

Schirwitz, Beate

**Research Report**

## Business Fluctuations, Job Flows and Trade Unions - Dynamics in the Economy

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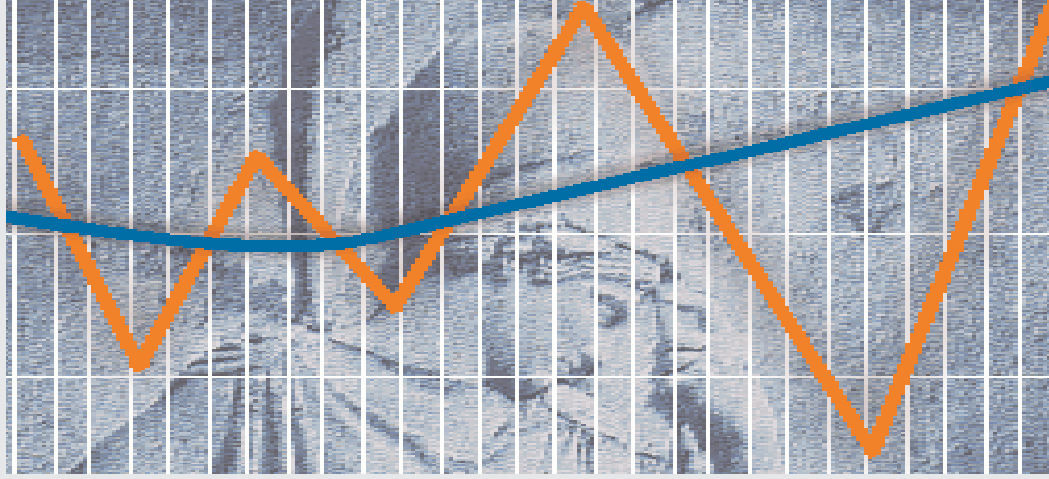
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## **ifo Beiträge zur Wirtschaftsforschung**

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Beate Schirwitz

**ifo** Institut

Leibniz-Institut für Wirtschaftsforschung  
an der Universität München e.V.

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## Preface

This study was prepared by Beate Schirwitz while she was working at the Ifo Institute's Dresden Branch. It was completed in February 2012 and accepted as a doctoral thesis by the Faculty of Law, Management, and Economics at the Johannes Gutenberg University Mainz in July 2012. It focuses on a variety of economic aspects for which the dynamic character of underlying parameters is essential: How can we identify business cycle phases from aggregated data? Why do we observe ambiguous output dynamics in response to positive productivity shocks? Can we identify heterogeneous productivity shocks and the adaptation they induce in empirical data? What consequences has the explicit inclusion of membership dynamics for the optimal behaviour of trade unions? To approach these questions theoretical as well as empirical methods were used. The empirical methods include parametric and non-parametric techniques to date the business cycle in aggregate data as well as the compilation and analysis of a micro data set. The theoretical chapters are based on versions of search and matching as well as union labour market models. To find and evaluate their equilibrium solutions and the path to get there, intertemporal optimization methods and comparative statics analyses are employed.

Chapter 1 gives an introduction and summary of the thesis. Chapter 2 develops a chronology of business cycles and recessions in the German economy. The subject of Chapter 3 is a theoretical analysis of a possible mechanism which might lie behind macroeconomic fluctuations. Chapter 4 is concerned with the empirical relevance of recession-inducing heterogeneous productivity shocks and presents findings regarding the high-frequency, cyclical and seasonal characteristics of gross job and aggregate employment flows. Chapter 5 analyses the employment effects which result from the explicit consideration of membership dynamics during optimization of unions' behaviour. The final Chapter 6 of this thesis summarizes and discusses the main findings of the previous chapters.

Parts of the thesis are based on published articles, see the respective references at the beginning of the chapters.

**Keywords:** Business cycles, business cycle dating algorithm; Pissarides-style labour markets, positive productivity shocks, recession; job flows, micro data; dynamic wage bargaining, endogenous union membership, bargaining centralization.

**JEL Class.:** C14, C22, C61, C81, E32, J51, J64, O40.

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I also thank the Ifo Institute for providing me with the research environment and infrastructure necessary to write and complete a thesis. In particular manager Prof. Dr. Marcel Thum and former managing director Prof. Dr. Michael Berlemann offered important support for my academic work. Many thanks also go to my colleagues there for their help, motivation, for listening and valuable hints.

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I owe gratitude to the German Academic Exchange Service (DAAD). It generously supported my research visit in Glasgow, which enabled substantial progress on my thesis, with a ‘Kurzstipendium für Doktorandinnen und Doktoranden’. I also really appreciate the assistance I received from the employees at the Research Data Centre of the Federal Employment Agency at the Institute for Employment Research and from Dr. Urban Janisch at the Research Data Centre of the Statistical Offices of the Länder in Dresden in my empirical analysis on gross job and employment flows. Many thanks also go to Prof. Dr. Thorsten Schank for his willingness to act as second referee and to Jun.-Prof. Andrey Launov.

This thesis was written in LaTeX, using WinShell as excellent editing tool. I also benefited from further software packages (see also the appendices of the respective chapters) and countless advice on the use and troubleshooting for these discussed in the world wide web. The efforts of software engineers and experts who offer their helpful products and knowledge for free are invaluable.

Finally I very much want to thank my friends and family for the encouragement, understanding and recreation they offered me during the last years. Especially, of course, I want to thank Rico – for his love, his patience and because he always believes in me. And I thank Johanna, simply for being there and brightening up our life.

# **Business fluctuations, job flows and trade unions**

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## **Dynamics in the economy**

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## List of Abbreviations and Notation

$\ln L$	Log-Likelihood
$t$	time period
adj.	adjusted
aggr.	aggregated
AR	autoregressive
BA	German Federal Employment Office (Bundesagentur für Arbeit)
BBQ	Bry and Boschan (1971) approach of business cycle dating
$\text{corr}(x, y)$	correlation coefficient of $x$ and $y$
D	manufacturing
DAAD	German Academic Exchange Service
DGP	data generating process
DJ	manufacturing of basic metals and fabricated metal products
DK	manufacturing of machinery and equipment not elsewhere classified
DL	manufacturing of electrical and optical equipment
FDZ	Research Data Centre (Forschungsdatenzentrum)
fract.	fraction
freq.	frequency
GDP	gross domestic product
hp shock	heterogeneous productivity-enhancing shock
IAB	Institute for Employment Research (Institut für Arbeitsmarkt- und Berufsforschung)
JKO	Jones (1987) and Kidd and Oswald (1987)

LIAB	Linked-Employer-Employee Data from the IAB
LIAB LM1	LIAB Longitudinal Model Version 1
LR	likelihood ratio
mfr.	manufacturing
MS	Markov-switching
MSI(x)	MS model, regime-dependent intercept, x regimes
MSIH(x)	MS model, regime-dependent intercept and error variance, x regimes
MSM(x)	MS model, regime-dependent mean, x regimes
MSMH(x)	MS model, regime-dependent mean and error variance, x regimes
NBER	National Bureau of Economic Research
OECD	Organisation for Economic Co-operation and Development
RBC	real business cycle
s.d.	standard deviation
s.e.	standard error
SVAR	structural vector-autoregressive
VAR	vector autoregression
X	model including a dummy

**Notation Chapter 2**

$\Delta y_t$	growth rate of log-level GDP at time $t$
$\mu_{s_t}$	regime-dependent mean
$\nu_{s_t}$	regime-dependent intercept
$A_i$	parameter value with index $i$ at time $t$
$p$	order of autoregressive process
$p_{ij}$	probability for a switch from $s_t = i$ to $s_{t+1} = j$
$s_t$	regime in period $t$
$u_t$	error term at time $t$



### Notation Chapter 3

$_{-h}$	index for values with higher productivity
$_{-i}$	index for values with initial productivity
$_{-n}$	index for newly matched jobs
$\bar{A}$	average labour productivity (output per filled job)
$\beta$	worker's bargaining power
$\hat{A}$	job-separation productivity threshold
$\mu_h$	current ratio of firms with higher productivity
$\theta m(\theta)$	job finding rate
$\theta = \frac{v}{u}$	labour market tightness
$\underline{\mu}_h$	ratio of firms initially hit by productivity-enhancing shock
$A$	labour productivity (output per filled job)
$b$	unemployment benefit
$d$	ratio of endogenously dissolved jobs
$E$	value of being employed
$h$	vacancy's search cost per instant
$J$	value of filled job
$j = i, h$	index for initial/higher values
$L$	employed workers
$m(\theta)$	vacancy filling rate
$N$	total number of workers
$r$	interest rate
$S$	surplus of a match
$s$	arrival rate of exogenous job destruction shock
$U$	value of being unemployed
$u \equiv \frac{N-L}{N}$	unemployment rate

$V$	value of vacancy
$v$	vacancy rate (vacancies per worker)
$w$	wage
$x(uN, vN)$	matching function
$Y$	total output

#### Notation Chapter 4

$absJC$	absolute job creation
$absJD$	absolute job destruction
$frJC$	fraction of job-creating establishments
$frJD$	fraction of job-destructing establishments
$L_t^i$	employment level of firm $i$ in period $t$
$n$	number of firms in sample
$NET$	net employment change
$SUM$	aggregate employment

#### Notation Chapter 5

$-c$	index for centralized case
$-d$	index for decentralized case
$\bar{\Pi}$	firm's minimum profit level
$\eta_c^b \equiv \frac{\partial b}{\partial c} \frac{c}{b} \in ]-1, 0[$	constant elasticity of the competitive wage with respect to employment
$\eta_n^w \equiv \frac{\partial w}{\partial n} \frac{n}{w} \in ]-1, 0[$	constant elasticity of union wage with respect to employment
$\gamma$	large number of identical union-firm pairs
$\lambda$	co-state variable in Hamiltonian
$\mathcal{H}$	Hamiltonian
$\phi_i$	number of unions included in the analysis
$\sigma$	membership loyalty rate in competitive sector
$\tilde{m} \equiv \frac{z}{\gamma}$	potential labour force per union-firm, maximum union membership

$b$	competitive wage
$c \equiv z - \gamma n$	workers in competitive sector
$f(n)$	isoelastic production function of union-firm
$g(c)$	isoelastic production function in competitive sector
$i = d, c$	index for decentralized/centralized case
$m$	membership per union
$n$	workers per union-firm
$r$	time preference rate
$u$	union's period utility
$v$	union's intertemporal utility
$z$	number of identical, risk-neutral workers



# Chapter 1

## Introduction

‘Panta rhei.’

‘Everything flows.’

– Heraklit

The economy is subject to permanent change and inherently dynamic. Indeed, much knowledge and resulting policy implications can already be derived from the analysis of static models, comparative statics and empirical cross-sections. This thesis, however, focuses on a variety of economic aspects for which the dynamic character of underlying parameters is essential: How can we identify business cycle phases from aggregated data? Why do we observe ambiguous output dynamics in response to positive productivity shocks? Can we identify heterogeneous productivity shocks and the adaptation they induce in empirical data? What consequences has the explicit inclusion of membership dynamics for the optimal behaviour of trade unions?

The term ‘dynamics’ refers to the change of crucial underlying parameters over time due to exogenous or endogenous influences, which needs to be considered explicitly in order to conduct meaningful analyses and comprehension. Dynamics apply to many and quite different topics considered in economic research, like the determination of output subject to growth and business cycles, the setting of asset pricing, time relevant frictions and transaction costs in markets, intergenerational issues, and much more. Despite its importance, the understanding of characteristics, backgrounds and consequences of many dynamic aspects in economics is still fragmentary. Advances in methodologies and data availability, however, foster the theoretical and empirical work in these fields enormously.

Like indicated above, this thesis in particular centres on several aspects of business fluctuations (Chapters 2–4) as well as the behaviour of trade unions subject to membership dynamics on the labour market (Chapter 5). Apart from this introduction and the concluding discussion, each chapter comprises a self-contained paper. Therefore, detailed discussions on the context, current state of research and own contributions are left to the respective introductory sections there. The remainder of the present chapter gives an overview and short summaries of the

chapters to come. As one of it is based on joint-work with a co-author, additionally information is given on the authorship of the several parts of this work.

Starting point of my research on business fluctuations was the concern to learn more about what mechanisms are behind recessions and time periods with declining economic output. If we look into the literature, there still are many questions on this important topic left unresolved. We also find that both in theoretical as well as empirical studies there is a broad scope and variety of approaches adopted to deal with what typically is called ‘the business cycle’. That research also partially overlaps with certain strands in theoretical growth and/or labour market theory and is likewise subject to diverse empirically based investigations. Rather often, however, the connection between different approaches is limited, apart from the fact that all of them are concerned with fluctuations in macroeconomic variables. I likewise consider varying aspects of such fluctuations. Nonetheless a unifying feature in the related chapter of this thesis is a particular focus on recessions, characterised as period with declining output measured in absolute levels.

*Chapter 2* develops a chronology of business cycles and recessions in the German economy. It is mainly based on an article published in the journal *Empirical Economics* (see Schirwitz, 2009), with minor illustrative extensions. Business cycle chronologies offer reference points for empirical studies used as benchmarks for further theory. A quasi-official chronology exists for the U.S. economy, but not for most European countries, including Germany. The literature contains a number of different ways to extract a business cycle from the data. I therefore put a discussion on the various approaches to the empirical business cycle in front of the technical analysis. While most other papers rely on one specific method, I present and discuss a number of different dating procedures based in particular on the classical concept of the business cycle. They include both non-parametric and parametric methods. These are applied to German data comprising the years 1970–2006. I look at the results implied by the different procedures and review occurrent discrepancies in more detail. Finally a consensus business cycle chronology for the German economy is suggested. Accordingly, between 1970 and 2006 Germany suffered from five pronounced recessions.

A theoretical analysis of a possible mechanism which might lie behind macroeconomic fluctuations is the subject of *Chapter 3*. It is based on a recent debate in the literature on the ambiguity in the responses of labour and output on positive productivity shocks. I develop a model in which productivity-enhancing shocks can induce a variety of possible fluctuation shapes for aggregate variables. Among others, impact-recessions might result from productivity progress. The theoretic framework is situated at the crossing of labour market, business cycle and growth models, supplemented by the explicit consideration of agents’ heterogeneity in the ability to implement the shock. I first present a standard search and matching model of the labour market. Then I study the transitional dynamics which result from an unanticipated productivity-enhancing shock there. Comparative statics and graphical illustrations complement the analysis. Afterwards I introduce heterogeneity in the firms’ capability to benefit from such a shock and examine the consequences for equilibrium and

impulse responses. It is shown how small changes on the micro-level of the economy translate into apparent ambiguity on the macro-level with such a modification. I find that long-run growth might involve temporary fluctuations in the rates of change in aggregate variables. Rational, forward-looking optimization can induce time spells of higher unemployment and even drops in aggregate output in response to productivity-enhancing shocks, as this helps to approach the new, more valuable steady state faster.

Based on the derivation and analysis of the theoretical heterogeneous productivity shock model, in *Chapter 4* I am concerned with the empirical relevance of such (in particular recession-inducing) shocks and outcomes. Therefore I develop an evaluation of their occurrence within a suitable empirical data set. First of all I derive from the theoretical model a set of time-series patterns connected to those shocks. It follows that the required data should allow high-frequency, long-time insights into aggregate and gross productivity, job and employment dynamics. I discuss the issue of data availability and the related literature of firm and employment dynamics analyses. Then the chosen data set is presented. It enables a novel insight into establishment employment-levels on a daily base. I illustrate descriptive methods, results and issues of the analysis. Additionally, findings regarding the high-frequency, cyclical and seasonal characteristics of gross job and aggregate employment flows are given. I discuss my results and give an outlook for additional research requirements.

After these analyses of several aspects of business fluctuations, *Chapter 5* of this thesis switches to research on unions at the labour market. It is based on joint work with Marcus Dittrich and mainly an extension of an article published in the journal *Economics Letters* (see Dittrich and Schirwitz, 2011a). There we analyse the employment effects which result from the explicit consideration of (rather generally specified) membership dynamics during optimization of unions' behaviour, while conventional models are static. Previous research found that static models overrate distortions caused by monopoly unions. We show, however, that this result only applies unconditionally if employment setting takes place by decentralized monopoly unions at the firm level. With centralized wage setting, however, it rather depends on both the elasticity of labour demand and union's time preference rate whether static models overrate or even underrate unions' distortions. Furthermore we find that employment in the unionized sector is higher if employment is determined centralized for the whole sector. In contrast to a firm-level union, a centralized union considers the consequences of its employment setting behaviour on the outcome in the competitive sector and hence recommends higher unionized employment. Standard models with exogenous outside option can not capture this effect. Based on supplementary work (Dittrich and Schirwitz, 2011b), in addition to Dittrich and Schirwitz (2011a), we extend our analysis to efficient bargaining where employment and wages are set simultaneously. We show that despite corresponding employment effects, the influence of membership dynamics on labour market distortions is quite inverse in both frameworks. Additionally, comparative static examinations complement our analysis. In particular, we examine the effects of endogenous union membership on wages and employment and find that a higher exit rate of union members has mixed employment effects depending on the degree of centralization.

Regarding the authorship of Chapter 5 note the following: The work on which the chapter is based was initiated by Marcus Dittrich. Responsibility for the two different optimization set-ups was split up such that I to a large part accounted for the monopoly union case and Marcus Dittrich for the efficient bargaining framework. Major parts of the output which originated from the collaboration, like the chosen modification in membership dynamics, interpretation of the results and the composition of the final manuscripts, were developed in mutual exchange and alternating revisions during the last years. Most recently I explicitly accounted for the formal proofs to Propositions 5.1, 5.3, 5.4 and 5.6, as well as the explicit derivation of transition from discrete to continuous time membership dynamics. I compiled Chapter 5 of this thesis based on our published articles and some extensions and according modifications. As our major contribution is in Dittrich and Schirwitz (2011*a*), that article is the foundation of the chapter. While Dittrich and Schirwitz (2011*a*) in particular focus on the monopoly union framework, in accordance with supplementary Dittrich and Schirwitz (2011*b*) I added the efficient bargaining framework and comparative statics. Novel to this thesis is, beside smaller modifications and comments, in particular the explicit consideration and discussion of resulting labour market distortions in the various frameworks compared to a pure competitive environment (replacing the maximization of a somewhat arbitrary welfare function in Dittrich and Schirwitz, 2011*b*), as well as the discussion of employment dynamics on the way to the steady state.

The final Chapter 6 of this thesis summarizes the main findings of the previous chapters. I also discuss their relationship and their contribution to increase our understanding on economic dynamics.



## Chapter 2

# Output fluctuations: A comprehensive German business cycle chronology

## 2.1 Introduction

Business cycles have been on the research agenda for at least a couple of decades now and there is a long list of theories that try to explain the phenomenon of fluctuations in the economy. Still, a number of questions remain to be resolved satisfyingly in a broad framework: Why does the economic output decline even when no plants are destroyed, no knowledge is forgotten and the potential workforce does not decline? Why does involuntary unemployment rise during recessions? Are recessions distinctive phases of the business cycles or just the mirror image of expansions?

Hence, there is still need for further research on business cycles. A prerequisite to evaluate the usefulness of a theoretical model, which aims to explain this economic aspect, is a thorough analysis of the empirical business cycle. By far the most work done so far is based on US data, while studies from other countries are rather rare. This is problematic as the implementation of the market economy in continental Europe partially deviates strongly from the Anglo-Saxon model. Business cycle chronologies are often the starting point for further analysis of the cycle and its components. Having such a reference for a variety of countries helps to extract commonalities and country specifics of the business cycle phenomenon.

A general difficulty in business cycle research is the broad usage of the term ‘business cycle’ and anything connected to it. As Harding and Pagan (2005) point out, a variety of definitions exists in current cycle research. Furthermore research on economic fluctuations includes various topics. These differences in the concepts and tasks naturally lead to different approaches to extract the business cycle from the data.

My aim is to develop a business cycle chronology for Germany comprising the years 1970–

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\* This chapter is mainly based on Schirwitz, Beate, 2009, “A comprehensive German business cycle chronology.” *Empirical Economics* 37(2):287–301, with kind permission of Springer Science+Business Media.

2006. Several methods known from the literature are adopted, all of them according to the concept of the classical business cycle and based on the gross domestic product (GDP). I provide a reference point for the use of German data for recession analysis and the derivation and evaluation of business cycle theories. Due to the general availability of GDP and since the analysis mainly builds on routines that can be automated, the procedure could easily be extended to other economies as well (see Appendix 2.A for the used software and programmes). Therefore a set of consistent business cycle chronologies, to be used in further standardized research, could be built following this example.

## 2.2 Empirical approaches to the business cycle

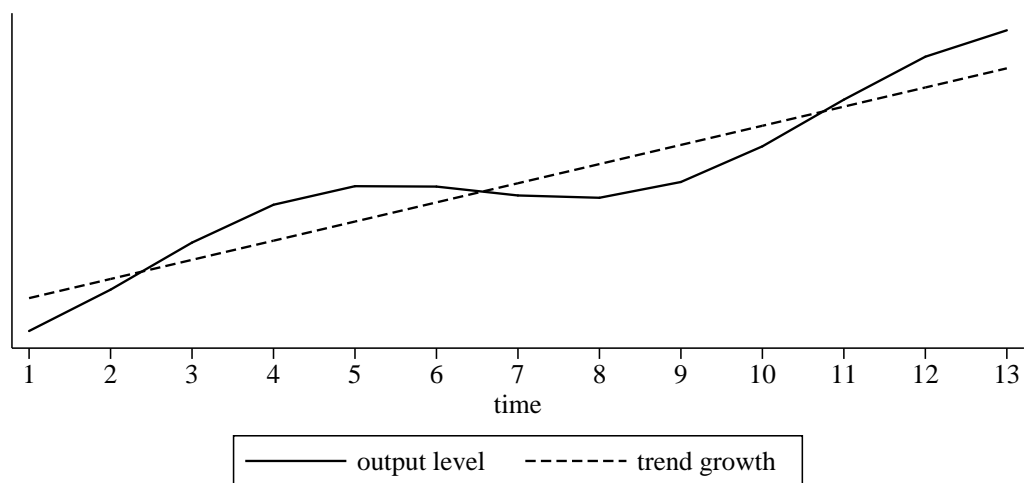
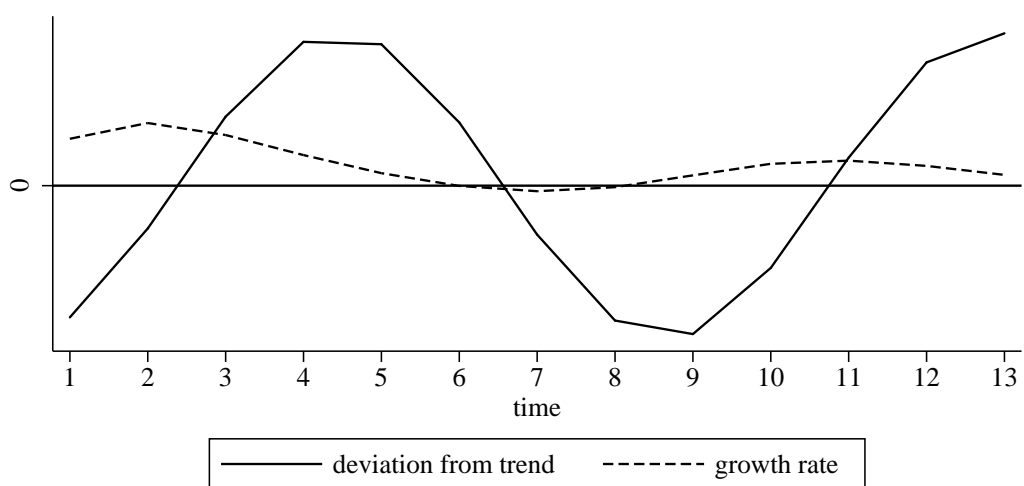
The stylized development of economic output is typically illustrated by a sine curve enveloping a linear trend, see Figure 2.1a. It reflects both main elements of macroeconomics' dynamics, long-run growth and the business cycle. Arthur Burns and Wesley Mitchell are considered by most authors as the pioneers in empirical research on the business cycle. Their definition of the business cycle as 'a type of fluctuation found in aggregate economic activity' given in Burns and Mitchell (1946) is probably the most cited one. Despite these common roots, the successors of Burns and Mitchell developed different directions to continue their research on economic fluctuations.

A first delineation is the selection of one or more appropriate series to indicate the business cycle. Burns and Mitchell derived the economic activity from a range of time series. A group of researchers deduced from this approach that co-movement among economic aggregates was one of the main characteristics of the business cycle (see, for example, Diebold and Rudebusch, 1996; Cooley and Prescott, 1995). However, as Harding and Pagan (2002) note, Burns and Mitchell's approach might also be understood as reflecting the paucity of suitable comprehensive data available at the time they conducted their research. By now, the quarterly availability of GDP, comprising the total value of all goods and services produced within an economic area, has closed this gap. Accordingly, the use of GDP as a direct measurement of the economic situation offers a suitable univariate alternative to multivariate methods.<sup>1</sup> The final choice of the appropriate data set is also decisively influenced by the particular research objective. For ex-post analyses and comparisons GDP is the optimal candidate. If instead the task is to construct a (monthly) indicator to evaluate the current economic state prior to official GDP releases or for forecasting purposes, then multivariate approaches based on additional and higher frequency data published with a shorter delay are usually preferred.<sup>2</sup>

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<sup>1</sup> A second popular single-series meter for the business cycle is industrial production, as industry sectors in general fluctuate more than service activities, see, e.g., Artis, Kontolemis and Osborn (1997) and Fritsche and Kouzine (2005).

<sup>2</sup> For the latter strand of research see also the rich literature on the construction of composite indices. Important stimulation came from Stock and Watson (1989), recent contributions and extensions include Altissimo et al.

**Figure 2.1:** Stylized business cycle**(a)** Output level and growth trend**(b)** Deviation from trend and growth rate

For dating and analysing the business cycle most often a 2-phases scheme is used. This scheme distinguishes expansions and recessions, which together make up the complete cycle. Textbooks sometimes discuss more detailed classifications including upswing, boom, downturn and recession. As empirical data typically strongly deviates from stylized illustrations, in practice this is rarely implemented, though. However research concepts also differ in how they identify the cycle in the time series chosen for inspection, which influences the resulting phase classifications. What is often termed the 'classical' approach considers business cycles in level data, where recessions are periods of absolute decline in the economic activity. In the stylized output development outlined in Figure 2.1a, this corresponds to periods 6 to 8, see also Figure 2.1b. Other approaches instead emphasize the level data to be the sum of a long-run trend and short-run deviations from it. Recessions are then periods in which actual output is below the trend level; that is, periods 7 to 10 in my illustration. As in reality the trend is not directly observable, a range of methods have been developed to de-trend and to filter the data, or to estimate potential output via a production function.<sup>3</sup> To distinguish this approach from the classical cycle, the term 'growth cycle' has started to prevail when deviations from the trend are the subject of investigation. Further distinct from that, though, is the concept which looks at the cycle in the growth rates of the original series. It considers recessions as times with declining, though not necessarily negative, growth, see periods 3 to 7 in Figure 2.1.

This variety of approaches to the business cycle naturally result in an array of research directions, each applying and expanding the knowledge and methods specific to the chosen concept of the cycle. Each of the existing approaches has its merits in exploring the nature of economic fluctuations. The classical cycle directly follows the spirit of Burns and Mitchell and allows the study of periods of absolute decline in economic performance. Such analyses are of particular interest to the public and are also in line with theoretical models emphasizing the links between growth trends and fluctuations. However, economic weakness does not necessarily involve a decrease in activity, it might also be characterized by prolonged periods in which output falls short of its potential. Therefore the analysis of deviations from the long-run trend complements the research on economic fluctuations, despite the difficulties connected to isolating the unobservable trend. Likewise the different research tasks like dating, dissecting or forecasting all improve our knowledge of the business cycle. Each of them is connected to particular methods. Hence, to find the appropriate approach and for meaningful comparison of the results, it is always necessary to be clear about the respective object of an analysis.

I identify the classical German business cycle 1970–2006. As the aim is to offer a reference

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(2001, 2006); Kholodilin (2005); Kholodilin and Yao (2005) and Mariano and Murasawa (2003).

<sup>3</sup> Some arbitrarily chosen examples are the Hodrick-Prescott filter, band-pass-filters like the Baxter-King and the Christiano-Fitzgerald filter, the method of unobserved components and production functions like the Cobb-Douglas based approach of the European Commission (see Denis, McMorro and Röger (2002)). Current research includes Döpke (2004), Harvey and Trimbur (2003) and Azuvedo, Koopman and Rua (2006) among others.

for ex-post analysis I base my evaluation on GDP data. Its widespread availability for many countries and regions and the application of common standards in its ascertainment<sup>4</sup> also ease the construction of a multi-country data set based on a uniform framework as an extension to the current analysis.

## 2.3 Methods to date the cycle

### 2.3.1 Official releases

To date the business cycle means to locate the turning points that signal the switch from one business cycle phase (sometimes also called ‘state’ or ‘regime’) to another; with *peaks* completing expansions and *troughs* ending recessions. A number of different procedures to determine the dates of an economy’s business cycle exists, and there are (quasi-)official and unofficial chronologies. For the U.S. economy the National Bureau of Economic Research (NBER) is considered the authority for dating the national business cycle. In accordance with the classical cycle its Business Cycle Dating Committee defines a recession as ‘a significant decline in economic activity’ (see National Bureau of Economic Research, 2006). Despite the advantage of having a generally accepted chronology of the business cycle, the NBER dating features at least two important drawbacks: First, because it is mainly based on experts’ evaluation, it is not very transparent and not necessarily uniform. Secondly, and for current research maybe the more important issue, there is a significant time lag in the announcement of the turning points.<sup>5</sup>

Furthermore, the existence of an institution like the NBER for the U.S. business cycle is rather unique. This fact, as well as the desire to make business cycle chronologies comparable across countries and regions, causes the need for alternative dating methods.

### 2.3.2 Non-parametric methods

There are two groups of methods used to date the business cycle: non-parametric and parametric. Non-parametric procedures often rest on some kind of pattern recognition algorithm. One example is the popular ‘newspaper’ definition, which states that in order for a recession to be present, there must be two consecutive quarters of negative GDP growth.

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<sup>4</sup> See the System of National Accounts (SNA 1993) of United Nations.

<sup>5</sup> For instance, the November 2001 trough was announced only in July 2003, i.e., almost one and a half year after the date passed.

A main advantage of non-parametric methods is the general simplicity of their rules, which supports understanding and replication of the results. As they do not impute certain characteristics on the time series, non-parametric rules are not very demanding concerning the underlying data. The results are rather robust, insensitive to changes in the sample size and easily comparable among different data sets. Still, the simplicity and non-specificity in terms of their underlying purpose is also the focus of critics of non-parametric approaches. Hamilton (2003) rejects such a method by stating that ‘one could use this rule to find business cycles in records of rainfall in Mongolia or the counts of spots on a shuffled deck of cards’. However, as Harding and Pagan (2003a) argue, employing a pattern that defines a recession for appropriate data is clear enough for ‘collecting evidence on the phenomena of interest’, which is at the centre of business cycle dating. Hence, their convenience makes non-parametric methods a popular tool for this task.<sup>6</sup>

I consider three non-parametric approaches in our analysis. The first one is the mentioned *newspaper* method. In line with the declaration of a recession’s beginning, the contraction is terminated with two consecutive quarters of positive growth. These rules can be transferred into a set of conditions, a data point  $t$  has to meet to qualify as a turning point. Table 2.1 sums up these conditions, together with those of the non-parametric approaches to come.<sup>7</sup>

After applying the newspaper method to U.S. data and comparing it with NBER dates, Boldin (1994) suggested some modifications. In addition to relaxing the strict two-in-a-row constraints into two-out-of-three requests, he claims that ‘growth should be higher than average after a recession ends.’ The latter introduces a threshold growth rate higher than zero into the dating rule for a trough. Although primarily intended to better match the NBER dates, Boldin’s modifications implement some additional features of business cycle thinking worth considering. The general idea of a recession as an economic downturn still applies if two quarters with negative growth rates are interrupted by one with (mostly weak) positive growth. The introduction of a positive growth rate threshold for the termination of a recession is in line with the observation that immediately after recessions growth rates would be particularly high, see, for example, Sichel (1994). When applying these rules to German data I follow Boldin’s proposal and set the threshold on the mean quarterly growth rate at 0.5%, see Table 2.1.

Probably the most cited academic representative of a non-parametric dating algorithm used for monthly data is that of Bry and Boschan (1971). I employ a quarterly version of it, proposed by Harding and Pagan (2002), the *BBQ* approach. Based on this method, turning points are local maxima or minima, respectively, of the considered time series. Table 2.1 also

<sup>6</sup> Examples apart from those considered in this section include Artis, Kontolemis and Osborn (1997); Bengechea, Camacho and Perez-Quiros (2006); Artis, Marcellino and Proietti (2004) among many others.

<sup>7</sup> Note that the use of growth rates in these algorithms is no contradiction to the classical business cycle: A decline in the level of a time series translates into negative growth rates, while the cycle is still detected in the level.

**Table 2.1:** Non-parametric rules to date the business cycle in log-level GDP  $\{y_t\}$ 

<b>conditions for a peak in <math>t</math></b>	
newspaper	$\Delta y_t > 0 \cap \Delta y_{t+1} < 0 \cap \Delta y_{t+2} < 0$
Boldin	$\Delta y_t > 0 \cap \Delta y_{t+1} < 0 \cap [\Delta y_{t+2} < 0 \cup \Delta y_{t+3} < 0]$
BBQ	$\Delta_2 y_t > 0 \cap \Delta y_t > 0 \cap \Delta y_{t+1} < 0 \cap \Delta_2 y_{t+2} < 0$
<b>conditions for a trough in <math>t</math></b>	
newspaper	$\Delta y_t < 0 \cap \Delta y_{t+1} > 0 \cap \Delta y_{t+2} > 0$
Boldin	$\Delta y_t < 0.5\% \cap \Delta y_{t+1} > 0.5\% \cap [\Delta y_{t+2} > 0.5\% \cup \Delta y_{t+3} > 0.5\%]$
BBQ	$\Delta_2 y_t < 0 \cap \Delta y_t < 0 \cap \Delta y_{t+1} > 0 \cap \Delta_2 y_{t+2} > 0$
<b>explicit censoring rules</b>	
newspaper	• peaks and troughs must alternate
Boldin	• peaks and troughs must alternate
BBQ	<ul style="list-style-type: none"> <li>• peaks and troughs must alternate</li> <li>• completed phases must not be shorter than two quarters</li> <li>• a complete cycle must not be shorter than five quarters</li> <li>• level at peak must be higher than at proximate trough</li> </ul>
Note: $\Delta y_i = y_i - y_{i-1}$ , $\Delta_2 y_i = y_i - y_{i-2}$ .	

Source: Own compilation, adapting Boldin (1994) and Harding and Pagan (2002).

gives a number of explicit censoring rules and cleansing procedures to make sure that the standard assumptions of the business cycle are met.

### 2.3.3 Parametric methods – Markov-switching models

Parametric procedures base their examination on a data generating process (DGP), which is assumed to have created the data. The most often employed procedure for business cycle dating is the idea of Markov-switching (MS) processes underlying the evolution of the economy, initiated by Hamilton (1989).<sup>8</sup>

An advantage of parametric approaches for business cycle research is that a successful

<sup>8</sup> Less used parametric approaches to the business cycle include variations of threshold autoregressive models (TAR) and smooth transition autoregressive models (STAR), see, e.g., Potter (1995) and Teräsvirta and Anderson (1992).

application implies characteristics about the underlying processes which can be directly transferred to theoretical models. Prior information may be utilised to assist in the dating process. MS models, for example, explicitly consider existing evidence on asymmetries in the business cycle, see, for example, Romer (2006, p. 177) for the U.S. cycle. Individual features of the underlying data set may also be taken into account. The drawback of these features is that the results might lack stability when faced with changes in the sample size or the data set itself.<sup>9</sup> Also, dating results of the MS approach do not necessarily coincide with business cycle phases when the assumption on the DGP is wrong and the data is additionally influenced by long-run structural changes or breaks. A final disadvantage of complex methods like MS is their opacity.<sup>10</sup> Still current research improves the fit of parametric models to economic time series which makes them a valuable instrument for a variety of business cycle analyses and forecasts.

