: Provision of Health Insurance

The provision of health insurance in the model is captured by the parameter ζ, which corresponds to the overall package of fringe benefits offered by the firm to each worker, including health insurance. I consider the effects of the adoption of new regulation that increases ζ and analyze its impact on the economy's steady state. My model predicts that higher fringe benefits are associated with higher levels of involuntary part-time ratio. More specifically, if ζ increases so that the share of fringe benefits in average full-time wages goes up by 1 percentage point, then the involuntary part-time ratio goes up from by 16 percent, from 4 percent to 4.65 percent.

The above results are computed using the baseline parameterization. In what follows I make additional assumptions regarding certain parameters in order to derive analytical expressions that will give further insights on the effects of changes in ζ. In particular, I assume full-substitutability ($\varepsilon = 1$), no firing costs ($\phi = 0$), and linear vacancy-posting costs ($g'(v_t) = \gamma_v$). In addition, the bargaining power and the exogenous separation rate of part-time workers are set to be the same as those of full-time workers ($\eta^P = \eta^F = \eta$ and $\rho^P = \rho^F = \rho$). Under these assumptions, the steady state thresholds from equations (23) and (24) can be written as

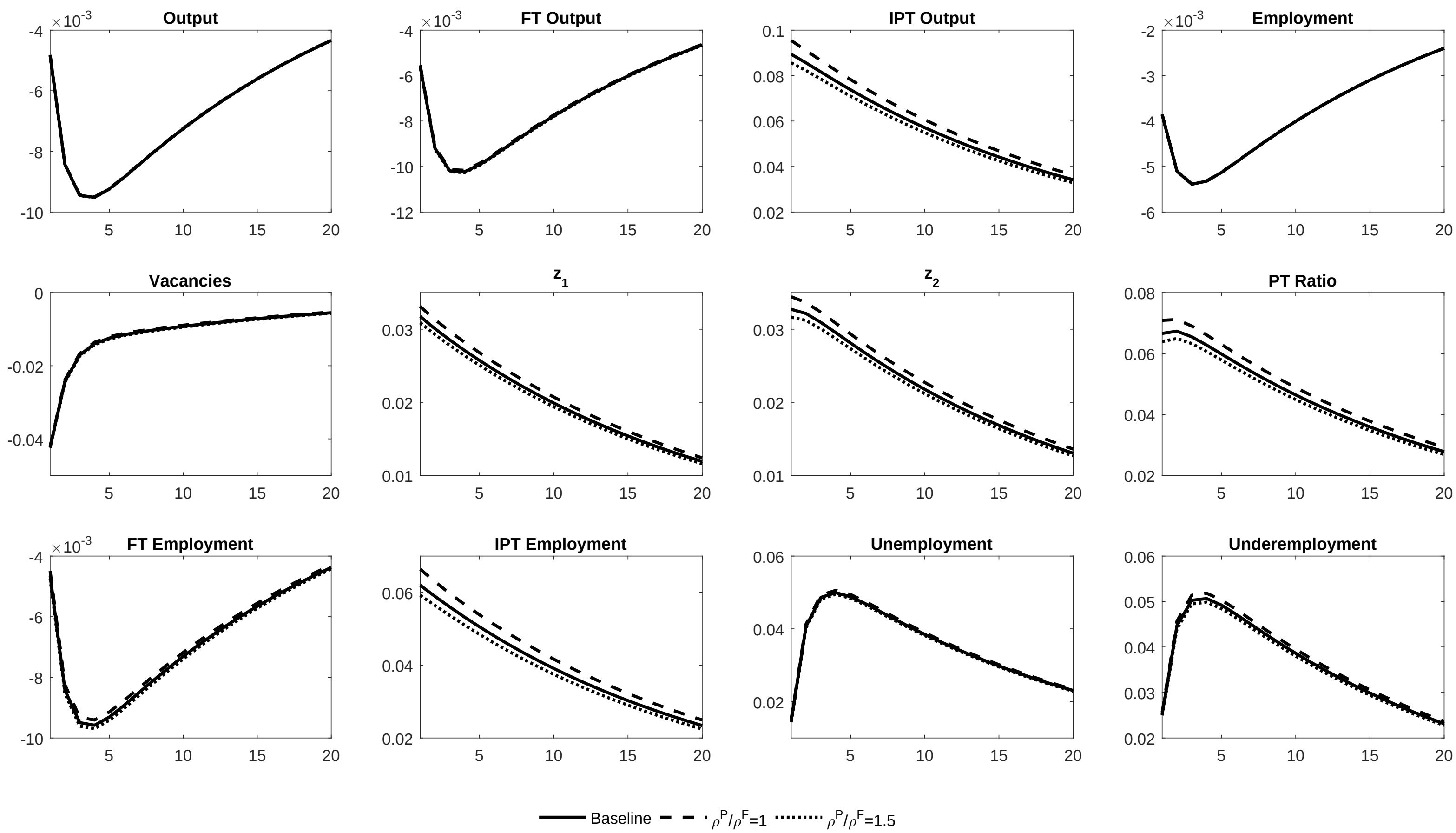
$$\tilde{z} = \frac{1}{(1-\eta)(1-\alpha)}\left[-(1-\rho)\gamma_v\left(\frac{1}{q} - \eta\theta\right) + (1-\eta)\frac{\chi}{1-\tau^n}\right] \tag{28}$$

Figure 4: Impulse Response Functions to a 1 S.D. Negative TFP Shock, for different degrees of wage stickiness



Notes: All figures represent log deviations from the steady state.

