Essays on the Macroeconomics of Labor Market Institutions

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Abstract

This thesis contributes to furthering the understanding of the macroeconomic impact of two types of labor market institutions: temporary help service agencies and temporary contracts.

In the first chapter, I depart from the observation that employment in the temporary help service industry in the United States has seen a secular rise in recent decades. The chapter provides a theory of the temporary help service industry within the steady state version of a random search model of the labor market with endogenous job destruction and a second sector in which employment relationships are intermediated. In this framework temporary jobs are endogenously of short duration and recruitment is fast. Conditions are provided under which intermediated employment relationships exist in equilibrium. The implications of the model for two possible explanations of the secular rise of employment in the temporary help service industry, technological progress and a rise in firm-level uncertainty, are such that technological progress as an explanation is favored.

In the second chapter, I investigate the impact of uncertainty shocks on a dual labor market using the Spanish economy as a case study. In an empirical analysis, I find that, given my identification strategy, fluctuations in uncertainty cause a significant drop in temporary employment, a non-significant reaction in permanent employment and a significant decline in GDP. Since in the data the responses to a second-moment shock are similar to the responses to a first-moment shock, a quantitative labor demand model of the Spanish labor market is built and calibrated. I use this model to generate simulated response functions to a (pure) second-moment, a (pure) first-moment and a combined first- and second moment shock. I find that the empirical impulse responses can only partially be rationalized by the model when considering a (pure) second-moment shock. A (pure) first moment shock in the model generates impulse response functions similar to the empirical ones. A combined first- and second moment shock can not improve on the first-moment shock in replicating the data.

Acknowledgements

Contents

1. Preface

This thesis is about the macroeconomic impact of two particular kinds of labor market institutions: temporary help service agencies and temporary contracts. *Temporary help service agencies* are labor market intermediaries that provide client firms with workers on an as-needed basis. The resulting employment relationship is very peculiar since the client firm is typically only responsible for the supervision of the worker on its premises whereas all other responsibilities for the worker remain with the temporary help service agency. Chapter one of this thesis contributes to understanding the secular growth these type of employment relationships have displayed in the United States since the early 1990s.

The rules on the usage of t*emporary contracts* were relaxed by many European governments in response to the sluggish performance of many European labor markets in the early 1980s. These types of employment contracts differ from regular, or permanent, employment contracts in that they typically offer very little employment protection. Chapter two of this thesis contributes to a large literature that tries to understand the consequences of temporary contracts for labor markets by studying how labor markets in which this type of contract is present react to uncertainty shocks.

In chapter one, I depart from the observation that employment in the temporary help service industry in the United States has seen a secular rise in recent decades. In particular, the share of THS employment in total employment rose from a meager 0.3% in 1972 to about 1% in January 1990 to a value of about 2.0% since 2000.

The chapter provides a theory of the temporary help service industry within the steady state version of a random search model of the labor market with endogenous job destruction and a second sector in which employment relationships are intermediated. Intermediaries have to create call sheets which they seek to fill with a worker. Once they added a worker to their call-sheet, they seek to place this worker with a client firm. The resulting employment relationship is triangular. As a consequence of this triangular employment relationship, temporary jobs are comparatively expensive to maintain and this means that they are destroyed relatively fast. The relatively short expected duration

also means that from the perspective of regular firms temporary jobs have to be, relative to regular jobs, quick to fill. Consequently, the framework employed generates two of the most salient features of jobs in the temporary help service industry endogenously: they are of short duration and recruitment is fast. Subsequently, I provide conditions under which intermediated employment relationships exist in the equilibrium of the model. I find that intermediaries need some special ability relative to the regular labor market in order to be willing to provide their services and I identify matching ability as a possible candidate.

The last part of this chapter investigate numerically the implications of the model for two possible explanations of the secular rise of employment in the temporary help service industry in recent decades: technological progress and a rise in firm-level uncertainty. I find that the implications of the theory favor technological progress as an explanation.

In chapter two, I investigate the impact of uncertainty shocks on a dual labor market, that is a labor market that is segmented along the lines of permanent and temporary contracts, using the Spanish economy as a case study. The Spanish economy is a particular relevant case study since temporary contracts are widely spread in Spain. They account for about one third of all employment contracts in Spain since the early 1990s. In the first part of the chapter, I investigate the impact of uncertainty shocks on the Spanish economy empirically through the lense of a structural VAR model. I make use of an identification strategy devised in Bloom (2009) which identifies uncertainty shocks as (exogenous) events that cause a sudden spike in proxies measures of uncertainty. I show that one such proxy measure of uncertainty in the Spanish economy, volatility of the main Spanish stock market index, the IBEX 35, displays large and sudden spikes that can be associated with arguably exogenous events such as the first and second Gulf War or Bear Stearn's bailout. I find that, given my identification strategy, these fluctuations cause a significant drop in temporary employment, a non-significant reaction in permanent employment and a significant decline in GDP.

Since I also find that in the data the responses to a second-moment shock are similar to the responses to a first-moment shock, a quantitative labor demand model of the Spanish labor market is built, calibrated and simulated in the second part of the chapter. Key features of the model are adjustment costs on both types of labor and a time-varying second moment of the driving process. I use this model to generate simulated response functions to a (pure) second-moment, a (pure) first-moment and a combined first- and second moment shock. I find that the empirical impulse responses can only partially be rationalized by the model when considering a (pure) second-moment shock. A first mo-

ment shock in the model generates impulse response functions similar to the empirical ones. A combined first- and second moment shock can not improve on the first-moment shock in replicating the data.

2. Chapter 1: The Temporary Help Service Industry and the Macro Economy

2.1. Introduction

Temporary help service (henceforth abbreviated as THS) agencies are labor market intermediaries who's business consists of placing workers with client firms for often short periods of time. The resulting employment relationships are triangular: the client firm pays a fee to the agency which uses part of this fee to compensate the worker.[1]As figure 2.1 illustrates, the incidence of these peculiar employment relationships has seen a secular rise in the United States in the last 20 years: Employment in the THS industry more than doubled between January 1990 and October 2014. Maybe more importantly, the share of THS employment in total employment rose from a meager 0.3% in 1972 to about 1% in January 1990 to a value of about 2% since 2000.

This paper addresses the question of what accounted for the rise of employment in the THS industry in a random search model of the labor market with endogenous job destruction. In particular, a two-sector version of the Diamond-Mortensen-Pissarides (henceforth abbreviated as DMP) framework with endogenous job destruction is put forward where in one of the sectors employment relationships are created with the help of intermediaries. It is shown that the model endogenously generates two of the main features of employment relationships in the THS industry: recruitment costs are low and job durations are short. Consequently, turnover in the intermediated sector of the economy is high just as it is in reality. Subsequently, in a numerical analysis, I evaluate

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[1]The fact that THS agencies are the employer of the worker, responsible for everything but on-site supervision, distinguishes them from other intermediaries in the labor market such as headhunters, job boards and public employment agencies. Moore (1965) provides an early description of the workings of the THS industry.
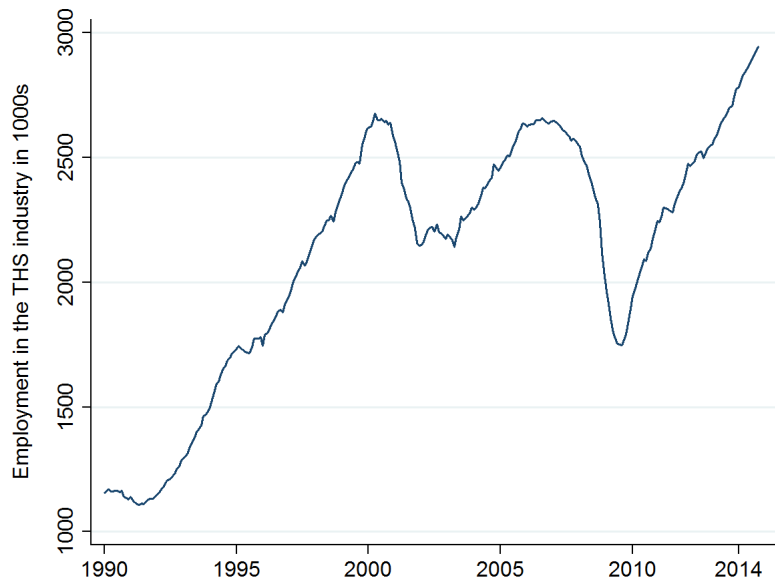
Figure 2.1.: Employment in the THS industry between January 1990 and October 2014 (monthly data, source U.S. Bureau of Labor Statistics (BLS), the values for September and October 2014 are marked as preliminary by the BLS).

the effect of technological progress and a change in the economic environment that comes in the form of increased dispersion of idiosyncratic productivity on the incidence of intermediated employment relationships.

Preview of the Model   The economic environment in this paper is based on the random search framework with endogenous job destruction pioneered in Mortensen and Pissarides (1994). The novelty in this paper lies in the consideration of two labor markets which I will refer to as the *temporary* and the *regular* labor market. The regular labor market functions just as the single labor market in Mortensen and Pissarides (1994). The temporary labor market, however, is characterized by the presence of intermediaries who are indispensable for the creation of matches between firms and workers in this market. More specifically, intermediaries can create *call sheets* which they seek to fill with an unemployed worker. Intermediaries who were successful in adding a worker to their call sheet then seek to place this worker with a *client firm*. Once an intermediary-worker pair has established contact with a client firm, the intermediary bargains with the firm over the total surplus of the match while at the same time she bargains with the worker over the division of the share of the surplus she was able to appropriate from the firm. Consequently, the ensuing employment relationship is triangular, and the intermediary

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continues to appropriate a share from the output generated by the worker and the firm for the whole duration of the employment relationship. This assumption on the bargaining structure is justified by the fact that in reality THS employment relationships are triangular as well: In particular, THS agencies typically charge client firms an hourly fee for the worker which then goes into the compensation of the worker, the coverage of overhead expenses and possibly profits.[2] Further key features of the model are ex-ante homogenous jobs, free entry from intermediaries into call sheet creation and free entry into the creation of temporary and regular jobs for firms.

Preview of Results   The first set of results concerns the characteristics of intermediated jobs in the steady state of the model. In particular, intermediated jobs are quicker to fill and of shorter duration than regular jobs. The intuition for this result is that, due to the presence of the intermediary, temporary jobs are comparatively more expensive to maintain. Therefore, they are more likely to be destroyed than regular jobs, or, put differently, they are of shorter expected duration. Since they are of shorter expected duration, they have to be quicker to fill as otherwise (regular) firms would not want to create jobs in the intermediated sector. This, in turn, then also implies that job creation and job destruction in the intermediated sector are high.

The second set of results provides an answer to the question under what conditions the model economy allows for an equilibrium in which intermediaries find it profitable to provide their services. In particular, I reduce the set of equations that determine the equilibrium variables to a single equation that reflects the intermediaries' cost and benefits of entry. I show that this equation is monotone. It can, therefore, be used to easily check whether an equilibrium with labor market intermediaries exists for a given parameterization of the economy. More importantly, this equation can be used to demonstrate formally that an equilibrium with an intermediated labor market can only exist if the intermediary is better than the regular labor market in creating matches between workers and firms.

In summary, these results imply that this paper provides a formal theory of the THS industry that endogenously generates two of the most salient aspects associated with the industry: the short duration of temporary jobs and the low recruitment costs for firms. Indeed, a look at the data confirms that all jobs last for about 2.5 years on average[3]

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[2]See for example Autor et al. (1999), p. 28 and Moore (1965), p. 554.
[3]See for example Shimer (2005).

whereas the average temporary jobs lasts for about 2.5 months[4]. Further, the second set of results shows that a precondition for this outcome is the industry's ability to provide matches more efficiently than the regular labor market. This seems to be a very intuitive precondition given that firms in this industry specialize in the creation of matches.

Subsequently, I turn to a numerical analysis of the model. In particular, I evaluate the implications of the model for two possible explanations for the secular rise of employment relationships intermediated by the THS industry: technological progress that benefited the matching technology at the hands of the intermediaries relative to the matching technology prevailing in the regular labor market and a change in the economic environment that comes in the form of increased dispersion in the idiosyncratic productivity shock. I find that both explanations can account for the observed rise in employment relationships intermediated by the temporary help service industry and that the change required in the underlying parameter is of plausible magnitude in both cases. However, the differing implications of the two driving forces on the unemployment rate and the duration of regular jobs make technological progress, according to the model, a more plausible explanation for the secular rise of THS employment in recent decades.

2.1.1. Related Literature

This paper is chiefly related to two partly overlapping literatures. From a methodological point of view, it draws on the literature that developed the search and matching approach to the study of the labor market. With regards to its subject matter, it is related to a literature that dealt with various aspects of the THS industry.

The search and matching approach to the study of the labor market was developed in Diamond (1982), Mortensen (1982) and Pissarides (1985). I consider an environment in which the job destruction decision is endogenous. Therefore, my paper is particularly closely linked to Mortensen and Pissarides (1994). Further, I consider a labor market with an intermediated and a regular sector which relates my paper to the literature that considers multiple sectors in the search and matching approach to the study of the labor market. One focus of this literature has been sectoral reallocation. In this line of research Davidson et al. (1987), Davidson et al. (1988) and Hosios (1990) are early contributions whereas Baley (2012), Chang (2012) and Pilossoph (2014) are more recent papers. Another focus has been the analysis of economies that features both an informal

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[4]See for example American Staffing Association (2010).

and a formal employment sector. Examples for this literature are the papers by Boeri and Garibaldi (2007), Zenou (2008), Albrecht et al. (2009) and Ulyssea (2010). My paper differs form this literature by having a different subject matter. The only paper from this literature that also deals with the THS industry is the paper by Neugart and Storrie (2005) which is discussed in more detail below.

The THS industry has been studied extensively from a microeconomic perspective. For instance, there are many papers that study the effect of employment in the THS on the career outcomes of workers. An introduction to this literature with many references can be found in Autor (2009). Another class of papers focuses on the motivation of firms to hire workers through THS agencies. The papers by Estevao and Lach (1999), Houseman (2001), Ono and Sullivan (2010) are examples for these kind of studies. There are also, albeit relatively few, papers that study the inner workings of the THS industry. An example is Autor (2001) who provides an explanation for the puzzling prevalence of ex ante and free general skills training in the THS industry. Another example is Komiss (2008) who analyzes how THS agencies deal with the danger that once they matched a worker and a firm the latter two agents have a strong incentive to eliminate the agency from the employment relationship.

For this paper particularly relevant are the studies that focus on the growth of the THS industry and or analyze the industry from a macroeconomic perspective. One of these studies is Autor (2003) who connects the rise of employment in the THS industry to the curtailment of the employment-at-will doctrine[5] that occurred contemporaneously. He finds that 20% of the growth of THS employment between 1973 and 1995 between can be attributed to the curtailment of the employment-at-will doctrine. Curtailments in the employment-at-will doctrine can be understood as an increase in firing costs.[6] Since my theory does not feature firing costs and Autor (2003)'s findings certainly leave room for other explanations for the observed growth in THS employment, I view my paper as complementary to his.

House and Zhang (2012) is another paper that studies the THS industry from a macroeconomic perspective. They focus on information problems in the labor market in a modelling framework that does not feature search frictions. In their model, THS agencies can emerge since they are able to guarantee the quality of a worker. Besides having

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[5] The employment at will doctrine states that workers and firms are free to terminate their employment relationship at any time and for any reason if there is not an explicit contract between them that says otherwise.

[6] See also the model in section II in Autor (2003).

a very different modelling framework and focus, their model is not able to speak endogenously to the characteristics of intermediated jobs and they do not consider the effect of increased dispersion in the idiosyncratic productivity shock on the incidence of intermediated employment relationships.

The paper most closely related to my work is Neugart and Storrie (2005). They focus on the impact of technological progress on the incidence of intermediated employment relationships in a random search model of the labor market that allows for transitions from intermediated jobs to regular jobs but does not feature endogenous job destruction. Their findings are similar to mine in the sense that they show that technological progress can account for the growth in THS employment. However, their model is not able to generate salient features of intermediated jobs endogenously and they are not able to study the impact of increased dispersion in the idiosyncratic productivity shock on the incidence of intermediated employment relationships.

Outline   The remainder of the paper is structured as follows. Section 2.2 introduces the economic environment. Section 2.3 characterizes the equilibrium of the economy and derives results related to the existence and uniqueness of an equilibrium that features labor market intermediation. Section 2.4 analyzes the effect of technological progress and increased dispersion on the model's equilibrium numerically. Section 3.5 concludes. Proofs and derivations are contained in the appendix.

2.2. The Model

The model is based on the classical random search model of the labor market with endogenous job destruction as pioneered by Mortensen and Pissarides (1994). The main difference to the standard model is the existence of a temporary (t) labor market besides the regular (r) labor market. The regular labor market works in the same way as the labor market in Mortensen and Pissarides (1994). In the temporary labor market *intermediaries* are indispensable for the creation of matches. Matching through intermediaries is a two stage process: First, intermediaries have to create empty *call sheets* which they seek to fill with a worker from the pool of the unemployed. Once the call sheet is filled, the intermediary worker pair seeks to place the worker with a firm. Upon finding a firm for her worker, the intermediary bargains with the firm over the total surplus of the match. At the same time the worker intermediary pair bargains over how

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to split the part of the total surplus that the intermediary eventually appropriates. I assume that intermediaries can costlessly create empty call sheets. Firms can freely create vacancies in the temporary and in the regular labor market. Workers search in both markets simultaneously. A graphical illustration of the model is provided in appendix A.1.

2.2.1. Basics

Time is continuous, all agents are infinitely-lived, risk-neutral and discount the future at common rate r. Firms possess control over a constant returns to scale production technology that produces an output of $p + \sigma\epsilon$ per unit time when paired with a worker. p is common across matches whereas $\sigma\epsilon$ is an idiosyncratic component of output. It is assumed that ϵ changes in accordance with a Poisson process whose parameter is λ. If a match is hit by a shock, a new ϵ is drawn from a cdf F whose support is given by $(-\infty, \epsilon_u)$ with $\epsilon_u < \infty$.

The following sections describe the two labor markets and the asset pricing equations of the model.

2.2.2. Regular Labor Market

In the regular labor market vacancies v^r and unemployed workers u are matched through a standard[7] matching function $m^r = M^r(v^r, u)$. The corresponding vacancy filling rate is q^r and the job finding rate is p^r.[8] The value of a match in the regular labor market with idiosyncratic productivity ϵ to the firm is $F^{rJ}(\epsilon)$ and to the worker it is $W^{rJ}(\epsilon)$. When a match is separated, the firm gets the value of a vacancy in the regular labor market F^{rV} and the worker becomes unemployed yielding him a value of W^U. The surplus of a match characterized by ϵ in the regular labor market is then given by

$$S^r(\epsilon) = F^{rJ}(\epsilon) + W^{rJ}(\epsilon) - F^{rV} - W^U.$$

I assume that the firm at any point in time can appropriate a share $0 < \eta^{rF} \leq 1$ of $S^r(\epsilon)$ and the worker gets the remainder $\eta^{rW} = 1 - \eta^{rF}$. There is free-entry into

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[7]All matching functions in this paper are, as in most of the literature, assumed to be homogeneous of degree one and concave in both arguments.

[8]As usual: $q^r = q^r(\theta^r) \equiv \frac{m^r(v^r, u)}{v^r}$ with $\theta^r \equiv \frac{v^r}{u}$- and $p^r = p^r(\theta^r) \equiv \frac{m^r(v^r, u)}{u}$.

vacancy creation in the regular labor market.

2.2.3. Temporary Labor Market

The temporary labor market is divided into two submarkets. The first of these consists of intermediaries equipped *with an empty call sheet* v^c and unemployed workers u who seek to from a *call sheet relationship* with each other.[9] The rate at which unemployed workers and intermediaries meet in this market is determined by a standard matching function $m^c = M^c(v^c, u)$ with *call sheet filling rate* q^c and *call sheet finding rate* p^c.[10] An important assumption here is that this stage of the temporary labor market is characterized by search frictions. One view of labor market intermediaries is that they eliminate search frictions in the labor market. I take the view here that they are not able to eliminate frictions completely and that locating intermediaries and forming a match still takes time, resources and has a certain element of randomness to it.[11]

The value of having a worker *on call* to the intermediary is denoted by I^{tV}. The value of being on the call sheet to the worker is W^{tV}. If the worker intermediary pair separates, the worker becomes unemployed, yielding him a value of W^u, and the intermediary is left with an empty call sheet with value I^{cV}. The presence of search frictions in this market imply that a match between an intermediary and a worker entails a surplus which is given by

$$S^c = W^{tV} + I^{tV} - W^u - I^{cV}.$$

I assume that the intermediary at any point in time can appropriate a share $0 < \eta^{cI} \leq 1$ from S^c and the worker gets the remainder $\eta^{cW} = 1 - \eta^{cI}$. This approach provides a tractable alternative to the arguably more realistic approach of contract posting from the intermediary.

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[9]Regarding the terminology: workers that are registered with a temporary help service agency but currently not placed at a client firm are frequently referred to as being "on call". I call the database which the agency uses to manage these workers a "call sheet". Intermediaries who have not yet established contact with a worker have an "empty call sheet". The relationship between a worker and an intermediary at this stage is called a "call sheet relationship".

[10]See footnote 8.

[11]For instance, THS agencies typically engage in screening and training activities (see Autor (2001) and Autor et al. (1999) for an analysis for the training activities of THS firms) before they are willing to place a worker with a client firm. This process is, of course, time consuming and its outcome could easily have an element of randomness to it. It is not clear that a matching function meant to capture this process is standard in the sense of footnote 7. However, since there is no information on this matching function available, "standard" assumptions on the matching function seem like a reasonable starting point.

The second submarket of the temporary labor market consists of intermediary worker pairs (created in the first submarket) and (regular) firms who seek to form *triangular employment relationships*[12] with each other.The rate at which worker intermediary pairs (mass u^c) meet vacancies (mass v^t) is determined by a standard matching function $m^t = M^t(v^t, u^c)$ with q^t being the rate at which firms locate intermediary worker pairs and p^t being the rate at which intermediary worker pairs locate firms.[13] Consequently, as in the first submarket, I assume that intermediaries are not able to eliminate all search frictions in this segment of the labor market as well.[14]

Matches in the second submarket will be characterized by some match-specific productivity ϵ. I denote the value of such a match to the intermediary by $I^{tJ}(\epsilon)$, to the worker by $W^{tJ}(\epsilon)$ and to the firm by $F^{tJ}(\epsilon)$. In case a match is not formed or separated, the values of the outside options of the three parties involved are given by I^{tV} for the intermediary, W^{tV} for the worker and by F^{tV} for the firm. The latter is simply the value of a vacancy in the temporary labor market. The former two are the value of the intermediary worker match to the worker and the intermediary. Consequently, I assume that upon destruction of the triangular employment relationship the worker intermediary pair remains together which seems a natural assumption in the context of the THS industry. The presence of search frictions implies again that any match in this market entails a surplus which here is given by

$$S^t(\epsilon) = F^{tJ}(\epsilon) + W^{tJ}(\epsilon) + I^{tJ}(\epsilon) - F^{tV} - W^{tV} - I^{tV}.$$

It is assumed that the firm can appropriate $0 < \eta^{tF} \leq 1$ of $S^t(\epsilon)$, the intermediary can appropriate η^{tI} ($\eta^{tI} + \eta^{tW} \leq 1$) and the worker gets the remainder $\eta^{tW} = 1 - \eta^{tI} - \eta^{tF}$. This bargaining arrangement is equivalent to one in which the client firm and the intermediary bargain over the total surplus with bargaining weights η^{tF} (firm) and $1 - \eta^{tF}$ (intermediary) and the intermediary and the worker bargain over the share of

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[12]Employment relationships intermediated by a THS agency are frequently referred to as "triangular" since the arrangement is typically such that the worker performs his duties at the site of the client firm which pays the THS agency an hourly "fee" out of which the agency compensates the worker. In this arrangement, the client firm is typically only responsible for the supervision of the worker whereas the THS agency is responsible for wage payments, social security contributions and the like (see Moore (1965)).