As the focus of this paper is to present and compare different approaches to date the business cycle that are stable and easily transferable to other data sets, I will only consider simple versions of MS models.<sup>11</sup> Basic MS models are built on autoregressive (AR) processes of order  $p$ . The parameter values of the processes (partly) depend on the current but unobservable regime  $s_t$  the economy is in. In our context, we can think of two regimes, namely recession ( $s_t = 1$ ) and expansion ( $s_t = 2$ ). The probability  $p_{ij}$  for a switch from  $s_t = i$  to state  $s_{t+1} = j$  is exogenous and depends only on  $s_t$ .

I use two main classes of MS models. The first one discriminates between different regimes by the assignment of regime-dependent means  $\mu_{s_t}$ , with

$$\Delta y_t - \mu_{s_t} = A_1 [\Delta y_{t-1} - \mu_{s_{t-1}}] + \dots + A_p [\Delta y_{t-p} - \mu_{s_{t-p}}] + u_t,$$

where  $\Delta y_t$  denotes the growth rate of log-level GDP, the  $A_i$  represent parameter values and  $u_t$  is an error term. I follow the classification of Krolzig (1997) and label the models as MSM if  $u_t \sim N(0, \Sigma)$  for all states. I also consider so called MSMH models, in which additionally the error variance depends on the current regime, that is,  $u_t \sim N(0, \Sigma_{s_t})$ .

The second class of models is based on a regime-dependent intercept  $\nu_{s_t}$  and reads

$$\Delta y_t = \nu_{s_t} + A_1 \Delta y_{t-1} + \dots + A_p \Delta y_{t-p} + u_t.$$

Here, too, I consider a version with constant error variance, called MSI, and one with regime-

<sup>9</sup> As Harding and Pagan (2003b) note, extensions of basic MS models also were induced by the inability to replicate Hamilton's (1989) results with a larger US data sample or for other countries.

<sup>10</sup> Harding and Pagan (2003b) show for the results in Hamilton (1989) how the BBQ rule relates to the MS dating rule. They are able to deduce a simple rule based on the magnitude of a weighted average of the growth rates. But the choice of the weights derived from the application of MS is still not very transparent and is of course dependent on the chosen data sample and its particular MS parameter values.

<sup>11</sup> See Kholodilin (2005) for a current more advanced and individual application in particular on the German business cycle, referring to composite indicators rather than to GDP.



dependent  $\Sigma_{s_t}$ , labelled MSIH. Fitting the model to the data includes finding the underlying process for each of the regimes as well as assigning individual data points to one of the regimes. For an introduction into the solution algorithm as well as current developments of regime switching models for business cycle research in general see for instance Hamilton and Raj (2002).

To date the German business cycle I use the MSVAR package (by Hans-Martin Krolzig) for the software Ox to estimate various MS specifications with up to 8 AR-lags. The non-linearity of multiple regime-dependent processes is the basis for using MS in business cycle dating. Hence I only consider those MS models that offer a significantly better fit than their respective linear counterpart. I use the likelihood ratio (LR) linearity test implemented in MSVAR, denoting  $p$ -values following Davies (see Davies, 1977, 1987), to decide on goodness of fit.<sup>12</sup> Included models are significant at least at a 90 per cent level. There are a number of additional specification tests which could be employed to optimize the fit of MS models to the underlying data (see, for example, Breunig, Najarian and Pagan, 2003). The full application of these methods, however, is beyond the scope of this paper, where MS models are considered one of many types of business cycle dating procedures.

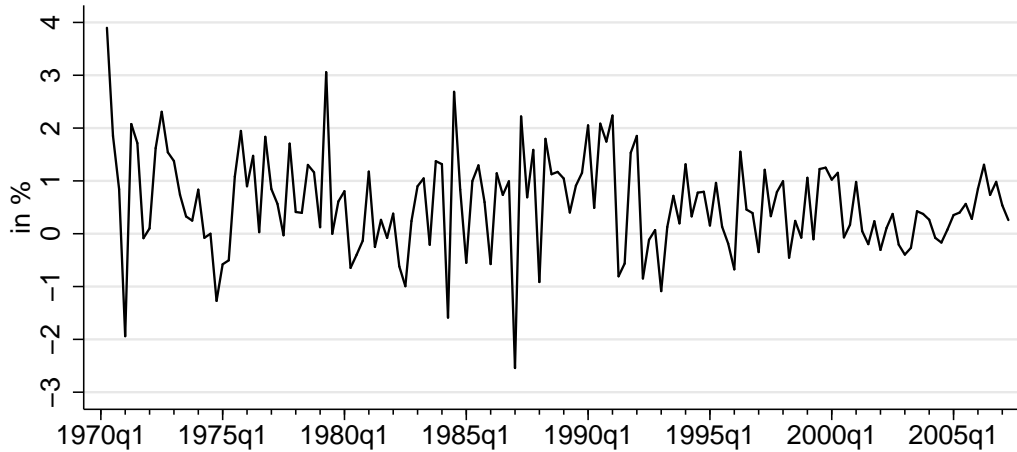
First I consider MS specifications which try to identify two regimes in the underlying German data. I find, in general, that MSM and MSI models distinguish between a low-growth and a high-growth regime. MSMH and MSIH models turn out to be unsuitable in the current business cycle dating task. While most of them actually passed the LR linearity test, they generally divide the whole time period only once, placing the segregation line between 1993:2 and 1994:2. Apparently, before this time, growth rates were higher on average but also more volatile. Therefore I additionally included a dummy into the analyses for periods after the most often placed regime border 1993:3.<sup>13</sup> Then the resulting level dampening effect of the dummy is so strong that after 1993 no more switches can be identified in otherwise significant regime-switching specifications. MSMH and MSIH models remain highly significant but rather unsuitable for the dating of business cycle phases.

Finally I consider the adaptation of a third regime, as the basic specifications only offered low-growth rather than negative-growth phases. Although these models are in general superior to their linear counterpart and have one regime with a negative parameter, this value is so extremely low, that most often recessions are defined only as one-quarter events.

Estimation results for significantly non-linear MS specifications, whose results might be interpreted meaningfully in business cycle context, are given in the Appendix 2.B. In Appendix 2.C I give the suggested business cycle phases of these models. In accordance with the non-parametric methods and business cycle thinking in general, I only include phases

<sup>12</sup> Alternative likelihood ratio linearity tests are proposed by Hansen (1992, 1996).

<sup>13</sup> The dummy is denoted as 'X' in the label of a model, i.e., MSM-ARX(1) for a MSM specification with one autoregressive lag and the dummy.

**Figure 2.2:** Quarterly growth rates of real German GDP, seasonally and calendar-adjusted

Source: Federal Statistical Office Germany (2006, 2007).

that last more than one quarter. Due to space considerations and for purposes of clarity, for Section 2.4 MS results were aggregated based on majority dates.<sup>14</sup>

## 2.4 Application: The German business cycle

### 2.4.1 Business cycle dates of the different methods

To identify the German business cycle phases for the years 1970–2006 I use quarterly seasonally-, calendar- and price-adjusted GDP of the German Federal Republic, that is, until 1990 West Germany and from 1991 on unified Germany.<sup>15</sup> However, growth rates are always calculated territorially consistently. Figure 2.2 gives a visual impression of the respective German growth rates.

As the application of the presented business cycle dating methods indicates, over the last decades Germany experienced several business cycles. Table 2.2 summarizes the German

<sup>14</sup> Exceptions from the majority rule were made for the time period after 1993, where I skipped those models from counting, that were not able to find any more recession there.

<sup>15</sup> Federal Statistical Office Germany (2006) for West German data up to 1991 and Federal Statistical Office Germany (2007) for German data from 1991 on.

**Table 2.2:** German business cycles 1970-2006

<b>Newspaper</b>		<b>Boldin</b>		<b>BBQ</b>		<b>MS, aggr.</b>	
<i>Peak</i>	<i>Trough</i>	<i>Peak</i>	<i>Trough</i>	<i>Peak</i>	<i>Trough</i>	<i>Peak</i>	<i>Trough</i>
1974:3	1975:2	1974:1	1975:2	1974:1	1975:2	1974:1	1975:2
1980:1	1982:3	1980:1	1982:4	1980:1	1980:4	1980:1	1982:4
				1982:1	1982:3		
1991:1	1991:3	1991:1	1991:3			1991:1	1991:3
1992:1	1993:1	1992:1	1993:2	1992:1	1993:1	1992:1	1993:2
1995:3	1996:1	1995:3	1997:1	1995:3	1996:1	1995:2	1996:1
		1998:1	1998:4			1998:1	1998:4
2002:3	2003:2	2001:2	2005:2	2002:3	2003:2	2001:1	2005:2
2004:1	2004:3			2004:1	2004:3		

business cycle chronology suggested by the different approaches. The dating methods generally agree on the approximate timing of economic downturns in Germany. Even though each dating approach focuses on distinctive features, they form a rather comprehensive concept of the classical business cycle. However, they somewhat differ in their judgement regarding where exactly to place the turning points and also in their sensitivity when distinguishing between different states in low-growth periods.

The mid-1970s downturn is met fairly consistently by each method. Likewise, there is agreement that in the beginning of the 1980s another economic descent took place, with particularly 1980 and 1982 being recessionary years. In this period the different claims to call a phase switch – with respect to the robustness of sign or magnitude changes in the growth rates – become visible between the dating methods. While the BBQ algorithm as well as a few MS-classifications indicate a short phase of recuperation between these years, the newspaper and the Boldin (1994) approach demand a more continuous or a stronger rise in the growth rates to detect an expansion.

Negative growth-quarters in the remaining 1980s, see Figure 2.2, remain too sporadic and alternate with high-growth quarters to indicate times of recessions. Only one of the MS specifications suggests a regime shift at about 1986, see Table 2.5 in Appendix 2.C. The suggested recession directly after German re-unification is somewhat surprising. Growth rates were negative in 1991:2 and 1991:3, long and pronounced enough for most approaches to signal a downturn. However, as a closer look into the data reveals, this decline must be due to the breakdown of the East German economy, because a decline is not detectable when looking only at West German data. I conclude that this event is not actually cyclical and should be considered as special case.

**Table 2.3:** Aggregated German turning points

<i>Peak</i>	<i>Trough</i>
1974:1	1975:2
1980:1	1982:3
1992:1	1993:1
1995:3	1996:1
2002:3	2004:3

There is agreement that the next actual recession started in 1992 and lasted about a year. A further commonly acknowledged downturn is placed in the mid-1990s. Later we again find negative growth quarters, in 1998 alternating with positive growth. These fluctuations are sufficient to suggest a recession in terms of Boldin's modified newspaper approach and some of the MS-specifications, but are not enough for the remaining methods to announce a switch of states.

All dating procedures indicate a recession after the turn of the millennium. While the MS- and the Boldin (1994)-method declare rather early the transition between expansion and recession, the newspaper and the BBQ approach follow later on. This deviation indicates the discontinuous development of the German GDP at that time, to which the considered approaches react differently. The disagreement continues in determining the end of the recession. Newspaper and the BBQ algorithm suggest a recession lasting about one year, followed by a short expansionary phase, before economic performance declined again. The last trough is eventually located at 2004:3 by both of these methods. Conversely, Boldin's approach and MS dating identify one long recession and consider it finished only in the middle of 2005. Apparently, growth rates were considerably lower until then, compared to the overall sample. Due to their construction, both procedures tend to add such low-growth quarters to preceding recessions.

#### 2.4.2 Suggesting a consensus German business cycle chronology

Despite variation in the exact dates suggested by the different methods, together they still give a general idea about when the German economy suffered from economic downturns. According to the findings, I suggest the comprehensive turning points for the German business cycle as denoted in Table 2.3. In the absence of an overall agreement on the timing of a turning point, I predominantly follow two principles: First, due to the classical concept of the business cycle with recessions as periods with *declining* output, I put most weight on negative growth rates. Secondly, since periods of extremely short expansions that subsequently move

into another recession are assumed to already experience some defect, or at least instability, these periods are adjoined with the downturns that surround them.

## **2.5 Conclusion**

Despite the long history of business cycle research, a number of questions still remain. In particular, governments and the public want to know what the mechanisms behind recessions are and how such economic and socially challenging times might be avoided, or at least dampened.

However, to analyse specifics about times of economic downturn, one first needs to indicate when such downturns occurred. Business cycle chronologies offer reference points for empirical studies and serve as benchmarks for business cycle and recession theory. While a quasi-official chronology exists for the U.S. economy with the NBER dates, this is not the case for Germany and most other European countries. As distinctive differences between these economies exist, it is desirable to further expand business cycle analysis for other countries. I presented a number of – parametric as well as non-parametric – common univariate business cycle dating methods, built on the original idea of business cycles as fluctuations in levels instead of filtered data and applied them to the German GDP. Discussing the findings and characteristics of the dating approaches, I finally recommend a consensus business cycle chronology for Germany.

## Appendix 2.A Software and program codes

The methods for business cycle dating were implemented in a number of Ox programs (see Doornik, 2002), which are available on request. The code for the BBQ-method borrowed strongly from the GAUSS code provided for the Harding and Pagan (2000) paper. Markov-switching specifications were found using the MSVAR package by Hans-Martin Krolzig. The figures were prepared using STATA.

## Appendix 2.B Estimation results of Markov-switching models

Given are the parameter values (and standard errors) of those significantly non-linear MS specifications whose results might be interpreted as meaningful in the business cycle context. Business cycle phases should last more than one quarter. However, specifications that only identified recessions in the periods 1971:4-1972:1 (only 3-regime models), 1974:4 to 1975:2 and/or 1991:2 to 1991:3 were excluded. Their focus is limited to finding periods with continued very strong decline, which is a too strict requirement for my context.

**Table 2.4:** Parameter values of appropriable MS models

	MSM(2)-AR(3)	MSI(2)-AR(3)	MSMH(2)-AR(3)	MSIH(2)-AR(3)
$\mu_1$ or $\nu_1$	0.0740 (0.1135)	0.1456 (0.2445)	0.0032 (0.0967)	0.0319 (0.1429)
$\mu_2$ or $\nu_2$	0.9579 (0.1499)	1.3002 (0.2036)	0.8063 (0.1589)	0.9972 (0.3255)
$\mu_3$ or $\nu_3$				
$A_1$	-0.2836 (0.0926)	-0.2181 (0.0850)	-0.1982 (0.1017)	-0.1383 (0.1299)
$A_2$	-0.2311 (0.0870)	-0.1383 (0.0846)	-0.1926 (0.0965)	-0.1235 (0.1088)
$A_3$	-0.1725 (0.0824)	-0.0866 (0.0821)	-0.1197 (0.0924)	-0.0863 (0.1193)
$A_4$				
$A_5$				
<i>dummy</i>				
$p_{11}$	0.8284	0.8302	0.8469	0.8559
$p_{22}$	0.8466	0.8601	0.9243	0.9426
$p_{33}$				
s.e.	0.7387	0.7332		
s.e. <sub>1</sub>			0.5420	0.5203
s.e. <sub>2</sub>			0.8842	0.8996
s.e. <sub>3</sub>				
$\ln L$	-184.8099	-185.7865	-182.1552	-183.1135
LR test	8.5135	6.5604	13.8230	11.9063

	MSM(2)-ARX(3)	MSI(2)-ARX(2)	MSI(2)-ARX(3)	MSM(3)-AR(3)
$\mu_1$ or $\nu_1$	-0.3028 (0.2929)	-0.4272 (0.2065)	-0.3496 (0.2246)	-0.2447 (0.4530)
$\mu_2$ or $\nu_2$	0.9539 (0.1451)	1.1878 (0.1485)	1.2667 (0.1653)	0.6646 (0.1247)
$\mu_3$ or $\nu_3$				1.5221 (0.3905)
$A_1$	-0.2173 (0.0847)	-0.1752 (0.0754)	-0.2006 (0.0768)	-0.6475 (0.2892)
$A_2$	-0.1105 (0.0910)	-0.0341 (0.0752)	-0.0772 (0.0905)	-0.5533 (0.2637)
$A_3$	-0.0855 (0.0855)		-0.0494 (0.0815)	-0.3489 (0.1463)
$A_4$				
$A_5$				
<i>dummy</i>	-0.6962 (0.2096)	-0.6648 (0.1674)	-0.7118 (0.1657)	
$p_{11}$	0.6166	0.5710	0.6613	0.6457
$p_{22}$	0.9137	0.9034	0.9276	0.7487
$p_{33}$				0.5592
s.e.	0.7240	0.6771	0.6903	0.5648
s.e. <sub>1</sub>				
s.e. <sub>2</sub>				
s.e. <sub>3</sub>				
$\ln L$	-184.1009	-185.2581	-182.8153	-180.0561
LR test	8.2523	7.6551	10.8236	18.0211

	MSMH(3)-AR(3)	MSMH(3)-AR(4)	MSIH(3)-AR(4)	MSIH(3)-AR(5)
$\mu_1$ or $\nu_1$	-0.1083 (0.1373)	-0.5401 (0.2765)	-0.8568 (0.3295)	-0.8949 (0.2912)
$\mu_2$ or $\nu_2$	0.7729 (0.1117)	0.4223 (0.1191)	0.0398 (0.0821)	0.0314 (0.0824)
$\mu_3$ or $\nu_3$	0.9607 (0.1890)	0.7756 (0.2283)	0.9313 (0.1434)	0.9553 (0.1503)
$A_1$	-0.3248 (0.0910)	-0.0805 (0.0853)	-0.1938 (0.0780)	-0.2252 (0.0934)
$A_2$	-0.2907 (0.0857)	0.0351 (0.0766)	-0.0516 (0.0710)	-0.0619 (0.0728)
$A_3$	-0.1409 (0.0841)	0.0998 (0.0782)	0.0272 (0.0755)	0.0226 (0.0756)
$A_4$		0.1908 (0.0794)	0.2271 (0.0589)	0.2239 (0.0611)
$A_5$				0.0382 (0.0639)
<i>dummy</i>				
$p_{11}$	0.7630		0.2774	0.3882
$p_{22}$	0.6330		0.8273	0.8214
$p_{33}$	0.7422		0.8861	0.8842
s.e.				
s.e. <sub>1</sub>	0.4871		0.6187	0.5915
s.e. <sub>2</sub>	0.4389		0.3231	0.3200
s.e. <sub>3</sub>	1.1524		0.6817	0.6790
$\ln L$	-176.2207		-168.5028	-167.6517
LR test	25.6919		20.5537	19.7450





<b>MSMH(3)</b> <b>-AR(3)</b>		<b>MSMH(3)</b> <b>-AR(4)</b>		<b>MSIH(3)</b> <b>-AR(4)</b>		<b>MSIH(3)</b> <b>-AR(5)</b>	
<i>Peak</i>	<i>Trough</i>	<i>Peak</i>	<i>Trough</i>	<i>Peak</i>	<i>Trough</i>	<i>Peak</i>	<i>Trough</i>
1974:1	1975:2	1974:2	1975:2	1974:3	1975:2	1974:3	1975:2
1980:1	1982:4			1980:1	1980:4	1980:1	1980:4
						1982:1	1982:3
				1991:1	1991:3	1991:1	1991:3
1992:1	1993:2	1992:1	1993:1				
1995:2	1996:1						
1998:1	1998:4						
2001:1	2005:1						



## Chapter 3

# Heterogeneous productivity shocks: Why is the reaction to productivity growth so ambiguous?

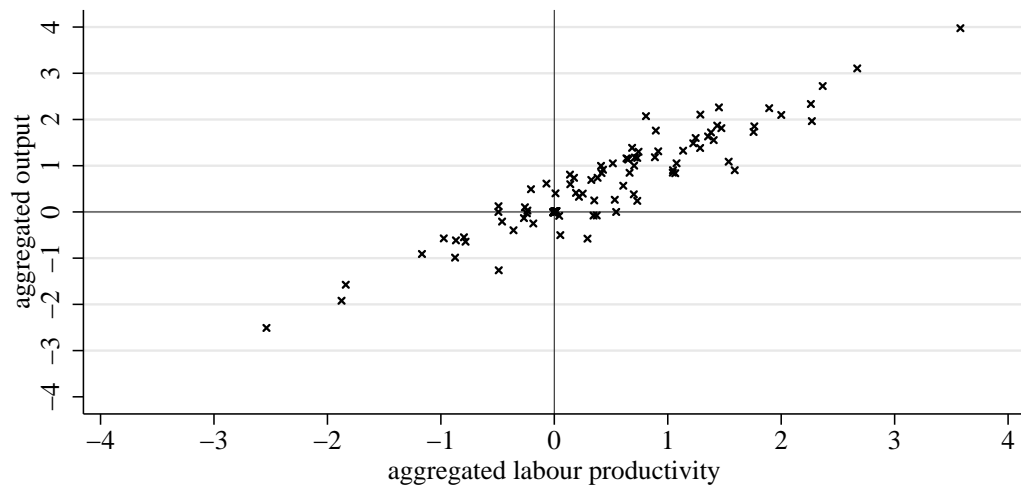
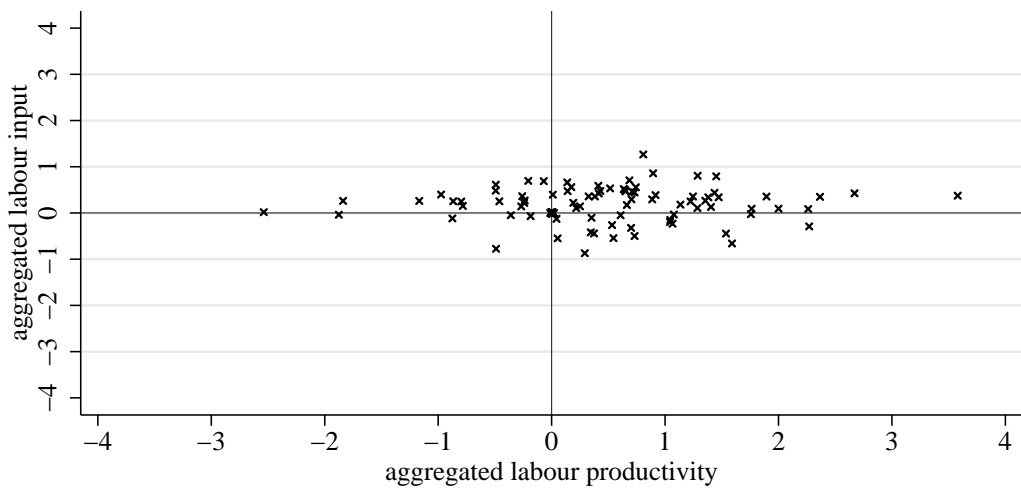
### 3.1 Introduction

The study of short-run as well as long-run dynamics of the economy is one of the most important topics in macroeconomics. In particular the changes in total output, its components and related aggregates like (un-)employment are of interest both for researchers and the public. Besides other possible candidates, often technology shocks on productivity are considered to cause these dynamics in many growth models (see Barro and Sala-i-Martin, 2003, for an overview) and in real business cycle (RBC) models referring to Kydland and Prescott (1982) and Long and Plosser (1983). Not only the shock itself configures economic dynamics, however, but also its propagation, amplification and assimilation in the economy. For these tasks, in turn, the labour market is regarded as particularly important (Hall, 1999).

Nonetheless many puzzles remain in the explanation of empirical changes of macroeconomic aggregates and their relationship. Take for example the visual impression of scatter-plots of growth rates of labour productivity and total output, as well as growth rates of labour productivity and labour input, for German data given in Figure 3.1. Per definition total output is the product of labour productivity and labour input. If we assume that labour productivity is a good proxy for technology, and that technology shocks are meaningful for output changes, there should be clear-cut patterns in these scatter-plots. Indeed, Figure 3.1a – plotting growth rates of productivity against growth rates of output – displays most points near the 45° line. Nonetheless, distinct deviations are not rare: Apart of damped or excessive output responses on productivity changes, on various occasions we find even drops in aggregate output in answer to productivity increases. These findings are mirrored in Figure 3.1b, which reflects the employment response on productivity shocks: There is hardly any systematic pattern visible in the relationship between both variables. If we refrain from measurement errors and other stochastic influences, these pictures suggest that in the short run a variety of adjustment

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\* Substantial parts of this chapter were generated during a research visit at the University of Glasgow. Financial support by a DAAD grant for this period is highly appreciated.

**Figure 3.1:** Scatter-plot with growth rates of macroeconomic variables (in %)**(a)** Labour productivity and total output (gross domestic product)**(b)** Labour productivity and number of employees

Note: Labour productivity per employee. Seasonally and price adjusted, quarterly data, 1970-2006.

Source: Federal Statistical Office Germany (2006, 2007), own calculations.

effects of total output and employment on changes in aggregate labour productivity seem possible.

There currently is a related debate in the macroeconomic literature whether in particular a positive technology shock empirically causes labour input to rise or to fall. The discussion started with Galí (1999) who applied structural vector-autoregressive (SVAR) models on US data and claimed that the response to a positive long-lasting technology shock was a decrease in the hours worked. Whether this finding arose from a correct implementation and interpretation of the SVAR instrumentation and related methods is not without controversy (see, for example, Christiano, Eichenbaum and Vigfusson, 2004; McGrattan, 2005; Pesavento and Rossi, 2005; Dedola and Neri, 2007). But besides such technical aspects, the discussion circulates around the question which type of economic model finally describes the macroeconomic responses to such an event best. On the one hand there are the proponents of RBC models, which as one constitutive element imply employment increases in response to a positive productivity shock. On the other hand those authors in line with the findings of Galí (1999) try to explain quite the opposite with a variety of alternative models.<sup>1</sup>

In contrast to this literature and as innovation to research on this topic, in this chapter of my thesis I explicitly consider that there actually is ambiguity in the response of labour input and aggregate output to technological productivity shocks. Therefore my aim is to develop a model framework which can capture this effect. It rests on a search and matching labour market setting in style of Pissarides (2000). In a modification to the base model I suggest that firms differ in their capability to benefit from productivity enhancement. I analyse the consequences and show how a productivity-enhancing shock and the resulting transitional processes might induce a variety of possible impulse responses on employment and total output, then. Depending on the size and scope of the productivity shock, labour input and total output can experience a continuing increase, but can also suffer from a temporary recession. Small differences in the parameter values might translate into considerable differences in the transitional process. The long-run effects on output and employment are clearly positive, though.

My particular focus on lasting productivity-advancement shocks and the fluctuations they induce on total output also builds a bridge between growth and business cycle theory. Most often, economic research studies both these phenomena separately. But already Joseph A. Schumpeter claimed a strong connection between them (Schumpeter, 1939, 1961). Several strands of literature mainly related to endogenous growth theory took up the idea that eco-

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<sup>1</sup> Galí (1999) offers a model class with imperfect competition, sticky prices, and variable effort, i.e., nominal frictions, to explain his findings, see also Galí and Rabanal (2005) for further specifications. Examples for alternative mechanisms in flexible price models are the employment of habit formation in consumption and adjustment costs in investment, or specific production technologies (Francis and Ramey, 2005); the inclusion of an open economy dimension with low trade elasticities and sluggish capital adjustment (Collard and Dellas, 2007), the implementation of random technical progress with slow diffusion rates (Rotemberg, 2003) or of frictions on the labour market in a model with neutral and investment-specific shocks (Michelacci and Lopez-Salido, 2007).

conomic growth and fluctuations influence each other (see Aghion and Howitt, 1998*a*, Chap. 8 for a survey). Some articles in particular consider that the process of technological progress itself causes cyclical (non-negative) fluctuations in the growth rates (for instance, Boldrin and Levine, 2001; Wälde, 2005), or is implemented via downturn-including creative destruction (see Francois and Lloyd-Ellis, 2003, 2009, among others). Other authors especially focus on so called ‘general purpose technologies’ – like electricity and information technology – and argue that the introduction and infusion of such growth-enhancing innovations is connected to phases of slow or even negative growth (for example, Helpman, 1992; Aghion and Howitt, 1998*b*; Jovanovic and Rousseau, 2005; Steger, 2007). The approach of this chapter shares the basic idea that adaptation to productivity-enhancing, long-run growth procedures might involve temporary fluctuations which reflect some kind of optimal resource reallocation.

In addition to that, however, I show that it is possible within a rather simple framework to explain a variety of shapes in the fluctuation of aggregate variables in response to productivity-enhancing shocks. This is accomplished with the explicit consideration of some sort of heterogeneity among agents. It turns out that such a modification on the micro-level translates into apparent ambiguity on the macro-level. This finding also points to possible drawbacks if only aggregate figures and homogeneous representative agents are considered in the analysis of macroeconomic phenomena: Such an approach always runs the risk to miss important and effective dynamics which take place ‘below the surface’ but are indeed reflected in aggregated data as well. The empirical importance of micro-heterogeneity for aggregate measures is summarized, for example, by Foster, Haltiwanger and Krizan (2001) studying (productivity) growth and by Davis, Faberman and Haltiwanger (2006) for labour market flows (see also Chapter 4). Despite these evidences, however, theoretical research typically neglects such connections between the macro- and the micro-level. That is particularly regrettable, as their implementations allowed for a rich variety of feedback dynamics, like for example shown in this chapter.

Regarding the structure of the chapter, at first a standard search and matching model of the labour market is presented. Then I assume that it is hit by an unanticipated productivity-enhancing shock and study the transitional dynamics to the new steady state. Comparative statics and (qualitative) simulations complement the analysis. Section 3.3 introduces heterogeneity in the firms’ capability to benefit from such a shock and examines the consequences for equilibrium and impulse responses. Finally, Section 3.4 discusses the results and concludes.

## 3.2 The basic search and matching labour market framework

The real-world labour market is far away from being a perfect market. It is constantly characterized by considerable job and worker flows and the simultaneous existence of

unemployment and vacant jobs.<sup>2</sup> Due to, for example, heterogeneities, spacial disparities and incomplete information, the matching of vacancies and unemployed workers into a productive job is subject to frictions. Therefore the search for a suitable partner – a vacancy for an unemployed worker and vice versa – which precedes a match must be considered as specific occupation like production or leisure. These findings, among others, are reflected in the well-known labour market model with undirected search of workers and firms, and wage determination according to Nash bargaining (Pissarides, 2000). The base model and its many modifications and extensions have proven invaluable for the understanding of unemployment and labour market flows as equilibrium phenomena. Their application in the analysis of other macroeconomic fields like the business cycle (for instance Merz, 1995; Andolfatto, 1996; Den Haan, Ramey and Watson, 2000) and growth research (Aghion and Howitt, 1994; Mortensen and Pissarides, 1998, among others) enriched the analysis a lot and improved the ability of the models to meet empirical facts.

This section firstly introduces the main features of the basic search and matching framework.<sup>3</sup> Afterwards I sketch the transitional dynamics following an unanticipated productivity-enhancing shock and discuss its usage for the explanation of the scatter-plots in Figure 3.1.

### 3.2.1 The labour market

In the basic search and matching framework the labour market comprises workers and firms. Each firm offers one job. Labour is the only considered input factor. Jobs can be filled, that is, matched with a worker, or vacant and searching for an employee. The number of firms is determined endogenously as long as non-negative profits are feasible. In contrast, the total number of workers is exogenously given by  $N$ . The ratio of vacancies per worker is denoted by  $v$ . Each worker is endowed with an equal amount of time, spent either completely working in a firm (= employee) or searching for a job (= unemployed). Hence there is no on-the-job search. The number of employed workers is denoted by  $L$ , whereas  $N - L$  gives the remaining unemployed workers. The unemployment rate  $\frac{N-L}{N}$  is represented by  $u$ .

### Matchings and separations

Due to frictions in the labour market, unemployed workers and vacant jobs can not be combined instantaneously. Instead, matching between them is a random event. The number

<sup>2</sup> See Cahuc and Zylberberg (2004, Chap. 9, Sec. 1) for a summary of international empirical evidence. For research on job flows consider also Chapter 4 of this thesis.

<sup>3</sup> For similar presentations see, e.g., Pissarides (1990, 2000, Chap. 1) and Cahuc and Zylberberg (2004, Chap. 9).

of successful matchings within an instant of time is represented by a matching function  $x(uN, vN)$ . It increases in both of its arguments, is concave and homogeneous of degree one. The so called labour market tightness is defined as  $\theta \equiv \frac{v}{u}$ . Vacant jobs are filled according to a Poisson process with arrival rate  $m(\theta) \equiv \frac{x(uL, vL)}{vL} = x\left(\frac{u}{v}, 1\right) = x\left(\frac{1}{\theta}, 1\right)$ . It holds that  $m'(\theta) \leq 0$ . To ensure further traceability, the elasticity  $\eta_\theta^m \equiv \frac{\partial m}{\partial \theta} \frac{\theta}{m}$  must fulfil  $-1 < \eta_\theta^m < 0$ .<sup>4</sup> The equivalent arrival rate for unemployed workers to find a job is given by  $\theta m(\theta)$ . Because all vacancies compete for the same workers, each individual open job induces negative externalities on the success of the remaining vacancies. In contrast, unemployed workers benefit from a higher  $\theta$ .

Operating jobs constantly face the risk to be hit by an idiosyncratic, exogenous negative productivity shock that prevents further production. This event is likewise described as a Poisson process; its arrival rate is given by  $s$ . Following from the matchings and separations, the unemployment rate in the economy evolves according to

$$\dot{u} = s[1 - u] - \theta m(\theta)u.$$

### 3.2.2 Workers

Workers are identical, infinitely living and derive utility from consumption. If they are risk-neutral, with a time preference rate equalling the interest rate  $r$ , the value  $E$  of being employed can be written as<sup>5</sup>

$$rE = w + s[U - E] + \dot{E}. \quad (3.1)$$

That is, the state of employment  $E$  is similar to an asset, whose interest payments  $rE$  should equal the expected gains from holding the asset. The latter is the sum of three elements: Firstly, the continuous income stream of the wage payment  $w$ . Secondly, the change in value associated with a switch from state ‘employment’ to ‘unemployment’, with the latter’s value denoted by  $U$ , weighted by the probability of this event  $s$ . Thirdly and finally a possibly deterministic change in the value over time captured by  $\dot{E}$ .

Accordingly, the value of being unemployed is described by

$$rU = b + \theta m(\theta)[E - U] + \dot{U}, \quad (3.2)$$

where  $b$  denotes some unemployment benefit. Here,  $\theta m(\theta)$  captures the probability that the worker switches from unemployment to employment.

<sup>4</sup> Note that this provides  $m(\theta) + \theta m'(\theta) > 0$ , which is employed in the later analysis.

<sup>5</sup> A formal derivation is given in Appendix 3.B.1.