Figure 5: Impulse Response Functions to a 1 S.D. Negative TFP Shock, for different exogenous separation rates of part-timers



Notes: All figures represent log deviations from the steady state.

and

$$\tilde{\tilde{z}} = \frac{(1-\eta)}{(1-\eta)(2\alpha-1)}\zeta. \tag{29}$$

The elasticities of the firing and reallocation cutoffs with respect to the fringe benefits are

$$\eta_{\tilde{z},\zeta} = \frac{1}{\tilde{z}} \frac{\left(1-\rho^P\right)\gamma_v}{(1-\eta)\,(1-\alpha)} \left(\frac{1}{q}\eta_{q,\zeta} + \eta\theta\eta_{\theta,\zeta}\right) \tag{30}$$

and

$$\eta_{\tilde{\tilde{z}},\zeta} = 1, \tag{31}$$

where $\eta_{\tilde{z},\zeta}$, $\eta_{\tilde{\tilde{z}},\zeta}$, $\eta_{q,\zeta}$ and $\eta_{\theta,\zeta}$ are the elasticities of the firing and reallocation cutoffs, of the job filling rate, and of the market tightness with respect to ζ.

Besides the expected direct effect of higher fringe benefits on the reallocation cutoff, the above expressions also show that fringe benefits may also affect the firing cutoff through their impact on market tightness. Higher fringe benefits are likely to reduce market tightness because it reduces the incentives of firms to post vacancies. This implies that the elasticity in equation (30) is negative: the expansion of healthcare coverage leads to a reduction in the firing cutoff. The opposite happens with the reallocation cutoff, which increases because each full-time match becomes less profitable. As a consequence, the involuntary part-time ratio increases.

The changes in ζ considered in this section aim to capture, in a very stylized way, the adoption of regulation such as the Employer Shared Responsibility provisions that are part of the Affordable Care Act (ACA). These provisions, which went into effect at the beginning of 2015, require firms with 50 or more employees to provide affordable health insurance to their full-time workers, or otherwise be subject to penalties that are based both on the number of full-time workers and on the number of months in which an affordable coverage was not offered.[22,23] One of the concerns around the new regulation has been that it would give incentives to firms to reduce their employee's hours below the 30-hour threshold to avoid the costs associated with offering them health insurance. In fact, in a survey carried out in 2014 by ADP Research Institute[24], 38 percent of the respondents indicated that they would adjust employee hours in response to the Employer Shared Responsibility provisions and, among them, 51 percent were considering the possibility of reducing hours.

[22] In the context of this law, full-time workers are defined as those who work more than 30 hours per week.

[23] If the firm offers a health insurance plan that is not affordable, it will be subject to penalties determined based on the number of full-time workers who receive a federal subsidy for the purchase of a policy on a health insurance exchange.

[24] ADP Research Institute, "Measuring the Impact of the Affordable Care Act", 2015.

Given the short period of time since the new regulation has been in place, and that its implementation coincides with a period of economic recovery after a major crisis, empirical evidence on the effects of ACA on part-time employment is inconclusive.[25] The results presented in this section shed some light on the effects that such regulation might have on involuntary part-time employment. If all firms in the economy were as the representative firm in my model, in the data we would see an increase in involuntary part-time employment as a consequence of ACA. However, these results should be taken with a grain of salt. In the US economy, 96 percent of firms have less than 50 workers and thus are not affected by the regulation. Therefore, not all firms may have incentives to adjust their workforce and thus the increase in part-time employment might be more modest than my model would predict. An heterogeneous agent model would be needed to provide more accurate predictions on the effects of this type of regulation. In addition, in my model I am not taking into account the effects that ACA may have on labor supply decisions, which might be sizeable according to estimates of Mulligan (2014).

8 "Big Shocks" or Structural Changes?

For the exercise in this section I am going to consider a longer period, starting in 1955, which is the first year for which series of involuntary part-time employment are available. This implies constructing consistent series that take into account the methodological breaks in the data introduced by the CPS redesign of 1994. Prior to this redesign, the survey did not ask part-time workers whether they wanted to or were available to work full-time; in addition, respondents were not asked about usual hours worked, only about actual hours worked. This resulted in an overestimation of the magnitude of involuntary part-time employment as a share of total employment of approximately 20 percent (Polivka and Miller, 1994).