[13]See footnote 8.

[14]In this market, frictions might arise from the fact that intermediaries have to learn about the exact needs of their client firms or from issues related to workers turning out to be unfit for the assignment in question. The caveat from footnote 11 also applies.

the total surplus which the intermediary was able to appropriate.[15] Since in actuality the client firm and the THS agency agree on a fee out of which the THS agency has to compensate the worker (see footnote 12), I view this as a good description of reality.

2.2.4. Firms

Firms can be in one of four states: they can have a vacancy in the temporary or in the regular labor market and they can engage in productive activity with a temporary or with a regular worker. This section describes the asset pricing equations associated with these four states.

The asset pricing equation for the value of a vacancy in the regular labor market is given by

$$rF^{rV} = -k + q^r \left(F^{rJ} \left(\epsilon_u \right) - F^{rV} \right). \tag{2.1}$$

The first term is the maintenance cost k of the vacancy. The second term is the capital gain the firm enjoys when paired with a worker. Meeting a worker happens at rate q^r. It is assumed that newly created jobs produce at productivity ϵ_u.[16]

In the temporary labor market the value of a vacancy is given by

$$rF^{tV} = -k + q^t \left(F^{tJ} \left(\epsilon_u \right) - F^{tV} \right). \tag{2.2}$$

The interpretation is analogous to the one given for equation 2.1. The assumption of free-entry into both labor markets is going to drive F^{tV} and F^{rV} to zero.

The asset pricing equation for a filled job in the regular labor market with current

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[15]In the equivalent arrangement the firm would get $\eta^{\tilde{t}F} S^t$ and the intermediary would appropriate $\left(1 - \eta^{\tilde{t}F} \right) S^t$ of the surplus from the match. The bargaining between the worker and the intermediary in turn mean that the worker gets $\eta^{\tilde{c}W} \left(1 - \eta^{\tilde{t}F} \right) S^t$ and the intermediary eventually $\left(1 - \eta^{\tilde{c}W} \right) \left(1 - \eta^{\tilde{t}F} \right) S^t$. The bargaining weights from the main text are then obtained by setting $\eta^{tF} = \eta^{\tilde{t}F}$, $\eta^{tW} = \eta^{\tilde{c}W} \left(1 - \eta^{\tilde{t}F} \right)$ and $\eta^{tI} = \left(1 - \eta^{\tilde{c}W} \right) \left(1 - \eta^{\tilde{t}F} \right) S^t$.

[16]The fact that newly created jobs produce at the highest possible productivity is a standard assumption in the literature (see for example Mortensen and Pissarides (1994)). It is usually justified by the argument that newly set-up firms can, and will, choose the best available production technology and or location at the time. The assumption is in any case not crucial for the theoretical results of this paper since they would also hold if matches would start at some randomly drawn idiosyncratic productivity level. I stick with the approach taken in Mortensen and Pissarides (1994) to make the exposition as clear as possible.

match-specific productivity ϵ is

$$rF^{rJ}(\epsilon) = p + \sigma\epsilon - w^r(\epsilon) + \lambda\eta^{rF}\int_{-\infty}^{\epsilon_u}\left[\max\{S^r(x),0\} - S^r(\epsilon)\right]dF(x). \qquad (2.3)$$

The first part of this equation reflects instantaneous profits. They are given by the difference of the match's product and the wage paid to the worker. The second part reflects the capital gain that accrues to the firm when the match in question is hit by a match-specific productivity shock. These shocks occur at rate λ. Importantly, if such a shock hits, the match is only continued if the new surplus is positive.

The corresponding value in the temporary labor market is given by

$$rF^{tJ}(\epsilon) = p + \sigma\epsilon - f(\epsilon) + \lambda\eta^{tF}\int_{-\infty}^{\epsilon_u}\left[\max\{S^t(x),0\} - S^t(\epsilon)\right]dF(x). \qquad (2.4)$$

The first part reflects again instantaneous profits. In this case, they are given by the product of the match less the payment the firm makes to the intermediary, which I denote by $f(\epsilon)$ (f for "fee").[17] The second part is the capital gain that accrues to the firm in case the match in question is hit by a match-specific productivity shock. Only matches with a positive surplus remain together.

2.2.5. Workers

Workers can be in four states: unemployment, working in a regular job, working in a temporary job and they can find themselves on the call sheet of an intermediary. Unemployed workers search for jobs in both labor markets simultaneously. They may receive either an offer from a THS agency to be added to their call sheet or they may receive an offer for a regular job from a firm that recruits in the regular labor market. The asset pricing equation for the value of unemployment is then

$$rW^u = b + p^c\left(W^{tV} - W^u\right) + p^r\left(W^{rJ}(\epsilon_u) - W^u\right).$$

Here, b represents the flow benefits of the worker when unemployed. He locates call sheets at rate p^c which yields him a capital gain of $\left(W^{tV} - W^u\right)$. He finds regular

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[17]See the interpretation of the bargaining process provided at the end of section 2.2.3.

jobs with capital gain $\left(W^{rJ} \left(\epsilon_u \right) - W^u \right)$ at rate p^r.[18] The assumption that workers may receive offers from both markets is made for two reasons: First, it proved to be much more tractable then alternative assumptions.[19] Second, many more workers then the THS industry's point in time employment suggests are employed by it in any given year. Therefore, it seems to be reasonable to assume that many unemployed workers consider temporary and regular jobs simultaneously (see Autor (2001) and Berchem (2006)).

The asset pricing equation for the value of a match in the regular labor market to the worker is given by

$$rW^{rJ} \left(\epsilon \right) = w^r \left(\epsilon \right) + \lambda \eta^{rW} \int_{-\infty}^{\epsilon_u} \left[\max \left\{ S^r \left(x \right), 0 \right\} - S^r \left(\epsilon \right) \right] dF \left(x \right). \qquad (2.5)$$

The interpretation is identical to the one of equation 2.3.

There are two asset pricing equations for the worker in the temporary labor market. The first is the asset pricing equation which gives the value of being on the call-sheet of an intermediary to the worker

$$rW^{tV} = z + p^t \left(W^{tJ} \left(\epsilon_u \right) - W^{tV} \right) + \kappa \left(W^u - W^{tV} \right).$$

In this equation, z reflects the bargaining outcome between the worker and the intermediary when they form a call sheet relationship. z can be interpreted as benefits or costs that arise to the worker when he is on the call-sheet of a THS agency but not on assignment. These costs and benefits could, for instance, stem from training activities.[20] The second term is the capital gain that accrues to the worker in case the worker intermediary pair gets matched with a firm. This happens at rate p^t, and means that the worker starts working in a temporary job with highest possible match-specific productivity ϵ_u.[21] In case the worker intermediary pair is subject to a separation shock, which

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[18]This equation does not include a term that captures the value of receiving an offer from both markets. This is because this term vanishes as time intervals move to zero in the continuous time formulation.

[19]One alternative assumption would be to have workers direct their search towards one of the sectors as in, for instance, Hosios (1990) and then "close" the model with a condition that states that the values of unemployment have to be identical in all sectors of the economy. Another alternative assumption would be to have a common matching function for both sectors as, for instance, in the paper by Acemoglu (2001). The route taken here is shared with the papers by Neugart and Storrie (2005), Ulyssea (2010) and Baley (2012).

[20]Training provided by THS agencies is a very common phenomenon. See Autor et al. (1999) and Autor (2001).

[21]This assumption was discussed in footnote 16.

are assumed to occur at exogenous rate κ,[22] the worker becomes unemployed and incurs a capital loss of $\left(W^u - W^{tV}\right)$.

The asset pricing equation for the value of working in a temporary job to the worker is

$$rW^{tJ}\left(\epsilon\right) = w^t\left(\epsilon\right) + \lambda\eta^{tW}\int_{-\infty}^{\epsilon_u}\left[\max\left\{S^t\left(x\right), 0\right\} - S^t\left(\epsilon\right)\right]dF\left(x\right). \qquad (2.6)$$

The interpretation of this equation is again analogous to equation 2.3 and 2.5.

2.2.6. Intermediaries

Intermediaries can be in three states. They can have an *empty call sheet* in which case they are looking for a worker to add to the call sheet, they can have a *filled call sheet* and they can have a worker working on a temporary job.[23] This section presents the asset pricing equations corresponding to these three states.

The asset pricing equation for the value of an empty call sheet to the intermediary is given by

$$rI^{cV} = -k^{cI} + q^c\left[I^{tV} - I^{cV}\right].$$

The activity of seeking to fill an empty call sheet entails costs of k^{cI} to the intermediary. These costs could for instance stem from expenses associated with screening and training workers. In case the intermediary locates a worker, which happens at rate q^c, she enjoys a capital gain given by the difference between the value of a filled and an empty call sheet.

The asset pricing equation for the value of a filled call sheet is

$$rI^{tV} = -z + p^t\left[I^{tI}\left(\epsilon_u\right) - I^{tV}\right] + \kappa\left[I^{cV} - I^{tV}\right].$$

The first term reflects the bargaining outcome between the worker and the intermediary when they form a call sheet relationship which was discussed in the previous sections. The second term is the capital gain the intermediary enjoys when he manages to place the

---

[22]Workers and intermediary pairs have to eventually separate as otherwise there will not be any unemployed workers (or regular jobs) in the model's steady state. An exogenous separation rate seems to be a natural choice given my modelling approach strives for simplicity at this part of the model. It is also a common assumption in the search and matching literature (see, for instance, Pissarides (2000)).

[23]See footnote 9 for an explanation of the terminology.

worker on a job. The last term reflects the capital loss accruing to the intermediary when the call sheet relationship with the worker gets separated by an exogenous separation shock κ (see footnote 22).

The value of a worker on assignment to the intermediary is given by

$$rI^{tJ}\left(\epsilon\right) = f\left(\epsilon\right) - w^t\left(\epsilon\right) + \lambda\eta^{tI}\int_{-\infty}^{\epsilon_u}\left[\max\left\{S^t\left(x\right),0\right\} - S^t\left(\epsilon\right)\right]dF\left(x\right).$$

This equation reflects the fact that a worker who is working on a temporary job is paid by the intermediary a wage $w^t\left(\epsilon\right)$. This wage payment is made out of the fee $f\left(\epsilon\right)$ the intermediary receives from the firm. Otherwise, this equation is to be interpreted as equations 2.5, 2.3 and 2.6.

2.2.7. Labor Market Stocks in the Steady State

In this section, I derive the equations that determine employment levels in the steady state. Workers can be in four states: They can be unemployed (corresponding mass is u), on the call sheet of an intermediary (u^c) and they can be employed in a temporary (e^t) or in a regular job (e^r). Since the population of workers is normalized to one we have to have

$$1 = e^r + u^c + u + e^t \tag{2.7}$$

Flows in and out of these stocks are equalized in the steady state. The flows in and out of call-sheets u^c have to satisfy

$$up^c + \lambda F\left(\epsilon_R^t\right)e^t = \left(p^t + \kappa\right)u^c. \tag{2.8}$$

The left-hand side are inflows which are coming from the pool of the unemployed and from temporary employment relationships that get separated[24]. The right-hand side are outflows which consist of workers that transfer into temporary jobs and workers who get separated from their intermediary and return to the pool of the unemployed.

The flows into and out of regular employment e^r have to satisfy

---

[24]The separation rate is going to turn out to be $\lambda F(\epsilon_R^t)$. In this formulation, it is assumed that the separation decision in the regular and in the temporary labor market has the reservation property. It will be demonstrated in section 2.3.1 that this is indeed the case.

$$p^r u = e^r \lambda F\left(\epsilon_R^r\right). \tag{2.9}$$

The left-hand side are inflows from the unemployed that find a regular job and the right-hand side are outflows which consist of those regular jobs that receive an idiosyncratic productivity shock and are destroyed as a consequence.

The flows into and out of temporary employment e^t are analogously given by

$$u^c p^t\left(\theta^t\right) = e^t \lambda F\left(\epsilon_R^t\right). \tag{2.10}$$

The population constraint 2.7 together with equations 2.8, 2.9 and 2.10 determine the equilibrium values of u, e^r, e^t and u^c *given* thresholds e_R^t and e_R^r as well as labor market tightnesses θ^t, θ^r and θ^c as shown in appendix A.2.

2.3. Equilibrium

In this section, it is at first described how to solve the model. Then, some properties of the equilibrium are derived. Subsequently, results regarding existence and uniqueness of the equilibrium are provided.

2.3.1. Solving The Model

To solve the model, it is first argued that, as in the standard random search model of the labor market with endogenous job destruction, the job destruction decision in both labor markets has the reservation property[25]. To see this, notice that equations 2.3 and 2.4 imply that $F^{tJ}\left(\epsilon\right)$ and $F^{rJ}\left(\epsilon\right)$ are linearly increasing in ϵ. From the Nash bargaining assumption, this implies that $W^{rJ}\left(\epsilon\right)$, $W^{tJ}\left(\epsilon\right)$ and $I^{tJ}\left(\epsilon\right)$ are also linearly increasing in ϵ.[26] Nash bargaining further implies that both parties agree on the job destruction decision.[27] Therefore, Lemma 1 can be stated.

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[25]Reservation property here means that all jobs characterized by an ϵ below a certain threshold ϵ_R are destroyed whereas jobs characterized by an ϵ above ϵ_R keep producing.

[26]Nash bargaining implies that $\eta^{tW}\left(F^{tJ}\left(\epsilon\right) - F^{tV}\right) = \eta^{tF}\left(W^{tJ}\left(\epsilon\right) + I^{tJ}\left(\epsilon\right) - W^{tV} - I^{tV}\right)$ and $\eta^{rW}\left(F^{rJ}\left(\epsilon\right) - F^{rV}\right) = \eta^{rF}\left(W^{rJ}\left(\epsilon\right) - W^u\right).$

[27]This is because if one party wishes to leave the match, the other party also wish to leave (see the equations in footnote 26).

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Lemma 1. *The job destruction decision in both labor markets has the reservation property. Further, all involved parties agree on the job destruction decision.*

The thresholds below which matches are dissolved in the regular and in the temporary labor market are denoted by ϵ_R^r and ϵ_R^t.

The key endogenous variables in this setting are the five variables $(\theta^r, \theta^t, \theta^c)$ and $(\epsilon_R^r, \epsilon_R^t)$. Knowledge of these variables allows to obtain all other equilibrium variables. Appendix A.3.1 shows how to derive with the help of lemma 1 the following five equations which determine the equilibrium values of these variables.

The first two of these equations are the job creation conditions for firms in the regular

$$\frac{k}{q^r} = \eta^{rF} \left[\frac{\sigma (\epsilon_u - \epsilon_R^r)}{r + \lambda} \right] \tag{2.11}$$

and in the temporary labor market

$$\frac{k}{q^t} = \eta^{tF} \left[\frac{\sigma (\epsilon_u - \epsilon_R^t)}{r + \lambda} \right]. \tag{2.12}$$

These expressions state that in both labor markets the expected costs of finding a worker (left-hand side of both equations) have to equal the expected discounted benefits from the match to the firm for which the right-hand side of both equations is an expression.

The job destruction condition for jobs in the regular labor market in this environment is given by

$$
\begin{aligned}
0 \;=\; & p + \sigma \epsilon_R^r + \frac{\sigma \lambda}{r + \lambda} \left[\int_{\epsilon_R^r}^{\epsilon_u} \left[1 - F(x) \right] dx \right] \\
& - \left[\underbrace{b + \theta^c \frac{\eta^{cW}}{\eta^{cI}} \left[k^{cI} \right] + \theta^r \left[\frac{\eta^{rW}}{\eta^{rF}} k \right]}_{rW^u} \right].
\end{aligned}
\tag{2.13}
$$

As in the standard Mortensen and Pissarides (1994) model, this equations says that at the job destruction threshold ϵ_R^r the benefits of remaining in the match have to exactly equal the opportunity costs associated with remaining in the match. The benefits are as in the standard (one labor market) environment: they consist of the current output

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plus an option value that reflects the fact that if the worker firm pair remains together they might receive a new productivity shock that lies above the reservation threshold. The costs are standard as well in the sense that they are an expression for the worker's imputed interested income from being unemployed rW^u (which are the *opportunity* costs of the match). In the set-up here, this value has an additional component (relative to the standard model with just one labor market) since unemployed workers might receive job offers from both labor markets. This has important implications for the existence of equilibrium (discussed in section 2.3.2), and also represents the channel through which spillover effects from one labor market into the other will take place.

The job destruction condition for jobs in the temporary labor market can be expressed as

$$
\begin{aligned}
0 \quad = \quad & p + \sigma \epsilon_R^t + \frac{\lambda \sigma}{r + \lambda} \left[\int_{\epsilon_R^t}^{\epsilon_u} \left[1 - F(x) \right] dx \right] \\
& - \left[\underbrace{ b + \theta^c k^{cI} \frac{\eta^{cW}}{\eta^{cI}} + \theta^r \frac{\eta^{rW}}{\eta^{rF}} k }_{rW^u} \right] - r \frac{k^{cI}}{q^c} \frac{1}{\eta^{cI}}.
\end{aligned}
\tag{2.14}
$$

This condition is identical to the job destruction condition in the regular labor market except for the very last term which increases the (opportunity) costs of matches in the temporary labor market over and above the ones in the regular labor market. This term represents the opportunity costs the intermediary incurs when staying in the current match. These costs rise with the maintenance costs of an empty call-sheet k^{cI} and fall with the rate at which empty call-sheets are filled.

When combining the two job destruction conditions, equations 2.13 and 2.14, one gets the following equation

$$
\begin{aligned}
\sigma \epsilon_R^r + \frac{\sigma \lambda}{r + \lambda} \left[\int_{\epsilon_R^r}^{\epsilon_u} \left[1 - F(x) \right] dx \right] \quad = \quad & \\
\sigma \epsilon_R^t + \left[\frac{\lambda \sigma}{r + \lambda} \right] \times \int_{\epsilon_R^t}^{\epsilon_u} \left[1 - F(x) \right] dx - r \frac{k^{Ce}}{\eta^{cI} q^C} \quad & .
\end{aligned}
\tag{2.15}
$$

Since the benefits of the job in both markets are increasing in the reservation threshold,

this equation allows us to immediately state the following proposition:

Proposition 1. *If both labor markets are open, then job destruction in the temporary labor market is higher than in the regular labor market, that is $\epsilon_R^r < \epsilon_R^t$.*

From this result we can then derive the following corollary

Corollary 1. *If $\eta^{tF} \leq \eta^{rF}$ then $q^r < q^t$.*

The corollary immediately falls from proposition 1 together with the fact that the job creation conditions (equations 2.11 and 2.12) imply a positive relationship between the vacancy filling rate q and the job destruction rate ϵ_R.

It has been shown that in any equilibrium in which intermediaries exist one must have that temporary jobs are destroyed more often than regular jobs, and, further, if ones assumes that the firm can not bargain better vis-a-vis the intermediary then vis-a-vis the worker, then vacancies in the temporary market have to have a quicker filling rate. Therefore, the model generates two of the key characteristics of jobs in the THS industry endogenously: quick filling rates and short duration which is synonymous with high turnover.

The last of the five equilibrium equations is derived from the assumption that there is free-entry into the creation of empty call sheets. It is given by

$$
(r + \kappa) \frac{k^{cI}}{q^c} = \eta^{cI} \left[\underbrace{\left[\frac{1 - \eta^{tF}}{\eta^{tF}} \right] \theta^t k - \left[\overbrace{b + \theta^c k^{cI} \frac{\eta^{cW}}{\eta^{cI}} + \theta^r \frac{\eta^{rW}}{\eta^{rF}} k}^{rW^u} \right]}_{S^c} \right] . \quad (2.16)
$$

This equation states that the costs of filling a call sheet with a worker (left-hand side) have to equal the benefits the intermediary enjoys from having a worker on his call sheet. These benefits are given by the product of the surplus from the match between the intermediary and the worker and the share of this surplus that goes to the intermediary. The surplus is composed of the value of unemployment which the worker gives up when being together with the intermediary and a term which represents the value of searching for a client firm.

With the five equations above one can define equilibrium as follows

Definition 1. In this environment, a *steady state equilibrium* (with both labor markets open) is given by a tuple $(\theta^r, \theta^t, \theta^c, \epsilon^r_r, \epsilon^t_r)$ that satisfies equations 2.11 and 2.12, 2.13, 2.14, 2.16. The corresponding steady state labor market stocks are then given by equations A.1, A.2, A.3 and A.4.

2.3.2. Existence and Uniqueness of Equilibrium

In the previous section, equations were derived that can be used to solve the model for an equilibrium in which both labor markets are operating. Further, some characterization of this equilibrium was provided. However, the characterization was made conditional on the fact that the equilibrium is indeed such that both labor markets are operating. This section is going to provide conditions under which both labor markets are indeed operating. Discussing existence of equilibrium in this setting is interesting because it is not as readily guaranteed as in the standard one-sector random search model with endogenous job destruction. Intuitively, this is because of the spillover effects the two labor market exert on each other. To see this more formally, notice that in an environment with only one labor market the job destruction condition (equation 2.13) will be positive for small θ^r and eventually negative for large θ^r if production at the highest possible idiosyncratic shock is worthwhile[28]. In an environment with two labor markets and workers searching in both labor markets, one can immediately see from equation 2.13 that this condition is not enough for guaranteeing the existence of a θ^r that solves equation 2.13 since $\theta^c > 0$ might still lead to a negative surplus *even though* θ^r is arbitrarily small.

Proposition 2 states conditions under which an equilibrium with both markets exist.

Proposition 2. *An equilibrium in this economy with both markets open exists if*

$$FE^{int}(\theta^c) =$$

$$\eta^{cI}\left[\left[\frac{1 - \eta^{tF}}{\eta^{tF}}\right]f_{\theta^t}(\theta^c)k - \left[b + \theta^c\frac{\eta^{cW}}{\eta^{cI}}k^{cI} + f_{\theta^r}(\theta^c)\frac{\eta^{rW}}{\eta^{rF}}k\right]\right] - (r + \kappa)\frac{k^{cI}}{q^C} \quad (2.17)$$

is s.t. $FE^{int}(0) > 0$ *and* $FE^{int}\left(\frac{\eta^{cI}}{\eta^{cW}}\frac{1}{k^{cI}}[p + \sigma\epsilon_u - b]\right) < 0$ *where*

$$0 = \tilde{JD}^t(\theta^c, f_{\theta^t}(\theta^c)) =$$

$$p + \sigma\epsilon^t_R(f_{\theta^t}(\theta^c)) + \frac{\lambda\sigma}{r + \lambda}\int_{\epsilon^t_R(f_{\theta^t}(\theta^c))}^{\epsilon_u}[1 - F(x)]\,dx - f_{\theta^t}(\theta^c)k\frac{(1 - \eta^{tF})}{\eta^{tF}} + \kappa\left[\frac{1}{\eta^{cI}}\right]\frac{k^{cI}}{q^c} \quad (2.18)$$

---

[28]Formally, if parameters satisfy $p + \sigma\epsilon_u - b > 0$

with

$$\epsilon_R^t \left(\theta^t \right) = \epsilon_u - \frac{k}{q^t \left(\theta^t \right)} \times \left[\frac{r + \lambda}{\eta \sigma} \right]$$

and

$$0 = \tilde{JD}^r \left(\theta^c, f_{\theta^r} \left(\theta^c \right) \right) =$$

$$p + \sigma \epsilon_R^r \left(f_{\theta^r} \left(\theta^c \right) \right) + \frac{\sigma \lambda}{r + \lambda} \left[\int_{\epsilon_R^r(f_{\theta^r}(\theta^c))}^{\epsilon^u} \left[1 - F \left(x \right) \right] dx \right] - \left[b + \theta^c \frac{\eta^{cW}}{\eta^{cI}} \left[k^{cI} \right] + f_{\theta^r} \left(\theta^c \right) \left[\frac{\eta^{rW}}{\eta^{rF}} k \right] \right] \quad (2.19)$$

with

$$\epsilon_R^r \left(\theta^r \right) = \epsilon_u - \frac{k}{q^r \left(\theta^r \right)} \times \left[\frac{r + \lambda}{\eta \sigma} \right]$$

and $f_{\theta^t} \left(\theta^c \right)$ ($f_{\theta^r} \left(\theta^c \right)$) denotes an implicit function describing the relation between θ^c and (θ^r) θ^t such that the job destruction condition in the temporary (regular) labor market is satisfied.