### 3.2.3 Firms

As stated above, firms consist of one job each that can either be filled or vacant. Filled jobs produce output  $A$  and induce costs that amount to the wage  $w$  per time instant. Jobs are destroyed exogenously at rate  $s$ . Vacant jobs search for an unemployed worker, which entails search costs of  $h$  per instant but also results in a match at rate  $m(\theta)$ . If  $J$  denotes the firm's value of a filled job and  $V$  the respective firm's value of a vacant job, we have

$$rJ = A - w + s[V - J] + \dot{J}, \quad (3.3)$$

and

$$rV = -h + m(\theta)[J - V] + \dot{V}. \quad (3.4)$$

With free market entry, jobs will be opened as long as there is economic rent to exploit, that is, until  $V = \dot{V} = 0$ . From this free-market entry and (3.4):

$$J = h/m(\theta), \quad (3.5)$$

which shows that the expected value from a filled job has to equal the expected costs necessary to put it into production. Equivalently, the free entry into (3.3) gives

$$J = \frac{A - w + \dot{J}}{r + s}. \quad (3.6)$$

Therefore the wage rate associated with zero profit can be written as function of the exogenous parameters and the job arrival rate:

$$w = A - \frac{h[r + s]}{m(\theta)} + \dot{J}. \quad (3.7)$$

The time derivative of (3.5) into the above gives:

$$w = A - \frac{h[r + s]}{m(\theta)} - \frac{hm'(\theta)}{m^2(\theta)}\dot{\theta}. \quad (3.8)$$

### 3.2.4 Wage bargaining

If an unemployed worker meets a vacant job, due to the search frictions this match produces a surplus  $S$ . It equals the sum of each party's advantage from the match over an ongoing

search:

$$S = E - U + J. \quad (3.9)$$

The surplus is shared between the firm and the worker during the process of wage bargaining. I follow the standard approach and employ Nash bargaining. The worker's relative bargaining power is denoted by  $\beta$ , with  $\beta \in [0, 1]$ . The instrument of bargaining is the wage and the respective threat point of each party is their situation outside the current match – unemployment and vacancy, respectively. Hence bargaining is described by

$$\max_w (E - U)^\beta J^{1-\beta}.$$

As a result the surplus is divided according to the respective bargaining powers:

$$\begin{aligned} E - U &= \beta S, \\ J &= [1 - \beta]S. \end{aligned} \quad (3.10)$$

Using (3.1) and (3.6), the surplus (3.9) can be rewritten as<sup>6</sup>

$$S = \frac{A - rU + \dot{E} + \dot{J}}{r + s}. \quad (3.11)$$

If we combine it with (3.10) and (3.1) we find that:

$$w = rU[1 - \beta] + \beta[A + \dot{E} + \dot{J}] - \dot{E}. \quad (3.12)$$

We can use (3.2) and (3.9), (3.10) and (3.5) to further eliminate  $rU$ :<sup>7</sup>

$$w = [1 - \beta]b + \beta[A + \theta h]. \quad (3.13)$$

### 3.2.5 Equilibrium

The crucial decision made by agents in the model economy is the firms' number of offered vacancies per unemployed worker, that is, labour market tightness  $\theta$ . All the remaining endogenous variables – like wages and (un)employment as well as the presented state values – result from this decision.

As mentioned above, vacancies are opened as long as the expected profit from doing so at least covers the expected costs. From the firm's point of view this implies a limiting peak wage determined by (3.8). The wage that actually results from bargaining between firms and

<sup>6</sup> See Appendix 3.C for details.

<sup>7</sup> Again, details are in Appendix 3.C.

workers, in turn, is given by (3.13). For the economy to be in equilibrium, both conditions must be fulfilled simultaneously, which ends up in

$$[A - b][1 - \beta] - \frac{h[r + s]}{m(\theta)} - \frac{hm'(\theta)}{m^2(\theta)}\dot{\theta} - \beta\theta h = 0. \quad (3.14)$$

**Proposition 3.1.** *Labour market tightness  $\theta$  is a jump variable, that is  $\dot{\theta} = 0$ , apart from the very moment of the jump.*

*Proof.* Equilibrium condition (3.14) is an implicit non-linear differential equation in  $\theta$  and  $\dot{\theta}$ , which implies a function  $\dot{\theta}(\theta)$  that describes the transition of labour market tightness towards a stationary (that is, steady state) value  $\theta^*$ . Hence it holds that  $\dot{\theta}(\theta^*) = 0$ . Employing the implicit function rule gives  $\dot{\theta}'(\theta^*) = r + s - \beta m^2(\theta)/m'(\theta) > 0$ , which indicates that the adjustment path of  $\theta$  towards its steady state level is unstable. Therefore, if outside the steady state, labour market tightness has to jump into it immediately, implying  $\dot{\theta} = 0$  apart from the instance of adjustment.  $\square$

**Corollary 1.** *The time derivatives of all value functions and the surplus are zero.*

*Proof.* With Proposition 3.1, the wage  $w$  in (3.8) becomes a jump variable as well. This implies that neither the value of being employed, unemployed nor having a filled job is influenced by any deterministically changing variable, which in turn translates into  $\dot{E} = \dot{U} = \dot{J} = 0$ . Then, again,  $\dot{S}$  equals zero, too.  $\square$

With these findings, and given particular functional forms as well as parameters, equilibrium in the considered economy is fully described by a system of equations. Labour market tightness  $\theta$  is implicitly determined by

$$[A - b][1 - \beta] - \frac{h[r + s]}{m(\theta)} - \beta\theta h = 0. \quad (3.15)$$

Given  $\theta$ , the wage rate can be derived from either the bargaining result (3.13) or the adapted zero-profit condition (3.8). Another and rather general display of the bargained wage, which in particular becomes useful in Section 3.3, is found if we solve (3.12) for  $rU$  and insert (3.13). Subsequent replacement of  $h$  with use of (3.7) and re-implementation in (3.12) ends up in<sup>8</sup>

$$w = [1 - \beta] \frac{b[r + s] + \beta\theta m(\theta)A}{r + s + \beta\theta m(\theta)} + \beta A. \quad (3.16)$$

<sup>8</sup> See Appendix 3.C for details.

The remaining aggregates in equilibrium are determined by differential equations.<sup>9</sup> In particular, the unemployment rate evolves according to

$$\dot{u} = s[1 - u] - \theta m(\theta)u. \quad (3.17)$$

Inverse to unemployment is the number of employees, described by

$$\dot{L} = \theta m(\theta)[N - L] - sL. \quad (3.18)$$

Finally, total output in the model economy can be deduced as  $Y = AL$ , which results in

$$\dot{Y} = A[\theta m(\theta)[N - L] - sL] + L\dot{A}. \quad (3.19)$$

### 3.2.6 The steady state and comparative statics

The steady state is a stationary equilibrium which the economy does not leave without exogenous impulse. Hence, all aggregate, macroeconomic values are constant there. Note, however, that nonetheless the stream of job creation and job destruction continues underneath the aggregate surface and induces constant dynamics at the microeconomic level. We find the steady state values setting all dotted variables in the equilibrium system (3.15)–(3.19) to zero:

$$0 = [A - b][1 - \beta] - \frac{h[r + s]}{m(\theta^*)} - \beta\theta^*h, \quad (3.20)$$

$$w^* = [1 - \beta] \frac{b[r + s] + \beta\theta^*m(\theta^*)A}{r + s + \beta\theta^*m(\theta^*)} + \beta A, \quad (3.21)$$

$$u^* = \frac{s}{s + \theta^*m(\theta^*)},$$

$$L^* = \frac{\theta^*m(\theta^*)}{s + \theta^*m(\theta^*)}N,$$

$$Y^* = \frac{\theta^*m(\theta^*)}{s + \theta^*m(\theta^*)}NA. \quad (3.22)$$

Only exogenous parameters determine these values, in particular the interest rate  $r$ , separation rate  $s$ , vacancy costs  $h$ , bargaining parameter  $\beta$ , productivity level  $A$  and the level of unemployment benefit  $b$ . Accordingly, changes in these parameters cause changes in the steady state values of the economy. Comparative statics analysis reveals their direction and size. Table 3.1 summarizes the resulting qualitative effects on the endogenous

<sup>9</sup> This indicates that they exhibit a stable path towards their stationary values. To show this follow the proof to Proposition 3.1; for instance, for unemployment  $\frac{\partial \dot{u}}{\partial u^*}|_{u^*} = -\theta m(\theta) < 0$ .

**Table 3.1:** Comparative statics of steady state values

	$s$	$r$	$h$	$\beta$	$A$	$b$
$\theta^*$	-	-	-	-	+	-
$w^*$	-	-	-	+	+	+
$u^*$	+	+	+	+	-	+
$L^*$	-	-	-	-	+	-
$Y^*$	-	-	-	-	+	-

variables, which are discussed in the following. Quantitative results can be found in Appendix 3.D.1.

### Comparative statics of $\theta^*$

Labour market tightness  $\theta^*$  represents the number of vacancies firms offer per unemployed worker. The opening of a vacancy induces search costs per instant the firm is looking for an unemployed worker. Naturally then, increasing vacancy costs  $h$  depress the creation of vacancies. After a successful match, however, the firm realizes a profit as long as the job is not destroyed. As firms' profit per instant is the excess of productivity over wages,  $\theta^*$  benefits from a growing productivity level  $A$  and decreases in workers' bargaining power  $\beta$  and outside option  $b$  (see also the comparative statics of  $w^*$ ). An increase in the separation rate  $s$  lowers the expected duration of a job and therefore induces less vacancy creation. The same holds for an increasing interest rate  $r$ : Because expected profits occur later than the costs of a new vacancy, in a present value calculation profits are much more then costs reduced by a rise of the discount rate.

### Comparative statics of $w^*$

The wage  $w^*$  will rise in response to any advancement in the worker's position in Nash bargaining. This applies for higher bargaining power  $\beta$  and a growing value of the unemployment state, their outside option. The latter is directly obtained with an increase of the income stream  $b$ , but indirectly also with any expansion of available jobs. This determines the influence of the separation rate  $s$ , interest rate  $r$ , productivity  $A$  and vacancy costs  $h$ . For the latter two parameters their effect is additionally magnified as wage bargaining splits them up between workers and firms.

### Comparative statics of $u^*$

The steady state level of the unemployment rate  $u^*$  is determined by the flows of workers into and out of unemployment. Inflows in the long run exclusively result from exogenous job destruction which occur at rate  $s$ , while outflows represent successful matches between unemployed workers and vacancies. The probability  $\theta^* m(\theta^*)$  for an unemployed worker to be matched to a vacancy rises the more vacancies are offered. Therefore parameter changes that induce a higher labour market tightness will shorten the average duration in unemployment and therefore result in lower unemployment, and vice versa.

### Comparative statics of $L^*$ and $Y^*$

As employment is the reverse of unemployment, its effects simply are inverted. The output level, in turn, is the product of employment and productivity, with the respective consequences for the comparative static results.

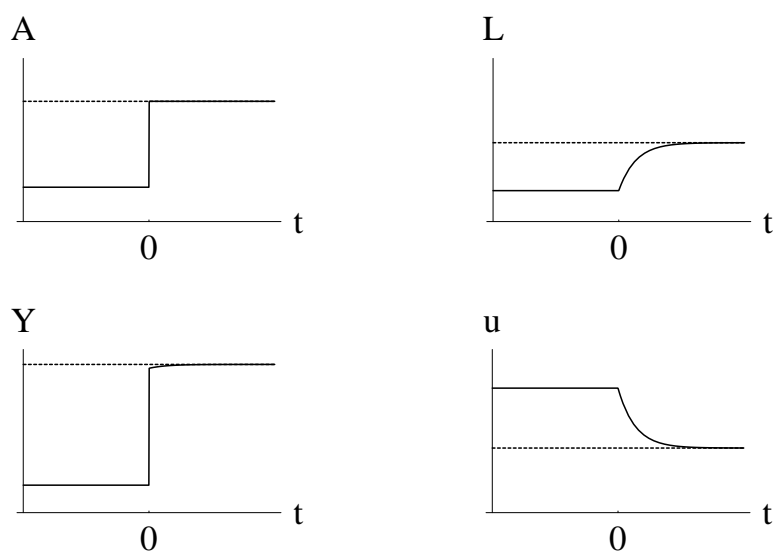
### 3.2.7 Transitional dynamics after a productivity shock

Having built up the foundations of my basic model, I come back to the productivity shock-puzzle now. If we assume the economy to rest in an initial steady state – what happens in response to an unanticipated productivity-enhancing shock?

According to the comparative statics analysis, such a jump in  $A$  finally implies a new steady state characterized by higher output and employment, higher wages and lower unemployment. The transitional dynamics of the economy's aggregate variables, which lead to this new stationary equilibrium, are found in (3.15)–(3.19) and qualitatively illustrated in Figure 3.2a. As discussed before, labour market tightness  $\theta$  adjusts to its final level immediately [see (3.15)], which indicates that on impact the number of vacancies jumps up. Due to the frictions in the labour market which are captured by the matching function, however, it takes time until the additionally offered jobs become filled and hence unemployment declines only gradually [see (3.17), (3.18)]. Transition of aggregate output mimics that of employment [(3.19)]. Altogether after-shock adjustment is smooth and monotone as verified in the impulse responses given in Figure 3.2b.

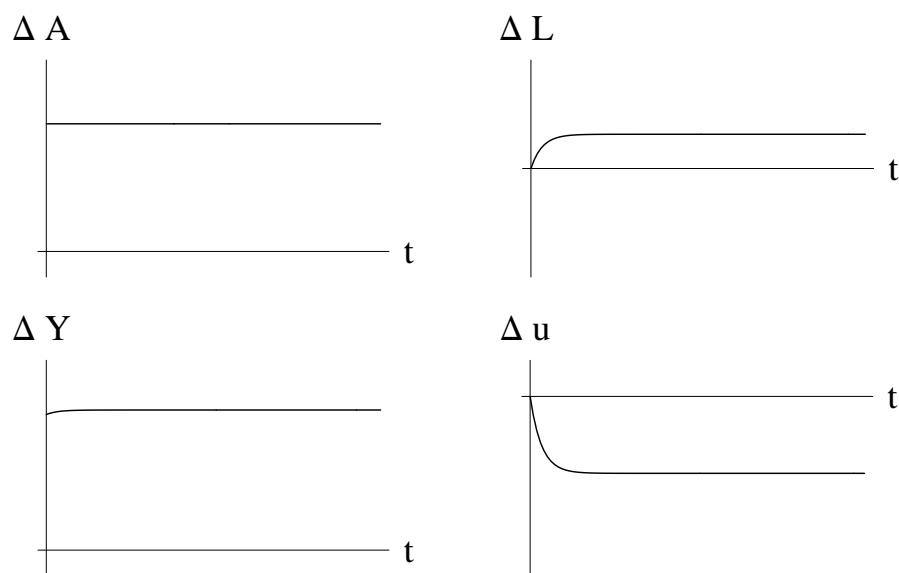
### 3.2.8 Implications for the scatter-plots

How much can the basic search and matching model contribute to explain scatter-plots like those presented in Figure 3.1? Which values could represent positive productivity shocks and

**Figure 3.2:** Response to a productivity-enhancing shock, basic framework

Notes: The shock is in  $t = 0$ . Dashed lines denote final steady state values.

**(a) Transitional dynamics**



**(b) Impulse responses**

their responses in the sketched economy? To answer these question, I differentiate between two ‘sub-processes’: at the one hand the shock itself, and at the other hand the therewith induced transition to the new steady state.

**Proposition 3.2.** *On impact of a positive productivity shock i) labour input remains at its initial level, and ii) output exhibits the same growth rate as the productivity shock.*

*Proof.* Ad i) The instantaneous increase in the vacancy rate induced by the shock and the jump in  $\theta^*$  is reflected in additional jobs only with a delay: Due to labour market frictions, matching takes time. Hence instantaneous labour input response is zero.

Ad ii) According to the definition of output and its rate of change given in (3.19) we find that

$$\frac{\dot{Y}}{Y} = \frac{\dot{A}}{A} + \frac{\dot{L}}{L} = \frac{\dot{A}}{A} \Leftrightarrow \frac{\dot{L}}{L} = 0.$$

□

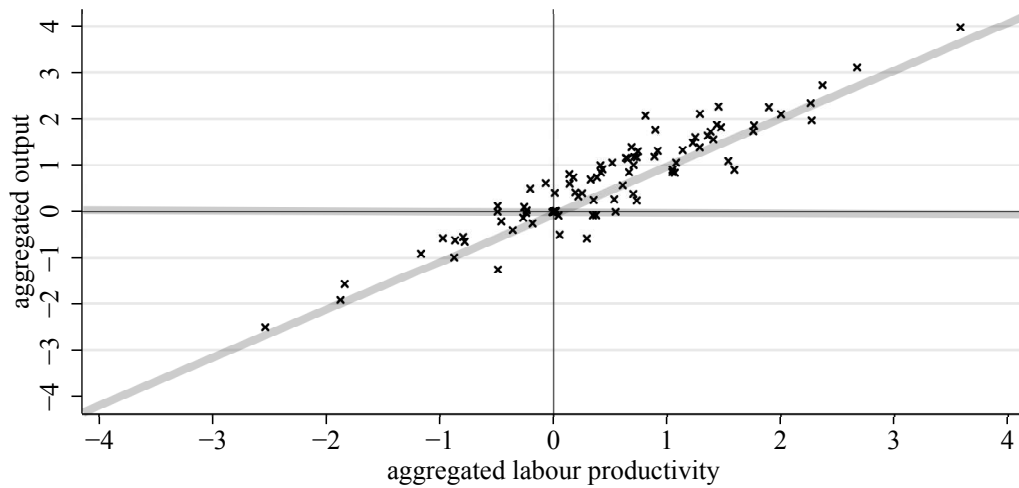
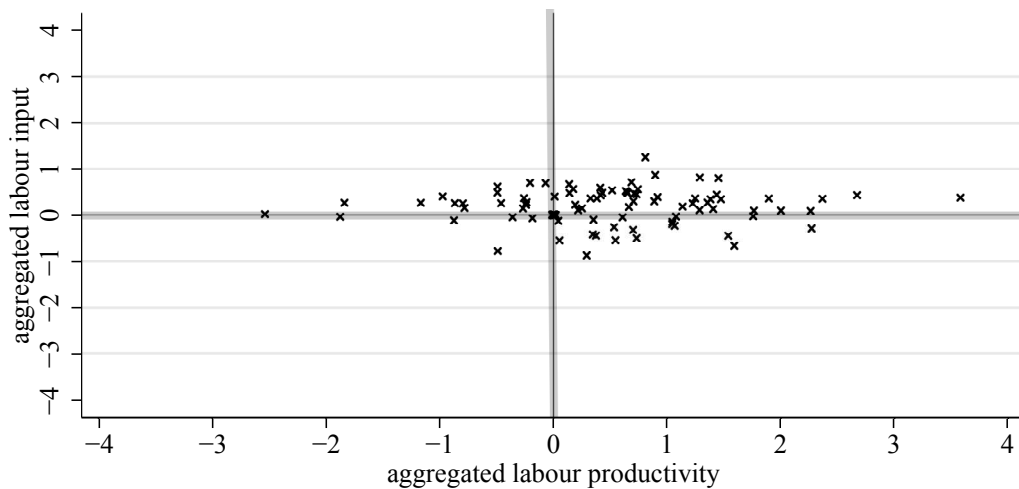
**Proposition 3.3.** *During transition labour input and output grow while productivity remains at its new level.*

*Proof.* Productivity had jumped to its final level instantly. Labour input approaches its resulting new steady states according to (3.18), which is independent of  $\dot{A}$ . According to (3.19) and equivalent to the proof of Proposition 3.2, the change of output in transition equals that of employment until the new steady state is achieved. □

In accordance to the puzzle discussed in the literature, the focus of my analysis is in particular at *positive* productivity shocks. Note for reasons of completeness, however, that in the basic framework the adjustment to a negative productivity shock simply is the reverse to it (if it is not strong enough to stop production completely). In contrast to a positive shock, the according employment decline is realized as exogenous job destruction outnumbered endogenous job creation until the new stationary equilibrium is obtained.

Figure 3.3 summarizes these findings: It highlights those areas in the scatter-plot at which values could be explained by unanticipated productivity shocks and the transition they induce in the basic search and matching framework. Apparently, the potential for that is rather limited. However, in contrast to a frictionless standard model of the labour market, the introduction of labour market frictions at least yielded a spread of the shock adjustment over multiple periods.



**Figure 3.3:** Implications from basic model for scatter-plot**(a)** Labour productivity and total output (gross domestic product)**(b)** Labour productivity and number of employees

Note: Labour productivity per employee. Seasonally and price adjusted, quarterly data, 1970-2006. Shaded area denote values which could be explained by unanticipated productivity shocks and the transition they induce in the basic search and matching framework.

Source: Federal Statistical Office Germany (2006, 2007), own calculations and markings.

### 3.3 Modification: heterogeneous productivity shocks

Apart from the existence of (not further specified) frictions in the labour market, the basic search and matching model analysed so far considers rather homogeneous firms and workers, respectively. While the assumption of homogeneous or representative agents is a major element of macroeconomic research, it of course represents a strong simplification not congruent with empirical evidence based on micro-data.<sup>10</sup> In order to improve the framework's ability to contribute to the positive productivity shock-puzzle, I therefore introduce a simple form of heterogeneity into the model and analyse the consequences.

In particular I assume that firms can differ in their ability to profit from advances in technology. To get the idea, remember that rather often than not there is a variety of profitable possibilities to do business. Firms might, among others, differ in machinery or in organization, and might still (initially) be equally successful. Technology shocks, in contrast, are often quite specific, think, for example, of considerable updates for a certain equipment. Despite such a generally available improvement, those firms that had opted for alternative equipment remain at their initial productivity level. If, therefore, such shocks are connected to rather irreversible – or at least very time-demanding in adjustment – investment decisions, they can split the universe of firms permanently into those which benefit from it and those which do not.<sup>11</sup>

I include this form of heterogeneity into the model introduced in the previous section and evaluate its consequences. Apparently, heterogeneity only matters in consequence of a productivity shock: Prior to the shock any difference between firms is negligible as they are equally productive in the initial steady state. For reasons of traceability I keep the analysis as simple as possible and focus on a single unanticipated productivity-enhancing shock. Possible limitations and extensions are discussed in Section 3.4.

#### 3.3.1 Heterogeneity in productivity advancements

##### Modifications to the base labour market

The model economy is hit by an unanticipated productivity-enhancing shock that affects a ratio  $\mu_h$  of all firms. In the later analysis I call this parameter the *scope* of the shock. The

<sup>10</sup> For literature references in particular on micro-level firm data see also Chapter 4.

<sup>11</sup> In the literature, heterogeneous productivity differences are typically implemented by stochastic shock-components with a general distribution but firm-specific realizations (e.g., Pissarides, 2000, Chap. 2, for the basic search and matching labour market framework). Such models enrich the analysis by the explicit consideration of heterogeneity in firm-productivity and their introduction of endogenous job destruction. For aggregate variables, however, such an approach is stationary and with respect to the productivity shock-puzzle mimics the basic model considered in the previous section.

productivity level of those firms hit by the shock is instantaneously and permanently raised from the initial to the higher after-shock level, while the other firms remain at the initial productivity stage. The difference between initial and after-shock productivity represents the *size* of the shock.

In order to analyse the transitional and long-run effects of such a heterogeneous productivity shock, I implement the resulting segmentation of firms into the structure of the base model from section 3.2. The index  $j = \{\text{initial, higher}\}$  discriminates between values and parameters of the sub-groups. Note that the term ‘firms’ not only includes matched jobs but also vacancies. Let  $\mu_h$  be the current ratio of firms with after-shock productivity, which in the course of transitional dynamics following the shock can differ from  $\underline{\mu}_h$ .

With a shock also the total number of employees is divided into two subgroups, hence  $L = L_i + L_h$ . I furthermore assume that before a successful match, unemployed workers can not differentiate between different types of vacancies regarding the productivity of the job they offer. They hence do not discriminate between vacancy types. Because all vacancies compete for the same workers, each of them induces negative externalities on the success of all the remaining vacancies, irrespectively of their individual type. Therefore all vacancies are subject to the same labour market tightness  $\theta$ .

### Modifications to workers’ value functions

After a shock firms might differ with respect to their values and wages, that is, we need to distinguish job-productivity specific value functions. For an employed worker it is<sup>12</sup>

$$rE_j = w_j + s[U - E_j] + \dot{E}_j. \quad (3.23)$$

Exogenous job destruction at rate  $s$  is not influenced by the specific productivity type of the job.

As it is not a priori clear to what kind of firm an unemployed worker finally is matched, the value of being unemployed is modified as

$$rU = b + \theta m(\theta)[\mu_h[E_h - U] + [1 - \mu_h][E_i - U]] + \dot{U}. \quad (3.24)$$

That is, with probability  $\theta m(\theta)$  the worker will switch from unemployment to employment. Then in turn with probability  $\mu_h$  this job is of higher productivity and with probability  $1 - \mu_h$  it is not.

<sup>12</sup> Formal derivations are given in Appendix 3.B.2.

### Modifications to firms' value functions

Because hiring is in general linked to administrative costs not directly connected to production, we assume that the search costs  $h$  of vacancies are independent of their respective productivity type. In contrast, due to individual bargaining the wage rate might account for possible productivity differences. Hence the modified value functions of the matched and unmatched firm are given by:

$$rJ_j = A_j - w_j + s[V_j - J_j] + \dot{J}_j, \quad (3.25)$$

and

$$rV_j = -h + m(\theta)[J_j - V_j] + \dot{V}_j, \quad (3.26)$$

respectively.

Again free market entry ensures that  $V_j = \dot{V}_j = 0$  as long as vacancies of type  $j$  exist at all.

**Proposition 3.4.** *All new jobs, that is, those jobs that current vacancies are expected to turn into when they are matched, have the same value  $J_n$ .*

*Proof.* From (3.26) and the free-market entry, the expected value from a filled job has to equal the expected costs necessary to put it into production,

$$J_j = h/m(\theta). \quad (3.27)$$

As the expected costs on the right hand side of the equation are the same for all vacancies, the expected value of new jobs must be  $J_j = J_n \forall j$ . Accordingly, also  $\dot{J}_j = \dot{J}_n \forall j$ .  $\square$

**Corollary 2.** *If vacancies differ in productivity, this must be reflected in different wage rates at the new jobs.*

*Proof.* To insert the free-entry condition into (3.25) gives for any job

$$J_j = \frac{A_j - w_j + \dot{J}_j}{r + s}. \quad (3.28)$$

For new jobs additionally (3.27) holds, so

$$\frac{A_j - w_j + \dot{J}_n}{r + s} = \frac{h}{m(\theta)}. \quad (3.29)$$

$\square$

## Modifications in wage bargaining

As each productivity-type of jobs features individual value functions, also the surplus from a successful match between firm and worker depends on the respective firm's type:

$$S_i = E_i - U + J_i. \quad (3.30)$$

The application of Nash bargaining results in

$$E_j - U = \beta S_j, \quad (3.31)$$

$$J_j = [1 - \beta] S_j, \quad (3.32)$$

which leads to

**Proposition 3.5.** *All new jobs pay the same wage  $w_n$ .*

*Proof.* From Proposition 3.4 all new jobs have common value  $J_n$ . Then, from (3.32), all new job matches create the same surplus. Because of (3.31) also the worker's value of being employed in a new job is independent on the type of the firm. Determining the time derivative from (3.30),  $\dot{S}_j = \dot{E}_j - \dot{U} + \dot{J}_j$ , and in turn splitting the change in surplus according to Nash bargaining gives an equivalent result. But then, because of (3.23), also the wage paid by any new firm must be the same.  $\square$

**Corollary 3.** *All vacancies have the same productivity level  $A_n$ .*

*Proof.* This follows directly from Corollary 2 and Proposition 3.5.  $\square$

Consequently, if due to the shock vacancies instantly differ in their productivity level, one type of vacancy will eventually disappear from the labour market, that is, be closed down and not be opened any more. Note that from the individual firm's point of view, there initially is no direct preference towards one or the other level of productivity. This is because  $\theta$  will always adapt to fulfil (3.28), so that the expected value from a job in equilibrium is not influenced by the productivity type. Later analysis will show which type of vacancy it is that continues on the labour market.

Independent of type and age of a job, similar to the procedure in the base economy, the bargained wage is given by

$$w_j = rU[1 - \beta] + \beta[A_j + \dot{E}_j + \dot{J}_j] - \dot{E}_j. \quad (3.33)$$

Rewriting (3.2) using  $E_n$  for any new job and (3.30), (3.31) and (3.27), the wage paid particularly in *new* jobs reads

$$w_n = [1 - \beta]b + \beta[A_n + \theta h]. \quad (3.34)$$

### Endogenous job separations

It is reasonable to assume that matched jobs are checked continuously whether they still generate a positive value for both partners.<sup>13</sup> Otherwise, they are shut down. By wage bargaining, firms and workers each receive a certain fraction of the surplus induced by a job, see, for example, (3.31) and (3.32), so there is agreement of both partners on the decision: Existing jobs of productivity  $A_j$  will be dissolved endogenously, if  $S_j < 0$ . We can adjust (3.11) to the modified framework with values indexed according to their specific type and find that this translates the job separation condition into

$$A_j < rU - \dot{E}_j - \dot{J}_j. \quad (3.35)$$

If we solve (3.33) for  $rU$ , insert (3.34) and (3.29) and employ the surplus splitting rules, (3.35) can be rewritten to be determined by parameters and time derivatives only:<sup>14</sup>

$$A_j < \frac{[b + \dot{U}][r + s] + \beta\theta m(\theta)[A_n + \dot{J}_n + \dot{E}_n]}{r + s + \beta\theta m(\theta)} - \dot{E}_j - \dot{J}_j. \quad (3.36)$$

### 3.3.2 Equilibrium

Like in the basic model, firms determine how many vacancies to open and hence set  $\theta$ . But in the heterogeneous shock framework considered here, additionally matched firm-worker pairs have to decide whether to stay matched or not, which in turn depends on  $\theta$ , see (3.35) and (3.24). Once both these decisions are made, the remaining endogenous variables can be derived recursively.

It is in particular the wage rate of the *new* jobs that determines  $\theta$ . In accordance to the basic framework, the economy is in equilibrium if the job creation condition (3.29) is in accordance

<sup>13</sup> Note that in Chapter 3.2 I could skip such an analysis, as all the existing jobs are equal there. If in this case an endogenous separation were optimal for one job, this would hold for any job. It is up to a sensible choice of parameter values to prevent this.

<sup>14</sup> See Appendix 3.C for details.

to the bargained wage rate (3.34):

$$[A_n - b][1 - \beta] - \frac{h[r + s]}{m(\theta)} - \frac{hm'(\theta)}{m^2(\theta)}\dot{\theta} - \beta\theta h = 0. \quad (3.37)$$

The congruence to (3.14) is highly visible. This implies that also in the modified framework  $\theta$  is a jump variable and all time derivatives of value functions are zero. Likewise the findings from the comparative statics analysis for  $\theta$  in the previous section apply. Additionally we find

**Proposition 3.6.** *For  $A_h > A_i$ , only vacancies of the higher productivity type are opened.*

*Proof.* Because of Corollary 3, only one type of vacancies exists, as soon as firm differ in productivity. As  $J_n$  is only determined by the vacancy cost  $h$  and the expected time of searching, see (3.27), there is no a priori preference for either type of vacancy. But as the comparative statics analysis revealed, it holds that  $\partial\theta/\partial A_j > 0$ , see also appendix 3.D.1 for the details. That is, a higher productivity level is reflected in a higher amount of vacancies with this productivity which can co-exist profitably. Hence, if  $A_h > A_i$  then  $A_n = A_i$  is no stable state, as the expected value of high productivity-type vacancies is still positive in the respective equilibrium- $\theta_i$ . In contrast,  $A_n = A_h$  is stable, as  $\theta_h$  then is too high for initial productivity-type vacancies to be maintained or newly opened.  $\square$

To sum our findings up, equilibrium labour market tightness  $\theta$  after the productivity advancement shock is implicitly determined by

$$[A_h - b][1 - \beta] - \frac{h[r + s]}{m(\theta)} - \beta\theta h = 0. \quad (3.38)$$

From  $\theta$  follow the wage rates

$$\begin{aligned} w_h &= [1 - \beta] \frac{b[r + s] + \beta\theta m(\theta)A_h}{r + s + \beta\theta m(\theta)} + \beta A_h, \\ w_i &= [1 - \beta] \frac{b[r + s] + \beta\theta m(\theta)A_h}{r + s + \beta\theta m(\theta)} + \beta A_i, \end{aligned}$$

for affected and (if still existing) non-affected jobs, respectively. From (3.35), adjusted to Proposition 3.6, we find that, given sensible choice of  $b$ , only matches that can not benefit from the productivity-enhancement might consider endogenous job separation, as  $rU$  is determined by new jobs with higher productivity. In particular we find that these jobs are destroyed if

$$A_i < rU = \frac{b[r + s] + \beta\theta m(\theta)A_h}{r + s + \beta\theta m(\theta)}. \quad (3.39)$$

Denoting the fraction of jobs to be dissolved endogenously by  $d$ , we have

$$d = \begin{cases} 1 - \mu_h & \text{if } A_i < rU = \frac{b[r+s]+\beta\theta m(\theta)A_h}{r+s+\beta\theta m(\theta)} \\ 0 & \text{otherwise} \end{cases}. \quad (3.40)$$

Accordingly, employment evolves in line with

$$\dot{L}_h = \theta m(\theta)[N - L] - sL_h, \quad (3.41)$$

$$\dot{L}_i = \begin{cases} -[1 - \mu_h]L & \text{if } A_i < \frac{b[r+s]+\beta\theta m(\theta)A_h}{r+s+\beta\theta m(\theta)} \\ -sL_i & \text{otherwise} \end{cases}, \quad (3.42)$$

which adds to

$$\dot{L} = \begin{cases} \theta m(\theta)[N - L] - [\mu_h s + [1 - \mu_h]]L & \text{if } A_i < \frac{b[r+s]+\beta\theta m(\theta)A_h}{r+s+\beta\theta m(\theta)} \\ \theta m(\theta)[N - L] - sL & \text{otherwise} \end{cases}. \quad (3.43)$$

The development of unemployment is then given by

$$\dot{u} = \begin{cases} [\mu_h s + [1 - \mu_h]][1 - u] - \theta m(\theta)u & \text{if } A_i < \frac{b[r+s]+\beta\theta m(\theta)A_h}{r+s+\beta\theta m(\theta)} \\ s[1 - u] - \theta m(\theta)u & \text{otherwise} \end{cases}. \quad (3.44)$$

In the basic framework aggregate productivity equalled the productivity level  $A$ . This is different in the modified economy, where we observe  $\bar{A} = \mu_h A_h + [1 - \mu_h]A_i$ . That is, aggregate productivity is the average of the available productivity levels, weighted by their fraction among jobs in the economy. It can not be decomposed if  $\mu_h$  is unknown. With total derivation we find that  $\dot{\bar{A}} = [A_h - A_i]\dot{\mu}_h$ , hence<sup>15</sup>

$$\dot{\bar{A}} = \begin{cases} [A_h - A_i][1 - \mu_h] \frac{\theta m(\theta)[N-L] + L_h[1-s]}{L} & \text{if } A_i < \frac{b[r+s]+\beta\theta m(\theta)A_h}{r+s+\beta\theta m(\theta)} \\ [A_h - A_i][1 - \mu_h] \frac{\theta m(\theta)[N-L]}{L} & \text{otherwise} \end{cases} \quad (3.45)$$

Because  $Y = \bar{A}L$ , in equilibrium total output evolves according to

$$\dot{Y} = \begin{cases} A_h[\theta m(\theta)[N - L] - sL_h] - A_i L_i & \text{if } A_i < \frac{b[r+s]+\beta\theta m(\theta)A_h}{r+s+\beta\theta m(\theta)} \\ A_h[\theta m(\theta)[N - L] - sL_h] - A_i sL_i & \text{otherwise} \end{cases}. \quad (3.46)$$

### 3.3.3 The steady state and comparative statics

As found above, the central equilibrium condition in my modified framework (3.38) corresponds to (3.15) in the basic model. All jobs are exposed to at least exogenous job destruction,

<sup>15</sup> See Appendix 3.C for details.



**Table 3.2:** Comparative statics of job-separation productivity threshold

	$s$	$r$	$h$	$\beta$	$A$	$b$
$\hat{A}$	+	+	+	+ / 0 / -	+	-

while job creation only comprises higher-productive jobs. Hence in the long-run, stationary equilibrium only high-productivity jobs will remain and any heterogeneity is gone. But then, replacing  $A$  by  $A_h$ , the steady state is described by the system of the base framework, see section 3.2.5. Also the comparative statics derived there apply in the modified framework.