One approach to correct the involuntary part-time employment statistics prior to 1994 is using the multiplicative adjustment factors computed by Polivka and Miller (1994), which control for parallel survey effects.[26] After re-constructing the long series of involuntary part-time employment, I compute its business cycle statistics for the period 1955-2016, as well as for two subsamples, 1955-1990 and 1990-2016.

Results are reported in Table 7. An analysis of business cycle statistics indicates that the

[25]See Hornstein and Price (2016) for a summary of empirical studies analyzing this issue.

[26]See Borowczyk-Martins and Lalé (2016b) for an alternative approach to address methodological breaks in the data.

Table 7: Business Cycle Statistics of Involuntary Part-Time Employment

	HP Filter			Bandpass Filter		
	1955 − 2016	1955 − 1989	1990 − 2016	1955 − 2016	1955 − 1989	1990 − 2016
Std. Dev.	0.092	0.085	0.098	0.079	0.073	0.086
Relative Std. Dev.	6.223	4.997	8.984	5.58	4.369	8.508
Autocorrelation	0.758	0.636	0.854	0.912	0.89	0.94
Correlation w/ Output	-0.819	-0.825	-0.882	-0.874	-0.932	-0.907

Notes: Author's own calculations based on data from BLS for the period 1955Q1-2016Q2. All variables are reported in logs and filtered using an HP filter with smoothing parameter 1600, as well as a bandpass filter with periodicities between 6 and 32 quarters.

behavior of involuntary part-time employment has changed over time. In particular, by comparing the two sub-periods, involuntary part-time employment in recent years has become much more volatile and persistent. This is consistent with Borowczyk-Martins and Lalé (2016b) who find that, during the Great Recession, the cyclical response of involuntary part-time work exceeded by a large factor what was observed in previous recessions.

What could be behind the changes in the cyclical behavior of involuntary part-time employment over time? I consider two possible explanations. The first one is that the Great Recession involved a much larger shock than any of the previous recessions occurred during the post-WWII period. If the response of involuntary part-time employment is disproportionately larger to bigger shocks than to smaller shocks, this could explain the substantial increase in involuntary part-time employment observed during the Great Recession. Under the light of my model, one mechanism through which this could be happening is the existence of nonlinearities in the distribution of idiosyncratic productivity. If the shock is large enough so as to move the reallocation cutoff to an area of the distribution where there is a nonlinear change in the probability mass, it would generate a much larger increase in involuntary part-time employment than the one driven by a small shock.

The second explanation is that structural changes have affected the behavior of involuntary part-time employment over the business cycle. In particular, I consider the role of organizational innovation.[27] Changes in organizational capital have been taking place for more than two decades, since the 1990s. It involves a complex innovation process that encompasses several dimensions

[27] Cajner et al. (2014), Valletta and Van Der List (2015), and Valletta et al. (2016) have also considered other structural factors behind the large increase in involuntary part-time observed during the Great Recession, such as changes in industry composition towards services-oriented sectors, demographic changes, and increases in labor costs through the introduction of new regulation such as the Employer Shared Responsibility provisions in the Affordable Care Act.

of human resources management.[28] This phenomenon was fueled by low IT prices and sustained economic growth, which led businesses to invest in IT equipment and software, as well as by cheaper and increasing electronic connectivity (Department of Commerce, 2000).

Organizational innovation and the adoption of workforce management technologies make it easier for firms to reallocate workers from full-time to part-time positions by increasing their degree of substitutability. It makes it easier and less costly to allocate workers in shifts, and reduces the difficulties associated to coordinating the availability, preferences and skills of heterogeneous workforces.

In my model, the degree of substitutability between full-time and part-time workers is captured by the parameter ε in the production function. To capture the process of organizational innovation occurred since the 1990s, I consider an increase in ε. Figure 6 shows the impulse responses to an aggregate productivity shock for different degrees of substitutability between full-time and involuntary part-time workers. When the substitutability is higher then the reallocation from full-time to part-time is easier and more profitable, which leads to a larger increase of the part-time ratio when facing a negative aggregate productivity shock. For firms that have adopted workforce management solutions that make it easier to replace a full-timer with several part-timers, then it is more likely that in a recession involuntary part-time work will rise more. The opposite happens for firms in which tasks cannot be easily split among different workers due, to some extent, to lack of information and management systems that automatize the allocation of tasks and resources.