Further, if an equilibrium with both labor markets exists, then it is unique.

The full proof of proposition 2 can be found in section A.3.2 of the appendix. The idea of the proof is that in any equilibrium in which both markets are open, there has to be a relation between θ^c and θ^r and θ^c and θ^t such that equations 2.18 and 2.19 are satisfied. This defines two implicit functions: $\theta^t = f_{\theta^t} \left(\theta^c \right)$ and $\theta^r = f_{\theta^r} \left(\theta^c \right)$ from equations 2.18 and 2.19. Further, equation 2.19 constrains the maximum value of θ^c to be $\frac{\eta^{cI}}{\eta^{cW}} \frac{1}{k^{cI}} \left[p + \sigma \epsilon_u - b \right]$ since at this value θ^r is zero. One can then show that the free-entry condition, that is equation 2.17, is downward sloping in θ^c. Therefore, for an equilibrium featuring intermediaries to exist, it is a necessary condition to have $FE^{int} \left(0 \right) > 0$. Intuitively, this means that in the best possible scenario for the intermediaries (θ^c arbitrarily small), they must be willing to enter. Of course, one also has to have for an equilibrium with both labor market operating that at the maximum permissible value of θ^c the free-entry condition is negative, that is $FE^{int} \left(\frac{\eta^{cI}}{\eta^{cW}} \frac{1}{k^{cI}} \left[p + \sigma \epsilon_u - b \right] \right) < 0$, as otherwise only an equilibrium without a regular labor market is attainable. Uniqueness of the equilibrium falls immediately from the fact that it can be shown that equation 2.17 is monotone.

After providing general conditions under which an equilibrium with two labor markets exists in proposition 2, it is now derived that the necessary condition $FE^{int} \left(0 \right) > 0$

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can only be satisfied if the intermediary has some advantage vis-a-vis the regular labor market for the worker. To make the argument clear, a case is considered where the firm's bargaining weight is identical in both markets, that is $\eta^{tF} = \eta^{rF} = \eta^{F}$. For this case one can proof the following proposition.

Proposition 3. *If $\eta^{rF} = \eta^{rt} = \eta^{F}$ and $q^{r}(\theta^{r}) = q^{t}(\theta^{t})$ whenever $\theta^{t} = \theta^{r}$ (meaning matching functions are identical), intermediaries are not finding it worth to enter, that is $FE^{int}(0) < 0$.*

Proof. It will be shown that given $\eta^{rF} = \eta^{rt} = \eta^{F}$ and $q^{r}(\theta^{r}) = q^{t}(\theta^{t})$ whenever $\theta^{t} = \theta^{r}$ we have $FE^{int}(0) < 0$ under all circumstances. To see this, write equation 2.16 evaluated at zero as

$$FE^{int}(0) = \eta^{cI}\left[-b + k\frac{1-\eta^{F}}{\eta^{F}} \times [f_{\theta^{t}}(0) - f_{\theta^{r}}(0)]\right]. \qquad (2.20)$$

One can show that $\tilde{JD}^{t}(0, f_{\theta^{t}}(0))$ and $\tilde{JD}^{r}(0, f_{\theta^{r}}(0))$ (equations 2.18 and 2.19) imply that indeed $f_{\theta^{t}}(0) > f_{\theta^{r}}(0)$. Notice that under the assumption of identical matching efficiency, that is $q^{r}(\theta) = q^{t}(\theta)$, it is immediately implied that $\epsilon_{R}^{r} > \epsilon_{R}^{t}$ from the job creation conditions (equations 2.11 and 2.12). This information is now used to sign equation 2.20 given what has been assumed in the proposition. To do this, subtract $\tilde{JD}^{r}(0, f_{\theta^{r}}(0))$ from $\tilde{JD}^{t}(0, f_{\theta^{t}}(0))$ (equation 2.18 from 2.19) to arrive at

$$\sigma\epsilon_{R}^{r}(\theta^{r}) + \frac{\sigma\lambda}{r+\lambda}\left[\int_{\epsilon_{R}^{r}(\theta^{r})}^{\epsilon^{u}}[1-F(x)]\,dx\right] - \left[\sigma\epsilon_{R}^{t}(\theta^{t}) + \frac{\lambda\sigma}{r+\lambda}\int_{\epsilon_{R}^{t}(\theta^{t})}^{\epsilon_{u}}[1-F(x)]\,dx\right] +$$
$$-b + \left[\theta^{t} - \theta^{r}\right]k\frac{1-\eta^{F}}{\eta^{F}} = 0$$

Notice that the second line is exactly the term one is interested in signing. It can be easily shown that, since $\epsilon_{R}^{r} > \epsilon_{R}^{t}$, the first line is positive. Therefore, it has to be that the second line is negative. This completes the proof. □

Importantly, it was established that in this environment the intermediary needs some special ability to exist. The previous condition suggests immediately matching ability as a possible candidate.[29] Formally, in this environment, "matching ability" means that $q^{r}(\theta^{r}) < q^{t}(\theta^{t})$ whenever $\theta^{r} = \theta^{r}$. Notice, within the context of the proof, dropping the assumption that $q^{r}(\theta^{r}) = q^{t}(\theta^{t})$ whenever $\theta^{r} = \theta^{r}$ means that from $f_{\theta^{t}}(0) > f_{\theta^{r}}(0)$ one can not conclude $\epsilon_{R}^{r} > \epsilon_{R}^{t}$ anymore.

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[29]The other possible special ability is bargaining ability.

In summary, in this model, if an intermediary with a particular ability in matching exists, then the employment relationships created by this intermediary will be such that the fix costs of search associated with them will be low and the duration of these employment relationships will be short. Further, turnover in the intermediated labor market exceeds turnover in the regular labor market.

2.4. Numerical Analysis

This section numerically investigates the implications of the model for two possible explanations for the secular growth of employment in the THS industry since the early 1970s (see figure 2.1). The first explanation is related to technological progress, that is to the ability of the THS industry to perform their services. The second explanation is a change in the economic environment in the form of an increase in idiosyncratic uncertainty. In the following sections, I explain my choice of functional forms and parameters used in the numerical analysis of the model, I discuss briefly the associated steady state and I analyze the response of the model to an increase in the matching ability of intermediaries and a rise in idiosyncratic uncertainty.

2.4.1. Calibration

Since the model above is based on a random search model of the labor market with endogenous job destruction, I follow the original Mortensen and Pissarides (1994) paper whenever it is possible in the choice of functional forms and parameters. Consequently, the model operates at a quarterly frequency ($r = 0.01$). It is assumed that the functional form of the matching function in the regular labor market is Cobb-Douglas $m^r = A^r \times u^{l^r} v^{1-l^r}$ and the idiosyncratic shock is uniformly distributed on the interval $[\epsilon_l, \epsilon_u]$. These "standard" parameter values are depicted in table 2.1.

Unfortunately, in my model, standard values for unemployment benefits[30] are not compatible with an equilibrium in which intermediaries are willing to enter the labor market. Ultimately, this goes back to the fact that in the model workers do not get payed unemployed benefits when they are on the call-sheet of an intermediary (but not working in a temporary job). The fact that, therefore, workers have to be compensated by the intermediary for giving up unemployment benefits makes intermediation prohibitively

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[30]Meaning $b \in [0.4, 0.925]$ - see for instance Shimer (2005) and Hagedorn and Manovskii (2008).

Parameter	Description	Value
r	interest rate	0.01
p	aggregate productivity	1
b	unemployment benefits	0*
λ	job-specific shock arrival rate	0.1
σ	job-specific shock disperson	0.0375
l^r	search elasticity of matching (regular labor market)	0.72
η^{rW}	worker's share of the surplus (regular labor market)	0.72
A^r	matching scaling parameter (regular labor market)	4
k	vacancy posting costs	0.2**
ϵ_u	upperbound support idiosyncractic shock	1
ϵ_l	lowerbound support idiosyncractic shock	-1

Table 2.1.: Standard parameter values. *this parameter is 0.92 in Mortensen and Pissarides (1994). See the discussion in the text. **this parameter is not reported in Mortensen and Pissarides (1994) but when I tried this value in their model it gave quantitative results that are close to the ones they report in their paper.

expensive in the current version of the model. Therefore, to be able to conduct an analysis in which intermediated employment relationships exist, I opted for setting $b = 0$.

As pertaining to the remaining "non-standard" functional forms and parameters, I proceed as follows: I take the two other matching functions of the model to be of the Cobb-Douglas variety as well, that is $m^c = A^c \times u^{l^c}v^{1-l^c}$ and $m^t = A^t \times u^{l^t}v^{1-l^t}$. This seems to be a reasonable choice given there is to my knowledge no estimate or study on these functions available.[31] For the same reason, I set the elasticity parameters of the two matching functions to the value of l^r in table 2.1. With respect to the remaining bargaining weights of the model, I assume that regular firms in the intermediated labor market can appropriate the same share from the surplus of a match as they do in the regular labor market ($\eta^{tF} = \eta^{rF}$). Intermediaries and workers have identical bargaining power, $\eta^{cW} = 0.5$. I do the former since this is in line with my proposition 3 and I do not have better information on the parameter. I do the latter simply because I do not have any better information on the parameter as of yet. I also set the vacancy maintenance cost of intermediaries k^{cI} to the same value as the one of regular firms and I pick an exogenous separation rate for intermediary worker relationships of $\kappa = 0.5$. Again there are no estimates available for these parameters, these values do not seem to be

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[31]Neugart and Storrie (2005), as far as I know the only other paper that investigates the THS industry in a search and matching environment, also assume a Cobb-Douglas technology in all sectors.

Parameter	Description	Value
l^c	search elasticity of matching (call-sheet market)	0.72
A^c	matching scaling parameter (call-sheet market)	0.05
l^t	search elasticity of matching (temporary labor market)	0.72
A^t	matching scaling parameter (temporary labor market)	10
η^{tF}	bargaining power of the firm (temporary labor market)	0.28
η^{cW}	bargaining power of the worker vis-a-vis the intermediary	0.5
k^{cI}	vacancy maintenance cost intermediaries	0.2
κ	separation rate workers intermediaries	0.5

Table 2.2.: Model specific parameter values.

totally unreasonable and values close to those chosen do not influence the qualitative results I obtain below. A^c and A^t are then chosen such that I obtain a realistic share of intermediated relationships in the resulting steady state equilibrium.

Table 2.3 depicts the equilibrium outcome associated with the parameters above.

The model, in this calibration, generates a number of intermediated employment relationships that is close to the number observed in reality.[32] Further, the model, as predicted in the analytical analysis of the equilibrium, does generate a shorter duration of temporary relative to regular jobs as the values for d^t and d^{r}[33] in table 2.3b demonstrate. Additionally, temporary jobs are much quicker to fill then regular jobs from the perspective of regular firms (q^r vs q^t). The duration rates, however, are both two large relative to the ones found in reality and the difference between them is too small.[34]

Unfortunately, employment in regular jobs is too high and the unemployment rate is too low. This is both due to the fact that I had to opt for setting unemployment benefits to zero. Consequently, labor market tightness in the regular labor market $\theta^r \equiv \frac{p^r}{q^r}$ is too high and so is the associated job finding rate p^r.[35] Further, the model generates a temporary labor market in which intermediaries are able to add workers to their call

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[32]Employment in the THS industry actually peaked in 2000. In that year, it accounted for about 2.0% percent of U.S. employment (see figure 2.1 and for instance Luo et al. (2010) chart 1 and page 4.)

[33]d^t (d^r) is expected job duration in the temporary (regular) labor market. It is defined as $d^t = \frac{1}{\lambda F(\epsilon_R^t)}$ $\left(d^r = \frac{1}{\lambda F(\epsilon_R^r)} \right)$ which is the expected duration of receiving a shock that is below the job destruction threshold.

[34]In the United States, all jobs last for about 2.5 years (see Shimer (2005)) on average whereas temporary jobs last for about 2.5 months on average (see American Staffing Association (2010)). The job durations here imply regular jobs lasting on average for about 4 years and temporary jobs lasting on average for 3 years.

[35]At the quarterly frequency here, p^r implies that it takes workers about 3 weeks to find a regular job whereas in reality this number is closer to nine weeks.

	e^r	e^t	u	u^c
Model	0.9694	0.0186	0.0119	0.00013
US data	0.92	0.02	0.06

(a) Labor market stocks. Shimer (2005) reports the unemployment rate to be 5.61% in an average month in the US economy. Since I do not have data on u^c available, and since workers on the call-sheet of a THS agency but not on assignment are counted as unemployed in the United Stata, I say that in the data $u + u^c = 0.06$. The value for e^t comes from the fact that since the early 2000s employment in the THS industry has been around 2% in the US economy.

	q^r	p^r	d^r	q^t	p^t	d^t	q^c	p^c
Model	2.4555	4.8358	16.8703	6.0822	12.1332	11.9677	15.4721	0.0054
US data	2.84	1.35	10	-	-	0.83	-	-

(b) Vacancy filling and job duration rates. The data for q^r and p^r comes from Hagedorn and Manovskii (2008). The duration rates come from Shimer (2005) in the case of d^r and from American Staffing Association (2010) in the case of d^t. As explained in the text, there is no data available on the other variables.

Table 2.3.: Steady state equilibrium.

sheet very quickly (q^c is high), and they are also able to place them fast with a client firm (p^t high). The rate at which workers obtain offers from the intermediaries to join their call sheets p^c is low. As a consequence of a low p^c and a high q^t, the stock of workers on the call sheet of intermediaries but not working at a client firm u^c is very small as well. These numbers stem from the fact that intermediaries, in this model, have to compensate workers on their call sheet for giving up searching in the regular labor market. Therefore, having workers on their call sheet is expensive for intermediaries and this explains why u^c is so low and p^t is so high. Given the high value of p^t, it is also understandable that p^c is so low since higher values would not be consistent with a realistic share of employment in the THS industry e^t in total employment.

Consequently, one has to acknowledge that the mechanism proposed in the model is likely to be not fully able to account quantitatively for the difference in duration between temporary and regular jobs. This seems logical since the model at this stage ignores possible ex-ante differences in temporary vs permanent employment positions and the possibility of "on-the-job" search by workers on the call sheet of intermediaries.

In summary, the mechanism of the model is generating some of the observed difference in the duration of temporary vs regular jobs as well as a difference in the vacancy filling

rates of the two types of jobs. The model in its current form, however, seems to be a too simplified description of labor market intermediation as it is not able to give a full quantitative description of an intermediated labor market. This can be seen, for instance, in the troubles stemming from the need to set unemployment benefits to zero in the calibration and the undershooting of the empirical difference in the duration of intermediated and regular jobs. Despite these limitations, I am now going to use the model in this calibration to evaluate two theories that have been proposed to explain the growth of employment in the THS in the past 30 years.

2.4.2. The Effect of Technological Progress (rise A^t)

The first explanation I am going to consider relates the increase in intermediated employment relationships to technological progress. It maintains that the THS industry has disproportionally, relative to the regular labor market, benefited from innovations in, for instance, IT and was therefore able to increase its share in overall employment.[36]I will model a technological improvement that relatively benefited the THS industry as an increase in A^t, that is everything else equal intermediaries find it now easier to place workers.

Figure 2.2.: Responses of regular employment, intermediated employment, unemployment and job duration rates to an increase in idiosyncratic uncertainty.

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[36]Innovations in IT certainly have reduced the costs of applications for workers. Regular firms might have difficulties to deal with the resulting swarm of applications whereas more specialized firms such as labor market intermediaries find it easier to cope with these types of pitfalls of technological improvements (see Autor (2001) for an elaboration on this idea).

An improvement of the matching technology at the hand of the intermediaries propagates through the model as follows: regular firms now find it less costly to recruit workers in the intermediated labor market since they are now able to locate matches quicker. From the job creation condition of regular firms (equation 2.12), this leads to an increase in the job destruction threshold and, consequently, the duration of temporary jobs shortens (see figure 2.2, bottom right panel). As intermediaries get more efficient at matching workers to firms, they create more call-sheets (θ^c rises). The effect on the regular labor market of an increase in A^t is triggered by the change in the value of unemployment. In particular, as can be seen for instance in equation 2.13, the value of unemployment is going to move up due to the increased presence of THS firms (which implies that θ^c increases). As a consequence, maintaining jobs in the regular labor market becomes more expensive and therefore the job destruction threshold also moves up and, consequently, the duration of regular jobs decreases (see figure 2.2, bottom right panel). This means, from the job creation condition in the regular labor market (equation 2.11), that the job filling rate in this market q^r has to rise, which implies that labor market tightness in the regular labor market has to fall. The effect on labor market stocks in this experiment is (see also figure 2.2) such that temporary employment increases, both in absolute terms and relative to regular employment. The prevalence of regular employment decreases whereas unemployment moves down but not by a lot. In sum, total employment increases.

In conclusion, this model provides a mechanism that explains how technological improvements, that favor the THS industry relative to the regular labor market, lead to an increase in employment in the THS industry. Additionally, the model predicts that this increase in THS employment comes at the expense of regular jobs due to a negative spillover effect from the temporary labor market into the regular labor market. The overall effect on employment is positive but small.

2.4.3. The effect of increased dispersion in productivity (rise in σ)

The second possible explanation that I am going to consider is a change in the economic environment which takes the form of an increase in idiosyncratic uncertainty. This might be relevant because there is evidence that idiosyncratic uncertainty has increased since the 1970 (see Comin and Philippon (2005)) alongside the secular growth of employment in the THS industry. Further, the paper by Ono and Sullivan (2010) provides evidence that manufacturing firms increase the usage of temporary workers in response to in-

creases in uncertainty. I model an increase in idiosyncratic uncertainty as an increase in σ.
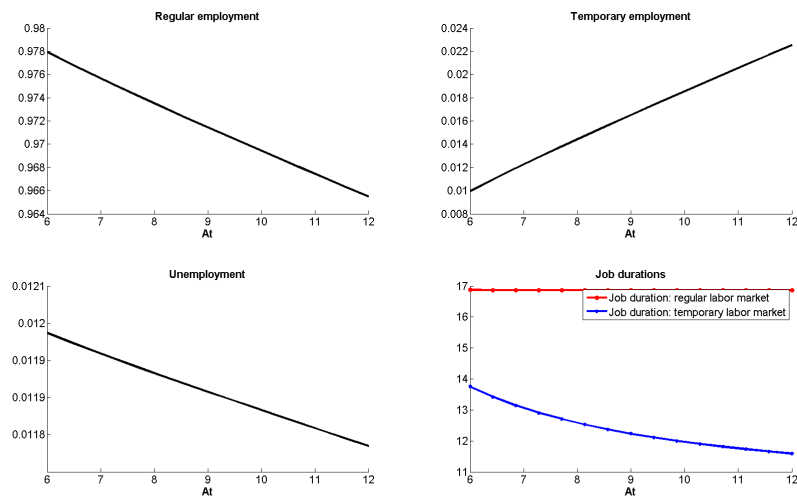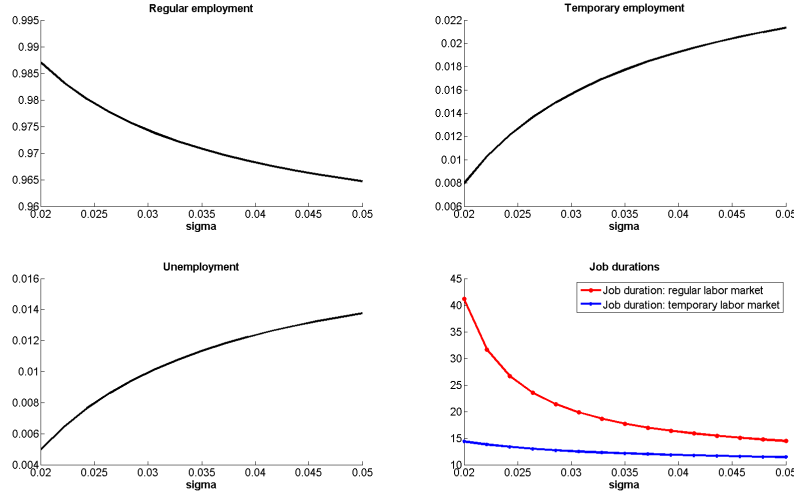

Figure 2.3.: Responses of regular employment, intermediated employment, unemployment and job duration rates to an increase in idiosyncratic uncertainty.

In response to an increase in idiosyncratic uncertainty, there is in both markets a direct impact on the job destruction thresholds (ϵ_R^r and ϵ_R^t) and on labor market tightness (θ^r and θ^t). Intuitively, in a setting with endogenous job destruction firms can shun the disadvantages of an increase in σ (which come in the form of a greater likelihood of low values of idiosyncratic productivity) by destroying jobs while reaping the benefits (a greater likelihood of high values of idiosyncratic productivity). Consequently, entry into both types of jobs becomes more attractive for firms, and both θ^t and θ^r move up. Additionally, both job destruction thresholds (ϵ_R^r and ϵ_R^t) move up (see figure 2.3).

While these effects are similar to the ones prevailing in a model with no intermediated labor market, in the present model there are several additional knock-on and spillover effects: the increase in θ^t leads to increased entry by intermediaries (θ^c rises) since they can now place their workers more easily. This increases the rate at which workers transit into call sheet relationships with intermediaries, p^c, and, on the flipside, decreases the rate at which intermediaries locate workers, q^c. The increase in θ^c then has a negative spillover effect on the regular labor market since contracting workers is now more expensive from the perspective of the firm. This is because the worker's outside option rU improves with θ^c (see for instance equation 2.13). This means, as before, that there is an additional negative effect on employment in the regular labor market, and,

indeeds the overall effect in this setting on regular employment is negative. The effect on temporary employment is positive, and, consequently, temporary employment rises absolutely and as a share of overall employment. The fact that temporary and regular employment move in two different directions is due to additional entry by intermediaries which influences job creation in the temporary labor market positively whereas it has a negative effect on entry in the regular labor market due to its effect on the value of unemployment which increases with additional entry by intermediaries.

In this section, I investigated the implications of a simple model of intermediated employment for two possible explanations for the secular increase in employment in the temporary help service industry since the 1970. I found that both technological progress and a rise in idiosyncratic volatility lead to an increase in employment in the THS industry. Both, increased idiosyncratic uncertainty and technological progress, require about a doubling of the respective parameter to generate the rise in intermediated employment observed in the data which seems plausible. When comparing the implications of the model for the two explanations in more detail, one can see that technological progress leads to a fall in unemployment whereas increased idiosyncratic uncertainty leads to a fairly sharpe increase in unemployment. Further, job durations in the regular labor market respond very strongly in the event of the uncertainty increase whereas its response is very muted in the case of the improvement in the matching technology. These two results seem to suggest that, according to the model here, technological progress is a more plausible explanation for the rise in THS employment in recent decades.