What might differ, however, is the shape and speed of the transitional process from the initial to the new steady state in response to an heterogeneous compared to a homogeneous productivity shock. That is because in contrast to the basic framework, the modifications introduced decisions about endogenous job destruction into the model. According to (3.39), for any initial value  $A_i$  there exists a threshold value  $\hat{A}$  inducing endogenous job destruction if  $A_h \geq \hat{A}$ . It is implicitly determined by

$$A_i = \frac{b[r + s] + \beta\theta(\hat{A})m(\theta(\hat{A}))\hat{A}}{r + s + \beta\theta(\hat{A})m(\theta(\hat{A}))}.$$

If the after-shock productivity level of new vacancies  $A_h$  equals at least  $\hat{A}$ , then current job matches with a productivity of  $A_i$  are dissolved in agreement by the involved firm and worker. With the details in Appendix 3.D.2, Table 3.2 summarizes the comparative statics of the job-dissolving threshold and the exogenous parameters. Marginal changes in most parameters induce non-ambiguous effects on the position of  $\hat{A}$ . As a rise in the exogenous separation rate  $s$  damps both the firms' incentive to create vacancies and the wage that a worker can expect from a new job, see Table 3.1, the productivity threshold rises. Similar considerations result for the interest rate  $r$  and the vacancy costs  $h$ . A higher initial level of productivity  $A_i$  necessitates a higher  $A_h$  for non-affected jobs to be dissolved immediately.

Things are less clear-cut, however, for the worker's bargaining power  $\beta$  and unemployment benefit  $b$ , which both induce opposing reactions on job creation than on wage payment. While a higher  $\beta$  lowers an unemployed worker's chance to find a job, a final success is rewarded by a larger share in the job's surplus. Indeed the sign of the derivative is indefinable due to the following term:

$$\beta m(\theta(\beta)) + \theta(\beta) m'(\theta(\beta)) \gtrless 0$$

The final result depends on the chosen specification of the matching function and the interplay

of parameters in the model's equation system. The sign of the derivative might also change for different values of  $\beta$ . Appendix 3.E shows for the example of a simple Cobb-Douglas matching function specification with elasticity of substitution  $\sigma = 0.5$  that as long as  $\beta < \sigma$ , infinitesimal changes in  $\beta$  result in a decrease of the job-dissolving productivity threshold and vice versa. If both parameters are equal, then positive and negative effect cancel each other out.

In case of a marginal increase of unemployment benefit  $b$ , a decrease in the vacancy rate on the one hand is accompanied by an increase in the bargained wage on the other hand. However, for the chosen parameter domains the analysis shows that the effect of the wage gain, which influences both current and future matches, dominates the effect on labour market tightness. As a result,  $\hat{A}$  declines.

### 3.3.4 Transitional dynamics after a productivity shock

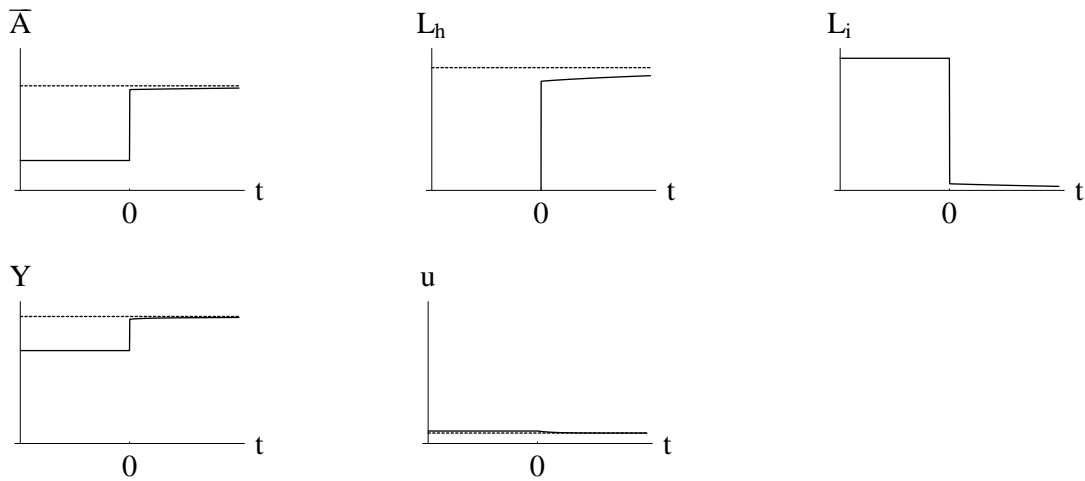
If we assume the economy to rest in an initial steady state, what happens in case of an unanticipated productivity-enhancing shock if on impact only a fraction  $\underline{\mu}_h$  of firms is able to benefit from it? How are the transitions reflected in the economy's aggregate values? As the following analysis shows, depending on the underlying parameter values, transitional dynamics might look quite different, even for only small parameter variations.

#### Adjustment without endogenous job destructions

Firstly assume that given current parameter values, the productivity shock is relatively small, such that the endogenous job destruction-condition is not fulfilled. However, job creation is effected by the shock: With Proposition 3.6 and Table 3.1 we find that more vacancies per unemployed workers are created than before and all of them are of productivity  $A_h$ . The economy approaches the new steady state with gradual disappearance of initial-productivity jobs by exogenous job destruction, and gradual expansion of higher-productivity jobs by job destruction. Unemployment decreases accordingly. Figure 3.4a illustrates the qualitative dynamics in unemployment, total output and aggregate productivity. In addition, impulse responses are given by Figures 3.4b.<sup>16</sup>

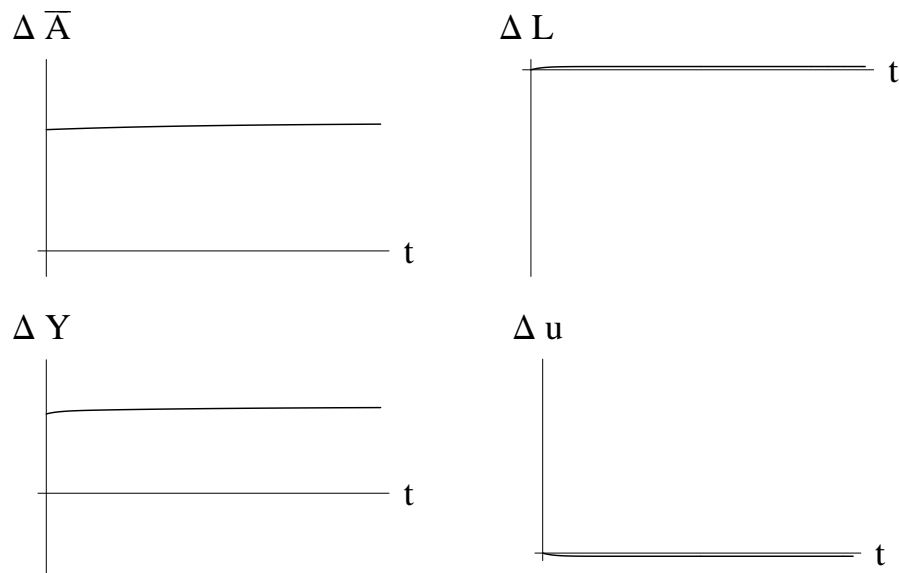
<sup>16</sup> The illustrations in Figures 3.4–3.6 were created using the according parameter values  $s = 0.1$ ,  $h = 0.213$ ,  $\beta = 0.72$ ,  $m(\theta) = 1.355(1/\theta)^\sigma$ ,  $\sigma = 0.72$ ,  $b = 0.4$ ,  $r = 0.012$  (see Shimer, 2005) and the standardizations  $L = 1$ ,  $A_i = 1$ . In the modified framework without endogenous job destruction the productivity shock is about 5 %, otherwise 7 %. In all but the temporary recession framework  $\mu_h = 0.95$ , in the latter case  $\mu_h = 0.9$ . Although axis ranges were turned off for demonstrative issues, all figures display uniform value ranges to mark the size relations of varying dynamics and the shock values were chosen to clearly illustrate the differences in possible outcomes.

**Figure 3.4:** Response to productivity-enhancing shock, modified framework, without endogenous job destruction



Notes: The shock is in  $t = 0$ . Dashed lines denote final steady state values.

**(a) Transitional dynamics**



**(b) Impulse responses**

### Adjustment with endogenous job destructions

If, alternatively, the productivity shock is high enough, at some point it becomes optimal to dissolve initial-productivity jobs immediately,  $d > 0$ . These job destructions raise unemployment on impact, see (3.44), while the expansion in jobs creation is gradual like before, see (3.41).

**Continuous output growth** The productivity-enhancing shock instantly induces a jump in output created by those firms that benefit from it. With immediate endogenous destruction of the remaining firms, their output in contrast is ceased. If this decline is more than offset by the increase from the profiting firms, then on impact the response of total output is positive. Figure 3.5a gives the aggregate transitional dynamics, while the according impulse responses are in Figure 3.5b.

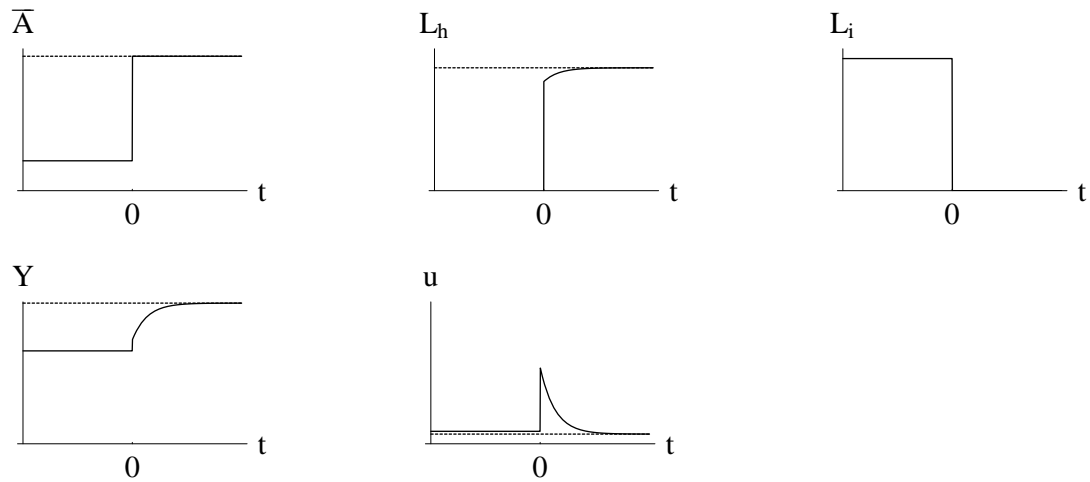
**Temporary recession** If the output increase in productivity-enhanced firms is not as high as the loss in the non-affected firms, then in immediate response to a *positive* productivity shock total output in the economy initially *declines*. Only gradually then, with ongoing job creation, output increases again to finally approach the new, higher steady state level. Figures 3.6a and Figure 3.6b illustrate the respective dynamics.

### Comparison and discussion

As illustrated, there are various possibilities how the transitional path in response to an unanticipated productivity-enhancing shock might be shaped if only a fraction of firms is able to benefit from it. The drafted dynamic scenarios mainly differ in their final steady states as well as in the shape of the aggregated variables' transition paths and the speed of transition. In particular, it is the decision of whether or not non-affected jobs are dissolved endogenously, that induces most of the differences. Two characteristics of a heterogeneous productivity shock in interplay with the remaining parameters determine the respective outcome: a) the *size* of the shock ( $A_h$  compared to  $A_i$ ) and b) the extent of heterogeneity, that is, the *scope*  $\underline{\mu}_h$ , of it.

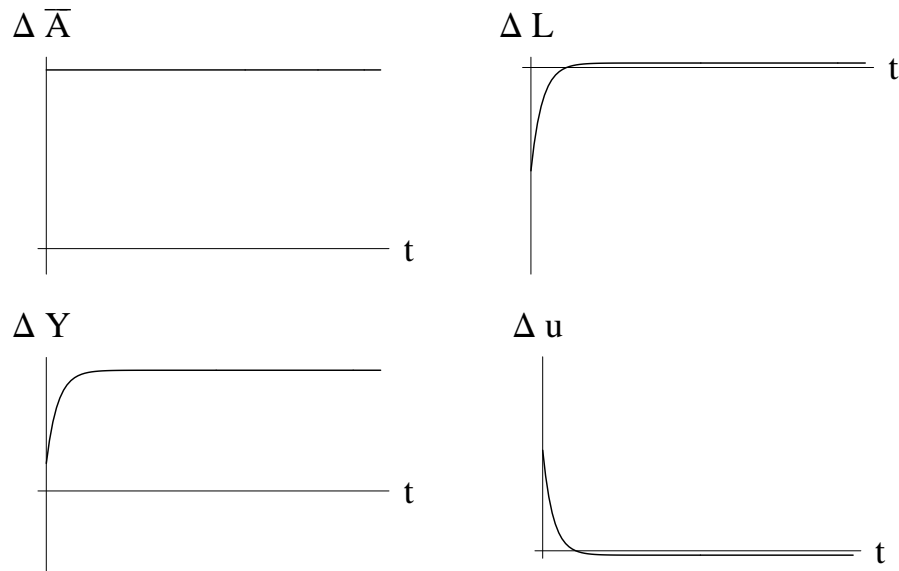
According to our analysis and comparative statics, it is  $A_h$  alone which determines the new steady state. It also determines whether or not discarded jobs are destroyed immediately or rather vanish gradually, which is crucial to further adjustment. The decision about endogenous job destruction is made by each firm-worker-match individually based on evaluation of (3.39) only. It is independent on how many other matches simultaneously make the same decision: Because of the jump characteristic of  $\theta$  the expected individual unemployment

**Figure 3.5:** Response to productivity-enhancing shock, modified framework, endogenous job destruction and continuous growth



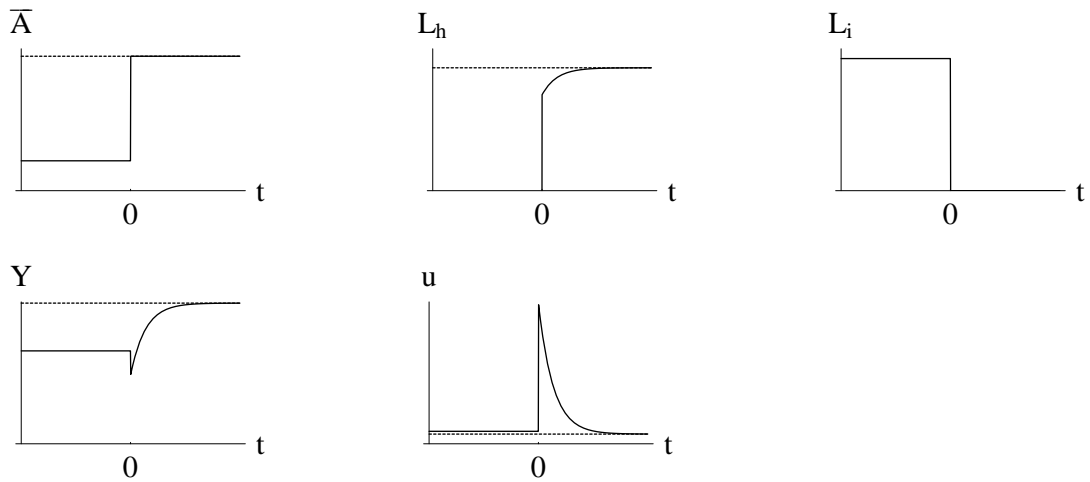
Notes: The shock is in  $t = 0$ . Dashed lines denote final steady state values.

(a) Transitional dynamics



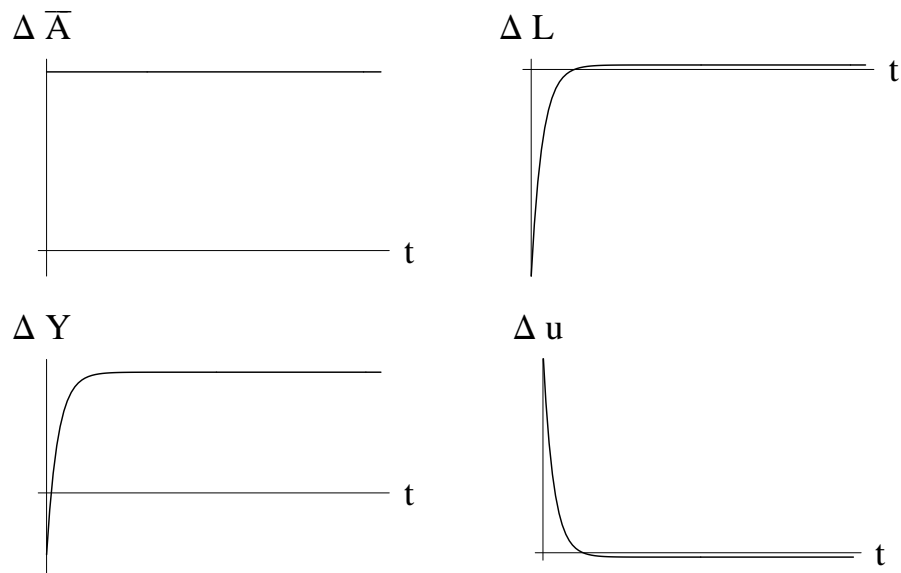
(b) Impulse responses

**Figure 3.6:** Response to productivity-enhancing shock, modified framework, endogenous job destruction and impact-recession



Notes: The shock is in  $t = 0$ . Dashed lines denote final steady state values.

**(a) Transitional dynamics**



**(b) Impulse responses**

duration  $\frac{1}{\theta m(\theta)}$  is independent of the stock of unemployed workers. If unemployment goes up, so does the number of vacancies to always provide the optimal vacancy-unemployment rate.

If the endogenous job destruction decision is positive, unemployment increases on impact. The magnitude of labour discharge, in turn, is regulated by  $\underline{\mu}_h$  only. Figure 3.7a illustrates the possible impact effects the shock can induce on unemployment. It is flat for rather small productivity shocks. But after the job destruction threshold  $\hat{A}$  is crossed, unemployment raises the stronger, the smaller  $\underline{\mu}_h$ .

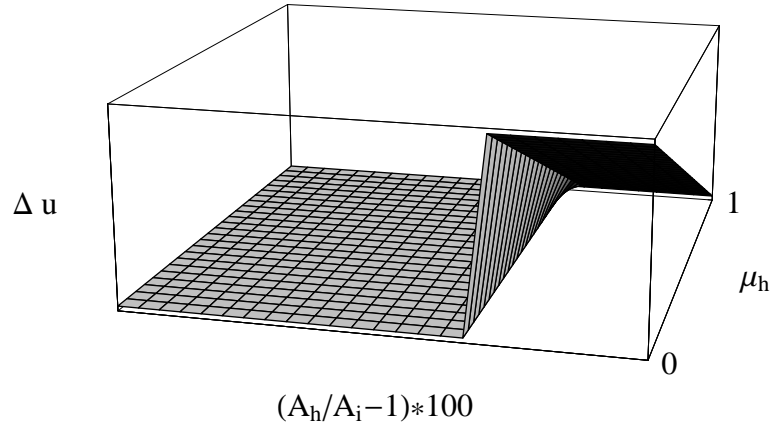
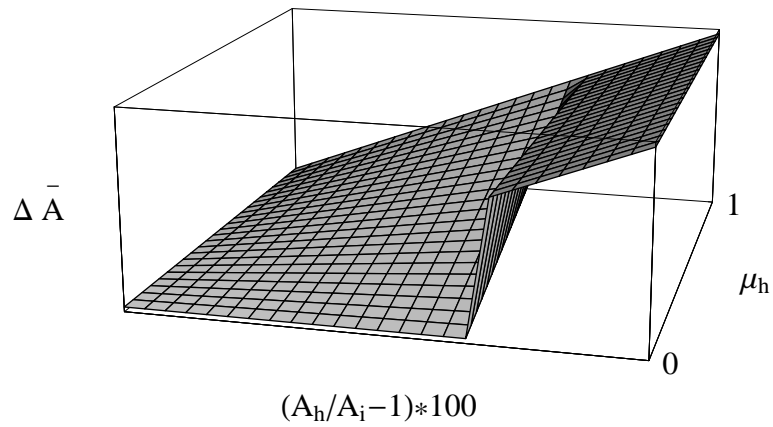
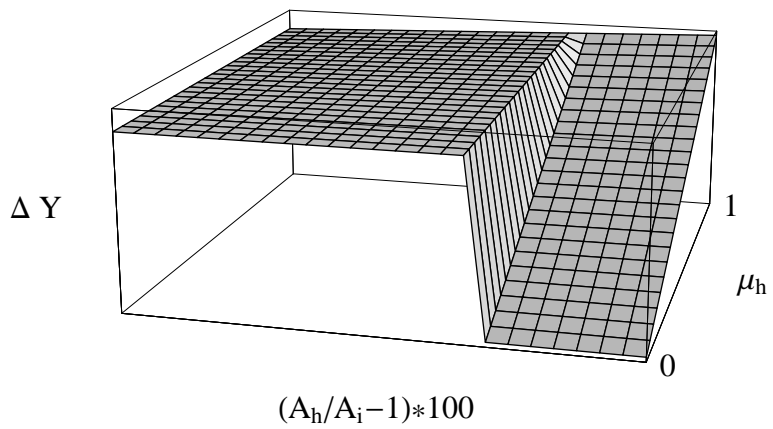
The interplay of the shock's size and scope together determine the scale of total output and aggregate productivity reaction. Due to the non-linearity in the endogenous job destruction-decision – either all non-affected jobs are destroyed or neither of them –, these responses are not continuous. A movement along the possible productivity space  $A_h$  first comprises productivity values connected to continuation of all jobs. Along this range, the higher the productivity shock and the more firms benefit from it, the higher  $\bar{A}$  and hence total output and aggregate productivity increase on impact. After the job destruction threshold  $\hat{A}$  is crossed, however, aggregate productivity jumps up to  $A_h$  immediately, as illustrated in Figure 3.7b. The according increase in unemployment is reflected in an initial *decrease* in aggregate output compared to its reaction to smaller productivity advancement. Depending on  $\underline{\mu}_h$  it might even be strong enough to let output fallen below its initial value. Figure 3.7c depicts the possible impact space of total output.

A comparison between the aforementioned scenarios also reveals differences in the speed of adjustment to the new steady state. Not surprisingly there is a trade-off between structure and magnitude of impact reactions – that is, sharp instant destructions versus gradual reduction of non-affected jobs – and the velocity of transformation.

To sum up, the variety of scenarios roots in particular in the asymmetry of the shock responses: Job creation on the one hand, is due to frictions committed to gradual adjustment. Job destruction, on the other hand, might take place immediately. It is in particular the instant moment of the shock which lays the foundation for different transitional dynamics, while the subsequent dynamics are smooth. Because the endogenous job destruction decision is of 0/1-type, (initial) shock responses might vary greatly even for small differences in the parameters.

### 3.3.5 Implications for the scatter-plots

After presentation and analysis of the modified search and matching model with heterogeneous productivity shocks, I finally evaluate how much it can contribute to understand the scatter-plots in Figure 3.1. What scatter points could originate from the kind of productivity

**Figure 3.7:** Possible impact reaction to heterogeneous productivity-enhancing shock**(a)** unemployment**(b)** aggregate productivity**(c)** total output



shocks presented in this section? Again I differentiate between the impact effect in the moment of the shock and the subsequent transition process.

**Proposition 3.7.** *On impact of a heterogeneous productivity-enhancing shock i) aggregate productivity jumps up, ii) labour input remains at its initial level or decreases, and iii) total output's rate of change might equal the productivity shock or falls short of it, up to a negative rate.*

*Proof.* Ad i) This follows per definition of the shock.

Ad ii) If (3.39) is fulfilled, endogenous job separations induce instantaneous reductions in employment,  $\frac{\dot{L}}{L} < 0$ , see (3.43). For the case where (3.39) is not fulfilled consult the proof to Proposition 3.2.

Ad iii) As established in (3.46) and the proof of Proposition 3.2,

$$\frac{\dot{Y}}{Y} = \frac{\dot{A}}{A} + \frac{\dot{L}}{L}.$$

Hence  $\frac{\dot{Y}}{Y} < \frac{\dot{A}}{A} \Leftrightarrow \frac{\dot{L}}{L} < 0$  and  $\frac{\dot{Y}}{Y} = \frac{\dot{A}}{A}$  otherwise. □

It should be noted that in contrast to general intuition we should expect employment decreases and hence particularly weak or negative responses in output primarily in connection to rather high productivity shocks.

**Proposition 3.8.** *During transition i) aggregate productivity might keep its level or increases furthermore, ii) labour input increases to its new steady state level independently of the productivity change, and iii) output increases to its new steady state with a growth rate that is higher than that of productivity.*

*Proof.* Ad i) According to (3.45), as long as  $\mu_h < 1$  and without endogenous job destruction, the productivity level keeps rising up to its new steady state. If initial-productivity jobs have been dissolved, however, aggregate productivity equals  $A_h$  immediately.

Ad ii) This follows from (3.43) according to the proof of Proposition 3.3.

Ad iii) With  $\frac{\dot{A}}{A} \geq 0$  and  $\frac{\dot{L}}{L} > 0$  we find that

$$\frac{\dot{Y}}{Y} = \frac{\dot{A}}{A} + \frac{\dot{L}}{L} > \frac{\dot{A}}{A}.$$

□

From the above it follows that regarding their output response in the scatter-plot, transitions to a new steady state become indistinguishable from instant shock periods without endogenous job destruction.

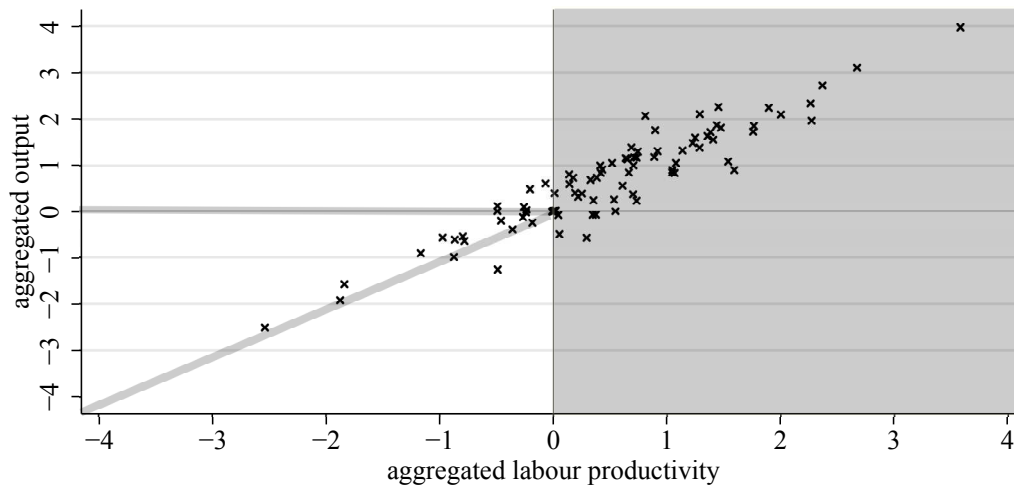
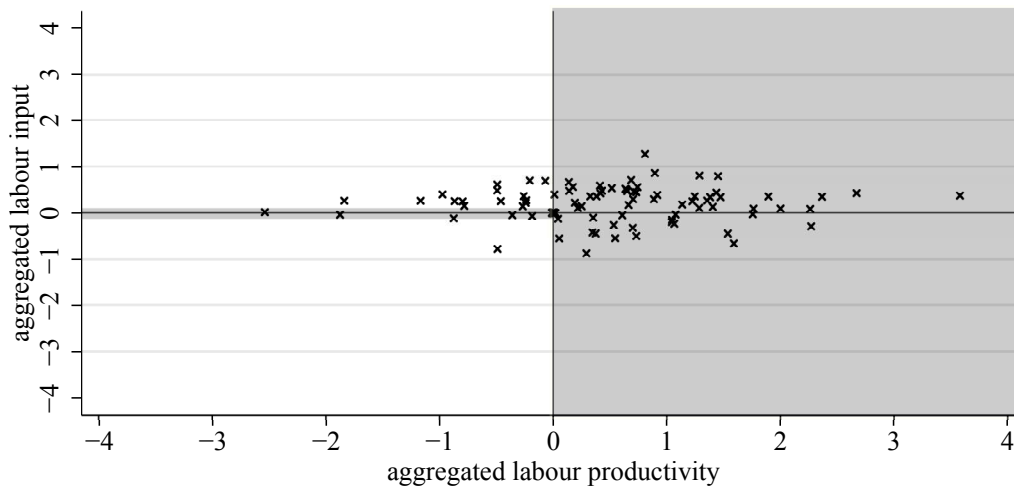
For reasons of completeness note that in the modified framework the analysis of a negative heterogeneous productivity shock would not simply result in the reverse of a positive shock. First of all, with such a shock the economy would not be subject to a new steady state; it would only move the economy out of the current one. With the findings of the analysis above, newly created jobs are of initial productivity. If the negative shock is small enough so that  $A_{lower} \geq rU$  – where  $rU$  keeps its initial level – then employment remains stable. On impact, output and aggregate productivity fall equally. During transition they jointly grow slowly back to their initial values with the exogenous disappearance of shock-affected matches. Otherwise these are dissolved endogenously on impact, reflected in a temporary spike in unemployment which results in a one-time output decrease at a constant level of aggregate productivity. Afterwards labour input and output jointly grow back to their initial steady state level, while productivity remains stable.

Figure 3.8 summarizes these findings and marks those areas in the scatter-plot that might be caused by an unanticipated productivity shock, which is implemented by only a fraction of all firms. Compared to the basic framework, we find that the modifications suggested in this section have increased the explanatory power considerably. In particular, principally all rates of change of labour input and output that occur with positive growth in aggregate productivity could stem from either the shock period or subsequent transitions according to our theory. However, a number of points can not be classified unambiguously as belonging to a certain (shock vs. transition) period or in their specific size and scope of the shock that created them.

### 3.4 Discussion and conclusion

I have shown in my analysis that a simple modification in the search and matching labour market model enables a variety of possible responses of employment and total output to a productivity-enhancing shock. Likewise, the shock itself and the transition process it induces allows for a wide range of possible combinations of productivity and output growth. Can these findings also help to solve the productivity shock-puzzle raised by Galí (1999) and briefly discussed in the introductory Section 3.1 of this chapter?

First of all note that econometric and statistic issues, the correct use and specification of (structural) VAR models and the time series employed therein are beyond the scope of my theoretical model. These are also matters of data characteristics and stochastic disturbances which are not included in the presented framework. Second of all, my framework is kept

**Figure 3.8:** Implications from modified model for scatter-plot**(a)** Labour productivity and total output (gross domestic product)**(b)** Labour productivity and number of employees

Note: Labour productivity per employee. Seasonally and price adjusted, quarterly data, 1970-2006. Shaded area denote values which could be explained by unanticipated heterogeneous productivity shocks and the transition they induce in the modified search and matching framework.

Source: Federal Statistical Office Germany (2006, 2007), own calculations and own markings.

simple and partial in order to concentrate on the ability of ambiguity in the macroeconomic response to productivity shocks. Those models employed for (S)VAR-analysis in contrast often are stochastic dynamic general equilibrium models. The transfer of my suggested mechanism into one of these is hindered by a type of path-dependency in my economy: Firm-level heterogeneity and the asymmetry in response to positive and negative productivity shocks impair the general traceability of the model. So far, my approach can be regarded to supplement this topic from an alternative perspective. However, more research should be devoted to enrich the analytical analysis of such models. Despite these technical challenges, already the simplified one-time shock framework demonstrates how important aspects of macroeconomic dynamics might be missed in an analysis which only considers aggregate variables and homogeneous representative agents. In my model heterogeneity which is hidden in aggregate numbers is crucial for its ability to create diversity in macroeconomic response to a productivity shock.

Calibration exercises offer first impressions on the dimension of such shocks analysed mainly qualitatively so far. If I choose parameter values close to (often cited though not uncontroversial) Shimer (2005) for example, I can for varying values of size and scope of a productivity shock reproduce the different dynamics discussed in this chapter.<sup>17</sup> Such procedure also shows, however, that the positive productivity shock must be rather large in my simplified framework to induce endogenous job destruction and the temporary unemployment increase quite high to trigger such a strong response like an impact recession.<sup>18</sup> Nonetheless, the following Chapter 4 is concerned in more detail with the empirical relevance of heterogeneous shocks and outcomes.

Despite the discussed constraints this chapter has demonstrated how already the introduction of simple heterogeneities into a basic model is able to increase the variety of dynamics for aggregate variables in response to a shock considerably. Given the characteristics of the real world, the consideration of heterogeneity also in macroeconomic (dynamic) models offers a promising route to better understanding of seemingly ambiguous observations. With regard to the productivity shock-puzzle, for example, I could offer an explanation for diversity in empirical observations: Variations might be based on differences that are hidden if we only look at typical aggregate numbers for productivity, employment and output, but which are crucial for the observable results.

Furthermore, the employed model also emphasized the importance that time-consuming reallocation of input factors has in the propagation, amplification and assimilation of shocks and therewith in general on dynamics in the economy. Even one-time shocks induce responses that might breed over several periods. With its focus on positive productivity shocks, the model in particular suggests that long-run growth might involve temporary fluctuations of the rates of change in aggregate variables. Finally, it was shown that rational, forward-looking

<sup>17</sup> See the figures of the simulated economy in this chapter.

<sup>18</sup> For the parameter values chosen to create the simulated dynamics consult Footnote 16.

optimization can induce time spells of higher unemployment and even drops in aggregate output in response to productivity-enhancing shocks as this helps to approach the new, more valuable steady state faster.

## Appendix 3.A Software and program codes

In order to evaluate the basic and modified search and matching model and analyse the effects of productivity shocks I simulated them in *Mathematica*. Also Figures 3.2 and 3.4–3.7 were produced this way. The corresponding program code is available on request. Figures 3.1, 3.3 and 3.8 were prepared using STATA and PDF-XChange Viewer.

## Appendix 3.B Derivation of the value functions

As in particular the value function of being unemployed in the modified framework, (3.24), is non-standard, I derive the worker's value function in detail according to Wälde (2011, Chap. 11.2). The firm's value functions can be found equivalently, then.

### 3.B.1 The basic economy

Workers are assumed to be identical, infinitely living and derive utility from consumption. The present value of the expected utility stream for risk-neutral workers with a time preference rate equalling the interest rate  $r$  is given by

$$E(U_t) = \int_t^\infty e^{-r[\tau-t]} c(\tau) d\tau.$$

If we further assume that the price of a unit of consumption is one and workers neither have capital income nor can save, the consumption in  $\tau$  equals the labour income in  $\tau$ . Then the consumption (and hence utility) stream is completely described by the evolution of income  $z$ . Income is state dependent: if a worker has a job then he or she earns labour income denoted by  $w$ , and otherwise gets some unemployment income  $b$ . Due to the ongoing, expected process of job creation and exogenous job destruction, the state may change over time from unemployment to employment, and vice versa. The corresponding Poisson processes counting how often such changes take place are given by  $q_b$  and  $q_w$ , respectively. Furthermore,  $w$  and  $b$  themselves might change over time deterministically as long as the economy strives to a new steady state. Thus, the change of income over time is described as

$$dz = f(z)dt - \Delta dq_w + \Delta dq_b, \quad (3.47)$$

with  $\Delta d \equiv w - b$ , and  $f(z)$  being a function describing the deterministic adjustment path to the economy's steady state.

Because only an employed worker can lose a job while only an unemployed worker may

find a job, the arrival rates for the Poisson processes are state dependent as well. I define them as  $\lambda(z)$  for  $q_b$ , with  $\lambda(w) = 0$  and  $\lambda(b) = \theta m(\theta)$ , and  $s(z)$  for  $q_w$ , with  $s(b) = 0$  and  $s(w) = s$ , respectively.