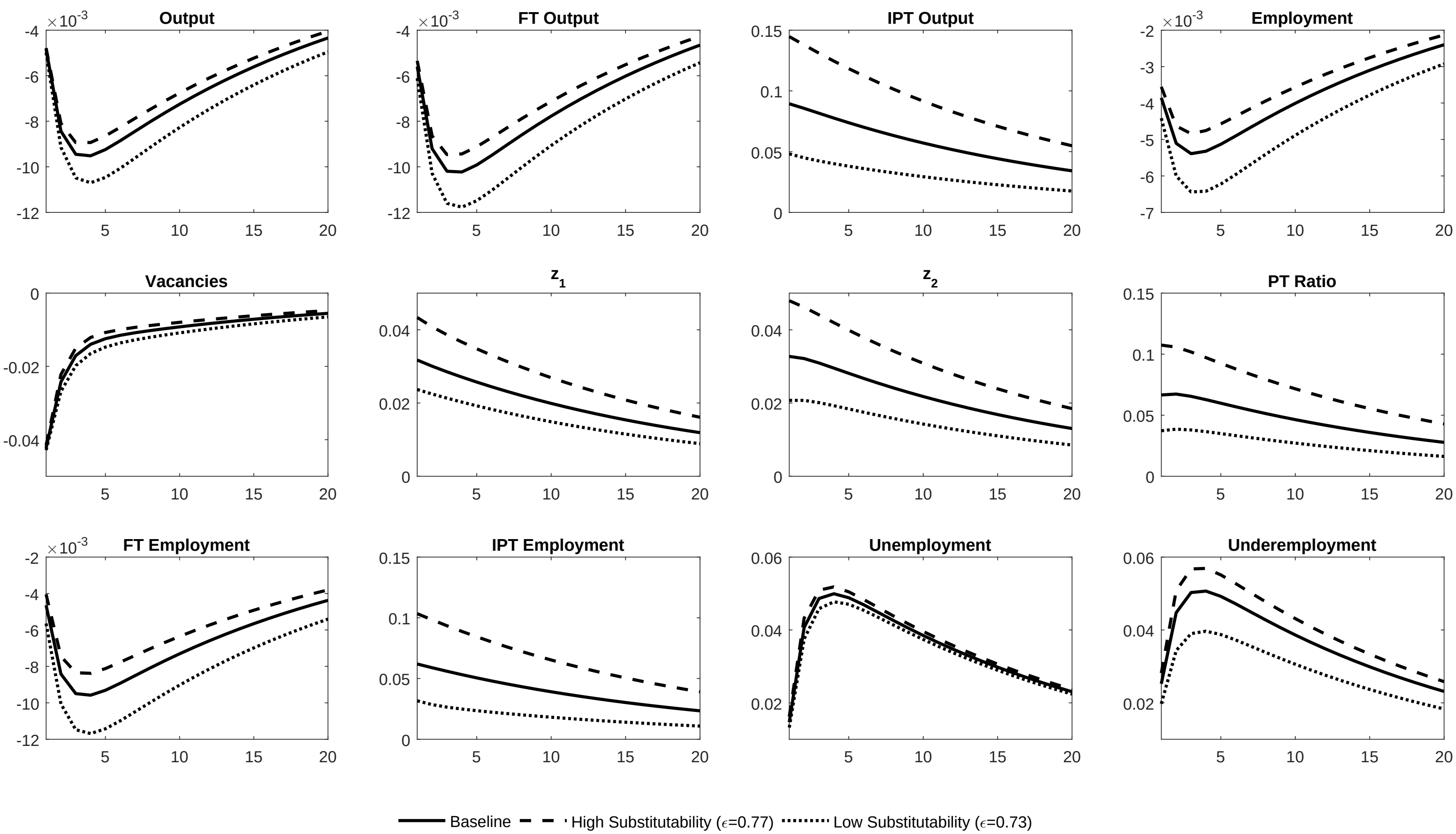
9 Conclusions and Future Work

In this paper I present empirical evidence on the business cycle properties of underemployment and, in particular, of involuntary part-time employment. I show that involuntary part-time employment is very volatile, nearly as much as unemployment, and strongly countercyclical. In order to explain these facts, I build a tractable model of involuntary part-time employment, featuring search and matching frictions, that is able to capture the dynamics of underemployment and of other key labor market variables. My model also allows me to do policy analysis, as well as to assess the role of structural changes in explaining the disproportionate increase in involuntary part-time employment occurred during the Great Recession.

The tractability of my model makes it suitable to be incorporated into more complex environ-

[28] See Black and Lynch (2005) and Lynch (2007) for a detailed explanation of the concept of organizational capital and the factors behind the adoption and diffusion of organizational innovation.

Figure 6: Impulse Response Functions to a 1 S.D. Negative TFP Shock, for different degrees of substitutability



Notes: All figures represent log deviations from the steady state.

ments to answer other research questions. First, my model abstracts from labor force participation decisions. However, one may think that labor force participation might be affected if, once hired, the worker could be reallocated into a contract that, from the point of view of the worker, is less favorable.

Second, the reallocation decision is tightly related to investments made on the worker before production takes place, e.g. in selection or on-the-job training. Accounting for this additional costs would make involuntary part-time work even more valuable for the firm, since it would be able to keep workers in which it has already invested, but under more profitable conditions (e.g. saving wages and benefits or adapting the amount of hours worked to a new state of the economy in which lower production is needed).

Finally, an important aspect of involuntary part-time employment is welfare. I abstract from the effects that reallocation has on workers, and just focus on the firm's decision and its incentives to do the reallocation. However, it is not obvious whether this would be welfare improving: individuals who are reallocated would work under worse conditions, but they would keep their job and would not face the possibility of being fired and facing the risk of not find a successful match.