2.5. Conclusion

This paper provided and investigated a random search model with endogenous job destruction that was augmented with a second sector in which employment relationships are created through intermediaries. It was shown that in this setting intermediated employment relationships are of short duration and quick to form from the perspective of employers. Therefore, the model generates two of the main characteristics of jobs in the THS industry relative to regular jobs endogenously. It was further shown that a superior matching ability of intermediaries is a necessary condition for an equilibrium with intermediated jobs to exist. Lastly, I performed two comparative static exercises numerically in order to study the models implications for two narratives that have been put forward to explain the salient growth of employment relationships intermediated by

the THS industry. I found that both, technological progress that effects the matching efficiency of THS agencies and an increase in idiosyncratic uncertainty in the economy, lead to a rise in intermediated employment relationships in the model at hand.

The analysis in this paper suggests several exciting research directions that could be pursued in future work. For once, the model presented in this paper is extremely stylized in the sense that all jobs and workers are ex-ante homogeneous. In reality, there is probably a considerable amount of ex-ante heterogeneity in jobs that determines to a large degree the observed characteristics of temporary vs regular jobs. Incorporating ex-ante heterogeneity in jobs into the model is both challenging and promising since it could help to overcome some of the current model's less desirable features such as the too small difference in job duration rates between regular and intermediated jobs in the calibration. Additionally, investigating the aggregate properties of the model seems to be a very interesting path to pursue in future work. The reason is that the data seems to suggest that the role of employment relationships in the THS is especially pronounced around business cycle turning points during which employment in the THS industry accounts for a strongly disproportional share in the change of employment (for instance the industry was responsible for 11% of net employment losses in the Great Recession).

3. Chapter 2: The Impact of Uncertainty Shocks on a Dual Labor Market, with an Application to Spain

3.1. Introduction

In the early 1980s, many European labor markets were characterized by high unemployment and restrictive employment protection legislation.[1] Governments seeking to boost employment by making the labor market more flexible quickly ran into political and social obstacles.[2] As a consequence, many governments in Western Europe resorted to eliminating restrictions on the usage of *fixed-term contracts* in the hope to make the labor market more flexible and thereby increasing employment. This led to the emergence of *dual labor markets* in which a majority of workers is working on an indefinite contract, characterized by high employment protection, whereas an often large minority of workers is working on fixed-term contracts, which provided little employment protection.[3][4] Due to their pervasiveness, the consequences of fixed-term contracts on workers, firms and the labor market as a whole have been subject to intense debate by politicians, the

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[1] For an account of the European unemployment problem see Blanchard (2006).

[2] For an analysis of the political and social obstacles governments face when seeking to reform labor markets, see Saint-Paul et al. (1996).

[3] For instance, in Spain the usage of fixed-term contracts has been liberalised in 1984. Since then the temporary employment rate in Spain has soared from about 15% in 1987 to about 35% in the early 1990s. See the paper by Bentolila et al. (2008) for an account of the historical developments. While the temporary employment rate in Spain is by far the highest, there are many other European countries in which the share of temporary employment relationships in all employment relationships is around 15% (see for instance table 1 in Booth et al. (2002)).

[4] In this paper, "duality" always means that the labor market is segmented along the lines of a permanent and a fixed-term employment contract.

public at large and academics. This paper contributes to this debate by investigating how uncertainty shocks affect a dual labor market, and it does so by focussing on the case of Spain.

The case of Spain is particularly relevant since Spain is the economy in which fixed-term contracts are most widely spread: around one third of all employment relationships are temporary. Additionally, a recent literature initiated by Bloom (2009) has demonstrated, in the context of the US economy, that large exogenous fluctuations in uncertainty (*uncertainty shocks*) have quantitatively important macroeconomic consequences and can generate business cycle fluctuations. In figure 3.1, one proxy measure of uncertainty in the Spanish economy, quarterly volatility of the IBEX 35, the Spanish benchmark stock market index, clearly shows that volatility in the Spanish economy displays large bursts after, argueably exogenous, major shocks.

In this paper, I start with investigating how uncertainty shocks affect the Spanish labor market through the lense of a structural VAR model employing the identification strategy devised in Bloom (2009). I find that given this identification strategy an uncertainty shock leads to a drop in employment of workers on fixed-term contracts, a negligible reaction of employment of workers on permanent contracts and a recession. I also find, however, that the response to an uncertainty shock is very similar to the response to a first-moment shock to the VAR system.[5] I attribute this finding to the fact that agents might perceive the events that were used to identify uncertainty shocks as bad news shocks or as combinations of uncertainty shocks and bad news shocks. I turn, therefore, to the analysis of a quantitative model of the dual labor market in order to see to what extent the response functions from the empirical analysis can be rationalized.

The model is a dynamic stochastic partial equilibrium model of labor adjustment.[6] Key features of the model are the existence of two types of employment contracts (fixed-term and permanent employment contracts) as well as a driving process (revenue shock process) that is characterized by a time-varying second moment. Both types of employment contracts are subject to adjustment costs, and I allow for the attrition rates of workers on the two types of contracts to differ. I interpret the attrition rate associated with employment on fixed-term contracts as expiring fixed-term that the firm cannot extend

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[5]The first-moment shock is proxied by a shock to the stockmarket level.

[6]This type of model has been used to study a wide variety of issues related to labor demand. Relevant examples include Bentolila and Saint-Paul (1992), Goux et al. (2001) and Aguirregabiria and Alonso-Borrego (2014) (dual labor markets), Bloom (2009) and Lang (2012) (uncertainty shocks), Bentolila and Bertola (1990) (European unemployment) and Cooper and Willis (2009) (aggregate implications of adjustment costs).
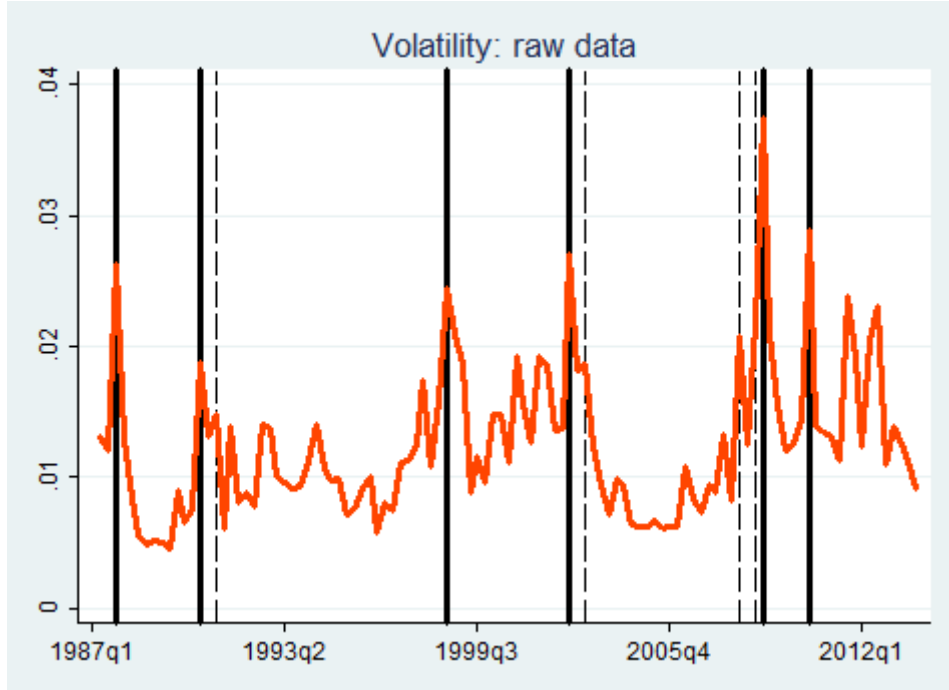
Figure 3.1.: Volatility measure (quarterly volatilities of the IBEX 35) with volatility events. The quarterly volatilities are obtained by computing the standard deviation of daily returns of the IBEX 35 that fall into a particular quarter. Vertical lines are large volatility events (from left to right): Black Monday (Q4 1987), Gulf War 1 (Q3 1990), Russian, LTCM default (Q3 1998), Worldcom and Enron/Prestige Oil Spill (Q3 2002), Gulf war II (Q1 2003), Credit crunch 1: Bear Stearns bailout (2008 Q1), Credit Crunch II: Lehman bankruptcy (2008 Q3), Credit Crunch III: Lehman aftermath (2008 Q4), European sovereign debt crises I: 1st Greek bailout program (2010 Q2). Straight lines use a stricter selection criterium than dashed lines (see section 3.2.1 for more details) .

further.[7] To my knowledge, this model is the first that features adjustment costs and ex-ogenous termination of fixed-term contracts in a dynamic stochastic partial equilibrium model of labor adjustment with aggregate shocks.

After calibrating the model economy to match key features of the Spanish labor market in the previous two decades, I analyze the impact of three types of shocks on the model economy: a (pure) second-moment shock, a (pure) first-moment shock and a combined first- and second-moment shock.

The *second-moment shock*[8] is analyzed in two environments. The first of these is a version of the model in which the adjustment of temporary labor is completely free for the firm. I find that in this environment a second-moment shock leads to a boom in temporary labor and a recession in permanent labor. The reason is that, as higher uncertainty in response to the shock has realized, in the aggregate, firms tend to substitute away from permanent labor to temporary labor since higher uncertainty entails the need to adjust labor more often and adjusting temporary labor is cheaper then adjusting permanent labor. The second environment in which I am considering a pure second-moment shock is the full version of the model where both types of labor are subject to adjustment costs and attrition. Intuitively, one could imagine that this type of model can generate responses to an uncertainty shock similar to those found in the empirical analysis. The reason is that adjustment costs mean that firms reduce their hiring and firing of both types of labor (wait-and-see effect) and at the same time continuing attrition leads to a severe recession in temporary labor whereas permanent labor, due to a very low attrition rate,[9] remains almost irresponsive. I find that this intuition is confirmed on impact of the uncertainty shock. The subsequent dynamics, however, are such that temporary labor recovers very quickly whereas permanent labor experiences again a relatively deep recession. The reason is the substitution effect described above.

Subsequently, I turn to the analysis of a *first-moment shock*[10] in the model. In this case, both temporary and permanent employment decrease gradually towards their respective troughs before, again gradually, returning back to their respective long-run levels. Further, the trough in temporary employment is, relative to its long-run level, much deeper

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[7]In the Spanish economy there is a limit on the maxium duration of fixed-term contracts (3 years for most of the period of time under consideration).

[8]The uncertainty shock is modelled as a jump in the second-moment of the driving process of the model that is revealed to firms one period in advance. This approach follows the literature sparked by Bloom (2009).

[9]The quarterly attrition rate on permanent labor in the Spanish economy is around 1%.

[10]In the model, the first-moment shock I consider is a standard aggregate TFP shock.

and quicker reached then the trough in permanent employment. Additionally, after the trough in total employment is reached, temporary labor accounts for the vast majority of net job creation in the economy. The resulting impulse response functions are similar to those obtained in the empirical section for the case of a first-moment shock, with the exception that permanent employment does display a significant negative reaction in the model.

Lastly, a combined *first- and second moment shock* is analyzed. A recent paper by Bloom et al. (2012) has shown that a combination of these two shocks provides a better description of business cycles in the United States than each of these shocks does on its own. I show that this result does not hold for the Spanish economy in the model considered here. In particular, the combined shock means that the response of temporary employment relative to the pure first-moment shock is biased towards zero and the reaction of permanent employment relative to the first-moment shock is biased towards minus infinity. Therefore, it appears that the strong difference in the variance of permanent and temporary employment over the business cycle that is observed in the data is better explained by a pure first-moment shock than by a combined first- and second-moment shock.

3.1.1. Literature

This paper is mainly related to two strands of literature: the literature on the quantitative impact of uncertainty shocks and the literature on the macroeconomic effects of duality in the labor market.

The literature on the quantitative impact of uncertainty shocks on employment and investment decisions was initiated by Bloom (2009). His paper, in turn, builds on the literature that investigates the effects of uncertainty on investment and employment decisions as well as on papers that studied the effect of adjustment costs on the choice of capital and employment. Important papers in the former literature are, for example, Hartman (1972),Abel (1983), Bernanke (1983) and Caballero (1991). The latter literature has benefited from the contributions of Fumio Hayashi (1982), Abel and Eberly (1994), Caballero et al. (1997) and Cooper and Willis (2009) among others. This paper takes from Bloom (2009) the idea that uncertainty shocks can have quantitatively important macroeconomic consequences and the way uncertainty shocks are modelled. Recent other papers that build on these ideas are Bloom et al. (2012) and Bachmann and

Bayer (2013), who investigate uncertainty shocks in a general equilibrium context, Arellano et al. (2011) and Gilchrist et al. (2010), who study how fluctuations in uncertainty interact with financial markets frictions, and Schaal (2010), who analyses fluctuations in uncertainty in a search model of the labor market.[11] The present paper further uses Bloom (2009)'s approach for identifying the impact of uncertainty shocks in the data. It contributes to the literature on uncertainty shocks by investigating their impact in an environment in which firms are allowed to make use of two different labor contracts in their employment decision.

The second strand of literature that is important for this paper is the literature on the macroeconomic impact of labor market duality. A particularly closely related paper with respect to the modelling environment is Bentolila and Saint-Paul (1992). They focus on the impact of aggregate productivty shocks on a labor market with two types of employment contracts in a partial equilibrium model of dynamic labor adjustment. Other papers with a similar modelling framework are Aguirregabiria and Alonso-Borrego (2014), who estimate a partial equilibrium model of a dual labor market that does not feature aggregate shocks, and Alonso-Borrego et al. (2006) ,who study the impact of duality in the labor market in a general equilibrium model with search frictions but without aggregate shocks. There is also a large literature that studies the impact of duality in the search and matching framework. This literature includes the papers by Blanchard and Landier (2002), Cahuc and Postel-Vinay (2002) and Bentolila et al. (2010). All these papers belong to a much bigger literature which tries to understand the abysmal performance of many European labor markets in recent decades (see Bertola (2008) for an introduction to this literature). My paper contributes to this literature by analysing how uncertainty shocks impact a dual labor market. It is further the first paper that investigates aggregate shocks in a dynamic firm model of labor demand with adjustment costs on both types of employment.

Lastly, there is a vast literature that investigates the impact of duality on labor market outcomes of individuals. This literature will be of some relevance in the calibration of the model. For an overview see Booth et al. (2002) and references therein.

The remainder of this paper is structured as follows: in section 3.2, I conduct the empirical analysis. Section 3.3 lays out the economic model. The quantitative analysis can be found in section 3.4. Section 3.5 concludes. The appendix contains robustness

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[11]Another interesting recent paper is Lang (2012) who studies what types of uncertainty shock generate the dynamics in Bloom (2009) and also provides an explanation for the disparate findings regarding the impact of uncertainty shocks in Bloom et al. (2012) and Bachmann and Bayer (2013).

checks for the empirical analysis and some additional information related to the model.

3.2. Empirical Analysis

In this section, I investigate the response of the Spanish labor market to an uncertainty shock through the lense of a structural VAR model using the identification strategy of Bloom (2009).

3.2.1. Uncertainty Measure and Data

The measure of quarterly uncertainty in the Spanish economy is derived from daily data of the main Spanish stock market index IBEX 35. This data is used to compute daily returns and subsequently the standard deviation of all returns that fall into a particular quarter.[12] This gives a series of quarterly volatilities of the IBEX 35 that goes from Q2 1987 to Q4 2013, which is the time period for which the IBEX 35 data exists. The series is plotted in figure 3.1.

Figure 3.1 shows that quarterly uncertainty in the Spanish economy displays large sudden spikes[13]. During these episodes, quarterly uncertainty in the Spanish economy often more than doubles relative to its level in normal times. Additionally, figure 3.1 demonstrates that these spikes can be associated with political and economic events that are arguably exogenous to the Spanish economy such as, for instance, Black Monday in Q4 1987 or Gulf war II in Q1 2003.[14]

All other data used in the analysis is available at a quarterly frequency and ranges from Q2 1987 to Q4 2013. Consequently, the time series consist of 107 observations in total.[15] The time series of real GDP comes from the OECD. The time series on employment on temporary and permanent contracts was obtained from the Instituto Nacional de

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[12]I compute quarterly volatilities since all other data is available at a quarterly frequency.

[13]Straight lines are at quarters where the volatility index is 1.65 standard deviations above its mean. Dashed lines are additionally at quarters where the volatility index was 1.28 standard deviations above its mean.

[14]One event that is possibly not exogenous to the Spanish economy is the first Greek bailout program in Q2 2010. I address this issue in the analysis below by conducting a robustness experiment in which I exclude the time period of the European sovereign debt crises from the analysis. Additionally, the events relating to the financial crises in 2008 might be viewed as a single volatility event. Again, I address this issue through robustness experiments in the analysis below.

[15]Unfortunately, time series data on the employment of workers on fixed-term contracts for the Spanish economy is not available for dates prior to Q2 1987.

Estadística which is the national statistic office of Spain. Since I am interested in an analysis at the business cycle frequency, I follow standard procedures in applying a Hodrick-Prescott filter (smoothing parameter equal to 1600) to the natural logarithm of all variables.

In Figure 3.2 and figure 3.3, I plot the raw data and the associated cyclical component for each times series employed in the analysis (figure 3.2 displays data related to the stock market and figure 3.3 data related to the real economy). Table 3.1 displays the standard deviation of each detrended series as well as the correlation of each detrended series with the detrended volatility measure and with detrended GDP. The figures and the table reveal the well known facts that employment on fixed-term contracts is more volatile than employment on permanent contracts and that the former is also tied closer than the latter to movements in GDP. Additionally, figure 3.3 reveals the spectacular growth of employment on fixed-term contracts that characterized the Spanish economy over much of the period considered in the analysis.

Figure 3.2 and table 3.1 further reveal that the volatility measure derived from the IBEX 35 is quite volatile relative to GDP and the two employment series. Further, the series of the level of the IBEX 35 and the volatility indicator derived from the IBEX 35 display a negative correlation indicating that times of high volatility are not necessarily times in which the stockmarket is in a state of crisis.
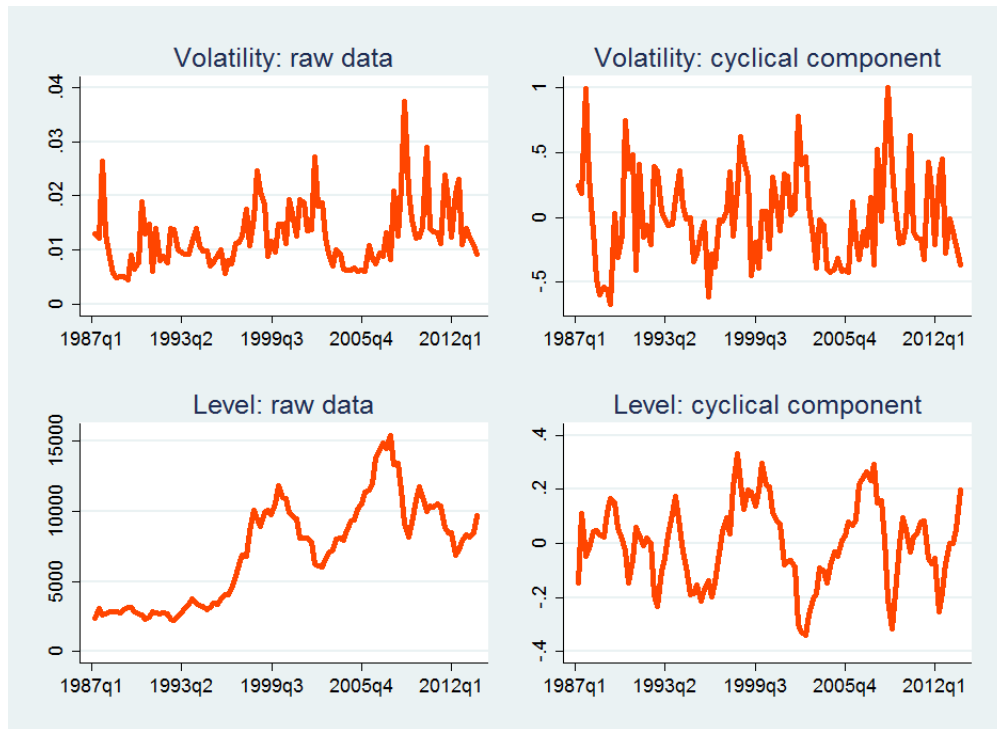
Figure 3.2.: Raw data (left-hand side) and cyclical component (right-hand side) of the IBEX35 and the volatility measure.

Variable	Standard deviation	Corr(x,volatiliy index)	Corr(x,GDP)
Volatility index	0.350	1	0.12
Stockmarket level	0.1499	-0.24	0.25
GDP	0.0153	0.12	1
Permanent employment	0.0162	0.24	0.5
Temporary employment	0.056	-0.18	0.65

Table 3.1.: Standard deviations and contemporaneous correlations of logged and detrended variables.
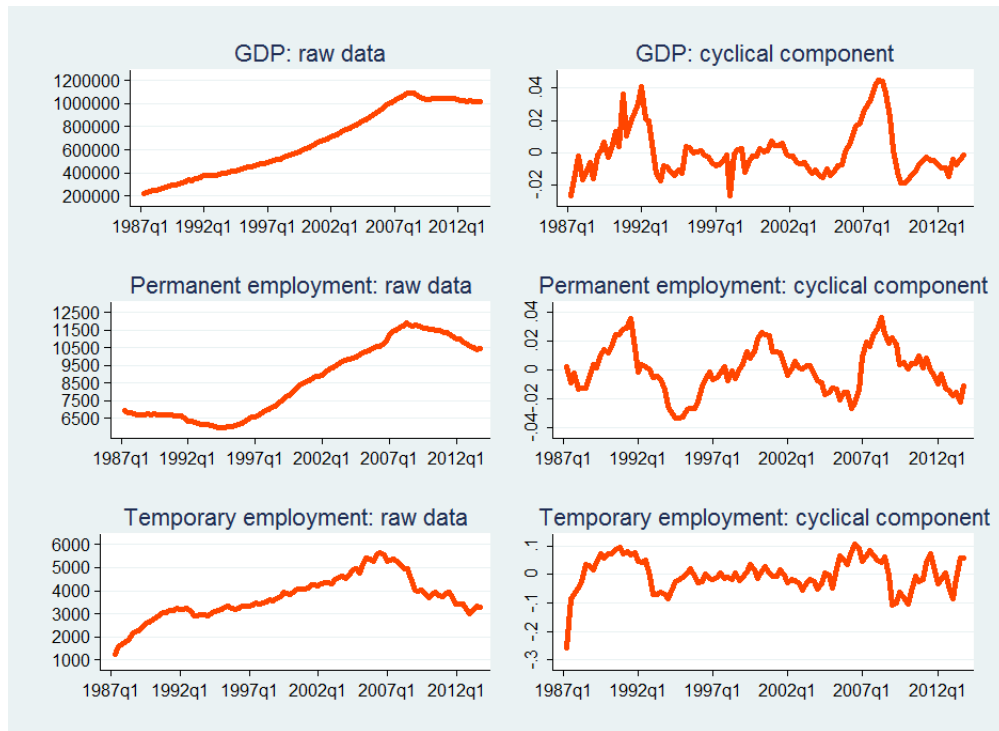
Figure 3.3.: Raw data (left-hand side) and cyclical component (right-hand side) of GDP, permanent and temporary employment.

3.2.2. Structural VAR analysis

In this section, first, the strategy used to identify the impact of uncertainty shocks on the Spanish economy is discussed. Second, I present the results for a baseline specification. Third, I discuss the robustness experiments I carried out (details of which are to be found in appendix B.1.1) and, fourth, I study the impact of a first-moment shock, proxied by a shock to the stock market level, on the Spanish economy.