The maximized Bellman equation, describing the value function of the expected income stream depending on state  $z$  is given by

$$rW(z) = z + \frac{1}{dt} E_t W(z), \quad (3.48)$$

with

$$dW(z) = W_z f(z) dt + [W(z - \Delta) - W(z)] dq_w + [W(z + \Delta) - W(z)] dq_b. \quad (3.49)$$

With  $W_z f(z) = \dot{W}(z)$  and  $E_t dq_w = s(z)$ ,  $E_t dq_b = \lambda(z)$ , we can rewrite (3.48) as

$$rW(z) = z + \dot{W}(z) + s(z)[W(z - \Delta) - W(z)] + \lambda(z)[W(z + \Delta) - W(z)]. \quad (3.50)$$

Now denote the value of being employed, that is,  $W(w) = W(b + \Delta)$ , as  $E$  and that of being unemployed,  $W(b) = W(w - \Delta)$ , as  $U$ . Then from (3.50) and the state dependent probabilities it follows that

$$\begin{aligned} rE &= w + s[U - E] + \dot{E} \\ rU &= b + \theta m(\theta)[E - U] + \dot{U}, \end{aligned}$$

which just equals (3.1) and (3.2).

### 3.B.2 The modified economy

In the modified framework I have to consider that jobs might differ in their productivity, wage and value, appropriately denoted by the index  $j = \{i, h\}$  again. That induces changes in particular in the value of unemployment. To see this note that (3.47) becomes

$$dz = f(z)dt - \Delta_i d_i q_{wi} - \Delta_h d_h q_{wh} + \Delta_i d_i q_{bi} + \Delta_h d_h q_{bh},$$

with  $\Delta d_j \equiv w_j - b$ . Accordingly the state depending arrival rates for the Poisson processes are denoted by  $\lambda_j(z)$  for  $q_{bj}$ , with  $\lambda_j(w_j) = 0$  and  $\lambda_h(b) = \theta m(\theta) \mu_h$ ,  $\lambda_i(b) = \theta m(\theta) [1 - \mu_h]$ , and  $s_j(z)$  for  $q_{wj}$ , with  $s_j(b) = 0$  and  $s_i(w_i) = s_h(w_h) = s$ ,  $s_i(w_h) = s_h(w_i) = 0$ , respectively. Appropriate modification of (3.49) gives

$$\begin{aligned} dW(z) &= W_z f(z) dt + [W(z - \Delta_h) - W(z)] dq_{wh} + [W(z - \Delta_i) - W(z)] dq_{wi} \\ &\quad + [W(z + \Delta_h) - W(z)] dq_{bh} + [W(z + \Delta_i) - W(z)] dq_{bi}. \end{aligned}$$

With  $W_z f(z) = \dot{W}(z)$  and  $E_t dq_{wj} = s_j(z)$ ,  $E_t dq_{bj} = \lambda_j(z)$ , (3.50) becomes

$$\begin{aligned} rW(z) = & z + \dot{W}(z) + s_h(z)[W(z - \Delta_h) - W(z)] + s_i(z)[W(z - \Delta_i) - W(z)] \\ & + \lambda_h(z)[W(z + \Delta_h) - W(z)] + \lambda_i(z)[W(z + \Delta_i) - W(z)]. \end{aligned}$$

Now like in the previous section denote the value of being employed in a job of type  $j$  –  $W(w_j) = W(b + \Delta_j)$  – as  $E_j$  and that of being unemployed –  $W(b) = W(w_j - \Delta_j)$  – as  $U$  and apply the state dependent probabilities to end up with

$$\begin{aligned} rE_j &= w_j + s[U - E_j] + \dot{E}_j \\ rU &= b + \theta m(\theta)[\mu_h[E_h - U] + [1 - \mu_h][E_i - U]] + \dot{U}. \end{aligned}$$

## Appendix 3.C Details to specific derivations

### 3.C.1 The basic economy

#### Derivation of (3.11)

Solve (3.1) for  $E$  and subtract  $U$  on both sides of the equation to get

$$E - U = \frac{w + sU + \dot{E}}{r + s} - \frac{[r + s]U}{r + s}.$$

Together with (3.6) in (3.9) it gives (3.11).

#### Derivation of (3.13)

Surplus splitting gives that

$$\begin{aligned} E - U &= \frac{\beta}{1 - \beta} J \\ &= \frac{\beta}{1 - \beta} \frac{h}{m(\theta)}, \end{aligned}$$

because of (3.5). Insert into (3.2) and simplify to find that

$$rU = b + \frac{\beta}{1 - \beta} \theta h + \dot{U}.$$



If we in turn put this equation in (3.12), rewrite it and because of (3.9) and (3.10) consider that

$$-[\dot{E} - \dot{U}] + \beta[\dot{E} - \dot{U} + \dot{J}] = -[\dot{E} - \dot{U}] + \beta\dot{S} = 0,$$

we end up in (3.13).

### Derivation of (3.16)

Given that in equilibrium all dotted variables are zero, from (3.12) we have that

$$rU = \frac{1}{1 - \beta} [w - \beta A]. \quad (3.51)$$

Zero-profit condition (3.8) implies

$$h = \frac{m(\theta)[A - w]}{r + s}.$$

Put that into (3.13), rewrite and simplify it to end up in

$$\begin{aligned} w &= \frac{[1 - \beta]b[r + s] + \beta[A[r + s] + \theta m(\theta)A]}{r + s + \beta\theta m(\theta)} \\ &= \frac{b[r + s - \beta r - \beta s + \beta\theta m(\theta) - \beta\theta m(\theta)] + \beta A[r + s + \theta m(\theta)]}{r + s + \beta\theta m(\theta)} \\ &= b + [A - b] \frac{\beta[r + s + \theta m(\theta)]}{r + s + \beta\theta m(\theta)}. \end{aligned}$$

That into (3.51) gives

$$rU = \frac{b[r + s] + \beta\theta m(\theta)A}{r + s + \beta\theta m(\theta)},$$

which inserting in (3.12) results in (3.16).

### 3.C.2 The modified economy

#### Derivation of (3.36)

Equation (3.33) in particular for  $j = n$  gives

$$rU = \frac{1}{1 - \beta} [w_n - \beta A_n - \beta[\dot{E}_n + \dot{J}_n] + \dot{E}_n]. \quad (3.52)$$

From (3.29) we find that

$$h = \frac{m(\theta)[A_j - w_j + \dot{J}_n]}{r + s}.$$

Insert into (3.34) to find

$$\begin{aligned} w_n &= \frac{[1 - \beta]b[r + s] + \beta[A_n[r + s] + \theta m(\theta)[A_n + \dot{J}_n]]}{r + s + \beta\theta m(\theta)} \\ &= \frac{b[r + s - \beta r - \beta s + \beta\theta m(\theta) - \beta\theta m(\theta)] + \beta[A_n[r + s + \theta m(\theta)] + \theta m(\theta)\dot{J}_n]}{r + s + \beta\theta m(\theta)} \\ &= b + [A_n - b] \frac{\beta[r + s + \theta m(\theta)]}{r + s + \beta\theta m(\theta)} + \dot{J}_n \frac{\beta\theta m(\theta)}{r + s + \beta\theta m(\theta)}. \end{aligned}$$

Put that into (3.52) and rewrite such that

$$rU = \frac{b[r + s] + \beta\theta m(\theta)[A_n + \dot{J}_n + \dot{E}_n]}{r + s + \beta\theta m(\theta)} - \frac{\beta}{1 - \beta} \dot{J}_n \frac{[r + s]}{r + s + \beta\theta m(\theta)} + \frac{\dot{E}[r + s]}{r + s + \beta\theta m(\theta)}. \quad (3.53)$$

Now consider that according to the surplus splitting rule

$$\frac{\beta}{1 - \beta} \dot{J}_n = \dot{E}_n - \dot{U}_n,$$

and therewith (3.53) becomes

$$rU = \frac{[b + \dot{U}][r + s] + \beta\theta m(\theta)[A_n + \dot{J}_n + \dot{E}_n]}{r + s + \beta\theta m(\theta)}.$$

We can insert that into (3.35) to end up in (3.36).

### Derivation of (3.45)

We have that  $\mu_h = \frac{L_h}{L_h + L_i}$  and both employment levels are potentially subject to change over time. Hence

$$\dot{\mu}_h = \frac{L_i \dot{L}_h - L_h \dot{L}_i}{(L_h + L_i)^2}.$$

If we consider (3.41) and (3.42) in each respective case and note that

$$\frac{L_i}{(L_h + L_i)^2} = \frac{1 - \mu_h}{L},$$

we end up in (3.45). Also note that for  $A_i < \frac{b[r+s]+\beta\theta m(\theta)A_h}{r+s+\beta\theta m(\theta)}$  this implies  $\dot{A} = 0$  beyond the very instant of the shock itself: Because on impact all jobs with initial productivity are dissolved,  $\mu_h$  equals 1 then and the average productivity immediately equals  $A_h$  and stays at this new level.

## Appendix 3.D Comparative statics

### 3.D.1 Steady state

The system of equations in section 3.2.6 describing the model's stationary equilibrium is recursive and hence shows strong relations between the endogenous variables. In particular, both the equilibrium values of labour market tightness  $\theta^*$  and the wage rate  $w^*$  are simultaneously determined by (3.13) and (3.8), resulting in a set of implicit functions:

$$\begin{aligned} 0 &= A - \frac{h[r+s]}{m(\theta^*)} - w^*, \\ 0 &= [1 - \beta]b + \beta[A + \theta^*h] - w^*. \end{aligned}$$

Once  $\theta^*$  is known, the equilibrium values for the unemployment rate  $u^*$ , employment  $L^*$  and output  $Y^*$  in turn can be derived as they are given by

$$\begin{aligned} u^* &= \frac{s}{s + \theta^*m(\theta^*)}, \\ L^* &= \frac{\theta^*m(\theta^*)}{s + \theta^*m(\theta^*)}N, \\ Y^* &= \frac{\theta^*m(\theta^*)}{s + \theta^*m(\theta^*)}NA. \end{aligned}$$

To evaluate the changes in these equilibrium values in response to marginal variations of the exogenous parameters – the time preference rate  $r$ , the job separation rate  $s$ , the vacancy costs  $h$ , bargaining power  $\beta$ , productivity  $A$  and the unemployment benefit  $b$  – it is convenient to firstly find the derivatives of the implicit system employing the Jacobinian determinant.<sup>19</sup> The remaining derivatives follow secondly from general rules of differentiation.

### Comparative statics of $\theta^*$

$$\frac{\partial \theta^*}{\partial r} = \frac{\partial \theta^*}{\partial s} = -\frac{m(\theta)}{\beta m(\theta)^2 - [r+s]m'(\theta)} < 0$$

<sup>19</sup> For some mathematical background and applications see, e.g. Chiang (1984, Chap. 7 and 8).

$$\begin{aligned}
\frac{\partial \theta^*}{\partial h} &= -\frac{m(\theta)[r+s+\beta\theta m(\theta)]}{h[\beta m(\theta)^2 - [r+s]m'(\theta)]} < 0 \\
\frac{\partial \theta^*}{\partial \beta} &= -\frac{m(\theta)^2[A-b+h\theta]}{h[\beta m(\theta)^2 - [r+s]m'(\theta)]} < 0 \\
\frac{\partial \theta^*}{\partial A} &= \frac{[1-\beta]m(\theta)^2}{h[\beta m(\theta)^2 - [r+s]m'(\theta)]} > 0 \\
\frac{\partial \theta^*}{\partial b} &= -\frac{[1-\beta]m(\theta)^2}{h[\beta m(\theta)^2 - [r+s]m'(\theta)]} < 0
\end{aligned}$$

### Comparative statics of $w^*$

$$\begin{aligned}
\frac{\partial w^*}{\partial r} &= \frac{\partial w^*}{\partial s} = -\frac{h\beta m(\theta)}{\beta m^2(\theta) - [r+s]m'(\theta)} < 0 \\
\frac{\partial w^*}{\partial h} &= \frac{(r+s)\beta[m(\theta) + \theta m'(\theta)]}{(r+s)m'(\theta) - \beta m^2(\theta)} < 0 \\
\frac{\partial w^*}{\partial \beta} &= \frac{(r+s)[A-b+h\theta]m'(\theta)}{[r+s]m'(\theta) - \beta m^2(\theta)} > 0 \\
\frac{\partial w^*}{\partial A} &= \frac{\beta[m^2(\theta) - [r+s]m'(\theta)]}{\beta m^2(\theta) - [r+s]m'(\theta)} > 0 \\
\frac{\partial w^*}{\partial b} &= \frac{[r+s][1-\beta]m'(\theta)}{[r+s]m'(\theta) - \beta m^2(\theta)} > 0.
\end{aligned}$$

### Comparative statics of $u^*$

$$\begin{aligned}
\frac{\partial u^*}{\partial s} &= -\frac{\theta^*m(\theta^*) - s[m(\theta^*) - \theta^*m'(\theta^*)]\frac{\partial \theta^*}{\partial s}}{[s + \theta^*m(\theta^*)]^2} > 0 \\
\frac{\partial u^*}{\partial r} &= -\frac{s[m(\theta^*) + \theta^*m'(\theta^*)]}{[s + \theta^*m(\theta^*)]^2} \frac{\partial \theta^*}{\partial r} > 0 \\
\frac{\partial u^*}{\partial h} &= -\frac{s[m(\theta^*) + \theta^*m'(\theta^*)]}{[s + \theta^*m(\theta^*)]^2} \frac{\partial \theta^*}{\partial h} > 0 \\
\frac{\partial u^*}{\partial \beta} &= -\frac{s[m(\theta^*) + \theta^*m'(\theta^*)]}{[s + \theta^*m(\theta^*)]^2} \frac{\partial \theta^*}{\partial \beta} > 0 \\
\frac{\partial u^*}{\partial A} &= -\frac{s[m(\theta^*) + \theta^*m'(\theta^*)]}{[s + \theta^*m(\theta^*)]^2} \frac{\partial \theta^*}{\partial A} < 0
\end{aligned}$$

$$\frac{\partial u^*}{\partial b} = -\frac{s[m(\theta^*) + \theta^* m'(\theta^*)]}{[s + \theta^* m(\theta^*)]^2} \frac{\partial \theta^*}{\partial b} > 0$$

### Comparative statics of $L^*$

$$\begin{aligned} \frac{\partial L^*}{\partial s} &= \frac{\theta^* m(\theta^*) - s[m(\theta^*) - \theta^* m'(\theta^*)] \frac{\partial \theta^*}{\partial s}}{[s + \theta^* m(\theta^*)]^2} N < 0 \\ \frac{\partial L^*}{\partial r} &= \frac{s[m(\theta^*) + \theta^* m'(\theta^*)]}{[s + \theta^* m(\theta^*)]^2} \frac{\partial \theta^*}{\partial r} N < 0 \\ \frac{\partial L^*}{\partial h} &= \frac{s[m(\theta^*) + \theta^* m'(\theta^*)]}{[s + \theta^* m(\theta^*)]^2} \frac{\partial \theta^*}{\partial h} N < 0 \\ \frac{\partial L^*}{\partial \beta} &= \frac{s[m(\theta^*) + \theta^* m'(\theta^*)]}{[s + \theta^* m(\theta^*)]^2} \frac{\partial \theta^*}{\partial \beta} N < 0 \\ \frac{\partial L^*}{\partial A} &= \frac{s[m(\theta^*) + \theta^* m'(\theta^*)]}{[s + \theta^* m(\theta^*)]^2} \frac{\partial \theta^*}{\partial A} N > 0 \\ \frac{\partial L^*}{\partial b} &= \frac{s[m(\theta^*) + \theta^* m'(\theta^*)]}{[s + \theta^* m(\theta^*)]^2} \frac{\partial \theta^*}{\partial b} N < 0 \end{aligned}$$

### Comparative statics of $Y^*$

$$\begin{aligned} \frac{\partial Y^*}{\partial s} &= \frac{\theta^* m(\theta^*) - s[m(\theta^*) - \theta^* m'(\theta^*)] \frac{\partial \theta^*}{\partial s}}{[s + \theta^* m(\theta^*)]^2} N A < 0 \\ \frac{\partial Y^*}{\partial r} &= \frac{s[m(\theta^*) + \theta^* m'(\theta^*)]}{[s + \theta^* m(\theta^*)]^2} \frac{\partial \theta^*}{\partial r} N A < 0 \\ \frac{\partial Y^*}{\partial h} &= \frac{s[m(\theta^*) + \theta^* m'(\theta^*)]}{[s + \theta^* m(\theta^*)]^2} \frac{\partial \theta^*}{\partial h} N A < 0 \\ \frac{\partial Y^*}{\partial \beta} &= \frac{s[m(\theta^*) + \theta^* m'(\theta^*)]}{[s + \theta^* m(\theta^*)]^2} \frac{\partial \theta^*}{\partial \beta} N A < 0 \\ \frac{\partial Y^*}{\partial A} &= \frac{s[m(\theta^*) + \theta^* m'(\theta^*)]}{[s + \theta^* m(\theta^*)]^2} \frac{\partial \theta^*}{\partial A} N A + \frac{\theta m(\theta)}{s + \theta m(\theta)} N > 0 \\ \frac{\partial Y^*}{\partial b} &= \frac{s[m(\theta^*) + \theta^* m'(\theta^*)]}{[s + \theta^* m(\theta^*)]^2} \frac{\partial \theta^*}{\partial b} N A < 0 \end{aligned}$$

### 3.D.2 Job-separation threshold in the modified economy

The endogenous job-separation threshold  $\hat{A}$  is implicitly defined by

$$A_i - \frac{b[r+s] + \beta\theta(\hat{A})m(\theta(\hat{A}))\hat{A}}{r+s + \beta\theta(\hat{A})m(\theta(\hat{A}))} = 0.$$

Because labour market tightness  $\theta$  is a function of  $\hat{A}$  itself, it is not possible to solve for  $\hat{A}$  directly. However, we can employ the implicit function theorem to analyse how the threshold reacts in response to marginal variations of the exogenous parameters.<sup>20</sup> To analyse and interpret the derivatives with respect to the bargaining power  $\beta$  and the unemployment benefit  $b$  we additionally have to use (3.38), the implicit condition determining  $\theta$ .

$$\begin{aligned} \frac{\partial \hat{A}}{\partial s} &= \frac{\partial \hat{A}}{\partial r} = - \frac{[\hat{A} - b] \left[ \frac{\partial \theta}{\partial s} [\theta m'(\theta) + m(\theta)] [r+s] - \theta m(\theta) \right]}{\frac{\partial \theta}{\partial \hat{A}} [m(\theta) + \theta m'(\theta)] [r+s] [\hat{A} - b] + \theta m(\theta) [r+s + \beta \theta m(\theta)]} > 0 \\ \frac{\partial \hat{A}}{\partial h} &= - \frac{\frac{\partial \theta}{\partial h} [\hat{A} - b] [r+s] [m(\theta) + \theta m'(\theta)]}{\frac{\partial \theta}{\partial \hat{A}} [m(\theta) + \theta m'(\theta)] [r+s] [\hat{A} - b] + \theta m(\theta) [r+s + \beta \theta m(\theta)]} > 0 \\ \frac{\partial \hat{A}}{\partial \beta} &= - \frac{[\hat{A} - b]^2 [r+s] m^2(\theta) [\beta m(\theta) + \theta m'(\theta)]}{\beta \left[ \frac{\partial \theta}{\partial \hat{A}} [m(\theta) + \theta m'(\theta)] [r+s] [\hat{A} - b] + \theta m(\theta) [r+s + \beta \theta m(\theta)] \right]} \gtrless 0 \\ &\quad h[\beta m(\theta)^2 - [r+s] m'(\theta)] \\ \frac{\partial \hat{A}}{\partial A_i} &= \frac{(r+s + \beta \theta m(\theta))^2}{\beta \left[ \frac{\partial \theta}{\partial \hat{A}} [m(\theta) + \theta m'(\theta)] [r+s] [\hat{A} - b] + \theta m(\theta) [r+s + \beta \theta m(\theta)] \right]} > 0. \\ \frac{\partial \hat{A}}{\partial b} &= \frac{[r+s] m'(\theta) \left[ [\hat{A} - b] [1 - \beta] \beta \theta m(\theta)^2 + [r+s + \beta \theta m(\theta)] h [r+s] \right]}{\beta \left[ \frac{\partial \theta}{\partial \hat{A}} [m(\theta) + \theta m'(\theta)] [r+s] [\hat{A} - b] + \theta m(\theta) [r+s + \beta \theta m(\theta)] \right]} < 0 \\ &\quad h[\beta m(\theta)^2 - [r+s] m'(\theta)] \end{aligned}$$

## Appendix 3.E Cobb-Douglas specification of the matching function

To find a closed-form solution for  $\theta$  requires a specification of the matching function. Typically, a Cobb-Douglas type is employed for this, see Petrongolo and Pissarides (2001) for a literature survey and Shimer (2005) for an example. If the matching function is of Cobb-Douglas-type, the number of successful matches per instant depends on the number of

<sup>20</sup> For details of the concept consider, e.g., again Chiang (1984, Chap. 8).

vacancies and unemployed workers, the overall matching efficiency  $M$  and the elasticity of substitution between vacancies and unemployed  $0 < \sigma < 1$ :

$$x(uL, vL) = M * (uL)^\sigma (vL)^{1-\sigma}.$$

As this matching function fulfils the requirement of homogeneity of degree one, the probability  $m(\theta)$  for a vacancy to become matched is then accordingly given by

$$m(\theta) = \frac{x(uL, vL)}{vL} = x(u/v, 1) = x(1/\theta, 1) = M * \left(\frac{1}{\theta}\right)^\sigma.$$

Inserting this specification into (3.38) in order to solve for  $\theta$  ends up with

$$[r + s]\theta^\sigma + \beta M\theta - \frac{[A_h - b]M[1 - \beta]}{h} = 0,$$

which shows that there is no closed form solution for  $\theta$  in this generality. It is only possible to solve for the special case of  $\sigma = 0.5$ , which implies to extract the square root and gives:

$$\theta = \left\{ \frac{-\left(-\left(h^2 (r+s)^2\right)+2 (A-b) h M^2 (-1+\beta) \beta+\sqrt{h^3 (r+s)^2 \left(h (r+s)^2-4 (A-b) M^2 (-1+\beta) \beta\right)}\right)}{2 h^2 M^2 \beta^2} \right. \\ \left. \frac{h^2 (r+s)^2-2 (A-b) h M^2 (-1+\beta) \beta+\sqrt{h^3 (r+s)^2 \left(h (r+s)^2-4 (A-b) M^2 (-1+\beta) \beta\right)}}{2 h^2 M^2 \beta^2} \right\}$$

Note that given specific parameter values, the upper solution might not be defined.

We can use this result to determine the sign of  $\partial \hat{A} / \partial \beta$  for  $\sigma = 0.5$ :

$$\beta m(\theta) + \theta m'(\theta) = \left\{ \frac{-1+2 \beta}{\sqrt{2} \sqrt{-\left(\frac{-\left(h^2 (r+s)^2\right)+2 (A-b) h M^2 (-1+\beta) \beta+\sqrt{h^3 (r+s)^2 \left(h (r+s)^2-4 (A-b) M^2 (-1+\beta) \beta\right)}}{h^2 M^2 \beta^2}\right)}} \right. \\ \left. \frac{-1+2 \beta}{\sqrt{2} \sqrt{\frac{h^2 (r+s)^2-2 (A-b) h M^2 (-1+\beta) \beta+\sqrt{h^3 (r+s)^2 \left(h (r+s)^2-4 (A-b) M^2 (-1+\beta) \beta\right)}}{h^2 M^2 \beta^2}}} \right\}$$

Apparently, for  $\beta = 0.5$  we have that  $\partial \hat{A} / \partial \beta = 0$ . If instead  $\beta > 0.5$  the numerator of these solutions is positive. Because of the root, the denominator, if defined at all, has to be positive, too, indicating  $\partial \hat{A} / \partial \beta > 0$  then. For  $\beta < 0.5$  the opposite holds.





## Chapter 4

### Empirical job dynamics: Heterogeneous shocks below the surface?

#### 4.1 Introduction

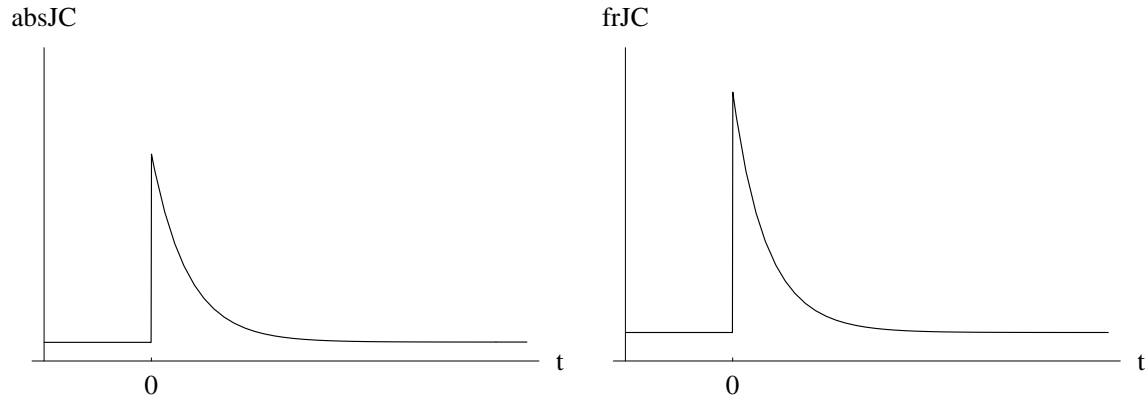
The theory presented in the previous Chapter 3 suggests that productivity-enhancements (might) arrive in the economy unevenly: There are productivity shocks which hit only a – a-priori non-identifiable – subgroup of firms within the economy, while the productivity level of the remaining firms keeps its pre-shock level. Depending on the size and scope of the productivity shock, in an economy described in a search and matching labour market framework, a variety of possible impulse responses on aggregate employment and total output can result. Among them, positive productivity shocks might even induce a temporary recession due to time-consuming reallocation of labour.

The current chapter of this thesis is concerned with the empirical relevance of such heterogeneous shocks and outcomes. Given their characteristics, they are hybrids between aggregate shocks, which hit all firms, and idiosyncratic shocks, which are only firm-specific. Therefore I have to look not only on aggregate net statistics like the development of total employment and output. Additionally I need to include variables which sum up individual gross developments and differences. For example, convenient measures to reflect heterogeneity in labour market dynamics are statistics on job creation, job destruction and the resulting job reallocation between firms. I am in particular interested in whether I can find evidence for the rather counter-intuitive event of impact-recessions in response to heterogeneous productivity-enhancing (hp) shocks.

Taking a highly-stylized model to the data requires a number of adaptations. First of all, my model prescinds from other but the considered type of shock. Empirical data, in contrast, reflects the full spectrum of ongoing inferences in economic development. Secondly, firms consist of exactly one job in the model, while in reality firms have an arbitrary number of employees. This deviation matters because in the model job creations and destructions due

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\* Substantial parts of this chapter were generated during a research visit at the University of Glasgow. Financial support by a DAAD grant for this period is highly appreciated.

**Figure 4.1:** Job creation in the model with heterogeneous productivity-enhancing shocks**(a)** Absolute job creation**(b)** Fraction of job creating firms

Notes: The shock is in  $t = 0$ .

to shocks are equal to firm exits and entries. If I refrain from a complex re-design of the framework,<sup>1</sup> I might either equate the single observed job or the complete observed firm with my conceptual model firm. As I motivated the existence of unevenly spread productivity enhancements by differences in ways to do business (see page 38), the second alternative seems more appropriate. But because in reality firms might additionally cover different business areas, both not all firms and not all jobs within a specific firm necessarily need to be effected by a specific shock. Consequently in contrast to the theoretic model, not being able to profit from a certain productivity-enhancing shock does not require the empirical firm to close down completely (within a short time).

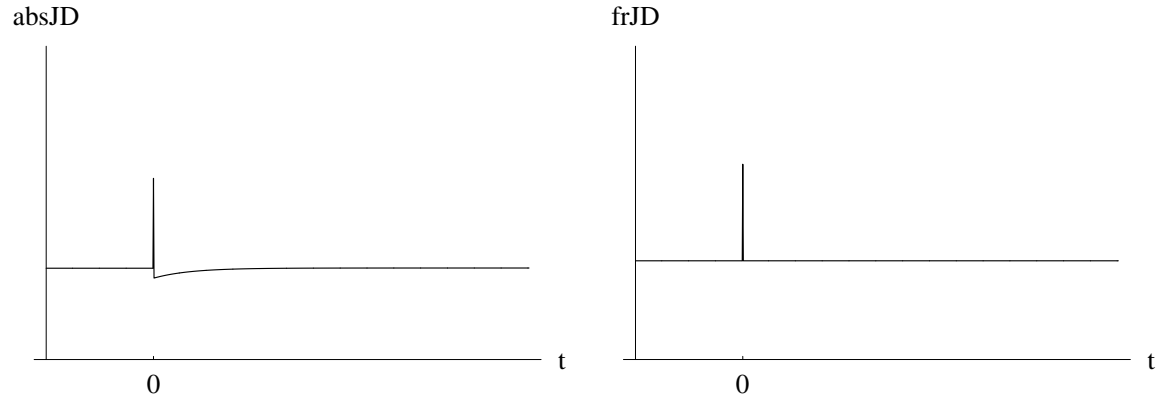
Analysing the theoretical model, we find that hp shocks, in particular those which induce impact-recessions, are reflected in the dynamics of individual and aggregate productivity and employment. In search for their empirical counterparts, bearing in mind the necessary adaptations and expected additional-shock disturbances just discussed, the findings imply to look for the following, (almost) synchronous patterns in a suitable set of time series data:

### 1. *Job creation*

Figure 4.1 illustrates the development of job-creation in response to a hp shock in the simulated model from Chapter 3.3. The number and ratio of (job creating) firms and (new) jobs coincides there. Adaptation to the empirical analysis in contrast implies that the time-consuming process of persistent employment increase is reflected in two distinctive statistics for these issues.

<sup>1</sup> See Pissarides (2000, Chap. 3.1) on the the issue of firm size in the basic search and matching framework. Recent analyses with a multi-worker version of search and matching frameworks include Cooper, Haltiwanger and Willis (2007); Elsby and Michaels (2008).

**Figure 4.2:** Job destruction in the model with heterogeneous productivity-enhancing shocks and endogenous job dissolving



(a) Absolute job destruction

(b) Fraction of job destructing firms

Notes: The shock is in  $t = 0$ .

*The number and ratio of job-creating firms temporarily goes up strongly, aggregated absolute job creation increases.*

## 2. Job destruction

The response of job-destruction in particular to a recession-inducing hp shock in the time-continuous theoretical model is represented in Figure 4.2.

*On impact, for a short period the ratio of job-destructing firms goes up, while aggregated absolute job destruction increases and outnumbers job creation.*

Also note that hp shocks without the ability to induce an impact-recession in any case are characterized by *non-decreasing* job destruction, see Chapter 3.3.4.

## 3. Aggregate employment

Figure 4.3a outlines the reaction of aggregate employment to a recession-inducing hp shock in our model.

*In the short-run aggregate employment decreases, while it rises in the long-run.*

Without impact-recession, a hp shock might alternatively result in an instant rise in or rather flat aggregate employment.

4. The (almost) simultaneous increase in job creation and job destruction temporarily influences the correlation between both time series positively.

**Figure 4.3:** Further dynamics in the model with heterogeneous productivity-enhancing shocks and endogenous job dissolving



### 5. Productivity dynamics

The theoretical development of aggregate productivity in response to a recession-inducing hp shock is given in Figure 4.3b.

These dynamics should also be reflected at the individual firm level for those firms hit by the shock. In contrast, productivity dynamics should be flat (non-decreasing) for the other firms.

*Aggregate productivity increases permanently. Individual productivity in job creating firms an average goes up and is non-decreasing in job destructing firms.*

### 6. Vacancy dynamics

On impact, the number of vacancies increases in response to hp shocks. In accordance with successful recruitment, the vacancy level then falls back to its new steady state value, which is higher than it was before the shock.

The occurrence of a (recession-inducing) hp shock hence implies a dynamic pattern among a set of time series. Additionally to qualitative evaluations, time periods which qualify for such a shock and its responses can be identified using quantitative thresholds to signal out-of-steady state behaviour. Possible candidates might, for instance, be points in time at which a time series' value deviates from its mean by more than a standard deviation. After looking at the time series' individually and checking for these respective pattern, the timing of the candidate periods can be compared to test for simultaneity within the complete set of time series and hence for the conformance with all aspects of recession-inducing hp shocks.

In this chapter I am going to develop an evaluation of the occurrence of recession-inducing heterogeneous productivity shocks within a suitable empirical data set. Section 4.2 discusses the issue of data availability and takes a look into the related literature of firm and employment dynamics analyses. The chosen data set, which enables a novel insight into daily establishment employment-level data, is presented in Section 4.3. Section 4.4 illustrates descriptive methods, results and issues of the hp shock analysis. Additionally, new findings regarding the high-frequency, cyclical and seasonal characteristics of gross job and employment flows are given. After an discussion and outlook for additional research requirements, Section 4.5 concludes.

## 4.2 Availability and analyses of disaggregated firm data

Section 4.1 presented a number of time series patterns which, according to my theoretical model, should be found in suitable data in case of hp shocks with impact-recession. In order to check for their actual empirical relevance, I need a data set which allows high-frequency, long-time insights into aggregate and gross productivity, job and employment dynamics: The high-frequency condition meets the concern to watch in particular transitional dynamics in response to shocks. Time series should be long because permanent productivity-enhancements are connected to growth processes which might only occur in rather larger intervals. The need for individual or gross firm data stems from the importance of heterogeneities in the shock process which can not fully be captured looking at aggregate (= net) statistics alone.

Apparently such data requirements are beyond standard and freely accessible macroeconomic aggregates as released by most statistical offices. Recent decades have witnessed growing appreciations among public authorities for the need of researches for disaggregated firm data. Due to legal requirements to provide business data to statistical offices, social security institutions and other authorities, official firm data collections exist in many countries. But apart from the increased effort, to make them accessible requires to balance research demands on the one hand and confidentiality obligations on the other hand. One solution to this conflict is the non-restricted release of highly-disaggregated statistics, take, for example, the Business Dynamics Statistics of the Center for Economic Studies of the U.S. Census Bureau. Alternatively, researches are allowed to use edited and anonymized micro-level data sets directly. Usually, however, the access on them is strictly regulated, restricted to the authorities' scientific staff and/or includes time-consuming, bureaucratic efforts, remote data access or the visit in specific research data centres. Alternative sources for micro-level firm data are sets which have been surveyed (temporarily) to meet the requirements of specific research projects or commercial enterprise data bases. In general, though, similar drawbacks apply here, too.

Reviewing micro-level firm data sets which have been employed in recent studies shows that none of these actually meets all requirements needed to conduct a thorough empirical test of all aspects of the presented theoretic model, however.<sup>2</sup> Apart from restrictions in accessibility, the provision of high-frequency longitudinal data in general and individual vacancy and productivity data in particular proves difficult. I found that the broadest set of currently available data which comes closest to the derived requests comprises gross job and employment information issued by the Research Data Centre of the German Federal Employment Office [Bundesagentur für Arbeit (BA)] at the Institute for Employment Research [Institut für Arbeitsmarkt- und Berufsforschung (IAB)], see the next section for more details. I therefore decided to concentrate my analysis on such aspects in order to identify hp shock and shock-adjustment periods. A sample of German establishments then makes up my research objects.