This model could also be adapted to study other types of alternative work arrangements. In particular, it is suitable to analyze temporary layoffs, a mechanism firms have resorted to in the past in order to adjust to changing economic conditions.

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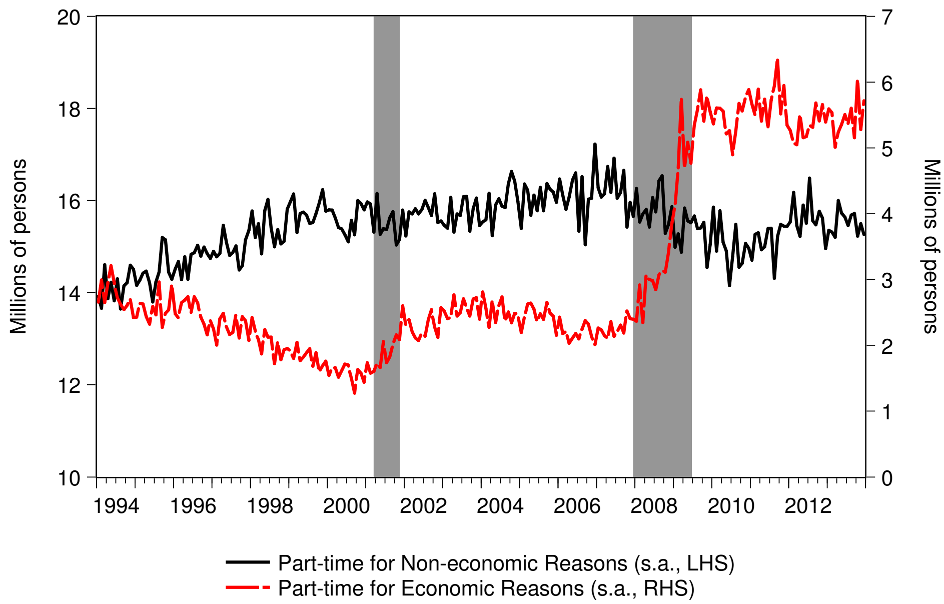
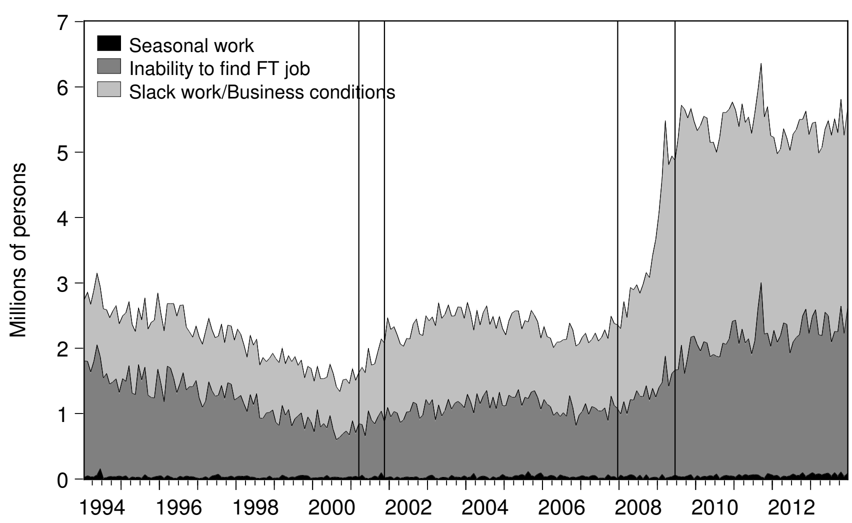
A Figures