As mentioned above, I borrow the strategy to identify the impact of uncertainty shocks on the Spanish economy from Bloom (2009) who empirically investigated the impact of uncertainty shocks on the US economy through the lense of a (structural) VAR model. His insight is that uncertainty shocks are caused by events that are exogenous to the economy under consideration. Therefore, it is justified to assume that shocks to the uncertainty measure employed affect the other variables in the VAR system contemporaneously but not vice versa which puts a restriction on the order of the variables in the VAR system. He then performs a wide variety of robustness checks to make sure that the results obtained from his baseline model do not depend on the order of the other variables in the VAR system, the definition of the exogenous events and or other spurious factors.[16]

I use a baseline model which includes the logged and detrended series of the volatility measure, employment on fixed-term contracts, employment on permanent contracts and GDP (in this order) with two lags. Figure 3.4 shows the estimated responses to an uncertainty shock (a shock to the volatility measure). The top left panel of figure 3.4 displays the response of the volatility measure. One can see that the volatility measure's response has a relatively short half-life time as inspection of the series shown in figure 3.1 suggested. The top right panel of figure 3.4 displays the response of employment on fixed-term contracts. It can be seen that employment on fixed-term contracts displays a significant negative reaction before returning to its long-run value. The response of employment on permanent contracts, displayed in the bottom left panel of figure 3.4, in contrast, does not display a significant reaction in response to the uncertainty shock. GDP, shown in the bottom right panel of figure 3.4, displays a (significant) recession in response to the uncertainty shock.

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[16]See section 2.2 in Bloom (2009) for the analysis of his baseline model and appendix A.3. for his robustness analysis.
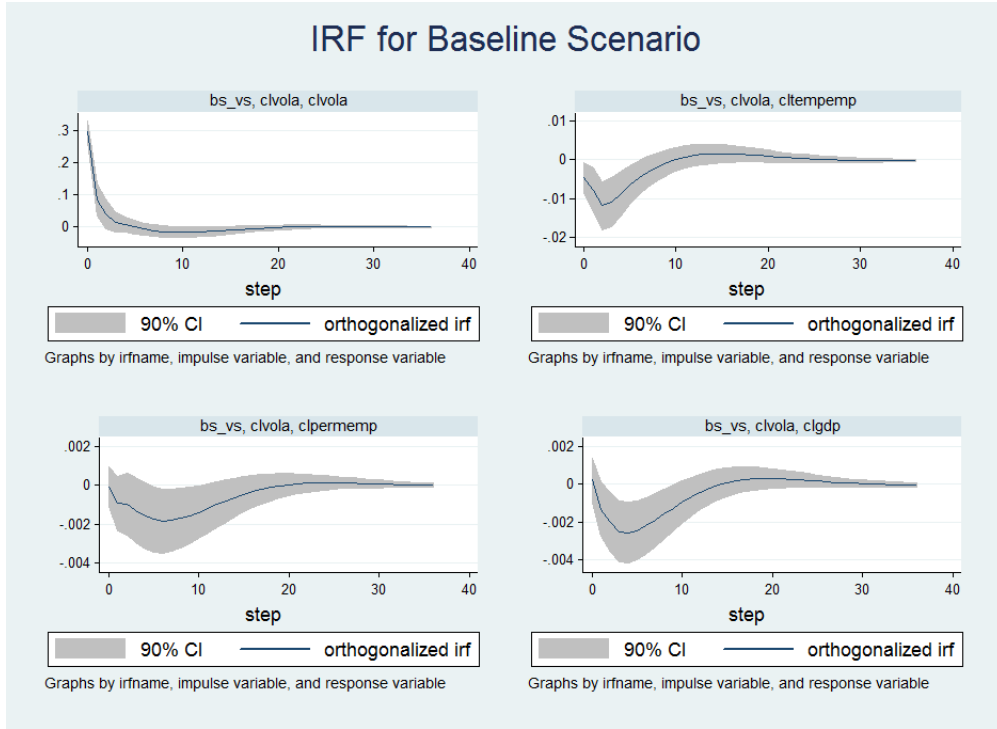
Figure 3.4.: Impulse-response functions to a volatility shock when the volatility measure is the actual volatility series: (clockwise from top left) uncertainty measure, temporary employment, GDP and permanent employment.

In appendix B.1.1, I demonstrate that the above findings are robust with respect to a set of changes in the specification of the VAR system. In a first set of experiments (see section B.1.1 in the appendix), I use, instead of the actual volatility measure as in figure 3.4, a binary series which takes on a value of 1 at each of the volatility shocks marked by the vertical lines in figure 3.1 and 0 otherwise. In case I use only "very large" volatility events (straight vertical lines in figure 3.1), the estimated impulse responses remain quantitatively very similar but they are not significant anymore. This is not surprising since in the time period covered by the data only six such "very large" volatility events occured. If we use all volatility events marked in figure 3.1 (straight and dashed vertical lines), the impulse responses of employment on fixed-term contracts and GDP are significant again. The results of this experiment are important since they give us confidence that the responses are indeed driven by the large, arguably exogenous, volatility shocks rather than by the many, possibly endogenous, smaller fluctuations of the volatility measure. In another experiment (see section B.1.1 in the appendix), I include the stock market level into the VAR system in order to make sure that the impact of stock market levels is already controlled for when looking at the impact of uncertainty shocks.

In an additional set of experiments (see section B.1.1 in the appendix), I confirm that the results displayed in figure 3.1 are robust towards excluding the period of the Euro crises from the analysis.[17]

Finally, I investigate the response of the VAR sytem in question to a (negative) first-moment shock to the stock market level. The corresponding impulse response functions are plotted in figure 3.5. It is apparent that these impulse response functions are quantitatively very similar to the responses to an uncertainty shock displayed in figure 3.4. This, unfortunately, makes it difficult at this stage to rule out the possibility that the impulse responses shown in figure 3.4 are not purely reflecting the response of the Spanish economy to an uncertainty shock. It seems, for instance, to be possible that the events that are behind the impulse response functions of figure 3.5 are perceived as bad news shocks (or a combination of bad news and an increase in uncertainty) by the agents constituting the Spanish economy and this is what drives the impulse responses in figure 3.5 *and* in figure 3.4.[18]

---

[17]I also conduct experiments to make sure that my results are robust towards the order of the two employment series and GDP in the VAR. These results are not reported in this document.

[18]For a summary article of the literature on how news can drive business cycle fluctuations see Paul Beaudry and Portier (2013).
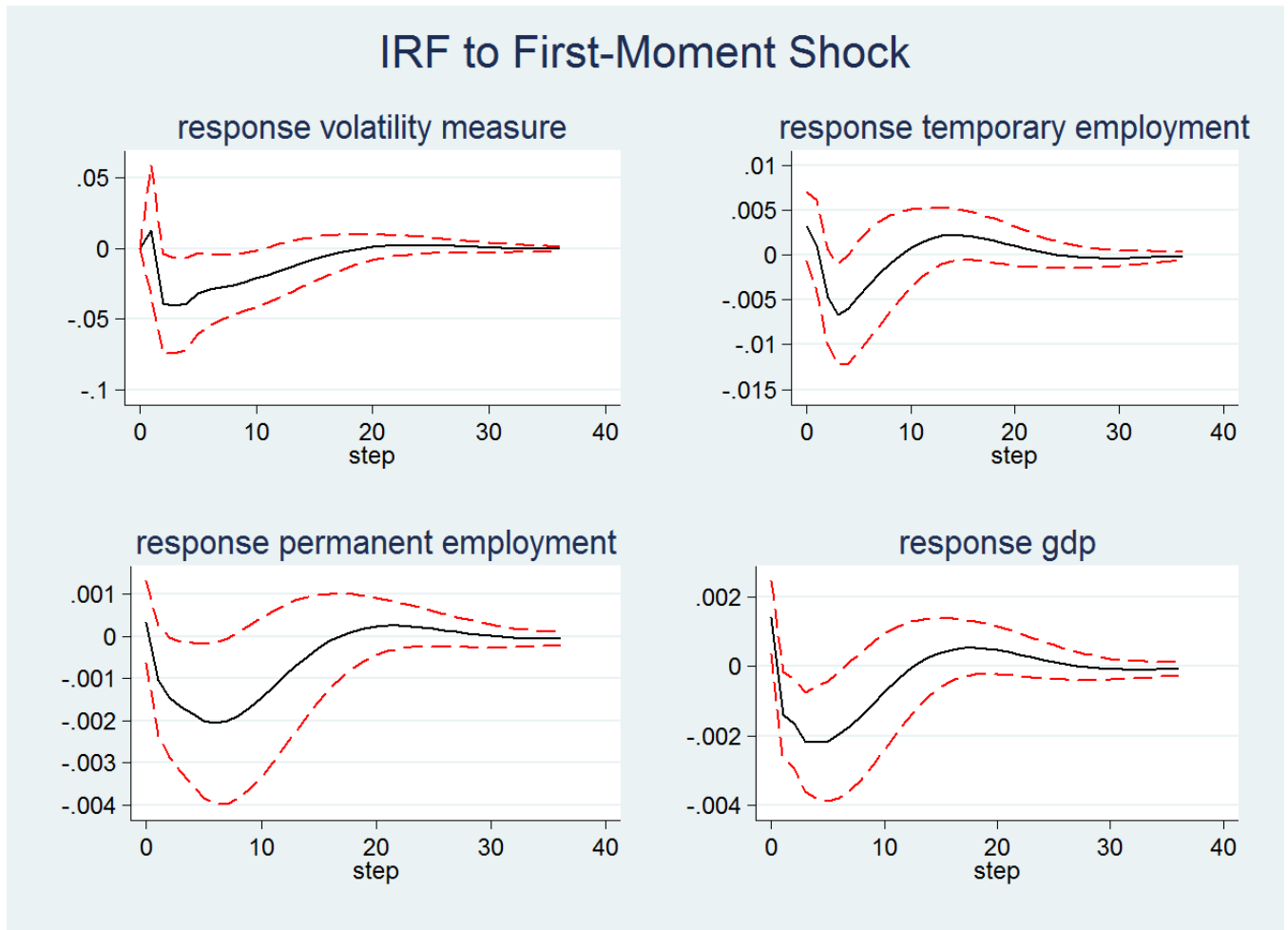
Figure 3.5.: Impulse-response functions to a (negative) first-moment shock (a negative shock to the stock market level): (clockwise from top left) uncertainty measure, temporary employment, GDP and permanent employment. The dashed red lines are the 90% confidence bands. The figure looks different from the other impulse-response functions in this text since it had to be manually created.

I conclude from the empirical analysis that *given the employed identification strategy* uncertainty shocks to the Spanish economy lead to fall in employment on fixed-term contracts, a negligible response in employment on permanent contracts and a recession. These results prevail in various robustness exercises. The analysis, however, also shows that the responses to an uncertainty shock are very similar to the responses to a first-moment shock (proxied by a shock to the stock market level). This might be because agents perceive the events in figure 3.1 not (only) as uncertainty shocks but (also) as bad news shocks. Consequently, the empirical analysis in this section is not fully conclusive

with respect to the impact of uncertainty shocks on the Spanish economy. Therefore, in the following section I proceed by devising a quantitative model of the dual labor market in order to investigate to what extent this model can rationalize the impulse response functions to an uncertainty shock documented in figure 3.4.

3.3. The Model Economy

In this section, I devise a dynamic stochastic partial equilibrium labor demand model of the dual labor maket in order to investigate to what extent the empirical findings from section 3.2 can be rationalized by this model. This type of model has been used by Bentolila and Saint-Paul (1992) and Aguirregabiria and Alonso-Borrego (2014) to analyze issues related to dual labor markets. Further, it has been used to understand the meager performance of European labor markets by, for instance, Bentolila and Bertola (1990) and in the context of uncertainty shocks by Bloom (2009) and Lang (2012).

The model economy is comprised of a large number of ex-ante identical firms which discount the future at rate r. These firms seek to maximize the infinite sum of expected discounted profits by selecting sequences of employment of permanent contract workers (PCW henceforth) and temporary contract workers (TCW henceforth) in the face of stochasticity in the demand for their product and or their productivity. They take wages for both types of labor as given, and changing employment might entail adjustment costs.

More specifically, firms face a constant elasticity demand function of the form

$$ Y^d \;=\; \tilde{B} P^{-\epsilon} \tag{3.1} $$

where ϵ is the elasticity of demand and $\tilde{B}$ is a potentially stochastic demand shifter.

They have further access to a constant or decreasing returns to scale production function given by

$$ Y \;=\; \tilde{A} K^{\alpha_K} L^{\alpha_L}. $$

Here, K is capital which is supposed to be freely and instantaneously adjustable throughout the analysis, $\tilde{A}$ is productivity and α_K and α_L are the output elasticities of capital

and labor respectively. L is labor in efficiency units employed in production, and it is assumed to be given by

$$L = l^P + \xi l^T.$$

In this formulation, it is assumed that labor in efficiency units employed in production is a linear combination of PWC and TWC employed, and their relative productivities are regulated by the parameter ξ. This formulation views PCW and TCW as perfect substitutes who differ in their contribution to labor in efficiency units employed in production. Productivity differences are meant to capture the fact that in reality TCW often enjoy fewer training than PCW and thus they contribute less per head to labor in efficiency units used in production. Perfect substitutability allows me to focus on adjustment costs and stochasticity in demand and or production conditions as motives for employing TCW. It is also a common assumption in the literature.[19]

The demand and the production function can be combined into a revenue function[20] of the form

$$R\left(l^P, l^T, A\right) = A^{\frac{\gamma}{1-\alpha}} \left(l^P + \xi l^T\right)^{\frac{\beta}{1-\alpha}} \times \kappa. \tag{3.2}$$

In equation 3.2, A is a firm-specific "revenue shock". The parameters α, β and γ are reduced-form parameters comprised of the parameters of the underlying demand and production functions, and κ is a parameter that depends on the interest rate and on parameters of the underlying production function and the demand schedule.

It is assumed that the firm-specific revenue shock at t $A_{t,i}$ is composed of a firm-level $A_{t,i}^F$ and an aggregate component A_t^A which combine multiplicatively to the revenue shock

$$A_{t,i} = A_{t,i}^F \times A_t^A. \tag{3.3}$$

Both components of the revenue shock are assumed to follow $AR\left(1\right)$ processes in logs.

---

[19]I share this assumption with the papers by Bentolila and Saint-Paul (1992), Goux et al. (2001), Alonso-Borrego et al. (2006), Aguirregabiria and Alonso-Borrego (2014) and many more papers. See Dolado et al. (2002a) section 2.1. for an analysis in which TCW and PCW are not perfect substitutes.

[20]See Appendix B.2 for a detailed derivation.

The firm-level component of the revenue shock evolves in accordance with

$$\ln A_{t,i}^F = \rho^F \ln A_{t-1,i}^F + \sigma_{t-1}^F \epsilon_{t,i}^F$$
$$\text{with } \epsilon_{t,i}^F \sim N(0,1) \qquad (3.4)$$

and the aggregate component in accordance with

$$\ln A_t^A = \rho^A \ln A_{t-1}^A + \sigma^A \epsilon_t^A$$
$$\text{with } \epsilon_t^A \sim N(0,1). \qquad (3.5)$$

Crucially, the standard deviation of the innovations in equation 3.4 is time-varying. I follow Bloom (2009) and the large literature he sparked in assuming that σ_t^F can take on two values,

$$\sigma_t^F \in \left\{ \sigma_L^F, \sigma_H^F \right\}, \qquad (3.6)$$

and that the transition between them is regulated by a transition matrix

$$\Pi^{\sigma^F} = \begin{bmatrix} \pi_{LL}^{\sigma^F} & \pi_{LH}^{\sigma^F} \\ \pi_{HL}^{\sigma^F} & \pi_{HH}^{\sigma^F} \end{bmatrix}. \qquad (3.7)$$

This formulation is both sparse and allows to study the impact of large exogenous uncertainty shocks in the model economy. It also embodies the timing assumption of Bloom (2009) and the literature thereafter in that the variance of the innovation of the firm-level component of the revenue shock is known to the decision maker in the model one period in advance. Further, with this formulation, I also make the assumption that the fluctuations in the uncertainty measure from figure 3.1 above translate into fluctuations in the variance of the distribution of the firm's revenue shock. This is a "leap" common in the literature on uncertainty shocks initiated by Bloom (2009). Further, as it is evident from equation 3.5, I assume that the variance of the aggregate component of the revenue shock does not feature any time-varying variance in the innovations. This simplifies the calibration and the solution of the model while still allowing me to study the impact of aggregate uncertainty shocks.

The model also allows for adjustment costs on both types of labor. Adjustment costs

are given by the following function

$$
\begin{aligned}
AC\left(e^P, e^T\right) &= \max\left(e^P, 0\right) \times \theta^{HP} - \min\left(e^P, 0\right) \times \theta^{FP} \\
&+ \max\left(e^T, 0\right) \times \theta^{HT} - \min\left(e^T, 0\right) \times \theta^{FT}
\end{aligned}
\tag{3.8}
$$

where e_t^P (e_t^T) is the *change* of PCW (TCW) used in production by the firm between two adjunct periods. I follow Aguirregabiria and Alonso-Borrego (2014) in allowing for hiring and firing costs for TCW. Intuitively, hiring a TCW from the unemployed requires expenses from the firm that might, for instance, stem from locating and screening the worker. The estimates from Aguirregabiria and Alonso-Borrego (2014) confirm that hiring costs are not much different between PCW and TCW. As pertaining to firing costs, it is important to note that statutory requirements actually are such that if a TCW is released *before* termination of his contract, then severance payments are similar to the ones for PCW.[21]Further, I focus on one type of adjustment cost since this allows me to convey the intuition behind my results below in a clear manner.[22] I chose piecewise linear adjustment costs since this type of adjustment costs captures mandatory severance payments which play such a large role in the Spanish labor market.[23]and because previous literature has found this type of adjustment costs to be the most important adjustment cost in the Spanish labor market for both types of contracts.[24]

It is further assumed that PCW' employment evolves in accordance with

$$
l_t^P = (1 - \delta^p)\, l_{t-1}^P + e_t^P.
$$

The parameter δ^P regulates how much of PCW' employment is destroyed from one period to another for reasons outside the control of the firm such as, for instance, exogenous quits and retirement. The evolution of TCW' employment is given by

$$
l_t^T = \left(1 - \delta^T\right) l_{t-1}^T + e_t^T.
$$

---

[21]See Dolado et al. (2002b), footnote 5, and Cahuc et al. (2012), appendix A. The paper by Cahuc et al. (2012) focuses on a theoretical analysis that centers around this feature of temporary contracts in a search and matching environment.

[22]Further, incorporating quadratic and fixed adjustment costs would not qualitatively affect my results.

[23]For instance, during the 1980 the termination of a permanent contract required the firm to pay 20 days of wages per year of service to the worker (up to 12 monthly wages). This could go up to 45 days of wages per year of service (up to 24 monthly wages) if the dismissal was deemed "unfair" by a court which was frequently the case. The regulations governing permanent contracts were reformed a few times in the period thereafter, but dismissal costs remained high (see table A in Güell and Petrongolo (2007) for details on these reforms).

[24]See table 4 on page 950 in Aguirregabiria and Alonso-Borrego (2014).

In this equation, δ^T reflects TCW' employment that is destroyed for reasons outside of the firm's control. Importantly, this parameter is meant to capture fixed-term contracts that terminate and that the firm can not extend for statutory reasons.[25] Including this feature is important since in Spain almost all destruction of temporary jobs occurs upon contract termination.[26] This modelling approach does not capture two aspects from reality. First, in reality, the firm can *choose* the duration of fixed-term contracts whereas here the duration of fixed-term contracts lies outside the control of the firm. The issue with letting the firm choose the duration of fixed-term contracts in this modelling environment is that it would mean that the optimization problem of the firm would feature as many state variables as contract durations which would make the model computationally intractable. The modelling approach suggested here captures the fact that at every point in time some temporary contracts will expire which the firm can not extend in a sparse manner.[27] Second, in reality, firms have the option to promote their TCW to a PCW. I did not include this feature into the model because of computational difficulties that arose when trying to solve such an extended model. I do not, however, expect that incorporating this feature would change my results qualitatively too much since conversion rates in recessions, the focus of the numerical analysis below, should be low.

Finally, the recursive formulation of the dynamic problem of the firm is given by

$$
\begin{aligned}
V\left(l_{t-1}^P, l_{t-1}^T, A_t, \sigma_t\right) \;=\; \max_{e_t^P, e_t^T} &\Big\{ R\left(l_t^P + \xi l_t^T, A_t\right) - AC\left(e_t^P, e_t^T\right) - w_t^P l_t^P - w_t^T l_t^T \\
&+ \frac{1}{1+r} \times \mathbb{E}_{A_t, \sigma_t}\left[V\left(l_t^P, l_t^T, A_{t+1}, \sigma_{t+1}\right)\right] \Big\}
\end{aligned}
\tag{3.9}
$$

subject to $l_t^P = \left(1 - \delta^P\right) l_{t-1}^P + e_t^P$, $l_t^T = \left(1 - \delta^T\right) l_{t-1}^T + e_t^T$ and $l_t^P, l_t^T \geq 0$.

---

[25] In Spain, the maximum duration for fixed-term contracts has been three years since 1984.

[26] See Dolado et al. (2002b), footnote 5.

[27] This modelling approach is similiar to an approach used in recent quantitative papers on sovereign default that study the effects of maturity and maturity structure in sovereign default models. In the papers by Hatchondo and Martinez (2009), Chatterjee and Eyigungor (2012) and Arellano and Ramanarayanan (2012) the sovereign, instead of holding a portfolio of bonds with different maturities, holds only one bond of which a certain exogenous fraction, which is to be understood as the average maturity of the bond portfolio, matures every year. Further, it is similar to the search and matching literature on dual labor markets of the type considered here which often assumes an exogenous high arrival rate of "job destruction shocks" for temporary jobs (see Bentolila et al. (2010)).

3.4. Quantitative Analysis

3.4.1. Calibration

I calibrate the model to reproduce key characteristics of the Spanish economy since the early 1990s.[28] A summary of all parameter values can be found in table 3.2.

A time period in the model is going to correspond to one quarter in the real world. Therefore, I set the discount factor of firms to $\frac{1}{1+r} = 0.95^{\frac{1}{4}}$.

Regarding the revenue function, I set $\alpha = 0.25$ and $\beta = 0.5$. These choices imply a coefficient on labor in efficiency units employed in production in the revenue function of $\frac{\beta}{1-\alpha} = \frac{2}{3}$. The latter value is close to values used and estimated in the literature on the Spanish economy. For instance, Aguirregabiria and Alonso-Borrego (2014) estimate the coefficient on labor in efficiency units employed in production in their revenue function to be 0.69 and Cabrales and Hopenhayn (1997) use $\frac{2}{3}$ as well. Further, the values of α and β are consistent with standard production function parameters of $\alpha_K = \frac{2}{3}$, $\alpha_L = \frac{1}{3}$ and a mark-up of 33%. I also set $\gamma = (1 - \alpha)$ which is a common assumption in models of this type.[29]

Regarding wages and relative productivities of TCW and PCW, I set the parameter that regulates relative productivity of the two types of labor to $\xi = 0.85$ which is the value Aguirregabiria and Alonso-Borrego (2014) estimate for this parameter. I set w^r, the wage of PCW, to 1 which together with $w^t = 0.865$ implies a share of TCW in total employment of about 1/3. Additionally, the fact that TCW earn about 14% less than PCW is consistent with actual wage differences between PCW and TCW (see Dolado et al. (2002a)).