The dynamics of gross job flows gained rising interest of researchers at the end of the 1980ies. In particular the studies of Davis and Haltiwanger (1990, 1992) and Davis, Haltiwanger and Schuh (1997), which emphasized the empirical importance, variability and business cycle links of gross job flows for U.S. data, proved highly influential. International comparisons of the importance and magnitude were given, for example, by OECD (1994, 1996). Previous analyses which focused on German data dealt with the division of job turnover into contributions from incumbent vs. entering and exiting firms (see, for instance, Cramer and Koller, 1988; Boeri and Cramer, 1992) or into firms of differing size (Wagner, 1995), as well as turnover determinants on the plant level (Fuchs and Weyh, 2010). Other topics recently analysed with (among others) empirical job dynamics data include the relevance of job reallocation between firms for aggregate productivity increases (see the review by Bartelsman and Doms, 2000) and the microeconomic issue of (non-)convexity in employment adjustment costs (for example, Varejão and Portugal, 2007). Also there is a rich strand of literature at the interface to industrial organization interested in the size and growth rate distribution of firms (see Caves, 1998, for a survey).

Some evidence for quarterly gross job dynamics is given in Davis, Haltiwanger and Schuh (1997) and Varejão and Portugal (2007). Otherwise, in accordance to data availability and the particular research topics, the data frequency in most studies is annual or less. This also holds for those mentioned analyses with focus on German establishments. They are based on special evaluations of the BA's 'Employment Statistics register' (OECD, 1994, 1996; Cramer and Koller, 1988; Boeri and Cramer, 1992), on the Establishment History Panel (Fuchs and Weyh, 2010) or on special evaluations of manufacturing data issued by a Regional Statistical

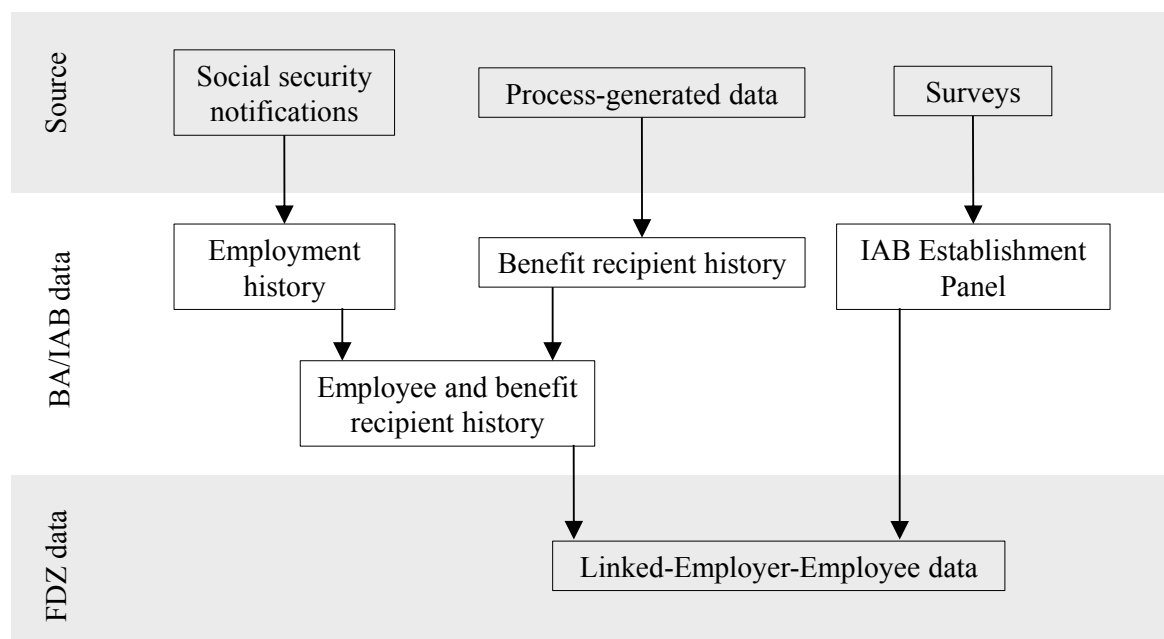
<sup>2</sup> Recent studies with a variety of firm end employment dynamics-related topics include, for instance, Generale (2008); Bendetto et al. (2007); Carlsson and Smedsaas (2007); Varejão and Portugal (2007); Foster, Haltiwanger and Krizan (2006); Lentz and Mortensen (2005); Marchetti and Nucci (2005); Gorter, Hassink and Russo (2003); Bartelsman and Doms (2000); Caballero, Engel and Haltiwanger (1997); Gerlach, Hübler and Meyer (1998). For explicit data set descriptions see, for example, Abowd, Haltiwanger and Lane (2004); Bellmann (2002), the comprehensive column 'European Data Watch' in Schmollers Jahrbuch: Journal of Applied Social Science Studies, and the web pages of statistical and research institutes.

Office (Wagner, 1995). Advantages and disadvantages of these and my chosen data set are, among others, discussed in the following section.

### 4.3 The data – LIAB LM1

To analyse the high-frequency dynamics of gross job flows and employment in search for recession-inducing hp shocks, this study uses the longitudinal model of the Linked-Employer-Employee Data (LIAB) (Version 1, Years 1993-2007) from the IAB. Data access was provided via on-site use at the Research Data Centre [Forschungsdatenzentrum (FDZ)] of the BA at the IAB and subsequently remote data access. The LIAB merges annual survey data on German establishments with daily individual-related process-produced data from social security, see Figure 4.4 (see also Alda, Bender and Gartner, 2005; Kohlmann, 2005, on details).

**Figure 4.4:** Data origin of the LIAB



Source: Modified detail of FDZ BA (2011), own compilation.

The employed LIAB Longitudinal Model Version 1 (LIAB LM1) covers among others exact-to-the-day employment information for about 4,200 German establishments in the years 1996 to 2002. An establishment in this context is ‘a regionally and economically separate unit, in which employees liable to social security work’ (Fischer et al., 2008, p. 6). No

additional conditions (with regard to industry, size class or region, for example) apply. Each such establishment in Germany has a unique establishment number which is assigned by the responsible employment office.

In the LIAB this number serves as identifier to link person-specific information derived from the integrated notification procedure for the health, pension and unemployment insurances to the respective establishment. Additionally, valid annual survey information from the IAB Establishment Panel exists at least from the years 1999 to 2001 for these establishments. In contrast to other longitudinal versions of the LIAB, the linkage quality between person and establishment data was explicitly tested when preparing the data set and approved to be good. For detailed information on the LIAB see also Jacobebbinghaus (2008), as well as Alda (2005a,b) on the preparation of the LIAB LM1.

The longitudinal versions of the LIAB offer the unique possibility to get a high-frequency picture of disaggregated employment level changes at the establishment level, which is an often-used firm classification in the empirical literature. Although only employment covered by social security is reflected in the data, in the considered time period this equates to about 72 per cent of total employment. More restrictions known from other data sets which were used in previous studies – for instance, in terms of establishment size or industry affiliation – are not present.

The choice of establishments to the LIAB LM1 has not been totally random, though. Instead it should ensure usability – given hard- and software memory restrictions –, analytically traceability – providing longitudinal establishment level information for a minimum number of consecutive years – as well as a reasonable linkage quality between establishment and person-specific data. See Alda (2005b) for more details and the resulting establishment coverage degree in the LIAB LM1 sample. Additionally, due to its construction, the sample only imperfectly reflects the dynamics of firm entries and firm exits on aggregate employment and gross job flows. Therefore previous research based on alternative data sets has a leap concerning representativeness of the found employment dynamics, although typically only derived for much lower frequencies.

Another possible weakness, which the LIAB shares with all BA/IAB data sets, is that the assignment of the establishment number is not without flaws. This might cause problems in the linkage quality between personal and establishment data. In general, however, these difficulties are assumed to be minor (Alda, Bender and Gartner, 2005, p. 330). Anyway, given my interest in high-frequency disaggregated employment dynamics, the linkage quality is a particularly sensitive issue. That is why I included some additional quality checks into my analysis. Note, nonetheless, that both the collection of survey information as well as the notification procedure naturally are prone to mistakes and inaccuracies. There is no reason to assume any systematic errors, though.

The raw data which makes up the LIAB LM1 in total comprises 16 data files: Firstly there are 15 volumes of the annual IAB establishment panel (1993-2007), whereat survey data of the about 4,200 LIAB LM1 establishments exists at least in the volumes 1999-2001. Collected



data in the IAB Establishment Panel comprise employment at the reference date 30th of June of the survey year but also firm turnover, investments, exports, innovations and wages, among others. Secondly there is a file containing the 1993-2007 employee and benefit recipient history of all employees which between 1996 and 2002 have worked at least one day in one of these LIAB LM1 establishments. In total these are about 1.9m persons. Apart from the beginning and the end of an employment spell, person-related data also contain demographic information, daily wage, occupation, information on benefit spells, the regional level, etc. Apparently there is a wide field of possible applications with the data set beyond the chosen topic.

Preliminary to any analysis a suitable data set must be compiled, which in particular contains high-frequency establishments' employment-level data. Constructing a panel of the employment information from the annual survey files only gives employment at the 30th of June of each year and additionally assuredly contains all included establishments only from 1999 to 2001. However, because social security notifications by law have to be exact to the day, it is possible to extract the establishments' employment-level on a daily base for 1996-2002 from the person-specific data. This is done summing-up all notifications which refer to the respective date and establishment on focus, after the elimination of doublets.

The resulting data set comprises the individual employment levels  $L_t^i$ , with  $i = 1, \dots, n$  denoting a consecutively numbered establishment identifier and  $t = 1\text{st Jan } 1996, \dots, 31\text{st Dec } 2002$  a time index. It can be used to calculate the following variables, whose dynamics finally are on the focus of my analysis:

- fraction of job-creating establishments

$$frJC_t = \frac{\text{COUNT\_IF}(\Delta L_t^i > 0)}{n}$$

- fraction of job-destructing establishments

$$frJD_t = \frac{\text{COUNT\_IF}(\Delta L_t^i < 0)}{n}$$

- absolute job creation

$$absJC_t = \sum_{i=1}^n \Delta L_t^i \quad \text{if} \quad \Delta L_t^i > 0$$

- absolute job destruction

$$absJD_t = \sum_{i=1}^n |\Delta L_t^i| \quad \text{if} \quad \Delta L_t^i < 0$$

- aggregate employment

$$SUM_t = \sum_{i=1}^n L_t^i$$

- net employment change

$$NET_t = \sum_{i=1}^n \Delta L_t^i = absJC_t - absJD_t = \Delta SUM_t,$$

with  $\Delta L_t^i = L_t^i - L_{t-1}^i$  and  $n = 4,264$  if the analysis refers to the full sample of LIAB LM1 establishments.

Job flows of establishments and resulting employment dynamics of LIAB LM1 establishments (1996-2002) are my objects to study. I miss, however, job reallocations *within* these establishments. Because the person who holds a particular job might change (indicating an additional worker flow), job flows mark the lower level of total labour market dynamics. Novel to previous research, I look at them up to a daily level, while most other studies focused on annual, at most quarterly data. Indeed, because of possible frictions in ‘excess’ worker flows, lower-frequency data might better reflect intentional and permanent job flows. My focus, however, is in particular on transitional dynamics which might be concealed at lower observation frequency.

## 4.4 Data analysis

### 4.4.1 Preliminary quality checks

I analyse high-frequency gross job flows and employment level changes. As described above, the establishments’ employment level data is derived from the summation of social security notifications per establishment number and day. This procedure hence demands an exact implementation of the notification procedure. Otherwise I will find a lot of spurious flows in the data.

**Table 4.1:** Extent and basic results of quality checks, LIAB LM1

	1996	1997	1998	1999	2000	2001	2002
# establishments with survey information	2,449	2,723	3,322	4,264	4,264	4,264	3,798
# establishments with faulty linkage quality	326	385	412	468	366	439	486
fault rate (%)	13	14	12	11	9	10	13

Note: The current employment level was a missing in 142 survey cases.

One of the reasons for my particular choice of the LM1 version of the LIAB was that the establishment selection there should ensure high linkage quality between survey and notification data, based on employment level information. Both sources determine the employment level independently. Hence a successful link likewise indicates a reliable quality of the notification procedure. According to Alda (2005a), however, those tests mainly referred to one particular year. Because of my increased quality requirements, I therefore executed some additional quality checks prior to the data analysis: I compared information on the employment levels between survey and notification data whenever possible. This applies to the 30th of June (reference date in the survey) for each year where survey information is available for an establishment, that is, at least for 1999-2001. Any such quality check necessarily must be patchy, of course. However, Table 4.1 surveys the extent and basic results of these comparisons.

In particular, for each available establishment I calculated the relative employment level deviations between the summation of social security information on the one hand and survey information of the respective year on the other hand. In a next step it was checked whether these deviations fall within size-depending intervals (see Alda, 2005b), given the fact that even for good linkage quality there is rarely an exact agreement of both sources (Jacobebbinghaus, 2008, p. 53). Any establishment which failed this quality check at least once during the observation period was excluded from the compilation of a so called ‘adjusted sample’.

Totally, that regards 1,495 establishments, 35 per cent of the full sample. It must be kept in mind, however, that due to the necessary fragmentariness and non-precision of my check, the adjusted sample could still contain faulty establishment histories. Likewise it should be assumed that some – in particular small – establishments are excluded from the adjusted sample wrongly, as high relative-deviations still might correspond to small absolute-deviations. I therefore decided to carry out my analysis with both samples. The findings from the adjusted sample can then be considered as robustness check for those from the complete sample, and

**Table 4.2:** Industry affiliation of LIAB LM1 establishments

industry	full sample		adj. sample	
	freq.	fract.	freq.	fract.
agriculture, hunting and forestry; fishing, operation of fish hatcheries and fish farms	125	0.03	90	0.03
mining and quarrying; energy & water supply	70	0.02	46	0.02
manufacturing	1,131	0.27	857	0.31
construction industry	484	0.11	334	0.12
wholesale and retail trade; repair of motor vehicles and household goods, hotels and restaurants; transport and communication	761	0.18	500	0.18
financial, real estate, renting and business activities	459	0.11	281	0.10
other service activities	1,234	0.29	661	0.24
total	4,264	1.00	2,769	1.00

vice versa. Table 4.2 summarizes the distribution of the establishments in the full and the adjusted LIAB LM1 sample among industries.

#### 4.4.2 Descriptive statistics

On an average day between 1996 and 2002 about 3.3 per cent of all LIAB LM1 establishments (2.9 per cent of the adjusted sample) increased their stock of employees ( $frJC$ ), see the first (second) data column of Table 4.3.<sup>3</sup> Average employment increase was about 2.7 (2.5) persons per job creating establishment ( $\frac{absJC}{frJC*n}$ ) or 0.04 (0.03) per cent of all jobs ( $\frac{absJC}{SUM}$ ). Simultaneously the number of jobs was reduced in about 3.9 (3.5) per cent of the considered establishments. The decrease on average was 2.4 (2.2) persons per job decreasing establishment or 0.04 (0.04) per cent of all jobs. The evaluation of net employment figures alone would have concealed a lot of this mobility.

<sup>3</sup> To ease comparisons among the results from different subsamples, Table 4.3 presents a number of ratios derived from the variables. For a more detailed breakdown on the pure parameter values compare the tables in Appendix 4.C.

**Table 4.3:** Descriptive statistics of employment flows, LIAB LM1

	all industries						manufacturing					
				15-37, D			27-28, DJ			29 DK		
	daily data			monthly averages								
	full	adj.	sample	full	adj.	sample	full	adj.	sample	full	adj.	sample
# of establishments	4,264	2,769	4,264	2,769	1,131	857	228	184	139	111	154	117
$frJC$ (%)	3.29	2.95	31.59	30.84	36.91	37.55	37.15	38.09	41.46	42.70	34.78	33.97
$\frac{absJC}{frJC*n}$	2.67	2.46	5.03	4.25	5.46	4.90	3.44	3.40	5.18	4.77	5.93	5.54
$\frac{absJC}{SUM}$ (%)	0.04	0.03	0.73	0.61	0.57	0.48	0.50	0.46	0.46	0.43	0.67	0.64
$frJD$ (%)	3.93	3.47	35.60	34.28	38.83	39.03	37.39	37.66	43.53	44.43	34.71	33.26
$\frac{absJD}{frJD*n}$	2.39	2.24	5.08	4.35	5.62	5.06	3.81	3.55	5.94	4.91	5.89	4.81
$\frac{absJD}{SUM}$ (%)	0.04	0.04	0.83	0.69	0.61	0.52	0.55	0.48	0.56	0.46	0.66	0.55
$\frac{SUM}{NET}$	-0.01	-0.01	-0.22	-0.18	-0.17	-0.13	-0.15	-0.04	-0.44	-0.14	0.02	0.28
$corr(frJC, frJD)$	0.67	0.67	-0.64	-0.77	-0.89	-0.92	-0.77	-0.81	-0.90	-0.92	-0.79	-0.78
$corr(absJC, absJD)$	0.72	0.70	-0.47	-0.43	-0.45	-0.39	-0.31	-0.33	-0.28	-0.59	-0.23	-0.36

Code of the manufacturing sub-industries according to the German Classification of Economic Activities, Edition 1993 (WZ93).  
Seasonally-adjusted monthly averages.

In fact, daily net aggregate employment change in this period sums to an average loss of less than 0.01 (0.01) employees per establishment, i.e. nearly zero change. These numbers approve the importance to implement job reallocation into models of the labour market, as is done in the search and matching framework.

Further analysis reveals, however, a strong variability in the parameter values.<sup>4</sup> I evaluated (cross) correlograms of the variables and employed t-tests to check for non-stochastic patterns.<sup>5</sup> The results indicate that daily gross job flow variables show clear calendar effects: As Figure 4.5a illustrates, employment changes typically take place at the beginning of a month, with a second but much smaller peak in the middle.

These findings imply that any evaluation of raw daily job flow data over time in search of hp shocks would be highly influenced by calendar effects. Therefore some kind of seasonally adjustment must precede. For daily data no elaborate procedure for that is available, though. Basically I could fit either a simple additive or multiplicative seasonal component (see Schlittgen and Streitberg, 2001, Chap. 1.7). Anyway, due to (bureaucratic) reasons probably rather independent of economic shocks, job creation and job destruction are primarily realized at only few particular days within a month.

Trading the advantages of a higher data frequency off against the risk of noise from poor seasonal adjustment, I decided instead to lower the observational frequency. Apparently not much information is lost if I summarize monthly developments, which still is a higher frequency than in most previous studies. To keep as much information as possible, I aggregated the daily data calculating the respective monthly average of the employment level per establishment.<sup>6</sup> I re-calculated the gross job flow and employment variables with the new data set. There were some additional, although much smaller, seasonal effects, see Figure 4.5b.<sup>7</sup> I therefore additionally implemented a standard ARIMA X12 seasonal adjustment analysis using the software package *gretl*.

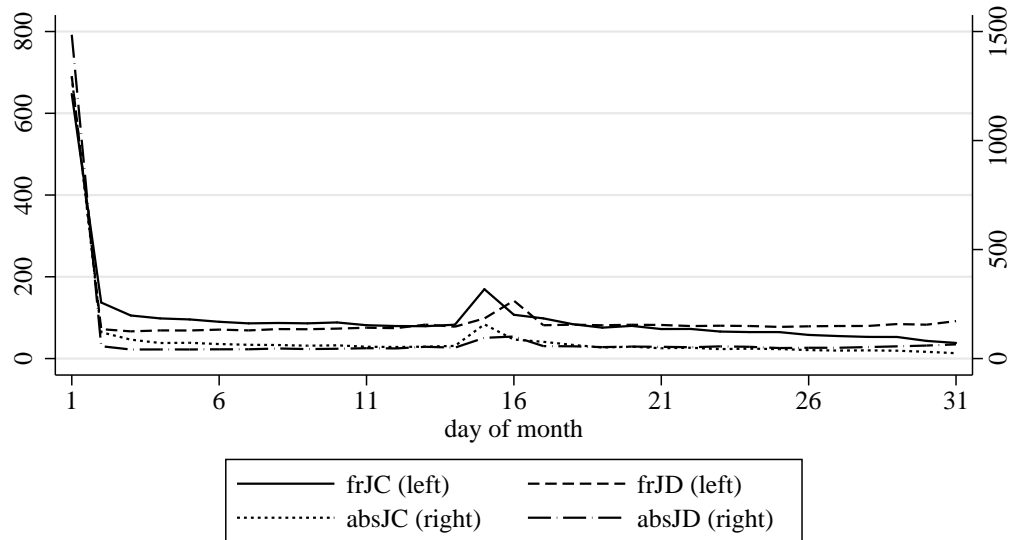
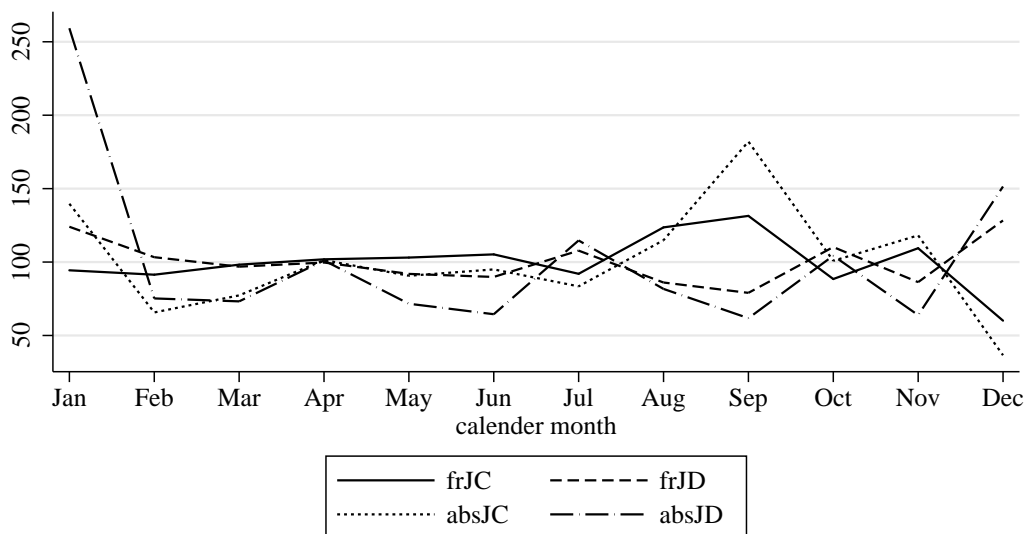
As summarized in the second column set of Table 4.3, in the course of an average month between 1996 and 2002 about 31.6 per cent of all LIAB LM1 establishments (30.8 per cent of the adjusted sample) raised the number of their employees. The average employment increase was about 5.0 (4.2) persons or 0.7 (0.6) per cent of all jobs. Simultaneously the number of jobs was reduced in about 35.6 (34.3) per cent of the LIAB LM1 establishments. On average the job loss was about 5.1 (4.4) persons per job destructing establishment or

<sup>4</sup> See also the variables' standard deviation given in Table 4.C in Appendix 4.C

<sup>5</sup> For details consult the log files available on request.

<sup>6</sup> As robustness check I alternatively analysed monthly time series which are based at values of the 1st of a month instead of monthly averages. Given the strong calendar effect, this procedure should include most employment changes. Simultaneously, potential noise from incorrect notifications during the month is reduced compared to monthly averages. The likewise significant employment adjustments in the middle of the month are missed with that procedure, however. For the results see Appendix 4.B and short discussions in following footnotes.

<sup>7</sup> The seasonal figure is robust also to the alternative in monthly aggregation.

**Figure 4.5:** Calender effects in gross job dynamics, 100 = mean of total sample**(a)** Mean per day of month**(b)** Mean per calendar month

Based on adjusted sample data and monthly aggregation based on monthly averages, but strong congruence in alternative samples.

Source: LIAB LM1, own calculations.

0.8 (0.7) per cent of all jobs. Monthly average net employment change had been a loss of 0.22 (0.18) employees per establishment. Job creation and job destruction on average are correlated highly significantly negative. Apparently general business cycle dynamics usually induce opposing reactions to economic shocks on the job flows.

The statistics presented so far have been based on the complete universe of LIAB LM1 establishment. However, we should expect that the mechanism described by the heterogeneous productivity shock model rather should be particularly strong within disaggregated industries: Establishments there have many jobs with similar focus which in turn implies a rather large influence of specific heterogeneous shocks. Therefore I additionally narrowed down my analysis to sub-industries. The final choice was influenced by the demands for a sufficient amount of observable establishments as well as for similarities in their underlying conditions (which excludes industry classifications with a too broad focus). I found these terms to be best fulfilled looking at the establishments engaged in manufacturing (mfr.) in general and, among those, in the respectively more than 100 establishments in mfr. of basic metals and fabricated metal products (DJ); mfr. of machinery and equipment not elsewhere classified (DK); and mfr. of electrical and optical equipment (DL) in particular. The resulting descriptive statistics of employment flows are given in the last sets of columns in Table 4.3.

We find that mean job reallocations in manufacturing outnumber the average of all industries if it is measured in the proportion of establishments which change its employment level. The same holds if such an assessment is based on the average number of persons affected in these plants. Anyway, if evaluated in terms of absolute rates of job creation and destruction on total employment, this order turns around. The seeming contradiction is explained by the fact that employment per establishment on average is larger in manufacturing. That also points to the fact that beside possible differences between industries also size effects play a role to explain differences in average gross job flows among various sectors. A further disaggregation of the manufacturing industry reveals the heterogeneity of these subgroups.

Summing up, gross job flows and according employment dynamics are strongly concentrated in particular at the beginning of a calendar month. Additionally there is a monthly seasonal component. Despite lacks in representativeness of the used data, this result should be rather robust. Comparing the results from the full to the adjusted sample, we find that differences in general are minor, with few expectations in higher disaggregated subindustries. However, as expected, gross job flows are (slightly) lower for the adjusted sample.<sup>8</sup> Further analysis focuses on the results for seasonally-adjusted monthly data.

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<sup>8</sup> Compared to the monthly-average variables, the fraction of job creating and job destructing establishments for first-of-month aggregated data is somewhat lower on average, of course. The absolute size of employment changes, however, is higher if mid-month employment changes and noise are eliminated from the calculations. Despite minor exceptions, the general picture described above looking at the results from the different sub-samples is robust to the alternative method of monthly aggregation.



### 4.4.3 Development of job and employment flows

While such averages presented in the previous section are informative, my main focus is on those particular pattern in the job and employment flows described in Section 4.1. I therefore concentrate on the time series realisations of the variables. A visual impression of the job and employment flow development 1996-2002 among the adjusted sample of LIAB LM1 establishments is given in Figure 4.6. The results of the full sample are rather similar, which is why I moved the respective picture to Appendix 4.C, see Figure 4.31 there. Some of the spikes visible in the full sample are flattened or levelled in the adjusted one. Apart from the fact that fewer establishments simply induce smaller absolute employment level changes, this illustrates the risk to misinterpret problems in the data and linkage quality as reflection of economic shocks.<sup>9</sup>

According to the Augmented Dickey-Fuller test for unit roots implemented in STATA, almost all gross job flow time series are stationary over the considered time period (exception: *frJC* manufacturing). The general negative correlation between job creation and job destructions is recognizable easily, in particular looking at the fraction of employment level-changing establishments. Job destruction outnumbers job creation most of the observation time, except for 1998 and some mixed (compare firms' fractions vs. absolute values) evidence in 2000. Net employment change and aggregate employment dynamics likewise reflect the overall dominance of job destruction. The general downward trend in aggregate employment, interrupted only sporadically, makes the latter time series non-stationary.

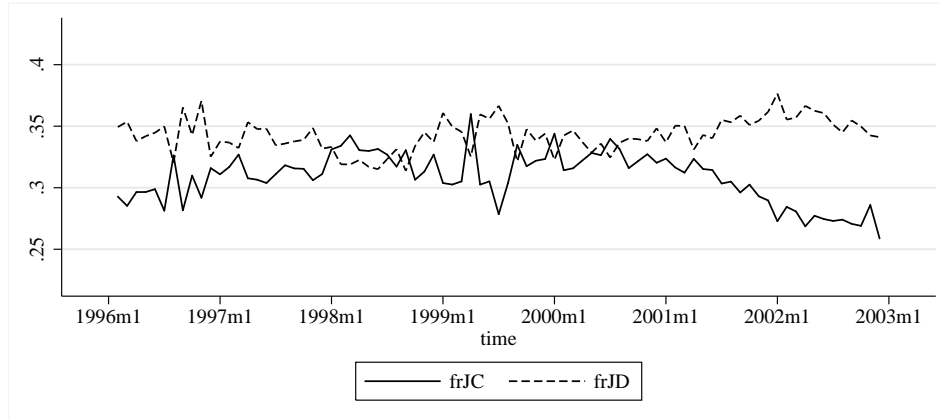
Taking a look at more disaggregated data, we find that in manufacturing phases with net job creation and net job destruction alternate more balanced than in the full industry sample. The same holds for manufacturing's observed sub-industries. As a result the general downward sloping trend in total employment found in the full industry sample is less intense here. Instead, in the sub-industries it is often rather reversed, apart from the last months. Considering the results of Chapter 2 which dated the German business cycle, the observed development of aggregate employment in the sample establishments points to the well-known fact that manufacturing is one of the industries with the closest link to the general business cycle. If we look at the concurrent development of gross job flows, the cyclical net change in aggregate employment seems to be caused by according variations in both its determining elements, job creation as well as job destruction.<sup>10</sup> Unfortunately, the time span of the available data set is too short for a more thorough analysis of cyclical characteristics of job flows.

Referring these findings to the hp shock-accompanying patterns described in Section 4.1, no obvious indication for such an event and its related transitional paths in gross job and

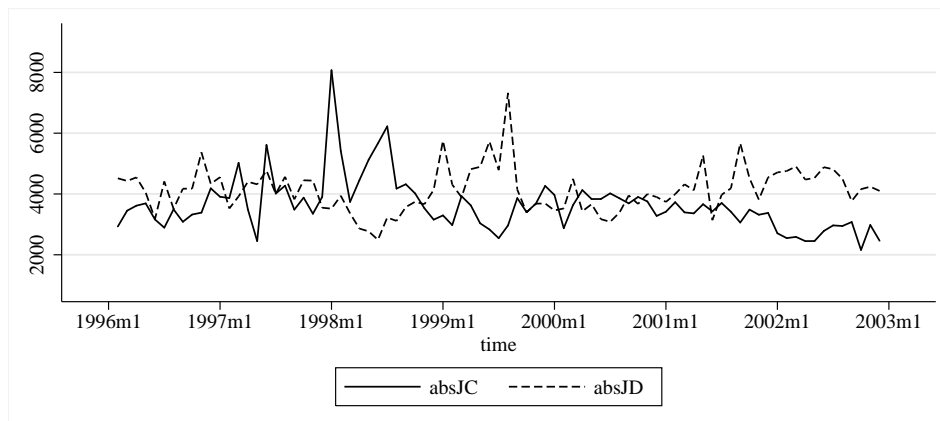
<sup>9</sup> The general findings of this section are robust to the alternative monthly aggregation.

<sup>10</sup> See the related debate about the ins and outs of unemployment over the cycle, e.g., Hall (2006); Shimer (2007); Elsby, Michaels and Solon (2009).

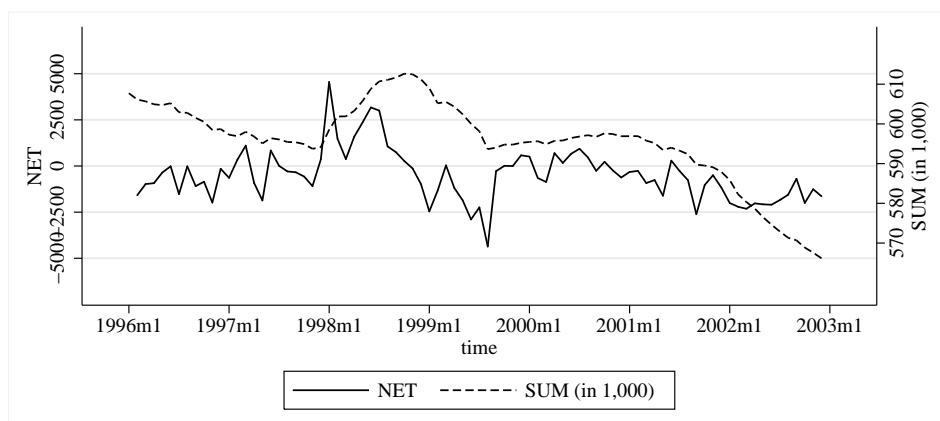
**Figure 4.6:** Development of job and employment flows, LIAB LM1, all industries, adjusted sample



(a) Fraction of job creating and job destructing establishments



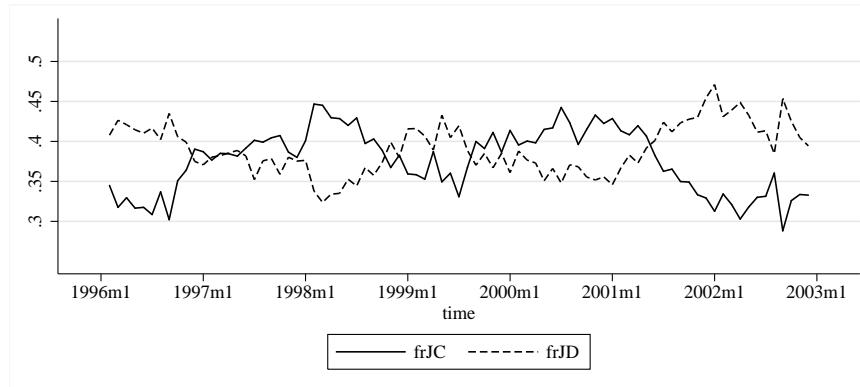
(b) Absolute job creation and destruction



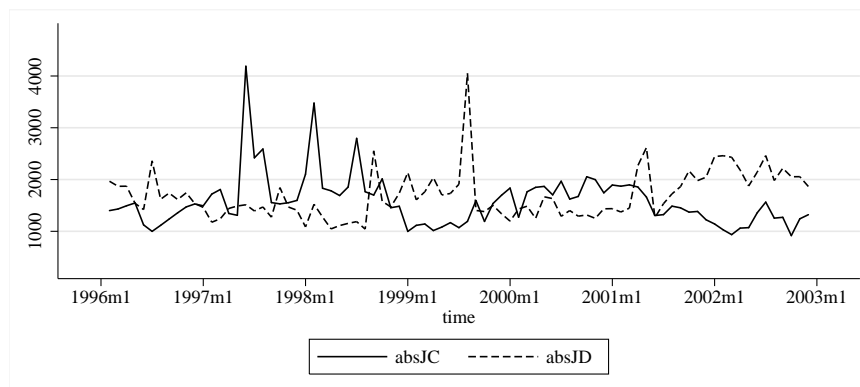
(c) Aggregate employment and employment change

Seasonally-adjusted monthly averages.