Figure 7: Part-time Employment: Economics vs. Non-Economic Reasons



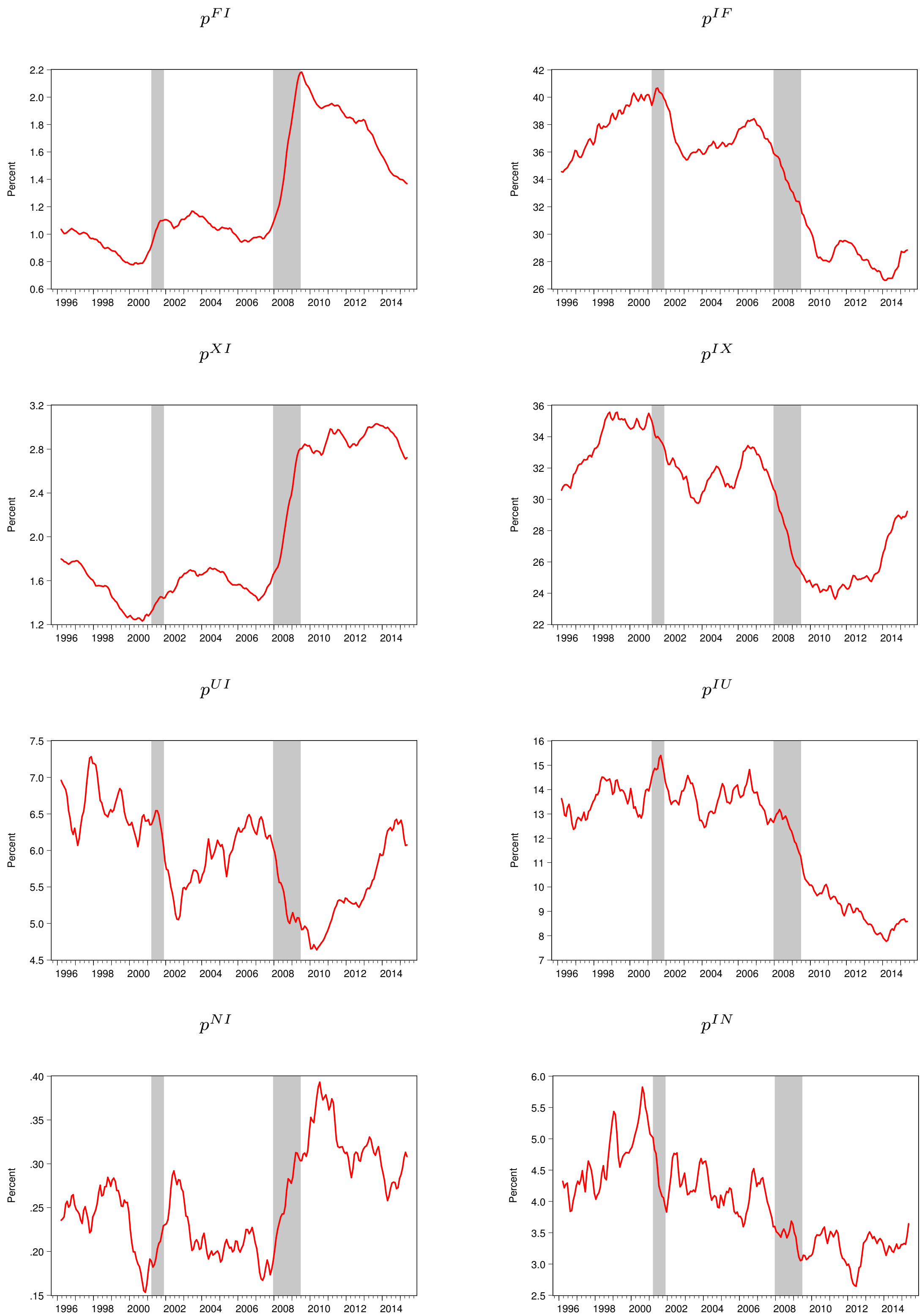
Source. Own calculations based on data from CPS.

Figure 8: Part-time Employment for Economic Reasons, by reason



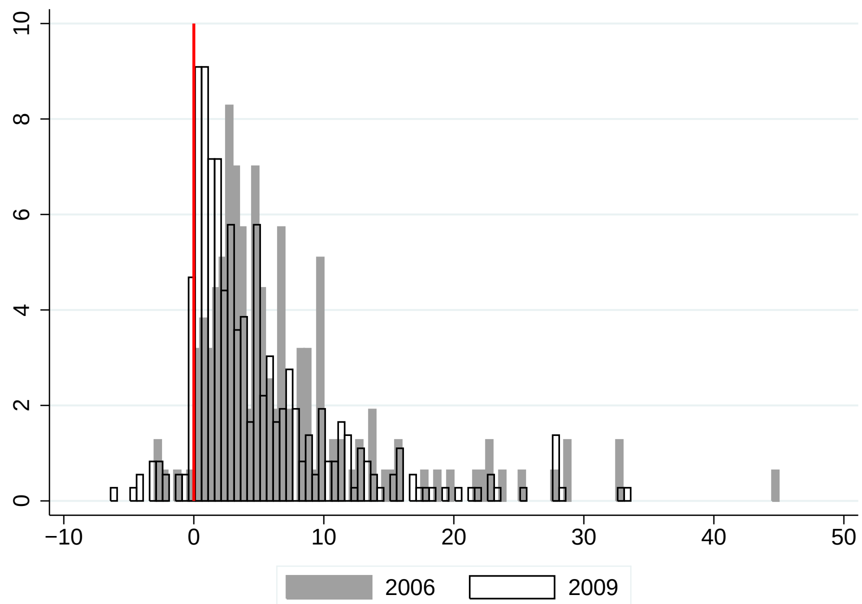
Source. Own calculations based on data from CPS.