As explained in section 3.3, I consider solely piecewise linear adjustment costs. Following Aguirregabiria and Alonso-Borrego (2014)'s estimates, for PCW I set hiring costs to 0.1 and firing costs to 0.5 of their yearly wage. For workers on fixed-term contracts, I use Aguirregabiria and Alonso-Borrego (2014)'s hiring cost estimate of 0.1 (of their yearly wage). I set firing costs to 0.5 (of their yearly wage) as well since this is consistent with statutory requirements described in section 3.3, and, further, this value ensures that almost all job destruction of temporary contracts occurs through contract termination.

---

[28]The growth of employment on temporary contracts caused by an employment reform in 1984 (see Dolado et al. (2002b), section I.) ended in 1992. At this point employment on temporary contracts made up slightly above 30% of total employment (see also figure 3.3). It had remained around that level ever since.

[29]See, for instance, Cooper and Willis (2009) and Aguirregabiria and Alonso-Borrego (2014).

Alonso-Borrego et al. (2006) report an annualized value of 0.0232 for the attrition rate of PCW. I am, however, setting this value to zero since (very) small attrition rates can not be handled by my computational algorithm. [30] Since this value is small in the data, I do not expect this choice to influence my results to a great deal. I opt to set $\delta^t = 0.125$ which is going to imply that each quarter about 12.5% of temporary workers leave their employment relationship.

Lastly, I turn to the parameters describing the revenue shock process. Regarding the transition matrix Π^σ, I make use of the information contained in the uncertainty measure from figure 3.1. I set the probability of transitioning from the regime with low uncertainty to the regime with high uncertainty to $\pi^\sigma_{L,H} = 0.056$. This means that agents in the model expect a period of heightened uncertainty to occur 6 times in 107 quarters which is the frequency with which the very large volatility events (straight lines) occur in the volatility measure. I, then, set $\pi^\sigma_{H,H} = 0.79$ which implies an average half-life of the high uncertainty regime of 3 quarters which is roughly the value found in my data. Regarding the standard deviation of the innovations and the persistence of the firm-specific component, I use the estimates from Aguirregabiria and Alonso-Borrego (2014). They find a value of 0.207 for the standard deviation of innovations and and a value of 0.931 for the persistence parameter using *yearly data* and a constant standard deviation of innovations. These two values imply a standard deviation of innovations of 0.102 and a persistence of $0.931^{\frac{1}{4}}$ at the quarterly frequency. Since in this study the standard deviation of innovations is time-varying, I set $\sigma^F_L = 0.075$ and $\sigma^F_H = 2.5 \times \sigma^F_L$ implying an average standard deviation of innovations of about 0.102. Having the standard deviation of innovations increasing by a factor of 2.5 in response to an uncertainty shock, seems reasonable when inspecting the series depicted in figure 3.1. Regarding the aggregate shock process, I use a process with $\rho^A = 0.95$ and $\sigma^A = 0.008$.

For a given calibration, I obtain the solution to the model numerically using discrete value function iteration.[31] To obtain the stochastic steady state of the model, I simulate a panel of 5000 firms over 300 periods 1500 times. The first 100 periods of each simulation are discarded and I subsequently compute the statistics of interest for each simulation and then average across simulations. The resulting values are depicted in table 3.3.

---

[30] The issue is that in my computational algorithm, which relies on discrete value function iteration, in order to make sure that all possible choices of labor lie on the grid the difference between two adjunct grid points y and x (where $y > x$) is always $y \times \delta$ (where δ is an attrition rate). As δ becomes very small (but remains different from zero), this leads to grids with a lot of gridpoints. See section B.3.1 for details on the computational algorithm.

[31] Additional information regarding my solution strategy is given in section B.3.1 in the appendix.

Parameter	Value
$\frac{1}{1+r}$	$0.95^{\frac{1}{4}}$
α	0.25
β	0.5
γ	$1-\alpha$
w^T	0.85
w^P	1
ξ	0.85
θ^{H^p}	$0.1*4*w^P$
θ^{F^p}	$0.5*4*w^P$
θ^{H^T}	$0.1*4*w^T$
θ^{F^T}	$0.5*4*w^T$
δ^P	0
δ^T	0.125
$\pi^{\sigma}_{L,H}$	0.056
$\pi^{\sigma}_{H,L}$	0.79
ρ^F	$0.931^{\frac{1}{4}}$
σ^F_L	0.075
σ^F_H	$2 \times \sigma^F_L$
ρ^A	0.95
σ^A	0.008

Table 3.2.: Parameters.

Statistic	Model	Data
standard deviation PCW' employment ($\times 100$)	1.38	1.62
standard deviation TCW' employment ($\times 100$)	6.02	5.6
% of TCW in total new hires	86.55	91 to 97
% of TCW fired every quarter	12.53	16
% of PCW fired every quarter	0.74	2
% of TCW in total employment	27.62	~30

Table 3.3.: Steady state characteristics. Standard deviation data is from my own cal-
culations (see table 3.1). Other data is from Güell and Petrongolo (2007).

Table 3.3 illustrates that the model reproduces many of the salient characteristics of the Spanish labor market in the last two decades. In particular, the model generates volatilities of PCW' employment and TCW' employment that are close to the ones in the data (see table 3.1). Further, as in reality the vast majority of new hires in the economy is on temporary contracts.[32] Turnover among TCW is high and much higher than for PCW. Quantitatively, the values for the percentage share of TCW in new hires and the two turnover numbers are somewhat below the corresponding numbers in the data. The percentage share of TCW in new hires was above 90% for the period between 1985 and 2002 (see Güell and Petrongolo (2007), figure 1) and it was 87.2% in the period 1998-2007 (as reported by Bentolila et al. (2010)). Regarding the two turnover numbers, Güell and Petrongolo (2007) (in table 1) report that the likelihood for a TCW to transition from employment to nonemployment is 0.1626 and the corresponding number for a PCW is 0.02.

3.4.2. Uncertainty Shock with Fully Flexible Fixed-term Contracts

I start the numerical analysis with an economy in which the adjustment of TCW is completely free $\theta^{HT} = \theta^{FT} = 0$.[33] This is of interest because a model of this type has been used often in the literature[34] and, additionally, helps to make the effect of an uncertainty shock in the model transparent.

Policy Functions.

To further understanding of the effect of an uncertainty shock in this model, I start with an analysis of the *policy functions* of firms. Figure 3.6 plots policy functions for the model with fully flexible fixed-term contracts. The left column shows policy functions for PCW, TCW and total employment as a function of inherited PCW ($lp - t$ on the x-axis) for a low revenue shock, and the right column does so for a high revenue shock. Each policy function is depicted once for an economy in which temporary contracts are

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[32]Since in the steady state the percentage share of TCW in total hires equals the percentage share of TCW in total firings, TCW also account for the vast majority of firings as in reality.

[33]In this case the value of δ^t does not matter for the optimal policy of the firm since workers that leave the firm for exogenous reasons can be replaced costlessly. I do also adjust w^t in order to obtain a share of TCW in total employment that is consistent with the data. In the present case, this implies $w^t = 0.92$ and the share of TCW in total employment is then 30.67%.

[34]See for example Bentolila and Saint-Paul (1992).

available (red lines) and for an economy without temporary contracts (blue lines).[35] Lastly, each policy function is shown for a low variance (dashed lines) and for a high variance regime (straight lines).
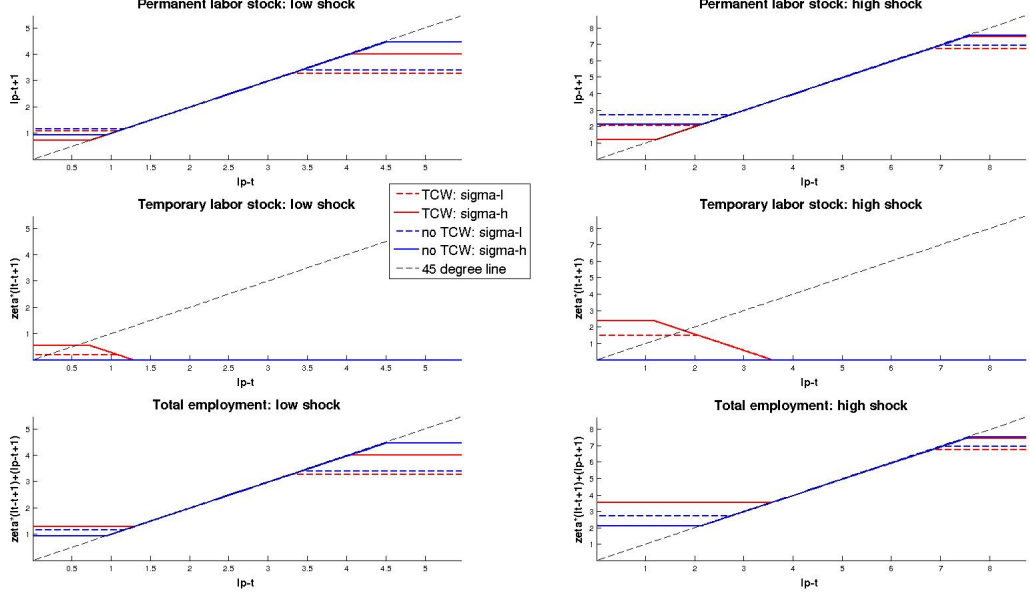

Figure 3.6.: Policy functions. x-axis is inherited PCW (l_t^P). Rows refer to policy functions for PCW (top, l_{t+1}^P), TCW (middle, $\xi \times l_{t+1}^T$) and total labor employed (bottom, $l_{t+1}^P + \xi l_{t+1}^T$) in efficiency units. The left column refers to a low revenue shock. The right column refers to a high revenue shock. Red lines refer to an economy in which TCW are available $(\xi > 0)$ and blue lines to one in which they are absent $(\xi = 0)$. Dashed lines refer to policies in the low variance regime (σ_L^F) and straight lines to policies in the high variance regime (σ_H^F).

The *demand for permanent contract workers* is shown in the top row of figure 3.6. It displays the characteristic inaction region for intermediate values of inherited PCW across all volatility regimes and economies. With the specification of adjustment costs considered here, the inaction region arises because for intermediate inherited values of PCW the marginal costs of adjusting upwards are too high to justify hiring and the marginal gains from adjusting downwards are too low to justify firing.[36] Turning to the

---

[35]In the economy with temporary contracts $\xi > 0$ and in the economy without temporary contracts $\xi = 0$.

[36]For an extended analytical analysis of the effect of piecewise linear adjustment costs in the context of an investment model, see, for instance, Abel et al. (1996).

effect of different levels of uncertainty on the policy function for PCW, one sees that the inaction region is larger under higher uncertainty for both economies. This is because of the *wait-and-see effect* which arises because higher uncertainty makes future adjustment more likely to be necessary and in order to avoid the associated costs firms tend to be more passive today. This effect of uncertainty has been explored theoretically by for instance Abel (1983) and Bernanke (1983) and its quantitative importance has been investigated in the literature sparked by Bloom (2009).

The *demand for temporary contract workers* is shown in the second row of figure 3.6. One can see that the demand for temporary labor is positive below the inaction region and then declines monotonically towards zero. The demand for TCW is positive below the inaction region because in this region, due to the presence of adjustment costs, the difference between marginal revenue and wages is positive at the chosen level of PCW. To the extent that marginal revenue at the choice of PCW is above the going wage for TCW the firm is going to want to hire TCW. Since below the inaction region the firm chooses to produce with a constant level of PCW (for a given revenue shock), the amount of TCW the firm hires is constant as well. As the inaction region for PCW is reached, PCW' employment rises with inherited PCW (at a rate of $(1 - \delta^p)$), and, therefore, the marginal revenue at the choice of PCW falls with inherited PCW and this lowers the demand for TCW linearly since TCW and PCW combine linearly to total labor (see equation 3.2). At the point where the demand for TCW becomes zero, the firm would in principal like to reduce total employment further, however, due to the presence of adjustment costs it does not find it profitable to reduce PCW and, of course, TCW employment can not be reduced below zero. Additionally, one can also see in figure 3.6 that the demand for TCW rises with the revenue shock. This is because the higher the revenue shock, the more careful firms are in their decision to hire PCW since, due to mean-reversion in the revenue shock process, they expect their (idiosyncratic) production environment to worsen. Further, one can see that the demand for TCW rises with uncertainty. This is because the demand for PCW falls with uncertainty and therefore the marginal revenue from PCW increases with uncertainty and this creates "space" for hiring TCW.

An interesting and important aspect to analyze is how the presence of temporary labor affects the demand for permanent labor. In figure 3.6, one can see that the presence of TCW actually causes firms to hire PCW more cautiously and to fire them more vigorously (compare red and blue lines in the top row of figure 3.6). The reason is that the presence of TCW provides firms with a device to adjust labor upwards relatively

cheaply but not downwards. This asymmetry is going to play a prominent role when analyzing the effect of an uncertainty shock on the economy with TCW.

Simulating an Uncertainty Shock

In this section, I investigate the effect of an uncertainty shock in the model with fully flexible fixed-term contracts. In particular, I simulate a panel of 5000 firms over 300 periods 2500 times. In period 200 the uncertainty shock occurs. I model the shock by setting $\sigma_{200}^F = \sigma_H^F$ across all 2500 simulations. Prior and after period 200 the dynamics of the uncertainty shock are governed by the volatility process' transition matrix (see equation 3.7). I obtain the responses by computing the statistics of interest (e.g. aggregate employment, TCW' employment and PCW' employment) for each simulation and then I average across simulations.

Figure 3.7 presents response functions for key time series of the model economy to an uncertainty shock (black lines). Additionally, figure 3.7 contains for comparative purposes the response functions for a model economy in which the adjustment of PCW is costlessly possible (blue lines)[37] and for an economy with adjustment costs on PCW but without fixed-term contracts [38] (red lines).

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[37] This is modelled by setting $\theta^{H^P} = \theta^{F^P} = 0$. Notice that in this economy firms never find it optimal to employ TCW.

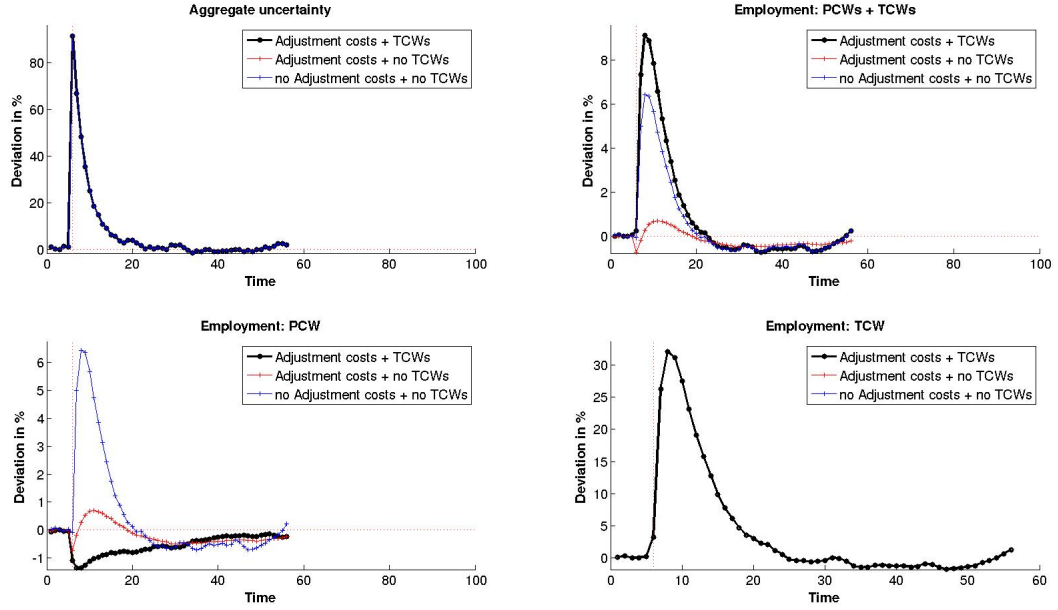[38] This is modelled by setting $\xi = 0$.

Figure 3.7.: Depicted series are: average value of σ_t^F (top right), total employment (top right), PCW' employment (bottom right), TCW' employment (bottom right). All series are expressed as percentage deviations from the stochastic steady state. The uncertainty shock occurs at the vertical line.

The evolution of average uncertainty in the economy is displayed in the top left panel of figure 3.7. One can see that upon impact the average level of uncertainty in the economy almost doubles and then returns to its pre-shock level quickly. This is consistent with the short half-life the uncertainty spikes in figure 3.1 have.

One further sees that in the economy with no adjustment costs on PCW (blue line) the uncertainty shock has no employment effect on impact and subsequently leads to a boom in total employment. This is because, in the calibration here, the optimal policy for PCW' employment in the absence of any adjustment costs is convex in the revenue shock and consequently as the variance of the revenue shock actually rises (which given the timing of the model happens one period after the uncertainty shock hit) employment booms. This effect is called the *Oi-Hartman-Abel effect* [39] in Bloom et al. (2012).

In the economy with adjustment costs on PCW but without TCW (red line), we see that an uncertainty shock leads to a small decrease in PCW' employment on impact and a boom in subsequent periods. The decrease on impact stems from a combination of two

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[39]See Oi (1961), Hartman (1972) and Abel (1983).

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effects. First, in a world with adjustment costs, an increase in uncertainty tomorrow causes firms to freeze hiring and firing today due to the high likelihood of having to revert today's hiring and firing decision tomorrow which is costly. This is the wait-and-see effect of an increase in uncertainty. Second, attrition of PCW continues unabatedly, and overall these two effects lead to a drop in employment. In the present calibration, the decrease in employment stemming from these two effects is small, and this is because attrition in the Spanish labor market is low. The subsequent dynamics are then driven by the Oi-Hartman-Abel effect described above.

Finally, in the economy with adjustment costs on PCW and TCW (black lines),d the uncertainty shock causes a boom in TCW' employment in the periods after the date at which the shock hits. Additionally, the shock causes a recession in permanent employment and a boom in overall employment. The behavior of TCW' employment is explained by the fact that, as the variance of the revenue shock rises, more firms find themselves in the (far) right tail of the revenue shock distribution, and these firms exploit their beneficial revenue shock (mainly) by hiring TCW. This is because mean reversion in the revenue shock process implies that firms do not expect their currently high revenue shock to last for a long time, and, therefore, they respond to it by hiring TCW to avoid labor adjustment costs today and in the future. Turning to the response of PCW' employment, notice that increased uncertainty means that hiring and firing is elevated. As argued above, in the present calibration, increased hiring dominates increased firing in the absence of TCW and this is due to the Oi-Hartman-Abel effect. In the presence of TCW, however, firms avoid costly hiring of PCW to a degree by employing TCW whereas this device is not available to the same degree for firing decisions. This is the asymmetry that was also manifest in the policy functions discussed in section 3.4.2.

Consequently, in this simple model, an uncertainty shock causes a boom in TCW' employment and a recession in PCW' employment. Further, the model's response to an uncertainty shock is strongly at odds with the response found in the empirical analysis in section 3.2.

3.4.3. Uncertainty Shock with Fixed-term Contracts with Adjustment Costs

This section analyzes the effect of an uncertainty shock in the version of the model economy that features adjustment costs and attrition on TCW. Intuitively, one could

imagine that this version of the model economy is able to generate responses to an uncertainty shock that resemble the ones found in the empirical analysis (see figure 3.4). The idea is that on impact of the uncertainty shock hiring and firing of TCW freezes due to the wait-and-see effect described in the previous section. At the same time, temporary contracts keep expiring (attrition of TCW continues unabatedly). The consequence is a steep recession in the employment of TCW. PCW' employment responds very little to the shock for two reasons: the wait-and-see effect causes a freeze in hiring and firing, and, additionally, the low attrition rate of PCW means that there is little attrition and consequently no recession in the employment of PCW. To see whether this intuition is confirmed in the actual dynamics generated by the model, I conduct the same simulation experiment as described in the previous section for the version of the model with adjustment costs and attrition on TCW.

Simulating an Uncertainty Shock

Figure 3.8 collects the responses of aggregate employment, PCW' employment and TCW' employment. One can see that on impact of the shock (at the vertical lines) TCW' employment displays a deep recession whereas PCW' employment is almost irresponsive. The mechanics behind these dynamics are exactly the ones described above: hiring and firing freezes on both types of contracts but the greatly differing attrition rates lead to a big fall in TCW' employment whereas PCW' employment remains close to its long-term level. The subsequent dynamics are such that TCW employment recovers quickly and then overshoots its long-run level whereas PCW' employment enters into a relatively deep and prolonged recession. The explanation for these dynamics is again that as higher uncertainty actually prevails in the economy, on the one hand, firms in the right tail of the revenue shock distribution hire TCW vigorously to exploit their favorable but likely short-lived production environment. Firms in the left tail of the revenue shock distribution, on the other hand, fire PCW and this explains why in the aggregate we observe a substitution away from PCW to TCW in the periods following the impact of the uncertainty shock.

In conclusion, the model is able to capture some of the features of the empirical response functions to an uncertainty shock from section 3.2.2. In particular, employment of TCW displays a large negative response upon impact of the uncertainty shock whereas PCW' employment displays almost no reaction on impact. Subsequently, however, the impulse response functions from the model and the empirical analysis diverge. This is due to the
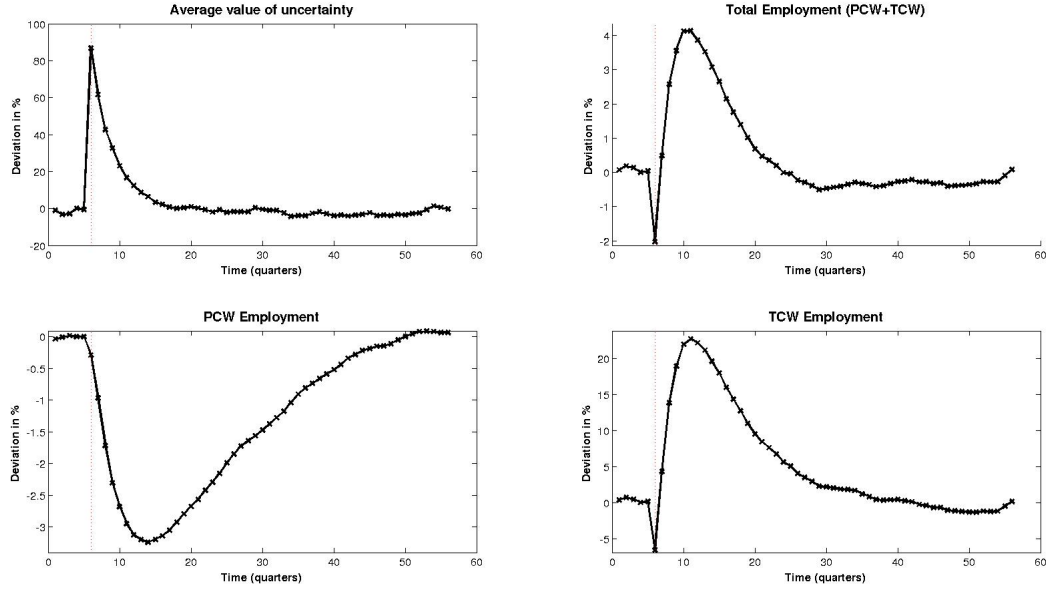
Figure 3.8.: Depicted series are: average value of σ_t^F (top right), total employment (top left), PCW employment (bottom right), TCW employment (bottom right). All series are expressed as percentage deviations from the stochastic steady state. The uncertainty shock occurs at the vertical line.

fact that as uncertainty is actually elevated in the model economy, firms with a good revenue shock start hiring TCW vigorously whereas firms with a bad shock fire PCW. This leads to a large boom in TCW' employment and to a large recession in PCW' employment.