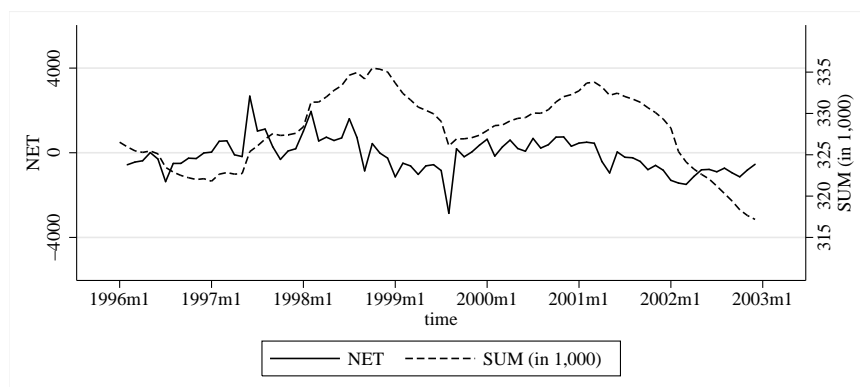
**Figure 4.7:** Development of job and employment flows, LIAB LM1, manufacturing 15-37 D, adjusted sample



**(a)** Fraction of job creating and job destructing establishments



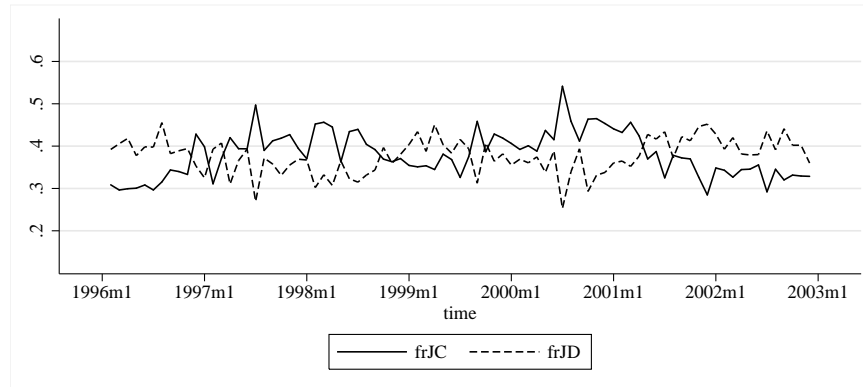
**(b)** Absolute job creation and destruction



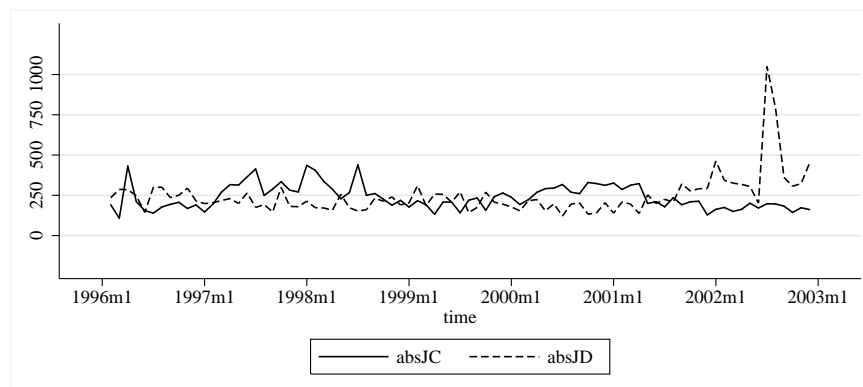
**(c)** Aggregate employment and employment change

Code of the manufacturing sub-industries according to the German Classification of Economic Activities, Edition 1993 (WZ93). Seasonally-adjusted monthly averages.

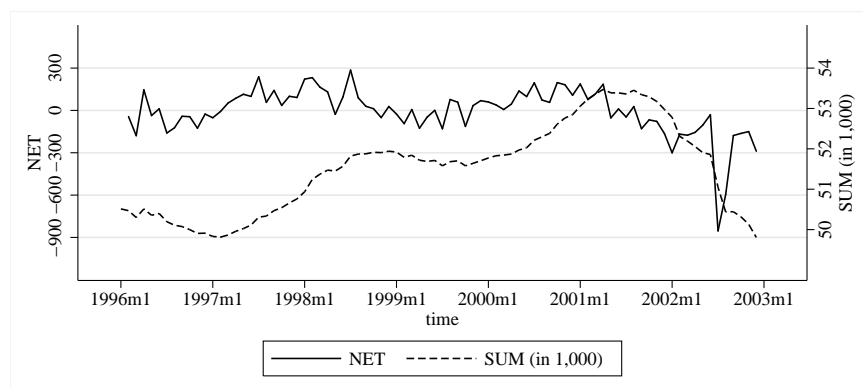
**Figure 4.8:** Development of job and employment flows, LIAB LM1, manufacturing 27-28 DJ, adjusted sample



(a) Fraction of job creating and job destructing establishments



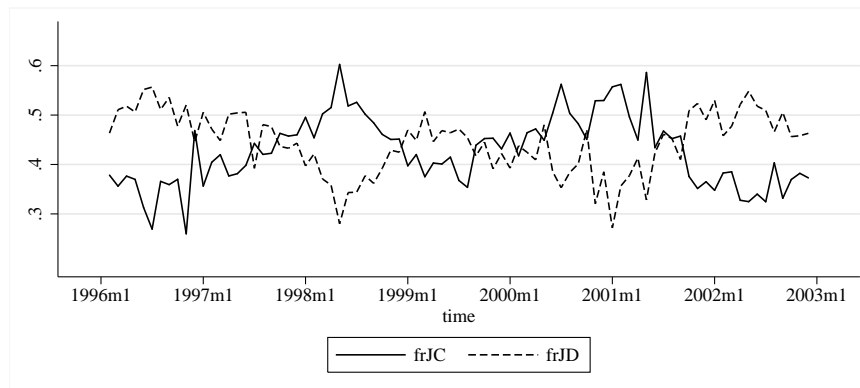
(b) Absolute job creation and destruction



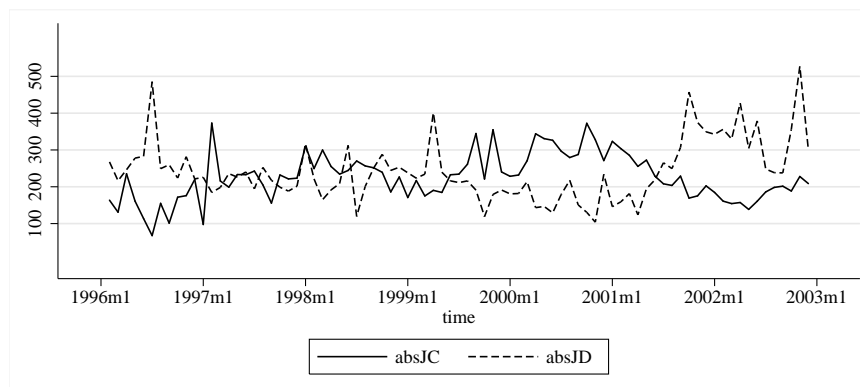
(c) Aggregate employment and employment change

Code of the manufacturing sub-industries according to the German Classification of Economic Activities, Edition 1993 (WZ93). Seasonally-adjusted monthly averages.

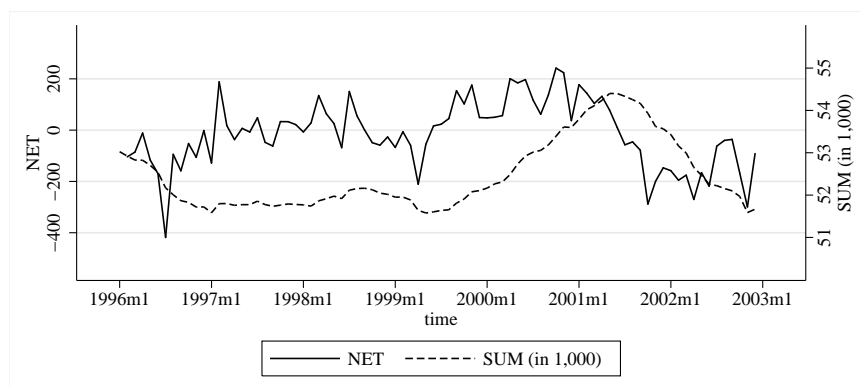
**Figure 4.9:** Development of job and employment flows, LIAB LM1, manufacturing 29 DK, adjusted sample



**(a)** Fraction of job creating and job destructing establishments



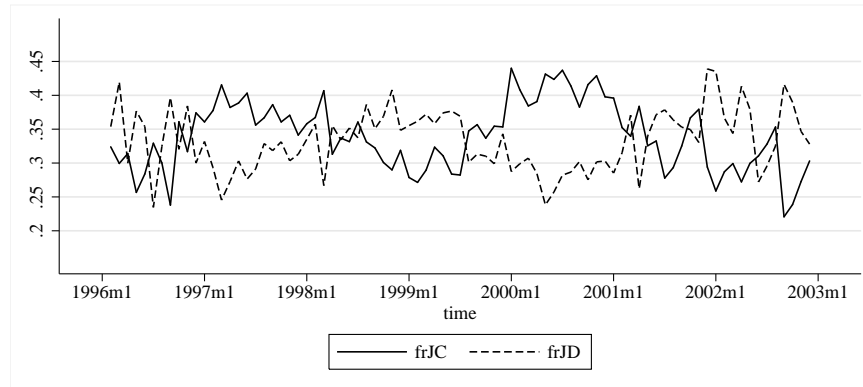
**(b)** Absolute job creation and destruction



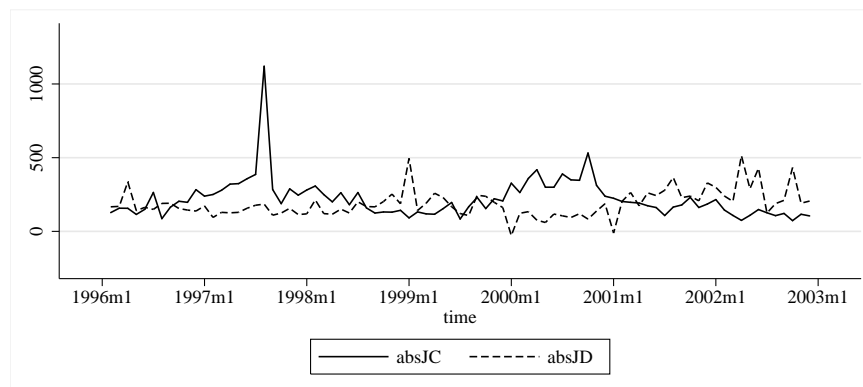
**(c)** Aggregate employment and employment change

Code of the manufacturing sub-industries according to the German Classification of Economic Activities, Edition 1993 (WZ93). Seasonally-adjusted monthly averages.

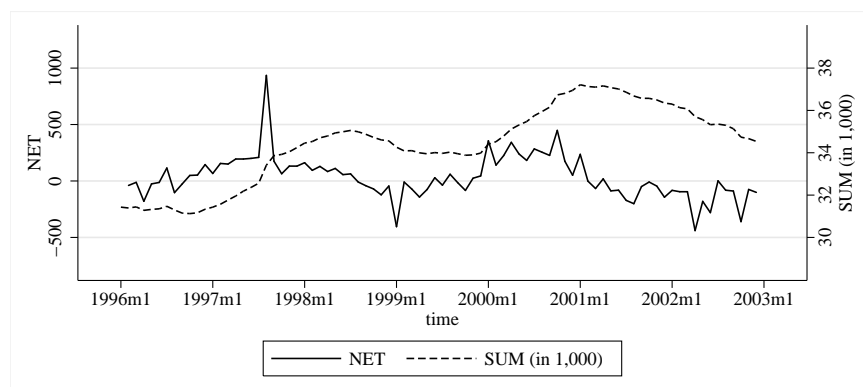
**Figure 4.10:** Development of job and employment flows, LIAB LM1, manufacturing 30-33 DL, adjusted sample



(a) Fraction of job creating and job destructing establishments



(b) Absolute job creation and destruction



(c) Aggregate employment and employment change

Code of the manufacturing sub-industries according to the German Classification of Economic Activities, Edition 1993 (WZ93). Seasonally-adjusted monthly averages.

employment flow is visible easily. Firstly, my particular focus is on periods with a *temporary drop* in aggregate employment and a *sustained employment increase* afterwards. This narrows the possible window of opportunity in particular in the full sample and during my available observational period considerably. Hence despite the high-frequency observational data set which results in many data points, given that I look at very specific events their appearance might still be rare over time. Secondly, the tendency of job creation and job destruction to move into opposite directions instead (at least temporarily) in unison seems rather robust in the samples. Nonetheless, to prevent to overlook hidden indications given the complex and volatile development of the variables, I further extended my analysis relating to statistical parameters and tests.

## Extensive gross job flows

First step is an exact identification of points in time where job creation and job destruction were distinctively high. In particular I defined these as variable values which exceed the respective mean by more than one standard deviation.<sup>11</sup> In order to detect hp shocks in the second step, these identified periods must overlap, with above-average job creation being longer-lasting than rather short extensive job destruction periods (see the findings in Section 4.1). To qualify also for an impact-recession inducing shock, the initial increase in job destruction must exceed that in job creation in absolute terms.

Tables 4.4 and 4.5 list the identified periods with above-average gross job flows in my various samples. As this formal analysis confirms again, typically phases of increased job creation and job destruction are distinctively separated. They often are longer in the sub-industries. We only observe one incident with overlapping job creation and destruction peaks (*absJC* and *absJD*, full sample, industry DL). This result, however, is not confirmed in the adjusted sample or found looking at fractions of job creating and job destructing establishments instead of absolute values. Furthermore absolute job creation exceeds absolute job destruction at that time, hence there is no indication for any recessionary effect. Similar findings apply if I somewhat relax my requirements and abstain from actual overlapping in favour of simple chronological adjacency.<sup>12</sup>

<sup>11</sup> An alternative might have been to look at detrended data – derived, for example, by the additional employment of the Hodrick Prescott- or another data filter – and consider periods with positive deviation from the trend. However, firstly I consider my theoretical framework to merge growth and fluctuations and look for non-standard shocks and transitions, which hampers the choice of frequencies to filter out. Secondly, my reasoning from Chapter 2.2 regarding the classical business cycle again applies. Therefore I opted against that. Instead I based my analyses on the dynamics of (albeit seasonally adjusted) raw level data.

<sup>12</sup> Application to the first-of-month aggregation data often gives similar results and also the same overlapping episode. Still there are some omitted or additional periods of extensive gross job flows.

**Table 4.4:** Periods with extensive job creation and destruction (year:month), LIAB LM 1, full sample

all industries				manufacturing, 15-37, D				manufacturing, 27-28, DJ			
<i>frJC</i>	<i>frJD</i>	<i>absJC</i>	<i>absJD</i>	<i>frJC</i>	<i>frJD</i>	<i>absJC</i>	<i>absJD</i>	<i>frJC</i>	<i>frJD</i>	<i>absJC</i>	<i>absJD</i>
	96:07		96:11		96:03	97:06			96:06	96:04	
	96:11	97:03			96:09	98:01			96:08	97:06	
	97:11		97:11	98:02		98:02		97:07		97:07	
98:01		98:01		98:03			99:01	98:02		97:10	
98:03		98:05		98:04			99:08	98:03		98:02	
98:05		98:06		98:05		99:10		98:04		98:03	
98:06		98:07		98:06		00:01		98:06		98:07	
98:07			99:01	98:07		00:05		98:07		99:04	
98:09		99:03			99:05		01:07		99:02	00:07	
	99:01		99:05		99:07		01:09		99:04		00:09
99:04			99:06	00:01			01:10		99:05	00:10	
	99:05		99:08	00:05			01:12		99:07		01:01
	99:06	99:12		00:06			02:01		99:08	01:03	
	99:07	00:01		00:07			02:02	99:09			
	99:08	00:05		00:08			02:03	00:07			
00:01			01:07	00:10			02:04	00:08			
00:06			01:09	00:11				00:09			
00:07			01:10	00:12				00:10			02:05
00:08			02:01	01:01				00:11			
	02:01		02:04	01:02				00:12			
	02:04			01:04				01:01			
					01:09			01:02			
					01:10			01:03			
					01:11				01:05		
					01:12				01:09		
					02:01				01:10		
					02:02				01:11		
					02:03				01:12		
					02:04				02:01		
					02:05				02:07		
					02:09						

Code of the manufacturing sub-industries according to the German Classification of Economic Activities, Edition 1993 (WZ93). *Highlighted periods* might qualify for heterogeneous productivity-enhancing shocks.



manufacturing, 29, DK				manufacturing, 30-33, DL			
<i>frJC</i>	<i>frJD</i>	<i>absJC</i>	<i>absJD</i>	<i>frJC</i>	<i>frJD</i>	<i>absJC</i>	<i>absJD</i>
	96:04	98:01			96:03	97:02	
	96:06	98:03			96:04	98:01	
	96:07	99:10			96:06	98:03	
	96:11	00:04			96:07		99:01
	97:04	00:05			96:08	99:09	99:09
98:04			01:10		96:09	99:11	
98:05			02:01		96:11	00:04	
98:06			02:06	98:03		00:05	
98:07			02:09	98:04		00:06	
98:08			02:11	98:05		00:07	
98:09				98:06		00:10	
00:06				98:07		00:11	
00:07				98:08		01:01	
00:11					99:03	01:02	
00:12				00:06			01:07
01:01				00:07			01:08
01:02				00:08			01:10
01:03				00:11			02:04
01:05				00:12			02:06
	01:10			01:01			
	01:11			01:02			
	02:01			01:05			
	02:03				01:10		
	02:04				01:11		
	02:05				02:01		
	02:06				02:04		
					02:05		
					02:06		
					02:07		

**Table 4.5:** Periods with extensive job creation and destruction (year:month), LIAB LM 1, adjusted sample

all industries				manufacturing, 15-37, D				manufacturing, 27-28, DJ			
<i>frJC</i>	<i>frJD</i>	<i>absJC</i>	<i>absJD</i>	<i>frJC</i>	<i>frJD</i>	<i>absJC</i>	<i>absJD</i>	<i>frJC</i>	<i>frJD</i>	<i>absJC</i>	<i>absJD</i>
	96:09		96:11		96:03		96:07		96:04	96:04	
	96:11	97:03			96:09	97:06			96:08	97:04	
98:01		97:06		98:02		97:07		97:07		97:05	
98:02		98:01		98:03		97:08		98:02		97:06	
98:03		98:02		98:04		98:01		98:03		97:07	
98:04		98:05		98:05		98:02		98:04		97:10	
98:05		98:06		98:06		98:07		98:06		98:01	
98:06		98:07		98:07			98:09	98:07		98:02	
98:09			99:01		99:05		99:08		99:02	98:03	
99:04	99:01		99:05	00:06			01:04		99:04	98:07	
	99:05		99:06	00:07			01:05	99:09		00:07	
	99:07		99:08	00:08			01:10	00:05		00:10	
99:09			01:05	00:10			02:01	00:07		00:11	
00:01			01:09	00:11			02:02	00:08		01:01	
00:07			02:03	00:12			02:03	00:10		01:04	
00:08			02:06	01:01			02:04	00:11			
	01:09			01:04			02:07	00:12			
	01:12				01:07		02:09	01:01			
	02:01				01:09			01:03			
	02:03				01:10				01:05		
	02:04				01:11				01:07		
	02:05				01:12				01:09		
	02:06				02:01				01:11		
					02:02				01:12		
					02:03				02:01		
					02:04				02:03		
					02:05				02:07		
					02:09				02:09		
					02:10						

Code of the manufacturing sub-industries according to the German Classification of Economic Activities, Edition 1993 (WZ93). *Highlighted periods* might qualify for heterogeneous productivity-enhancing shocks.

manufacturing, 29, DK				manufacturing, 30-33, DL			
<i>frJC</i>	<i>frJD</i>	<i>absJC</i>	<i>absJD</i>	<i>frJC</i>	<i>frJD</i>	<i>absJC</i>	<i>absJD</i>
	96:03	97:02			96:03		96:04
	96:04	98:01			96:09	97:06	
	96:06	98:03			96:11	97:07	
	96:07	99:09		97:03		97:08	
	96:08	99:11		97:06			99:01
	96:09	00:04		98:03		00:03	
	96:11	00:05			98:08	00:04	
98:03		00:06			98:11	00:07	
98:04		00:07		00:01		00:10	
98:05		00:10		00:02			01:08
98:06		00:11		00:04			01:12
98:07		01:01		00:05			02:01
98:08		01:02		00:06			02:04
	99:03		01:10	00:07			02:05
00:06			02:01	00:08			02:06
00:07			02:06	00:10			02:10
00:08			02:09	00:11			
00:11			02:11	00:12			
00:12				01:01			
01:01					01:07		
01:02					01:12		
01:05					02:01		
	01:10				02:04		
	01:11				02:05		
	02:01				02:09		
	02:04				02:10		
	02:05						
	02:06						
	02:07						

While the particular focus of this chapter is on hp shocks which induce impact recessions, this was just one possible outcome identified in my theoretic model of Chapter 3.3. It occurs in case of rather high productivity increases which are missed by a relatively high number of jobs. In response to weaker or wider-spread hp shocks, output and possibly even employment can increase right away. In either case, such a shock is still reflected in increasing job creation and non-decreasing job destruction. Otherwise it would rather characterize a general – not heterogeneous – favourable shock.

To check whether there is at least such general evidence of hp shocks, I took a further look at longer periods with extensive job creation. I employed a t-test to check whether job destruction was near its 1996-2002-average value in those periods. Despite the small data sample of only few months per occurrence, I found that usually this hypothesis was strongly rejected in favour of the alternative of significantly smaller job destruction. These results are not in line with such shocks described in my model.

Few exceptions remained, though. The majority of them comprise not more than three months (including the overlapping period mentioned above), which due to small sample issues are hard to judge. Still three longer periods stand out: 1998:3-1998:8 in full sample DL (*frJC*, *frJD*), 2000:10-2001:2 *ibid.* (*absJC*, *absJD*), and 1997:4-1997:7 in adjusted sample DJ (*absJC*, *absJD*). I could not reject the hypothesis that higher job creation has been accompanied of (at least) average job destruction there, compared to the alternative of lower job destruction, at a significance level of 10 per cent or less. Hence these could have been periods which fit my heterogeneous productivity-enhancement shock framework. However, these findings could not be confirmed in alternative measures of job creation and job destruction (full vs. adjusted sample, fraction of establishments vs. absolute flows).<sup>13</sup>

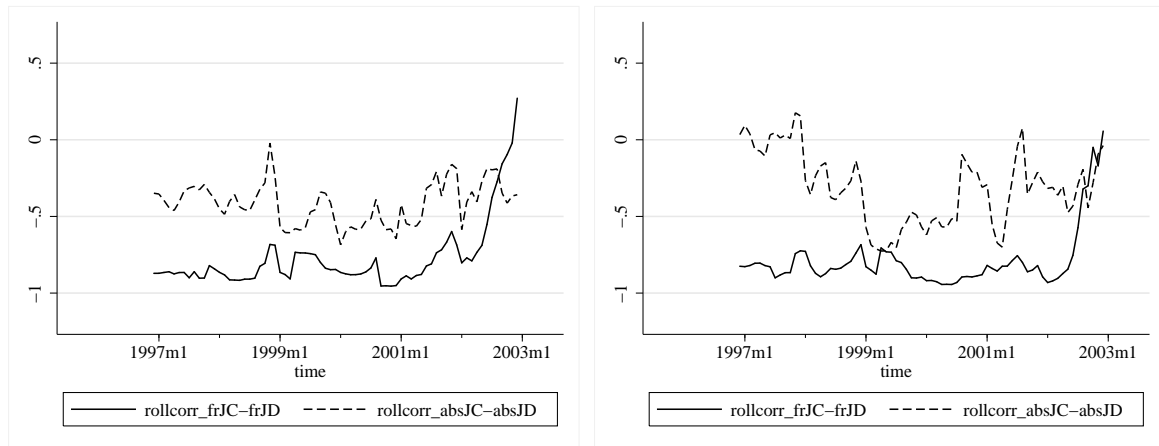
Summing up, despite few hints, there is no obvious evidence in terms of extensive gross job flows that during the observational period our respectively sampled LIAB LM1 establishments experienced hp shocks like those analysed in Chapter 3.3.

## Correlation between job creation and destruction

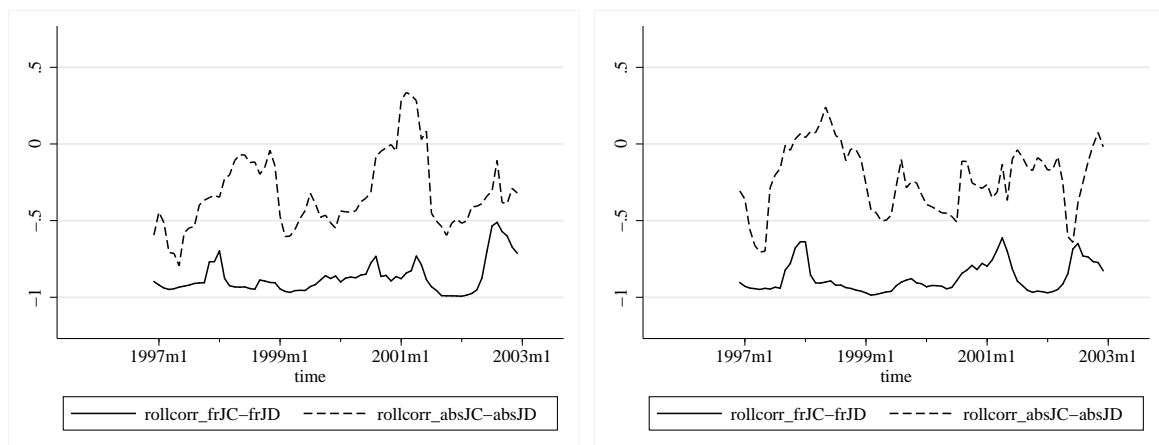
Looking at particularly outstanding episodes of job creation and job destruction only, however, might still miss important although smaller joint dynamics. Therefore I additionally analysed yearly rolling windows of the correlation-coefficient between job creation and job destruction. I did this in order to detect variation in this parameter over time, keeping in mind that on average it is highly negative in monthly data, see Table 4.3.

Figures 4.11–4.15 illustrate the development of the correlation coefficient with a window

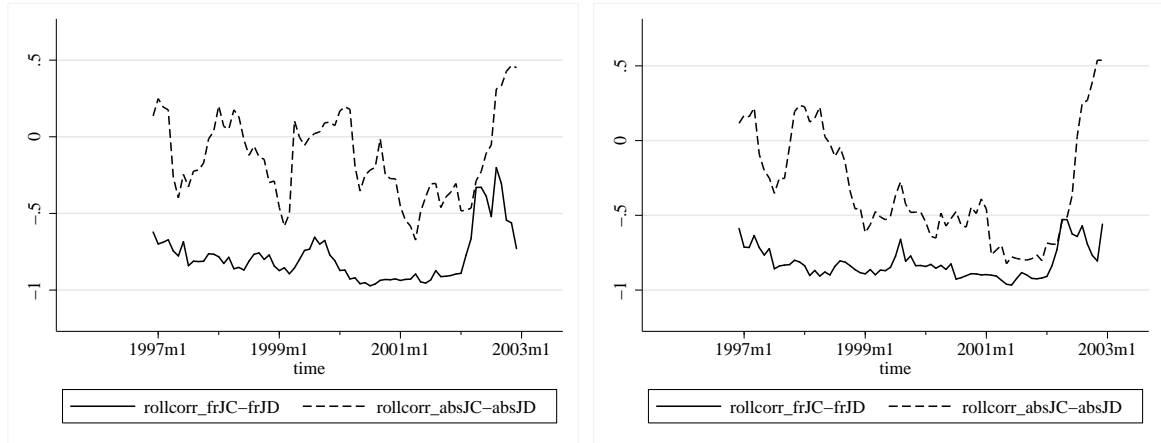
<sup>13</sup> The results also failed the robustness check in terms of alternative monthly aggregation.

**Figure 4.11:** Rolling correlation (12 months), LIAB LM1, all industries**(a)** Full sample**(b)** Adjusted sample

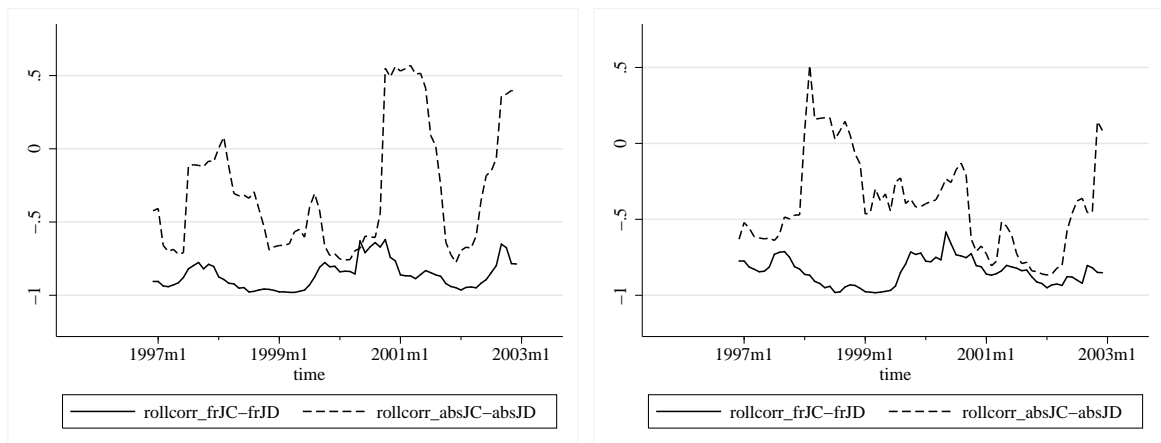
Code of the manufacturing sub-industries according to the German Classification of Economic Activities, Edition 1993 (WZ93). Seasonally-adjusted monthly averages.

**Figure 4.12:** Rolling correlation (12 months), LIAB LM1, manufacturing 15-37 D**(a)** Full sample**(b)** Adjusted sample

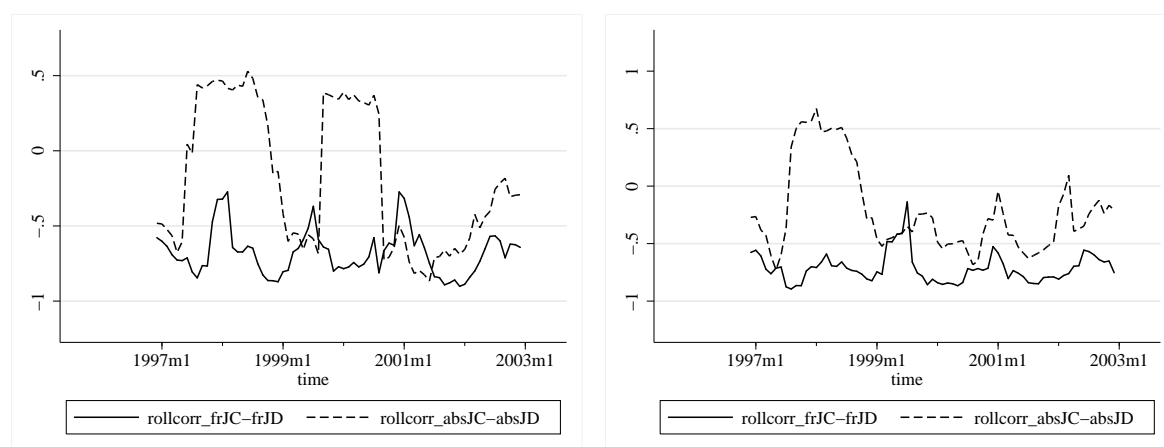
Code of the manufacturing sub-industries according to the German Classification of Economic Activities, Edition 1993 (WZ93). Seasonally-adjusted monthly averages.

**Figure 4.13:** Rolling correlation (12 months), LIAB LM1, manufacturing 27-28 DJ**(a)** Full sample**(b)** Adjusted sample

Code of the manufacturing sub-industries according to the German Classification of Economic Activities, Edition 1993 (WZ93). Seasonally-adjusted monthly averages.

**Figure 4.14:** Rolling correlation (12 months), LIAB LM1, manufacturing 29 DK**(a)** Full sample**(b)** Adjusted sample

Code of the manufacturing sub-industries according to the German Classification of Economic Activities, Edition 1993 (WZ93). Seasonally-adjusted monthly averages.

**Figure 4.15:** Rolling correlation (12 months), LIAB LM1, manufacturing 30-33 DK**(a)** Full sample**(b)** Adjusted sample

Code of the manufacturing sub-industries according to the German Classification of Economic Activities, Edition 1993 (WZ93). Seasonally-adjusted monthly averages.

comprising the previous twelve months, respectively, for the various samples I considered. The Adjusted Dickey-Fuller fails to reject a unit root for most specifications. As visible, the correlation parameter is rather sensitive to changes in the underlying time series.<sup>14</sup>

We find that correlation in general varies quite considerably and with differing intensity. Apparently economic shocks indeed are able to temporarily loosen the in general highly negative relationship between job creation and job destruction. This leaves room for the existence of heterogeneous productivity-enhancing shocks in my sample data, although these types are just one possible candidate. Note that, for instance, time periods with simultaneous decelerating (instead of accelerating) job creation and destruction might likewise increase the correlation of both time series, as can be seen at the end of the observational period in many considered samples.

## 4.5 Discussion and conclusion

I compiled and analysed high-frequency gross job and employment dynamics of a sample – and several sub-samples – of German establishments 1996-2002. With that I have gained

<sup>14</sup> Comparing with the results of the first-of-month aggregation data sample, we find that the development of the rolling correlation of *frJC* and *frJD* varies rather strongly, while that of *absJC* and *absJD* is more similar to those presented here.

novel insights into the high-frequency, cyclical and seasonal characteristics of gross job and employment flows. Once again it was shown that job flows by far exceed net employment changes. But complementary to previous research mostly based on annual data, I was able to look at the specific dynamics during the year and even during the month. I found that changes in establishments' employment levels are highly concentrated to few days within a calendar month and additionally show clear seasonal patterns. Considering these facts, job creation and job destruction are correlated negatively and influenced by the general business cycle.

Beyond these global characteristics, I initialized an evaluation of the occurrence of heterogeneous productivity-enhancing shocks, which were introduced in the theoretical model of Chapter 3.3, within my observational sample. A particular focus was set on recession-inducing hp innovations. From my model I derived a number of patterns in the time series of (among others) gross job and employment variables that mark the arrival of hp shocks and the adaptive dynamics within the economy. I dissected my empirical variables' time-series in search for these patterns. Evidences appeared to be sparsely, though, when I employed a primarily descriptive approach.

Looking at the time series I found that the tendency of job creation and job destruction to diverge seems rather robust in my sample, while I was interested in temporary joint increases. Comparing the timing of episodes with distinctively high (in particular more than one standard deviation above mean) job creation or job destruction, I could identify a single event with overlapping in one sub-sample. I also discovered periods with extensive job creation for which statistical tests could not reject that job destruction was at least at its mean level at that time. Although not recession-inducing – given that job creation always outnumbered job destruction then – these might indicate hp shocks. My findings were not very robust among different measures of job flows and establishment samples, however. Nonetheless, the inspection of yearly rolling windows of the correlation-coefficient between job creation and job destruction confirmed that economic shocks apparently are able to temporarily loosen the in general highly negative relationship between them.

A number of issues hindered my analysis. First of all, empirical data is influenced by a continuous stream of additional shocks beyond those considered in the highly-stylized theoretical model. These shocks overlap and hence hamper their distinctive identification and segregation, that is, produce noise in the data. Without explicit examination I can not filter it out with routine procedures without facing the risk to lose also information on those particular, non-standard, fluctuation and growth effects-merging shock responses I am interested in.

Secondly, there are data issues. I have no access to the full set of variables needed for a thorough analysis of all aspects of the model. Furthermore the use of an extensive and unique set of personal and establishment data has two sides: While it enabled the high-frequency analysis for many establishments over several years, at the same time it is prone to include faulty



data and excludes comprehensive quality checks. Both these issues hamper the convincing identification of outstanding developments as specific shocks.

Thirdly, heterogeneous positive productivity shock with identifiable aggregate consequences might be comparably rare occasions, comparable with the development of new general purpose technologies with similar consequences. Not having found clear evidence but only mild indications in my special, not fully representative sample is hence no evidence of non-existence, in particular given noisy data.