Figure 9: Transition Probabilities In and Out of Involuntary Part-time Employment



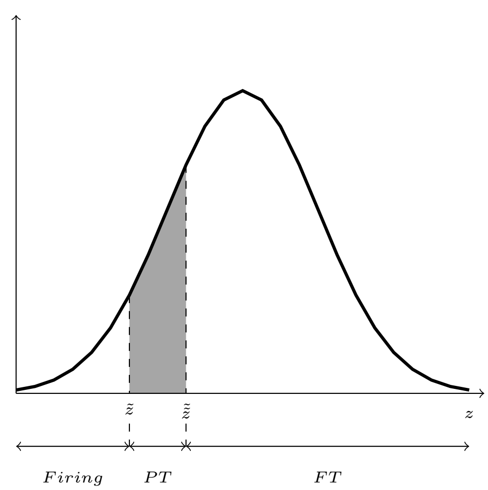
Source. Own calculations based on data from CPS. Series are MA-smoothed and adjusted for seasonality and aggregation bias. Shaded areas correspond to NBER recessionary periods.

Figure 10: Involuntary Part-Time Hourly Wages and the Minimum Wage



Source. Own calculations based on data from CPS. Data on minimum wage for each state are from the Department of Labor.

Figure 11: Reallocation and Firing Decisions



B Data Description

ADD DETAILS ON CONSTRUCTION OF DATA AND DESCRIPTIVE STATISTICS

C Firm Optimization

ADD DERIVATION OF OPTIMALITY CONDITIONS OF THE FIRM

D Nash Bargaining

ADD DERIVATION OF NASH BARGAINING WAGES FOR FULL-TIMERS AND PART-TIMERS

E Model Equations

Household optimality condition:

$$u'(c_t) = E_t\left\{\beta u'(c_{t+1}) R_{t+1}\right\}$$

Firm optimality conditions:

$$\frac{g'(v_t)}{q_t} = E_t\Bigg\{\Xi_{t+1|t}\Bigg[\frac{Y_{t+1}}{n_{t+1}} - \frac{W_{t+1}}{n_{t+1}} - \phi F(\tilde{z}_{t+1}) - \zeta\left[1 - F\left(\tilde{\tilde{z}}_{t+1}\right)\right] + \\ + \frac{g'(v_{t+1})}{q_{t+1}}\left(1 - F(\tilde{z}_{t+1}) - \rho^P\left[F\left(\tilde{\tilde{z}}_{t+1}\right) - F(\tilde{z}_{t+1})\right] - \rho^F\left[1 - F\left(\tilde{\tilde{z}}_{t+1}\right)\right]\right)\Bigg]\Bigg\}$$

$$(1-\alpha)\frac{Y_t}{n_t}\left(\frac{Y_t^P}{Y_t}\right)^{\varepsilon}\frac{\tilde{z}_t}{\int_{\tilde{z}_t}^{\tilde{\tilde{z}}_t} z dF(z)} - w_t^P(\tilde{z}_t)\,\bar{h}\left(1-\rho^P\right)\frac{g'(v_t)}{q_t} = -\phi$$

$$(1-\alpha)\frac{Y_t}{n_t}\left(\frac{Y_t^P}{Y_t}\right)^{\varepsilon}\frac{\tilde{\tilde{z}}_t}{\int_{\tilde{z}_t}^{\tilde{\tilde{z}}_t} z dF(z)} - w_t^P\left(\tilde{\tilde{z}}_t\right)\bar{h} + \left(1-\rho^P\right)\frac{g'(v_t)}{q_t} = \\ = \alpha\frac{Y_t}{n_t}\left(\frac{Y_t^F}{Y_t}\right)^{\varepsilon}\frac{\tilde{\tilde{z}}_t}{\int_{\tilde{\tilde{z}}_t}^{\infty} z dF(z)} - w_t^F\left(\tilde{\tilde{z}}_t\right) - \zeta + \left(1-\rho^F\right)\frac{g'(v_t)}{q_t}$$

Wages:

$$w_t^F = \omega w_t^{F,NB} + (1-\omega)\, w_{ss}^{F,NB}$$

and

$$w_t^P = w_t^{P,NB}$$

where the Nash bargaining wages are given by

$$w_t^{F,NB} = \eta^F\Bigg[\alpha\frac{Y_t}{n_t}\left(\frac{Y_t^F}{Y_t}\right)^{\varepsilon}\frac{z_t}{\displaystyle\int_{\tilde{\tilde{z}}_t}^{\infty} z f(z) dz} - \zeta + \left(1-\rho^F\right)\theta_t g'(v_t) - \\ - \left(1-\rho^F\right)(1-\theta_t q_t)\, E_t\left\{\Xi_{t+1|t}\phi F(\tilde{z}_{t+1})\right\}\Bigg] + (1-\eta^F)\frac{\chi}{1-\tau^n},$$

and

$$w_t^{P,NB} = \frac{\eta^P}{\bar{h}} \left[(1-\alpha) \frac{Y_t}{n_t} \left(\frac{Y_t^P}{Y_t} \right)^{\varepsilon} \frac{z_t}{\int_{\tilde{z}_t}^{\tilde{\tilde{z}}_t} z f(z) dz} + \right.$$
$$\left. + \left(1-\rho^P\right) \theta_t g'(v_t) - \left(1-\rho^P\right) \left(1-\theta_t q_t\right) E_t \left\{ \Xi_{t+1|t} \phi F\left(\tilde{z}_{t+1}\right) \right\} \right] + \frac{1-\eta^P}{\bar{h}} \frac{\chi}{1-\tau^n}.$$