3.4.4. First-Moment Shock and Combined First- and Second-Moment Shock

In this section, I investigate the impact of a first-moment shock and a combined first- and second-moment shock in the model. The first-moment shock in both cases is a negative shock to the aggregate component of the revenue process.

Figure 3.9 shows the response function to a first-moment shock.[40] It is evident that this shock leads to a big recession in total employment which contracts by about 6% relative to its stochastic steady state value. Additionally, the brunt of the labor adjustment in

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[40] The simulation experiment is as above except that now at period 400 I set the aggregate component of the revenue shock to a low value across all simulations.

the recession is borne by TCW. Indeed, from peak to trough TCW' employment contracts by about 16% whereas PCW' employment reaches its trough about 2.5% below its stochastic steady state value. One also sees that both, PCW' and TCW' employment, decline gradually, due to the adjustment costs, towards their respective trough. This trough is reached earlier for TCW employment. These dynamics are consistent with real world time series of the Spanish economy. They also underscore that it is important to include adjustment costs on TCW in the model.[41] Lastly, these dynamics are largely consistent with the ones found when investigating the impact of a first-moment shock in the empirical analysis (see figure 3.5). The exception is the response of PCW' employment which is significant in the model whereas it is not in the data.
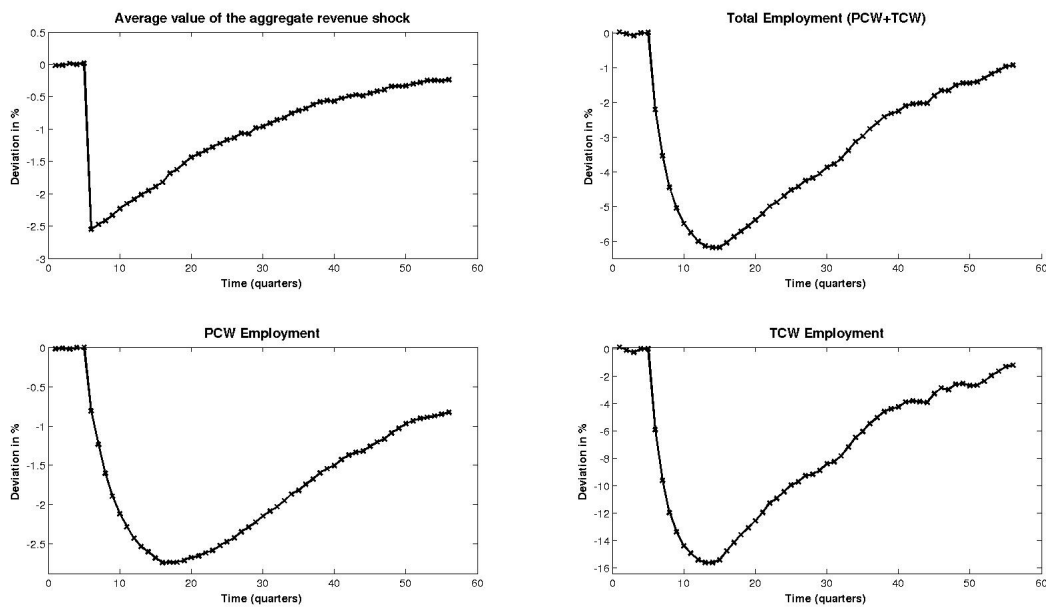

Figure 3.9.: First-moment shock. Depicted series are: average value of the the aggregate component of the revenue shock, total employment (top left), PCW employment (bottom right), TCW employment (bottom right). All series are expressed as percentage deviations from the stochastic steady state. The first-moment shock occurs at the vertical line.

Figure 3.10 shows the response function to a combined first- and second-moment shock (black lines).[42] For the purpose of comparison, the response functions to a pure first-

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[41] A first moment shock of this type in the model without adjustment costs on TCW would mean that TCW' employment in response to the first-moment shock reaches its trough after one period. This dynamic is clearly not observed in reality.

[42] The simulation experiment is as above except that now at period 400 I set the aggregate component of

moment and a pure second-moment shock are included as well. As pertaining to the response of TCW' employment, one can see that the initial response is most negative in the case of the combined first- and second-moment shock. Subsequently, the dynamics of the response are for a while governed by the second-moment shock: the fact that idiosyncratic productivity is now actually further spread out causes firms that find themselves in a favorable production environment to hire TCW. After some quarters, however, the effect of the negative first-moment shock starts to take over and TCW' employment falls again below its long-run value to which it subsequently returns slowly. The fact that at first the effect of the second-moment shock dominates the dynamics and later the effect of the first-moment shock is explained by the differing degrees of persistent in the two shocks: while the first-moment shock is relatively persistent, the second moment has a very brief half-life (see the top left panel of figure 3.10). As pertaining to the response of PCW' employment, one can see that the first- and second-moment shock actually reinforce each other. Consequently the trough in PCW is by far the gravest in case of the two shocks occurring together. Relative to the first-moment shock, the combined first- and second moment shock causes the response functions of PCW' and TCW' employment to diverge in the wrong direction: the response of PCW' employment to the shock becomes more negative whereas it becomes less negative for TCW' employment. Therefore, in this model, a combined first- and second-moment shock does not seem to help to describe the Spanish business cycle dynamics better than a first moment shock alone. This result contrasts with the finding in Bloom et al. (2012) that a combined first- and second-moment shock provides a better description of business cycles in the US economy then each of these shocks does on its own.

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the revenue shock to a low value *and* the variance of the innovations of the idiosyncratic component of the revenue shock to a high value across all simulations.
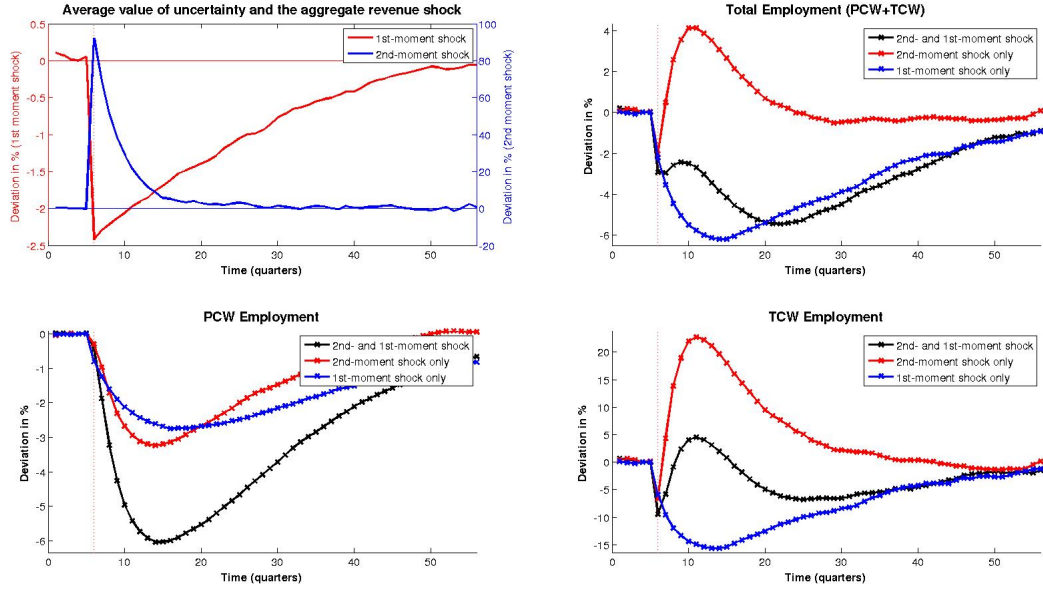
Figure 3.10.: Combined first- and second-moment shock. Depicted series are: average value of the the aggregate component of the revenue shock, total employment (top left), PCW employment (bottom right), TCW employment (bottom right). All series are expressed as percentage deviations from the stochastic steady state. The combined first- and second-moment shock at the vertical line.

3.5. Conclusion

In this paper, I investigated the impact of uncertainty shocks on a dual labor market focussing on the case of Spain. I showed in an empirically analysis that, given the employed identification strategy, uncertainty shocks in the Spanish economy seem to cause a significant drop in temporary employment, a negligible reaction of permanent employment and a recession. However, in the empirical analysis, I was not able to exclude the possibility that these dynamics stem from first-moment shocks or from a combination of first- and second-moment shocks.

Therefore, I devised a dynamic stochastic partial equilibrium model of the dual labor market that allowed for aggregate first- and second-moment shocks. I calibrated the model to reproduce key characteristics of the Spanish economy in recent decades. I analyzed the impact of a (pure) second-moment, a (pure) first-moment and a combined first- and second-moment shock in the model. For the (pure) second-moment shock,

I found that the reaction of permanent and temporary employment to an uncertainty shock is consistent with the empirical responses on impact of the uncertainty shock. The subsequent dynamics, however, are very different in the sense that temporary employment quickly starts to boom whereas permanent employment enters a relatively deep recession. For the (pure) first-moment shock, I found that the associated dynamics are qualitatively consistent with the ones from the empirical analysis in the sense that the shock in the model leads to large decline in temporary and permanent employment. Further, the decline in temporary employment is larger relative to its stochastic steady state value, and the trough in temporary employment is reached quicker. For the combined first- and second moment shock, I found that it is unlikely that such a shock helps to improve explaining the business cycle dynamics of the Spanish economy relative to a pure first-moment shock. The reason is that the second-moment shock amplifies the drop in permanent employment from the first-moment shock whereas it dampens the response of temporary employment to the first-moment shock. Therefore, this type of shock is less likely relative to a (pure) first-moment to generate the fact that in Spain temporary employment is much more volatile than permanent employment along the business cycle.

In this paper, I investigated the response of the Spanish labor market to uncertainty shocks in a partial equilibrium model. The recent study by Bloom et al. (2012) has shown that general equilibrium effects tend to dampen the Oi-Hartman-Abel effect. Therefore, they are crucial for their model to provide a good description of US business cycle dynamics. In the present environment, however, general equilibrium effects are unlikely to reconcile the model's response to an uncertainty shock with the response found in the data. The reason is that the disparities stem chiefly from the presence of a substitution effect from PCW to TCW in response to the uncertainty shock and not from the Oi-Hartman-Abel effect. It seems, therefore, that the main results of this paper are likely to be robust towards general equilibrium effects. Nevertheless, studying aggregate shocks in a general equilibrium model of the dual labor market remains a largely unexplored and important avenue for future research.

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A. Appendix to Chapter 1
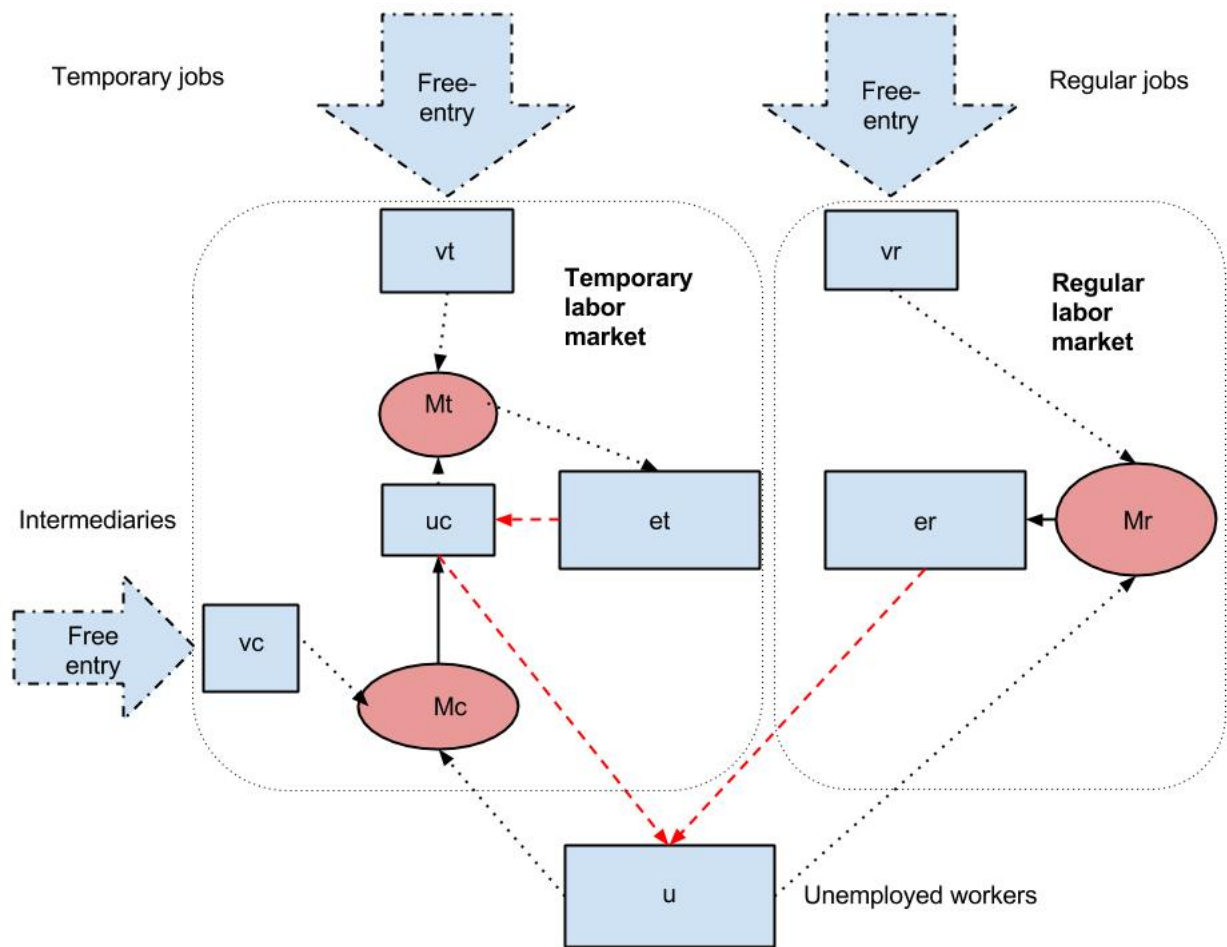
A.1. Graphical Illustration of the Model

Figure A.1.: Graphical illustration of the flows of the model. The regular labor market is on the right and the temporary labor market on the left.

Red ellipses are matching functions: Mr - matches unemployed workers with firms. Mc - matches unemployed workers and intermediares with empty call sheets, M^t - matches intermediary worker pairs with (client) firms.

Rectangles are labor market stocks: u - unemployed workers, er - regular employment relationships, vr - vacancies in the regular labor market, vc - empty call sheets, uc - filled call sheets (search worker intermediary pairs), et - temporary (intermediated) jobs, vt - firms searching for temporary workers.

Straight (black) lines are matches. Dashed (black) are inputs into matching functions. Red (dashed) lines are flows of destroyed matches.

A.2. Labor Market Stocks

Equations 2.8, 2.9 and 2.10 imply the following equilibrium values of u, e^r, e^t and u^c *given* thresholds e_R^t and e_R^r and labor market tightnesses θ^t, θ^r and θ^c

$$u = \frac{\kappa \times \lambda F\left(\epsilon_d^r\right) \times \lambda F\left(\epsilon_d^t\right)}{p^c \times \left[\lambda F\left(\epsilon_d^r\right)\lambda F\left(\epsilon_d^t\right)\right] + p^r \kappa \lambda F\left(\epsilon_d^t\right) + p^t p^c \times \lambda F\left(\epsilon_d^r\right) + \kappa \lambda F\left(\epsilon_d^r\right)\lambda F\left(\epsilon_d^t\right)} \quad \text{(A.1)}$$

$$e^r = \frac{p^r \times \kappa \lambda F\left(\epsilon_d^t\right)}{p^c \times \left[\lambda F\left(\epsilon_d^r\right)\lambda F\left(\epsilon_d^t\right)\right] + p^r \kappa \lambda F\left(\epsilon_d^t\right) + p^t p^c \times \lambda F\left(\epsilon_d^r\right) + \kappa \lambda F\left(\epsilon_d^r\right)\lambda F\left(\epsilon_d^t\right)} \quad \text{(A.2)}$$

$$e^t = \frac{p^t p^c \times \lambda F\left(\epsilon_d^r\right)}{p^c \times \left[\lambda F\left(\epsilon_d^r\right)\lambda F\left(\epsilon_d^t\right)\right] + p^r \times \kappa \lambda F\left(\epsilon_d^t\right) + p^t p^c \times \lambda F\left(\epsilon_d^r\right) + \kappa \lambda F\left(\epsilon_d^r\right)\lambda F\left(\epsilon_d^t\right)} \quad \text{(A.3)}$$

$$u^c = \frac{p^c \times \lambda F\left(\epsilon_d^r\right) \times \lambda F\left(\epsilon_d^t\right)}{p^c \times \left[\lambda F\left(\epsilon_d^r\right)\lambda F\left(\epsilon_d^t\right)\right] + p^r \times \kappa \lambda F\left(\epsilon_d^t\right) + p^t p^c \times \lambda F\left(\epsilon_d^r\right) + \kappa \lambda F\left(\epsilon_d^r\right)\lambda F\left(\epsilon_d^t\right)} \quad \text{(A.4)}$$

A.3. Omitted Derivations

A.3.1. Derivation of Equilibrium Equations

Derivation of Job Destruction Condition

The surplus in the temporary labor market is given by

$$S^t(\epsilon) = F^{tJ}(\epsilon) + W^{tJ}(\epsilon) + I^{tJ}(\epsilon) - I^{tV} - U^{tV}$$

Multiplying through with r, inserting the corresponding asset pricing equations and making use of the threshold property (Lemma 1) gives

$$
\begin{aligned}
(r + \lambda) S^t(\epsilon) &= p + \sigma\epsilon + \lambda \int_{\epsilon_R^t}^{\epsilon_u} S^t(x) \, dF(x) \\
&\quad - \left[\underbrace{z + p^t \left[W^{tJ}(\epsilon^u) - W^{tV} \right] + \kappa \left[W^u - W^{tV} \right]}_{W^{tV}} \right] \\
&\quad - \left[\underbrace{-z + p^t \left[I^{tJ}(\epsilon^u) - I^{tV} \right] - \kappa \left[I^{cV} - I^{ItV} \right]}_{I^{tV}} \right]
\end{aligned}
$$

Making use of the implications of Nash bargaining and the free entry assumptions this can be written as

$$
\begin{aligned}
(r + \lambda) S^t(\epsilon) &= p + \sigma\epsilon + \lambda \int_{\epsilon_R^t}^{\epsilon_u} S^t(x) \, dF(x) \\
&\quad - \left[\frac{\eta^{tW}}{\eta^{tF}} k \times \theta^t - \kappa \left[\frac{\eta^{cW}}{\eta^{cI}} \right] \frac{1}{q^c} k^{cI} \right] \\
&\quad - \left[\frac{\eta^{tI}}{\eta^{tF}} k \times \theta^t - \kappa \frac{1}{q^c} k^{cI} \right]
\end{aligned}
$$

which is

$$(r + \lambda) S^t (\epsilon) = p + \sigma\epsilon + \lambda \int_{\epsilon_R^t}^{\epsilon_u} S^t (x) \, dF (x)$$

$$- \frac{\left(1 - \eta^{tF}\right)}{\eta^{tF}} k \times \theta^t + \kappa \left[\frac{\eta^{cW}}{\eta^{cI}} + 1\right] k^{cI} \times \frac{1}{q^c} \qquad (A.5)$$

Inserting equation A.6 solved for $\kappa\frac{1}{\eta^{cI}}\frac{k^{Ce}}{q^e}$ and evaluating at $\epsilon = \epsilon_d^t$ delivers the job destruction condition for the temporary labor market (equation 2.14) :

$$0 = p + \sigma\epsilon_R^t + \frac{\lambda\sigma}{r + \lambda} \left[\int_{\epsilon_R^t}^{\epsilon_u} [1 - F (x)] \, dx\right] - \left[b + \theta^c k^{cI}\frac{\eta^{cW}}{\eta^{cI}} + \frac{\eta^{rW}}{\eta^{rF}} k \times \theta^r\right] - r k^{cI}\frac{1}{\eta^{cI}} \times \frac{1}{q^c}.$$

The derivation of the job destruction condition for the regular labor market is analogous.

Derivation of the Equilibrium Version of the Intermediarie's Free-Entry Condition

Remember the definition of the surplus when a worker and an intermediary form a call-sheet relationship

$$S^c = W^{tV} + I^{tV} - W^u$$

Multiplying through by r and inserting the corresponding asset pricing equations delivers

$$rS^c = p^t \left[I^{tJ} (\epsilon_u) - I^{tV}\right] + p^t \left[W^{tJ} (\epsilon_U) - W^{tV}\right]$$
$$+ \kappa \left[W^u - I^{tV} - W^{tV}\right] - rW^u$$

Notice that from Nash bargaining $I^{tJ} (\epsilon_u) - I^{tV} = \eta^{tI} S^t (\epsilon_u)$ and $\left[W^{tJ} (\epsilon_U) - W^{tV}\right] = \eta^{tW} S^t (\epsilon_u)$. Further, the firm's free-entry condition into the temporary labor market implies that $F^{tV} = 0$ in equilibrium and therefore equation 2.2 implies $\frac{k}{q^t} = F^{tJ} (\epsilon_u)$. Since $F^{tJ} (\epsilon_u) = \eta^{tF} S^t (\epsilon_u)$ from Nash bargainning we can write

$$(r + \kappa) S^c = \left[\frac{\eta^{tW} + \eta^{tI}}{\eta^{tF}}\right] k \times \theta^t - rW^u$$

which since $\eta^{tW} + \eta^{tI} = \left(1 - \eta^{tF}\right)$ is the same as

$$(r + \kappa) S^c = \left[\frac{1 - \eta^{tF}}{\eta^{tF}}\right] k \times \theta^t - rW^u$$

Further, rW^u is given by

$$rW^u = b + p^c \left(W^{tV} - W^u\right) + p^r \left(W^{rJ} \left(\epsilon_u\right) - W^u\right).$$

Nash bargaining when workers are added to an intermediaries call sheet implies $W^{tV} - W^u = \eta^{cW} S^c$ and from the intermediaries free-entry condition it can be concluded that $\frac{k^{cI}}{q^c} = I^{cV} = \eta^{cI} S^c$ in equilibrium. Further, in the regular labor market Nash bargaining implies that $\left[W^{rJ}\left(\epsilon_u\right) - W^u\right] = \eta^{rW} S^r \left(\epsilon_u\right)$ and $\frac{k}{q^r} = F^{rJ}\left(\epsilon_u\right) = \eta^{rF} S\left(\epsilon_u\right)$. Therefore,

$$rW^u = b + \frac{\eta^{cW}}{\eta^{cI}} k^{cI} \times \theta^c + \frac{\eta^{rW}}{\eta^{rF}} k \times \theta^r$$

The surplus S^c can consequently be expressed as

$$(r + \kappa) S^c = \left[\frac{\left(1 - \eta^{tF}\right)}{\eta^{tF}}\right] k \times \theta^t - \left[\underbrace{b + \theta^C k^{Ce} \frac{\eta^{cW}}{\eta^{cI}} + \theta^r \frac{\eta^{rW}}{\eta^{rF}} k}_{rW^u}\right]$$

The free-entry condition for intermediaries implies

$$\frac{k^{cI}}{q^c} = \eta^{cI} S^c$$

and therefore

$$(r + \kappa) \frac{k}{q^C} = \eta^{cI} \left[-k^{Cf} + \left[\frac{\left(1 - \eta^{tF}\right)}{\eta^{tF}}\right] \theta^t k - \left[b + \theta^C k^{Ce} \frac{\eta^{cW}}{\eta^{cI}} + \theta^r \frac{\eta^{rW}}{\eta^{rF}} k\right]\right] \qquad \text{(A.6)}$$

which is equation 2.16.