Law of motion for the stock of employment:

$$n_{t+1} = n_t \left(1 - F\left(\tilde{z}_t\right) - \rho^P \left[F\left(\tilde{\tilde{z}}_t\right) - F\left(\tilde{z}_t\right)\right] - \rho^F \left[1 - F\left(\tilde{\tilde{z}}_t\right)\right]\right) + q_t v_t$$

Government budget constraint:

$$\left[1 - n_t + n_t F\left(\tilde{z}_t\right)\right] \chi + R_t b_{t-1} = \tau^n W_t + b_t$$

Aggregate resource constraint:

$$c_t + g(v_t) + \phi n_t F\left(\tilde{z}_t\right) + \zeta n_t \left[1 - F\left(\tilde{\tilde{z}}_t\right)\right] = Y_t$$

F Log-logistic Distribution

For the quantitative exercise in this paper I assume that the idiosyncratic productivity is distributed log-logistic with scale parameter α and shape parameter β. This is equivalent to say that the logarithm of idiosyncratic productivity has a logistic distribution with mean $\mu = ln(\alpha_z)$ and $s = {}^{1}/_{\beta_z}$. The choice of this distribution is due to two main benefits. First, its support corresponds to the set of nonnegative real numbers, which is appropriate to represent a non-negative random variable as productivity. Second, and most important, its cumulative distribution function can be written in closed form, which makes it more attractive over other distributions (e.g. log-normal).

The probability density and cumulative distribution functions of the log-logistic distribution are, respectively,

$$f(z) = \frac{\left(\beta/\alpha\right)\left(z/\alpha\right)^{\beta-1}}{\left[1+\left(z/\alpha\right)^{\beta}\right]^{2}}$$

and

$$F(z) = \frac{1}{1+\left(z/\alpha\right)^{-\beta}}.$$

The mean of this distribution also has a closed form expression given by

$$E(Z) = \frac{\alpha\pi/\beta}{sin\left(\pi/\beta\right)}.$$

The computation of conditional expectations in the paper requires the solution of the following integral:

$$\begin{aligned}
\int_0^x z\frac{\left(\beta/\alpha\right)\left(z/\alpha\right)^{\beta-1}}{\left[1+\left(z/\alpha\right)^{\beta}\right]^{2}}dz &= \alpha\int_{\frac{1}{1+(x/\alpha)^{\beta}}}^{1}\left(\frac{1}{u}-1\right)^{1/\beta}du \\
&= \alpha\int_0^1\left(\frac{1}{u}-1\right)^{1/\beta}du - \alpha\int_0^{\frac{1}{1+(x/\alpha)^{\beta}}}\left(\frac{1}{u}-1\right)^{1/\beta}du \\
&= \frac{\alpha\pi/\beta}{sin\left(\pi/\beta\right)} - \alpha\int_0^{\frac{1}{1+(x/\alpha)^{\beta}}}u^{-1/\beta}(1-u)^{1/\beta}du \qquad (32)
\end{aligned}$$

The integral in the last row of equation (32) corresponds to an Incomplete Beta function: $B\left(\frac{1}{1+(x/\alpha)^{-\beta}}; 1-\frac{1}{\beta}, 1+\frac{1}{\beta}\right)$. One of the properties of the Incomplete Beta function is that it can be rewritten in terms of a hypergeometric function as follows:

$$
\begin{aligned}
& B\left(\frac{1}{1+(x/\alpha)^{\beta}};1-\frac{1}{\beta},1+\frac{1}{\beta}\right)= \\
& =\frac{1}{1-\frac{1}{\beta}}\left[\frac{1}{1+\left(\frac{x}{\alpha}\right)^{\beta}}\right]^{1-\frac{1}{\beta}} F\left(\left[1-\frac{1}{\beta},-\frac{1}{\beta}\right],2-\frac{1}{\beta},\frac{1}{1+\left(\frac{x}{\alpha}\right)^{\beta}}\right).
\end{aligned}
\tag{33}
$$

Therefore, using the equality in (33), equation (32) can be rewritten as

$$
\begin{aligned}
& \int_0^x z\frac{(\beta/\alpha)\,(z/\alpha)^{\beta-1}}{\left[1+(z/\alpha)^{\beta}\right]^2}dz= \\
& =\frac{\alpha\pi/\beta}{sin\,(\pi/\beta)}-\alpha\frac{1}{1-\frac{1}{\beta}}\left[\frac{1}{1+\left(\frac{x}{\alpha}\right)^{\beta}}\right]^{1-\frac{1}{\beta}} F\left(\left[1-\frac{1}{\beta},-\frac{1}{\beta}\right],2-\frac{1}{\beta},\frac{1}{1+\left(\frac{x}{\alpha}\right)^{\beta}}\right),
\end{aligned}
$$

which is the expression used for the computation of conditional expectations in the paper.