A.3.2. Proof of Proposition 2 (Existence and Uniqueness)

The proof of proposition 2 goes as follows: Take the job destruction condition of the regular labor market (equation 2.13) and solve it for θ^c.

$$\theta^c = \frac{\eta^{cI}}{\eta^{cW}} \frac{1}{k^{cI}} \times \left[p + \sigma \epsilon_R^r \left(\theta^r \right) + \frac{\sigma \lambda}{r + \lambda} \left[\int_{\epsilon_R^r(\theta^r)}^{\epsilon^u} \left[1 - F\left(x \right) \right] dx \right] - b - \frac{\eta^{rW}}{\eta^{rF}} k^r \times \theta^r \right] \quad \text{(A.7)}$$

Notice that $\epsilon_R^r \left(\theta^r \right) = \epsilon_u - \frac{k}{q^r(\theta^r)} \left[\frac{r+\lambda}{\sigma \eta^{tF}} \right]$ are those combinations of θ^r and ϵ_R^r that are consistent with the job creation condition for firms in the regular labor market (equation 2.11). This function determines the range of possible values for θ^c that are consistent with both $\theta^r \geq 0$ and $\theta^c \geq 0$ as

$$\theta^c \in \left[0, \frac{\eta^{cI}}{\eta^{cW}} \frac{1}{k^{cI}} \left[p + \sigma \epsilon_u - b \right] \right] \quad \text{(A.8)}$$

Denote the implicit function mapping θ^c into θ^r such that equation A.7 is satisfied by $f_{\theta^r} \left(\theta^c \right)$. On the interval described in equation A.8 one can use the implicit function theorem to get

$$\frac{\partial f_{\theta^r} \left(\theta^c \right)}{\partial \theta^c} = \frac{\partial \theta^r}{\partial \theta^c} = - \frac{-\frac{\eta^{cW}}{\eta^{cI}} k^{cI}}{\frac{\partial \epsilon_R^r(\theta^r)}{\partial \theta^r} \times \left[\frac{\sigma \left[r + \lambda F\left(\epsilon_R^r(\theta^r) \right) \right]}{r + \lambda} \right] - \frac{\eta^{rW}}{\eta^{rF}} k} < 0$$

Intuitively, since a larger θ^c means a higher value of unemployed, firms find it less attractive to create jobs in the regular labor market and consequently θ^r is going to fall in equilibrium.

Now turn to the job destruction condition in the temporary labor market written as (see equation A.5 evaluated at the job destruction threshold).

$$\begin{aligned}
0 = {} & p + \sigma \epsilon_d^t \left(\theta^t \right) + \lambda \int_{\epsilon_d^t(\theta^t)}^{\epsilon_u} \left[1 - F\left(x \right) \right] dx \\
& - k \frac{\eta^{tW} + \eta^{tI}}{\eta^{tF}} \times \theta^t + \kappa \left[\frac{1}{\eta^{cI}} \right] \frac{k^{cI}}{q^c} \quad \text{(A.9)}
\end{aligned}$$

Again $\epsilon_R^t\left(\theta^t\right) = \epsilon_u - \frac{k}{q^t}\left[\frac{r+\lambda}{\eta^{tF}\sigma}\right]$ are those combinations of θ^t and ϵ_R^t that are consistent with the job creation condition for firms in the temporary market (equation 2.12). This equation defines an implicit relation between θ^t and θ^c. The mapping of θ^t into θ^c such that equation A.9 is satisfied is denoted by $f_{\theta^t}\left(\theta^c\right)$. Notice that as long as $0 \le \theta^t < \infty$ this equation can always be satisfied and therefore the relevant range for θ^c is indeed given by equation A.8 as stated in proposition 2.

Further, the implicit function theorem delivers

$$\frac{\partial f_{\theta^t}\left(\theta^c\right)}{\partial \theta^c} = \frac{\partial \theta^t}{\partial \theta^c} = -\frac{\frac{\partial JD^t}{\partial \theta^c}}{\frac{\partial JD^t}{\partial \theta^t}} = -\frac{-\kappa\left[\frac{k^{cI}}{\eta^{cI}}\frac{1}{[q^c]^2}\left[q^c\right]'\right]}{\frac{\partial \epsilon_d^t}{\partial \theta^t}\left[\frac{\sigma\left[r+\lambda F\left(\epsilon_d^t(\theta^t)\right)\right]}{r+\lambda}\right] - k\frac{\eta^{tW}+\eta^{tI}}{\eta^{tF}}} > 0$$

Intuitively, an increase in θ^c means more intermediaries in the market which in turn makes the market more attractive for regular firms such that θ^t rises.

Consider now the free-entry condition of intermediaries (equation 2.16). The implicit relations $f_{\theta^r}\left(\theta^c\right)$ and $f_{\theta^t}\left(\theta^c\right)$ are used to write it as a function of θ^c only.

$$FE(\theta^c) = \eta^{cI}\left[\left[\frac{\eta^{tW}+\eta^{tI}}{\eta^{tF}}\right]k \times f_{\theta^t}\left(\theta^c\right) - \left[b + k^{cI}\frac{\eta^{cW}}{\eta^{cI}} \times \theta^C + \frac{\eta^{rW}}{\eta^{rF}}k \times f_{\theta^r}\left(\theta^c\right)\right]\right] - (r+\kappa)\frac{1}{\eta^{cI}}\frac{k^{cI}}{q^c}$$

$$(A.10)$$

The goal is now to sign this function. The derivative of A.10 w.r.t. θ^c is given by

$$\frac{dFE}{d\theta^c} = \left[\frac{\eta^{tW}+\eta^{tI}}{\eta^{tF}}\right]k \times \frac{\partial \theta^t}{\partial \theta^c} - \frac{\eta^{cW}}{\eta^{cI}}k^{cI} - \frac{\eta^{rW}}{\eta^{rF}}k \times \frac{\partial \theta^r}{\partial \theta^c} + (r+\kappa)\left[\frac{1}{\eta^{cI}}\right]\left[\frac{k}{[q^c]^2}\right]\left[q^c\right]'$$

Forming a commong denominator one can write

$$\begin{aligned}
\frac{dFE}{d\theta^c} &= \left[\frac{\eta^{tW}+\eta^{tI}}{\eta^{tF}}\right]k\left[\frac{\kappa\left[\frac{k^{Ce}}{\eta^{cI}}\frac{1}{[q^c]^2}\left[q^c\right]'\right]}{\frac{\partial \epsilon_d^t}{\partial \theta^t}\left[\frac{\sigma\left[r+\lambda F\left(\epsilon_R^t(\theta^t)\right)\right]}{r+\lambda}\right] - k\frac{\eta^{tW}+\eta^{tI}}{\eta^{tF}}}\right] - k^{cI}\frac{\eta^{cW}}{\eta^{cI}} \\
&\quad - \frac{\eta^{rW}}{\eta^{rF}}k\left[\frac{\frac{\eta^{cW}}{\eta^{cI}}k^{cI}}{\frac{\partial \epsilon_r(\theta^r)}{\partial \theta^r} \times \left[\frac{\sigma\left[r+\lambda F\left(\epsilon_R^r(\theta^r)\right)\right]}{r+\lambda}\right] - \frac{\eta^{rW}}{\eta^{rF}}k}\right] + (r+\kappa)\frac{1}{\eta^{cI}}\left[\frac{k^{cI}}{q^C}\right]\left[q^C\right]'
\end{aligned}$$

Cancelling terms brings us

$$
\frac{\left[\frac{\eta^{tW}+\eta^{tI}}{\eta^{tF}}\right] k\kappa \left[\frac{k^{Ce}}{\eta^{cI}}\frac{1}{[q^c]^2}[q^C]'\right] + (r+\kappa)\frac{1}{\eta^{cI}}\left[\frac{k^{Ce}}{[q^C]^2}\right][q^C]' \times \left[\frac{\partial \epsilon_d^t}{\partial \theta^t}\left[\frac{\sigma\left[r+\lambda F\left(\epsilon_d^t\left(\theta^t\right)\right)\right]}{r+\lambda}\right] - k\frac{\eta^{tW}+\eta^{tI}}{\eta^{tF}}\right]}{\frac{\partial \epsilon_d^t}{\partial \theta^t}\left[\frac{\sigma\left[r+\lambda F\left(\epsilon_R^t(\theta^t)\right)\right]}{r+\lambda}\right] - k\frac{\eta^{tW}+\eta^{tI}}{\eta^{tF}}} +
$$

$$
\frac{-k^{cI}\frac{\eta^{cW}}{\eta^{cI}}\left[\frac{\partial \epsilon_R^r(\theta^r)}{\partial \theta^r} \times \left[\frac{\sigma\left[r+\lambda F\left(\epsilon_d^r(\theta^r)\right)\right]}{r+\lambda}\right] - \frac{\eta^{rW}}{\eta^{rF}}k\right] - \frac{\eta^{cW}}{\eta^{cI}}k^{Ce}\frac{\eta^{rW}}{\eta^{rF}}k}{\left[\frac{\partial \epsilon_r(\theta^r)}{\partial \theta^r} \times \left[\frac{\sigma\left[r+\lambda F\left(\epsilon_d^r(\theta^r)\right)\right]}{r+\lambda}\right] - \frac{\eta^{rW}}{\eta^{rF}}k\right]}
$$

This is the same as

$$
\frac{(r+\kappa)\frac{1}{\eta^{cI}}\left[\frac{k^{Ce}}{[q^C]^2}\right][q^C]'\frac{\partial \epsilon_d^t}{\partial \theta^t}\left[\frac{\sigma\left[r+\lambda F\left(\epsilon_d^t\left(\theta^t\right)\right)\right]}{r+\lambda}\right] - r\frac{1}{\eta^{cI}}\left[\frac{k^{Ce}}{[q^C]^2}\right][q^C]'k\frac{\eta^{tW}+\eta^{tI}}{\eta^{tF}}}{\frac{\partial \epsilon_d^t}{\partial \theta^t}\left[\frac{\sigma\left[r+\lambda F\left(\epsilon_d^t(\theta^t)\right)\right]}{r+\lambda}\right] - k\frac{\eta^{tW}+\eta^{tI}}{\eta^{tF}}} +
$$

$$
\frac{-k^{Ce}\frac{\eta^{cW}}{\eta^{cI}}\frac{\partial \epsilon_r(\theta^r)}{\partial \theta^r} \times \left[\frac{\sigma\left[r+\lambda F\left(\epsilon_d^r(\theta^r)\right)\right]}{r+\lambda}\right]}{\left[\frac{\partial \epsilon_r(\theta^r)}{\partial \theta^r} \times \left[\frac{\sigma\left[r+\lambda F\left(\epsilon_d^r(\theta^r)\right)\right]}{r+\lambda}\right] - \frac{\eta^{rW}}{\eta^{rF}}k\right]} < 0
$$

which is negative since $\frac{\partial \epsilon_d^t\left(\theta^t\right)}{\partial \theta^t} < 0$, $q^c < 0$.

Therefore, in any equilibrium in which both labor markets are open the free-entry condition of intermediaries is downward sloping in θ^c.

Therefore, for an equilibrium with intermediaries to exist we have to have that as $\theta^c \to 0$ the value of entry has to be positive. This is equivalent to saying that parameters have to be such that

$$
\eta^{cI}\left[\left[\frac{\eta^{tW}+\eta^{tI}}{\eta^{tF}}\right] f_{\theta^t}(0) k - \left[b + f_{\theta^r}(0)\frac{\eta^{rW}}{\eta^{rF}}k\right]\right] > 0
$$

is satisfied.

B. Appendix to Chapter 2

B.1. Appendix to Empirical Part

B.1.1. Robustness Exercises

In this section, I conduct robustness exercises for the VAR results from section 3.2.2. I show that the results prevail when using a binary variable that indicates the large volatility events from figure 3.1 as the volatility measure in the VAR (section B.1.1). I further demonstrate that the results are robust towards controlling for movements in the stock market level (section B.1.1) and towards changes in the time period for which the analysis is conducted (section B.1.1).

Binary series of large volatility events

Figure B.1 shows that the estimated impulse resposes from the VAR model are quantitatively very similar when volatility is measured by a 1/0 indicator of "very large" and crucially argueably exogenous volatility events (straight lines in figure 3.1). Unfortunately, the results loose their significance in this event. This is expected since the 1/0 indicator of "very large" volatility events contains only six events. For this reason, I use a relaxed criterium to select volatility events from the series in figure 3.1 (straight and dashed lines in the figure) which gives me 10 events in total. Here, as figure B.2 demonstrates, the impulse responses have the same significance properties as the impulse responses from the main text.
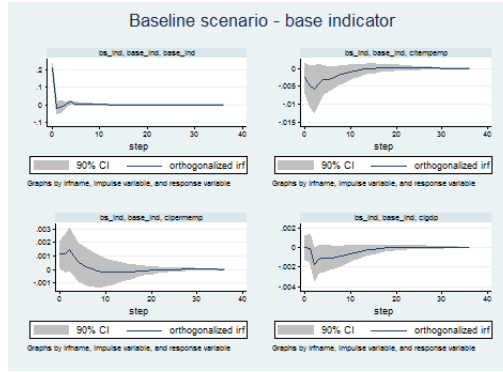
Figure B.1.: Impulse response functions to a volatility shock when the uncertainty measure is an indicator of "very large" volatility events (events marked by straight vertical lines in figure 3.1): (clockwise from top left) uncertainty measure, employment on fixed-term contracts, GDP and employment on permanent contracts.
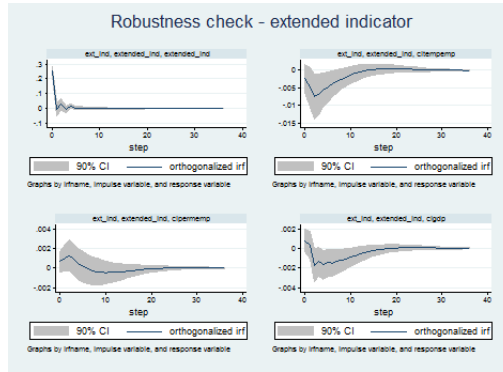

Figure B.2.: Impulse response functions to a volatility shock when the uncertainty measure is an indicator of "large" volatility events (events marked by straight *and dashed* vertical lines in figure 3.1): (clockwise from top left) uncertainty measure, employment on fixed-term contracts, GDP and employment on permanent contracts.

Controlling for the stock market level

To control for the possibility that my VAR results are in fact driven by changes in the stock market level, I investigate whether the results are robust towards including said variable into the VAR estimation. The results are shown in figure B.3 and are clearly very similar to the ones of the baseline model in section 3.2.2. I also repeat this exercise by replacing the actual volatility series from figure 3.1 by the two volatility indicators from section B.1.1. The results from the main text remain robust.
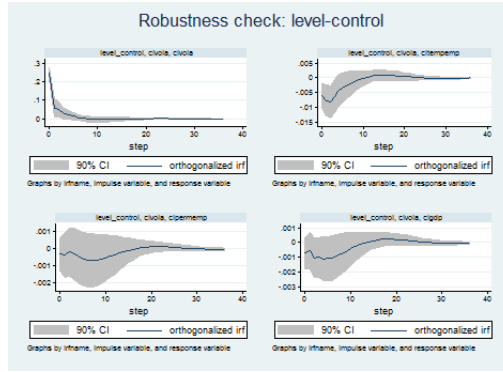
Figure B.3.: Impulse response functions to a volatility shock when the uncertainty measure is the actual volatility series from figure 3.1 (logged and detrended) and we control for shocks to the stock market level: (clockwise from top left) uncertainty measure, employment on fixed-term contracts, GDP and employment on permanent contracts.

Controlling for the Euro crises

Lastly, I restimate the VAR model on a time period that excludes the Euro crises since fluctuations in my uncertainty measure during that period are argueably not exogenous to the Spanish economy. Figure B.4 shows that the resulting impulse responses are again very similar to the ones from the baseline model in section 3.2.2. Again I also repeat this exercise by replacing the actual volatility series from figure 3.1 by the two volatility indicators from section B.1.1. The results from the main text remain robust.
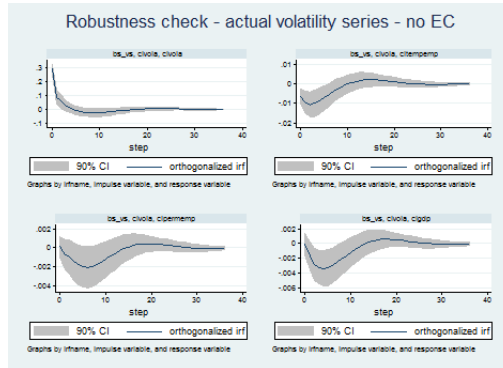

Figure B.4.: Impulse response functions to a volatility shock when the uncertainty measure is the actual volatility series from figure 3.1 (logged and detrended) and the period of the Euro crises is exluded in the analysis: (clockwise from top left) uncertainty measure, employment on fixed-term contracts, GDP and employment on permanent contracts.

B.2. Derivation of the Revenue Function

Demand is given by

$$Y^d = \tilde{B}P^{-\epsilon}$$

Output is given by

$$Y = \tilde{A}K^{\alpha_K}L^{\alpha_L}$$

Revenue is given by

$$
\begin{aligned}
\tilde{R}\left(\tilde{A}, \tilde{B}, K, L\right) &= \tilde{B}^{\frac{1}{\epsilon}}\left(Y\right)^{-\frac{1}{\epsilon}} \times Y \\
&= \tilde{B}^{\frac{1}{\epsilon}}\left(\tilde{A}K^{\alpha_K}L^{\alpha_L}\right)^{-\frac{1}{\epsilon}}\left(\tilde{A}K^{\alpha_K}L^{\alpha_L}\right) \\
&= \tilde{B}^{\frac{1}{\epsilon}}\tilde{A}^{\frac{\epsilon-1}{\epsilon}}K^{\alpha_K\left[\frac{\epsilon-1}{\epsilon}\right]}L^{\alpha_L\left[\frac{\epsilon-1}{\epsilon}\right]}
\end{aligned}
$$

Then define $\alpha \equiv \alpha_K \frac{\epsilon-1}{\epsilon}$ and $\beta \equiv \alpha_L \left[\frac{\epsilon-1}{\epsilon}\right]$ and then define $A^\gamma \equiv \tilde{B}^{\frac{1}{\epsilon}}\tilde{A}^{\frac{\epsilon-1}{\epsilon}}$.

Then we have

$$R\left(A, K, L\right) = A^\gamma K^\alpha L^\beta$$

Then we solve for r given A and L

$$\left(A^\gamma L^\beta\right)\alpha K^{\alpha-1} = r$$

Then we get

$$
\begin{aligned}
K &= \left[\frac{r}{A^\gamma L^\beta \alpha}\right]^{\frac{1}{\alpha-1}} \\
&= \left[r^{-\frac{1}{1-\alpha}}\alpha^{\frac{1}{1-\alpha}}\right] \times A^{\frac{\gamma}{1-\alpha}}L^{\frac{\beta}{1-\alpha}}
\end{aligned}
$$

Then we insert this into the above to get

$$
\begin{aligned}
\Pi\left(A,L\right) &= A^{\gamma}L^{\beta} \times \left[\left[r^{-\frac{1}{1-\alpha}}\alpha^{\frac{1}{1-\alpha}}\right] \times A^{\frac{\gamma}{1-\alpha}}L^{\frac{\beta}{1-\alpha}}\right]^{\alpha} - r\left[\left[r^{-\frac{1}{1-\alpha}}\alpha^{\frac{1}{1-\alpha}}\right] \times A^{\frac{\gamma}{1-\alpha}}L^{\frac{\beta}{1-\alpha}}\right] \\
&= A^{\frac{\gamma}{1-\alpha}}L^{\frac{\beta}{1-\alpha}}\left[\left[r^{-\frac{\alpha}{1-\alpha}}\alpha^{\frac{\alpha}{1-\alpha}}\right]\right] - r^{-\frac{\alpha}{1-\alpha}}\alpha^{\frac{1}{1-\alpha}} \times A^{\frac{\gamma}{1-\alpha}}L^{\frac{\beta}{1-\alpha}} \\
&= A^{\frac{\gamma}{1-\alpha}}L^{\frac{\beta}{1-\alpha}}\left[r^{-\frac{\alpha}{1-\alpha}}\left[\alpha^{\frac{\alpha}{1-\alpha}} - \alpha^{\frac{1}{1-\alpha}}\right]\right] \\
&= A^{\frac{\gamma}{1-\alpha}}L^{\frac{\beta}{1-\alpha}}\left[r^{-\frac{\alpha}{1-\alpha}}\left[\alpha^{\frac{\alpha}{1-\alpha}}\alpha^{\frac{1-\alpha}{1-\alpha}}\alpha^{-\frac{1-\alpha}{1-\alpha}} - \alpha^{\frac{1}{1-\alpha}}\right]\right] \\
&= A^{\frac{\gamma}{1-\alpha}}L^{\frac{\beta}{1-\alpha}}\left[r^{-\frac{\alpha}{1-\alpha}}\left[\alpha^{\frac{1}{1-\alpha}}\alpha^{-1} - \alpha^{\frac{1}{1-\alpha}}\right]\right] \\
&= A^{\frac{\gamma}{1-\alpha}}L^{\frac{\beta}{1-\alpha}}\left[r^{-\frac{\alpha}{1-\alpha}}\alpha^{\frac{1}{1-\alpha}}\left[\alpha^{-1} - 1\right]\right]
\end{aligned}
$$

We write this as

$$
\Pi\left(A,L\right) = A^{\frac{\gamma}{1-\alpha}}L^{\frac{\beta}{1-\alpha}} \times \kappa
$$

and $\kappa = \left[r^{-\frac{\alpha}{1-\alpha}}\alpha^{\frac{1}{1-\alpha}}\left[\alpha^{-1} - 1\right]\right]$.

B.3. Appendix Related to the Quantitative Part

B.3.1. Computational Algorithm

To solve the model, I use discrete value function iteration. I discretize all four continuous state variables $\left(l^{P}, l^{T}, A^{A}, A^{F}\right)$. To discretize A^{A} and A^{F}, I use Tauchen (1986)'s procedure. I use an adapted code for A^{F} that is able to take into account the two uncertainty regimes.[1] I construct the grid for l^{P} and l^{T} such that the difference between two adjunct grid points x_{i} and x_{i+1} $(x_{i+1} > x_{i})$ is exactly δx_{i+1} whenever $\delta > 0$.[2] With this method, I make sure that I do not have to interpolate in the value function iteration. Interpolation in the value function iteration is problematic in the case considered here since with adjustment costs the value function is potentially non-smooth. This method has two potential problems: first, the grid is unevenly spaced with large gaps between the large values in the grid. I address this problem by interlinking multiple grids constructed in the manner described above. The second disadvantage is that at the lowest grid point

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[1]Eventually, I ended up using code from the paper Bloom et al. (2012) which I downloaded from Nicholas Bloom's website. I wish, however, to explicitly thank my former colleagues Jan-Hannes Lang for providing me with his code at an earlier stage of this project.

[2]δ is the attrition rate that is $\delta = \delta^{T}$ or $\delta = \delta^{P}$ depending on whether we look at the grid for PCW or for TCW.

firms necessarily have to pay adjustment costs. However, this problem is not very severe since the grid is very fine as the grid points approach zero (I also include zero in the grid) when using this method of constructing the grid. In case $\delta = 0$, I use an evenly spaced grid. Then, I solve the model using simple discrete value function iteration.

As pertaining to the number of grid points I set $N_{l^P} = 50$, $N_{l^T} = 110$, $N_{A^A} = 5$, $N_{A^F} = 20$.