A number of possible extensions to my analyses might help to overcome some of these issues and clarify the role of (recession-inducing) hp shocks in the development of macroeconomic aggregates. One starting point is the modification and enlargement of my theoretical framework to explicitly allow for regular stochastic elements. Given its continuous-time setup, the inclusion of Brownian motions seems promising to reflect the average dynamics of gross job flow and employment variables (see Wälde, 2011, Part IV, for an applied introduction into stochastic processes and their use in economic models). Appropriate calibration which matches average moments of empirical data enables the simulation of probability distributions on economic fluctuations. It therewith allows the direct application of statistical tests to check for the occurrence of additional (like my hp) shocks in empirical data. Beyond such an exercise for a specific sample which might or might not include particular shocks, this approach more generally gives insights into the required magnitude of hp shocks to induce outstanding effects at the aggregate level, which likewise can serve as plausibility check for the relevance of such events.

Alternatively one might refer directly to the empirical time series. It should be possible to conduct a structural vector autoregressive (SVAR) analysis in order to explicitly disentangle different kind of shocks. For that the variables are considered to evolve according to a multivariate autoregressive process which is subject to a set of distinctive innovation paths (for an introduction into SVAR analysis see, for example, Enders, 2004, Chapt. 5). In my context this should include (recession-inducing) hp shocks and some general fluctuations. In can be shown that to disentangle particular innovation paths out from the observable data some identification scheme is necessary. Despite non-standard, shape and sign-restrictions like those patterns derived in Section 4.1 can serve this function (see Canova, 2007, p. 148f., and the references therein). If successful, with the possibility to employ a variance decomposition, the SVAR analysis provides quantitative results to explicitly evaluate the importance of specific shocks identified by the respective patterns.

Further insights might be gained enlarging the set of evaluated variables. I already taped the full potential concerning high-frequency data derivable from social security notifications. Additionally, however, one could use the survey (IAB Establishment Panel) data to calculate proxies for an establishment's productivity level (see, for instance, Lutz, 2005; Schank, 2005, for some applications) and get information on output and current vacancies. Given limited survey data availability and the annual focus of the panel, these results necessarily must

remain fragmentary. Nonetheless, with sufficient data regression analyses could evaluate whether establishments with enhanced productivity indeed response with long-term job creation, and whether they are able to negatively influence the job flows of establishments with persistent productivity levels. Additionally this supplementary data could help to analyse the relationship between individual and aggregate dynamics not only in terms of (gross) employment but also productivity and output.

It also might be promising to continue my analysis at even more disaggregated sub-industries. The influence of hp shocks on aggregate fluctuations might be considerably higher if looking at rather narrow industries, because establishments are more similar there. Note that almost all periods identified above to possibly indicate the occurrence of hp shocks stem from sub-industry samples. However, the opportunities for this strategy might be limited due to too small resulting establishment samples.

Additional research could explicitly analyse what drives empirical net employment changes: Are these rather changes in the average number of persons affected per job creating or job destructing establishment, or instead changes in the fractions of respectively employment level changing firms? Are changes in either job creation or job destruction more important? Do these pattern change over the business cycle or at time periods with considered hp shocks? Answers to these questions allow further conclusions concerning the size and scope of economic shocks.

Such extensions are beyond the scope of this chapter, though. More research is necessary to assess the relevance of heterogeneous productivity-enhancing shocks in general and in their ability to induce impact recessions in particular. However, the suggested approaches appear promising to further contribute to our understanding concerning the important mechanisms which cause and govern economic fluctuations.

## Appendix 4.A Software and program codes

The data analysis and resulting pictures were carried out using STATA and *gretl*, see Cottrell and Lucchetti (2011) for the latter. Figures 4.1–4.3b were produced in *Mathematica*. The corresponding program code is available on request.

## Appendix 4.B Robustness check: first-of-month aggregation

**Table 4.6:** Additional descriptive statistics, all industries, LIAB LM1, first-of-month aggregation

		total sample	adjusted sample
# of establishments		4,264	2,769
<i>frJC</i>	mean	0.26	0.25
	s.d.	0.02	0.02
<i>frJD</i>	mean	0.29	0.28
	s.d.	0.01	0.01
<i>absJC</i>	mean	7,077.32	3,798.64
	s.d.	2,011.83	920.08
<i>absJD</i>	mean	7,980.31	4,284.36
	s.d.	1,435.40	770.75
<i>SUM</i>	mean	931,162.50	597,085.30
	s.d.	18,756.41	10,333.31
<i>NET</i>	mean	- 903.00	- 485.73
	s.d.	2,960.62	1,456.43
corr( <i>frJC</i> , <i>frJD</i> )		- 0.71	- 0.81
corr( <i>absJC</i> , <i>absJD</i> )		- 0.46	- 0.48

Monthly data seasonally adjusted.

**Table 4.7:** Additional descriptive statistics, manufacturing, LIAB LM1, first-of-month aggregation

		total sample	adj. sample
15-37, D			
# of establishments			
<i>frJC</i>	mean	0.30	.31
	s.d.	0.04	.04
<i>frJD</i>	mean	0.33	0.33
	s.d.	0.03	0.030
<i>absJC</i>	mean	2,388.46	1,632.36
	s.d.	915.41	512.47
<i>absJD</i>	mean	2,565.75	1,763.65
	s.d.	728.57	497.06
<i>SUM</i>	mean	403,105.00	327,119.80
	s.d.	7,157.59	4,520.20
<i>NET</i>	mean	-177.28	-131.29
	s.d.	1,414.46	861.97
corr( <i>frJC</i> , <i>frJD</i> )		-0.91	-0.92
corr( <i>absJC</i> , <i>absJD</i> )		-0.47	-0.46
27-28, DJ			
# of establishments		228	184
<i>frJC</i>	mean	0.31	0.30
	s.d.	0.05	0.05
<i>frJD</i>	mean	0.31	0.31
	s.d.	0.04	0.04
<i>absJC</i>	mean	301.83	248.54
	s.d.	94.11	80.24
<i>absJD</i>	mean	339.55	259.57
	s.d.	172.81	122.32
<i>SUM</i>	mean	58,359.88	51,372.80
	s.d.	1,261.87	1,067.02
<i>NET</i>	mean	-37.73	-11.03
	s.d.	222.61	167.33
corr( <i>frJC</i> , <i>frJD</i> )		-0.76	-0.78
corr( <i>absJC</i> , <i>absJD</i> )		-0.33	-0.34

		total sample	adj. sample
29, DK			
# of establishments		139	111
<i>frJC</i>	mean	0.35	0.36
	s.d.	0.06	.07
<i>frJD</i>	mean	0.38	0.38
	s.d.	0.05	0.06
<i>absJC</i>	mean	302.07	234.00
	s.d.	124.92	72.92
<i>absJD</i>	mean	368.62	251.43
	s.d.	132.47	83.75
<i>SUM</i>	mean	64,096.11	52,415.59
	s.d.	1,091.54	880.55
<i>NET</i>	mean	-66.55	-17.42
	s.d.	216.19	140.66
corr( <i>frJC</i> , <i>frJD</i> )		-0.86	-0.89
corr( <i>absJC</i> , <i>absJD</i> )		-0.41	-0.61
30-33, DL			
# of establishments		154	117
<i>frJC</i>	mean	0.30	0.29
	s.d.	0.05	.04
<i>frJD</i>	mean	0.29	0.28
	s.d.	0.04	0.04
<i>absJC</i>	mean	328.45	230.43
	s.d.	177.94	160.09
<i>absJD</i>	mean	324.86	195.75
	s.d.	182.35	94.10
<i>SUM</i>	mean	47,373.77	34,299.53
	s.d.	1,864.68	1,823.58
<i>NET</i>	mean	3.58	34.97
	s.d.	285.52	211.47
corr( <i>frJC</i> , <i>frJD</i> )		-0.76	-0.66
corr( <i>absJC</i> , <i>absJD</i> )		-0.26	-0.33

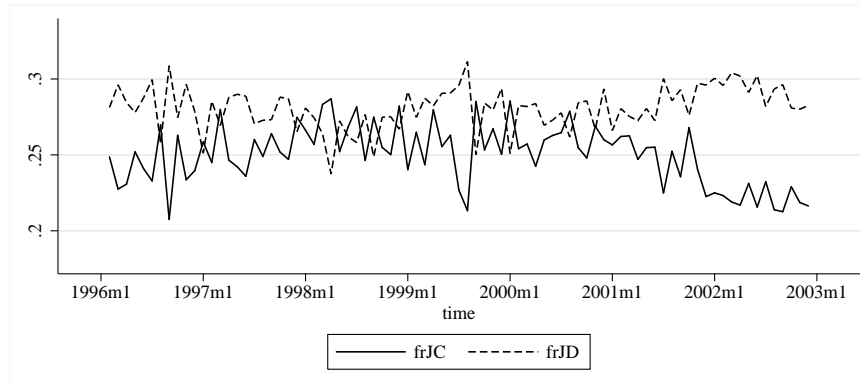
Code of the manufacturing sub-industries according to the German Classification of Economic Activities, Edition 1993 (WZ93). Monthly data seasonally adjusted.

**Table 4.8:** Descriptive statistics of employment flows, LIAB LM 1, first-of-month aggregation

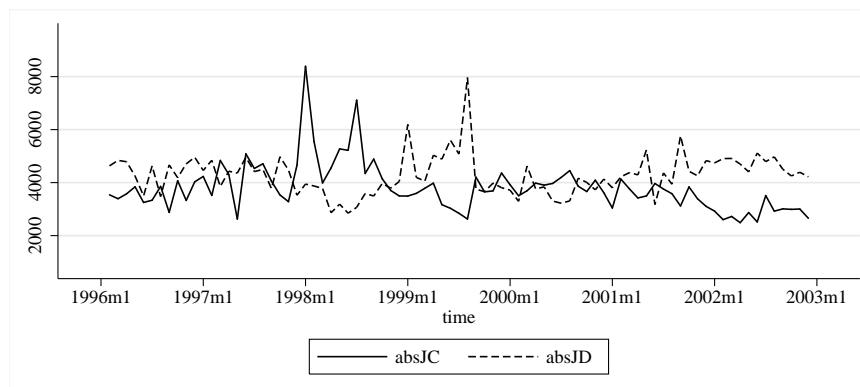
	all industries			manufacturing								
	15-37, D			27-28, DJ			29 DK			30-33, DL		
	first of month											
	full	adj.	sample	full	adj.	sample	full	adj.	sample	full	adj.	sample
# of establishments	4,264	2,769	1,131	857	228	184	139	111	154	117		
$frJC$ (%)	25.97	24.96	30.46	30.80	29.58	30.37	34.95	36.09	29.61	28.75		
$\frac{absJC}{frJC * n}$	6.39	5.50	6.93	6.18	4.48	4.45	6.22	5.84	7.20	6.85		
$\frac{absJC}{SUM}$ (%)	0.76	0.64	0.59	0.50	0.52	0.48	0.47	0.45	0.69	0.67		
$frJD$ (%)	29.49	28.09	32.76	32.86	31.05	31.41	37.61	38.35	29.50	28.48		
$\frac{absJD}{frJD * n}$	6.35	5.51	6.93	6.26	4.80	4.49	7.05	5.91	7.15	5.87		
$\frac{absJD}{SUM_{NET}}$ (%)	0.86	0.72	0.64	0.54	0.58	0.51	0.58	0.48	0.69	0.57		
	-0.21	-0.18	-0.16	-0.15	-0.17	-0.06	-0.48	-0.16	0.02	0.30		
$corr(frJC, frJD)$	-0.71	-0.81	-0.91	-0.92	-0.76	-0.78	-0.86	-0.89	-0.76	-0.66		
$corr(absJC, absJD)$	-0.46	-0.48	-0.47	-0.46	-0.33	-0.34	-0.41	-0.61	-0.26	-0.33		

Code of the manufacturing sub-industries according to the German Classification of Economic Activities, Edition 1993 (WZ93).  
 Seasonally-adjusted first of month-data.

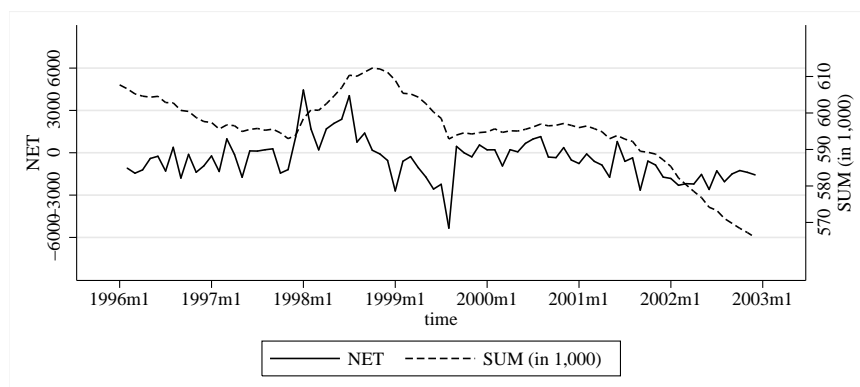
**Figure 4.16:** Development of job and employment flows, LIAB LM 1, all industries, adjusted sample, first-of-month aggregation



**(a)** Fraction of job creating and job destructing establishments



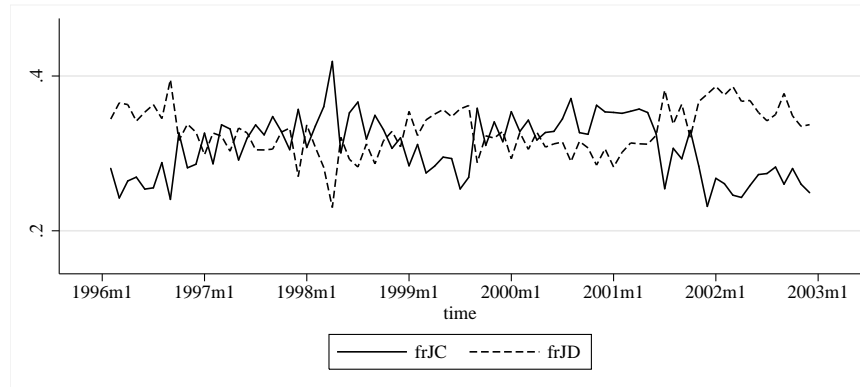
**(b)** Absolute job creation and destruction



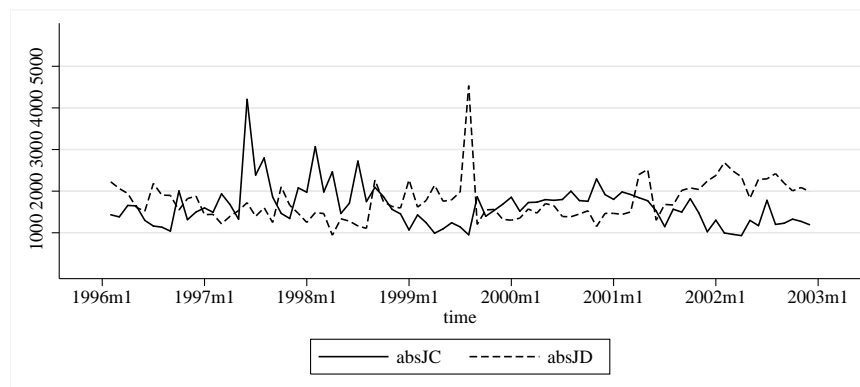
**(c)** Aggregate employment and employment change

Code of the manufacturing sub-industries according to the German Classification of Economic Activities, Edition 1993 (WZ93). Seasonally-adjusted first-of-month data.

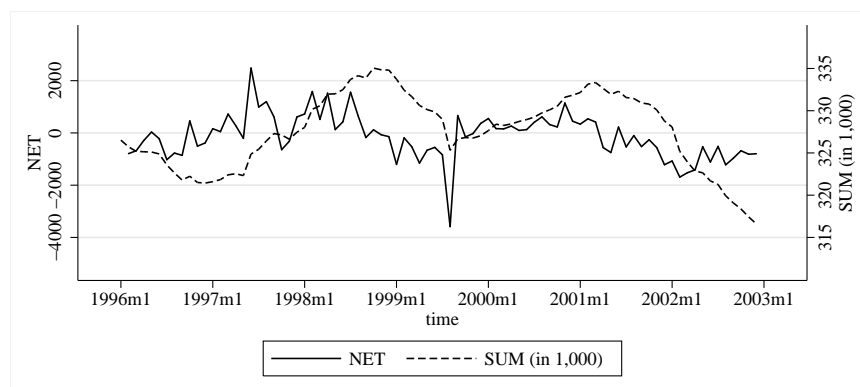
**Figure 4.17:** Development of job and employment flows, LIAB LM1, manufacturing, adjusted sample, first-of-month aggregation



(a) Fraction of job creating and job destructing establishments



(b) Absolute job creation and destruction

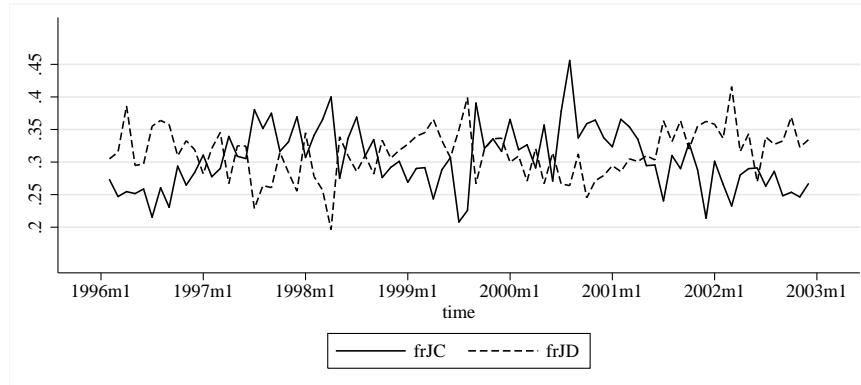


(c) Aggregate employment and employment change

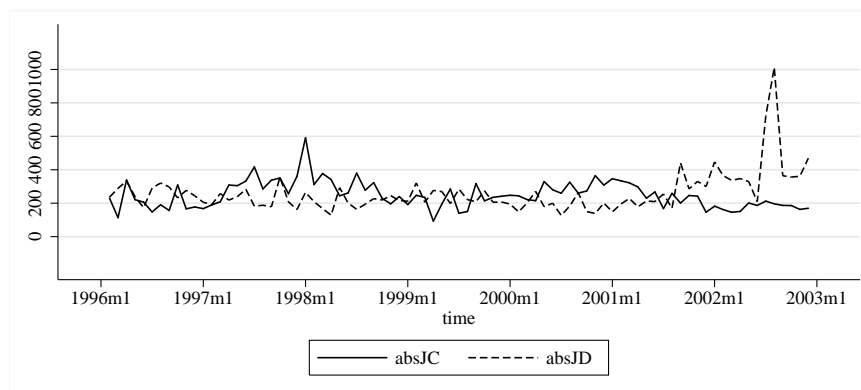
Code of the manufacturing sub-industries according to the German Classification of Economic Activities, Edition 1993 (WZ93). Seasonally-adjusted first-of-month data.



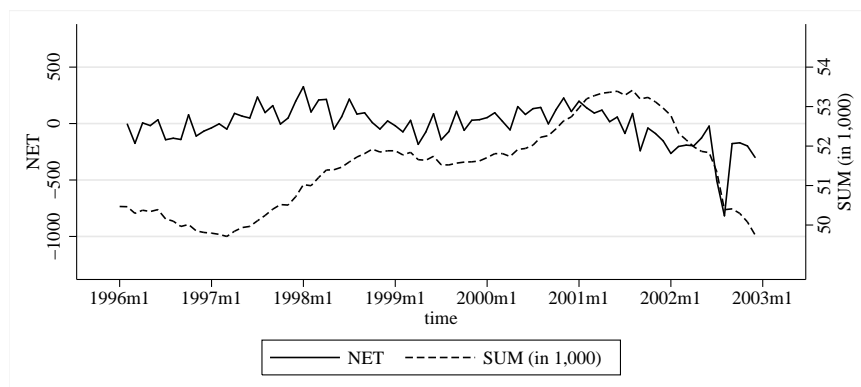
**Figure 4.18:** Development of job and employment flows, LIAB LM1, manufacturing 27-28 DJ, adjusted sample, first-of-month aggregation



**(a)** Fraction of job creating and job destructing establishments



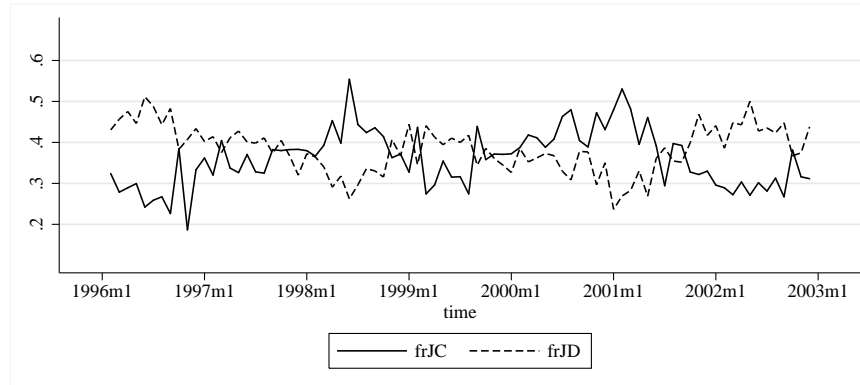
**(b)** Absolute job creation and destruction



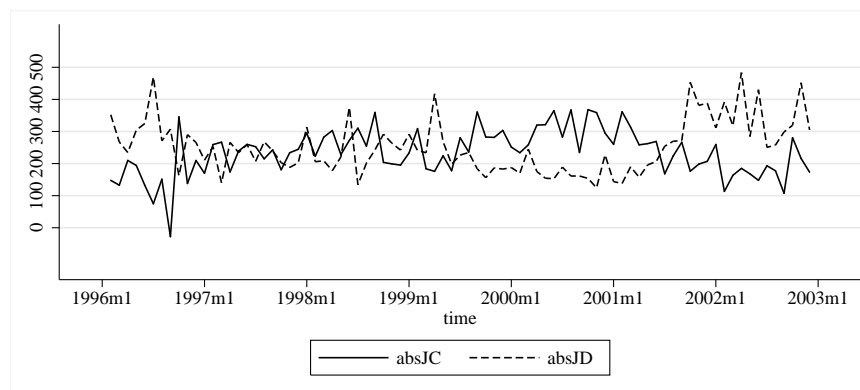
**(c)** Aggregate employment and employment change

Code of the manufacturing sub-industries according to the German Classification of Economic Activities, Edition 1993 (WZ93). Seasonally-adjusted first-of-month data.

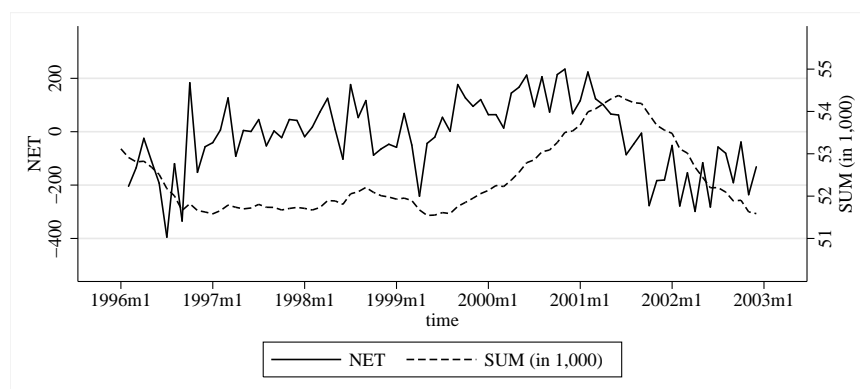
**Figure 4.19:** Development of job and employment flows, LIAB LM1, manufacturing 29 DK, adjusted sample, first-of-month aggregation



**(a)** Fraction of job creating and job destructing establishments



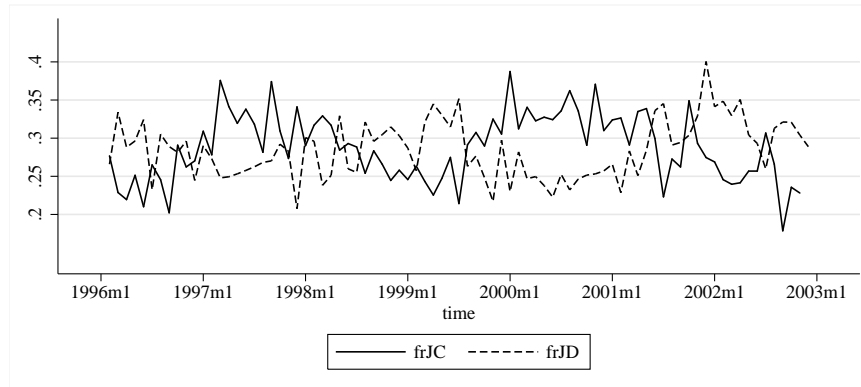
**(b)** Absolute job creation and destruction



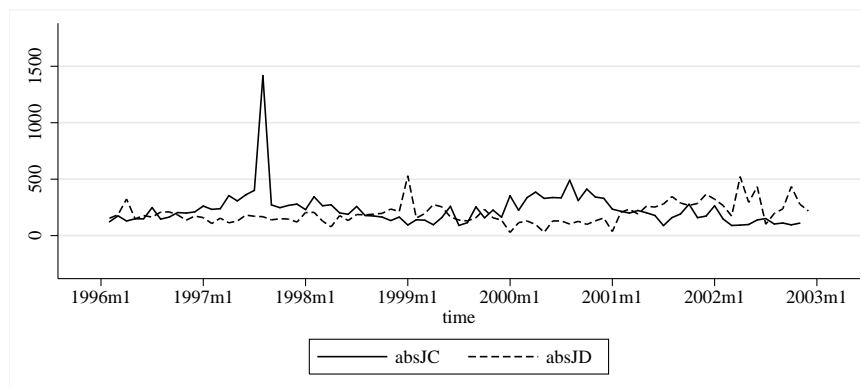
**(c)** Aggregate employment and employment change

Code of the manufacturing sub-industries according to the German Classification of Economic Activities, Edition 1993 (WZ93). Seasonally-adjusted first-of-month data.

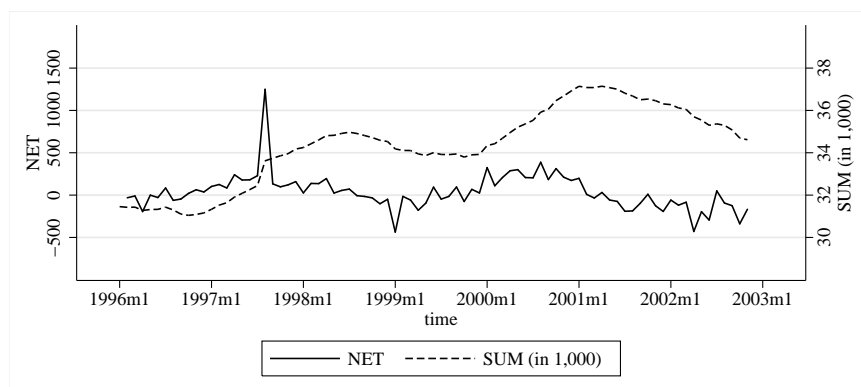
**Figure 4.20:** Development of job and employment flows, LIAB LM1, manufacturing 30-33 DL, adjusted sample, first-of-month aggregation



(a) Fraction of job creating and job destructing establishments



(b) Absolute job creation and destruction



(c) Aggregate employment and employment change

Code of the manufacturing sub-industries according to the German Classification of Economic Activities, Edition 1993 (WZ93). Seasonally-adjusted first-of-month data.

**Table 4.9:** Periods with extensive job creation and destruction (year:month), LIAB LM 1, full sample, first-of-month aggregation

all industries				manufacturing, 15-37, D				manufacturing, 27-28, DJ			
<i>frJC</i>	<i>frJD</i>	<i>absJC</i>	<i>absJD</i>	<i>frJC</i>	<i>frJD</i>	<i>absJC</i>	<i>absJD</i>	<i>frJC</i>	<i>frJD</i>	<i>absJC</i>	<i>absJD</i>
	96:03		97:02		96:03		97:02		96:04	97:07	
	96:07	97:03			96:04	97:03			96:07	97:09	
96:08			97:11		96:06	97:06			96:08	97:10	
	96:09	98:01			96:07	97:08			96:09	97:12	
	96:11	98:05			96:09	98:01		97:07		98:01	
97:03		98:06		97:03		98:02		97:12		98:03	
	97:04	98:07		97:12		98:07		98:03		98:07	
97:12			99:01	98:03			99:01	98:04		98:09	
98:03		99:04		98:04			99:08	98:06		99:04	
98:04			99:05	98:06		00:01		98:07		00:08	
98:06			99:06	98:07		00:05			99:04		00:09
98:07			99:08		99:05		01:07		99:05	00:11	
98:09		00:01			99:07		01:09		99:07	01:02	
98:12		00:05			99:08		01:10		99:08	01:03	
	99:01		01:07	00:01			01:12	99:09			01:10
99:04			01:09	00:08			02:02	00:01			02:02
	99:08		01:10	00:11			02:04		00:04		02:04
99:09			02:01	00:12				00:05			
99:11			02:04	01:01				00:07			
00:01				01:02				00:08			
00:08				01:03				00:10			02:12
	00:09			01:04				00:11			
00:11					01:07			00:12			
	02:01				01:09			01:02			
	02:03				01:11			01:03			
	02:04				01:12				01:07		
	02:06				02:01				01:09		
					02:02				01:12		
					02:03				02:03		
					02:04						
					02:05						

Code of the manufacturing sub-industries according to the German Classification of Economic Activities, Edition 1993 (WZ93). *Highlighted periods* might qualify for heterogeneous productivity-enhancing shocks.

manufacturing, 29, DK				manufacturing, 30-33, DL			
<i>frJC</i>	<i>frJD</i>	<i>absJC</i>	<i>absJD</i>	<i>frJC</i>	<i>frJD</i>	<i>absJC</i>	<i>absJD</i>
	96:03		97:07		96:03	97:08	
	96:04	98:01			96:06	98:01	
	96:06	98:03			96:09	98:02	
	96:07	98:04		96:10			99:01
	96:09	98:06		97:03		99:09	99:09
	97:05	99:10		97:09		00:07	
98:04		00:05			97:10	00:08	
98:06		00:06		97:12		00:10	
98:07		00:12		98:02		00:12	
98:09		01:02		98:03			01:07
	99:01		01:10		98:11		01:08
99:02			02:01		99:03		01:10
99:09			02:02		99:04		01:12
00:07			02:06		99:07		02:04
00:08			02:09	00:01			02:06
00:11			02:11	00:03			
00:12				00:05			
01:01				00:07			
01:02				00:08			
01:03				00:10			
01:05				00:11			
	01:12			00:12			
	02:01			01:01			
	02:04			01:02			
	02:05			01:04			
	02:07				01:07		
	02:12			01:10			
					01:12		
					02:01		
					02:02		
					02:03		
					02:04		

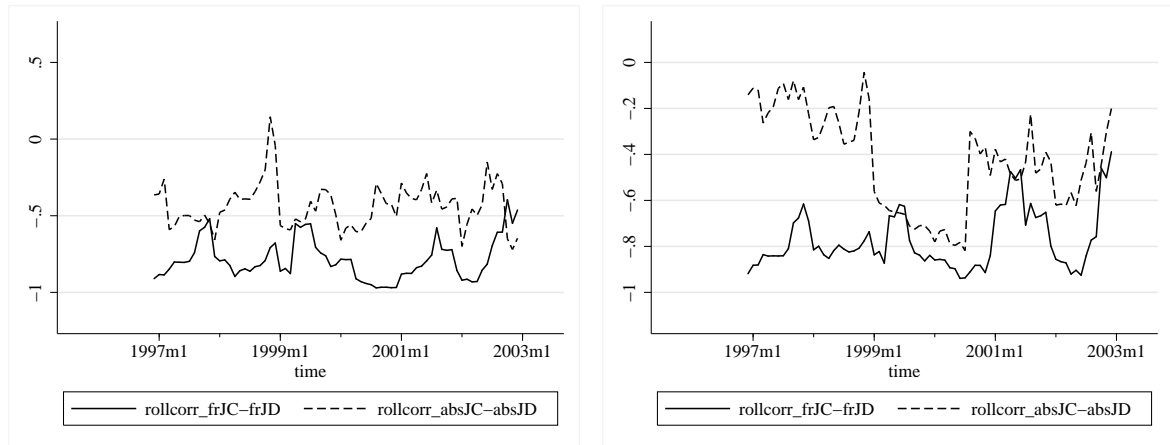
**Table 4.10:** Periods with extensive job creation and destruction (year:month), LIAB LM 1, adjusted sample, first-of-month aggregation

all industries				manufacturing, 15-37, D				manufacturing, 27-28, DJ			
<i>frJC</i>	<i>frJD</i>	<i>absJC</i>	<i>absJD</i>	<i>frJC</i>	<i>frJD</i>	<i>absJC</i>	<i>absJD</i>	<i>frJC</i>	<i>frJD</i>	<i>absJC</i>	<i>absJD</i>
	96:03	97:03			96:03				96:04	96:04	
	96:07	97:06			96:04	97:06			96:07	97:06	
96:08		98:01			96:07	97:07			96:08	97:07	
	96:09	98:02			96:09	97:08			96:09	97:09	
	96:11	98:05		97:09		98:02		97:07		97:10	
97:03		98:06		97:12		98:04		97:09		97:12	
97:12		98:07		98:03		98:07		97:12		98:01	
98:03		98:09		98:04			98:09	98:03		98:03	
98:04			99:01	98:06			99:01	98:04		98:04	
98:07			99:06	98:07			99:08	98:07		98:07	
98:09			99:07	98:09		00:11			99:04	00:05	
98:12			99:08		99:08		01:04		99:08	00:11	
99:04			01:05	99:09			01:05	99:09		01:01	
	99:07		01:09	00:01			02:01	00:01		01:02	
	99:08		02:06	00:08			02:02	00:05			01:09
99:09				00:11			02:03	00:07			02:01
00:01				00:12			02:04	00:08			02:07
00:08				01:01			02:06	00:10			02:08
	01:07			01:02			02:07	00:11			02:12
	01:11			01:03			02:08	01:02			
	01:12			01:04				01:03			
	02:01			01:05					01:07		
	02:02				01:07				01:09		
	02:03				01:09				01:11		
	02:04				01:11				01:12		
	02:06				01:12				02:01		
	02:09				02:01				02:03		
					02:02				02:10		
					02:03						
					02:04						
					02:05						
					02:09						

Code of the manufacturing sub-industries according to the German Classification of Economic Activities, Edition 1993 (WZ93). *Highlighted periods* might qualify for heterogeneous productivity-enhancing shocks.

manufacturing, 29, DK				manufacturing, 30-33, DL			
<i>frJC</i>	<i>frJD</i>	<i>absJC</i>	<i>absJD</i>	<i>frJC</i>	<i>frJD</i>	<i>absJC</i>	<i>absJD</i>
	96:03		96:02		96:03		96:04
	96:04		96:07		96:06	97:07	
	96:05	96:10		97:03		97:08	
	96:06		98:06	97:04			99:01
	96:07	98:07		97:06		00:08	
	96:08	98:09		97:09		00:10	
	96:09	99:02		97:12			01:08
98:04			99:04		98:05		01:12
98:06		99:09			99:04		02:01
98:07		00:04			99:05		02:04
98:09		00:05			99:07		02:05
	99:01	00:06		00:01			02:06
99:02		00:08		00:03			02:10
	99:03	00:10		00:07			
99:09		00:11		00:08			
00:07		01:02		00:09			
00:08		01:03		00:11			
00:11			01:10	01:04			
00:12			01:11	01:05			
01:01			01:12		01:06		
01:02			02:02		01:07		
01:03			02:04	01:10			
01:05			02:06		01:11		
	01:11		02:11		01:12		
	02:03				02:01		
	02:04				02:02		
	02:05				02:03		
	02:09				02:04		

**Figure 4.21:** Rolling correlation (12 months), LIAB LM1, all industries, first-of-month aggregation

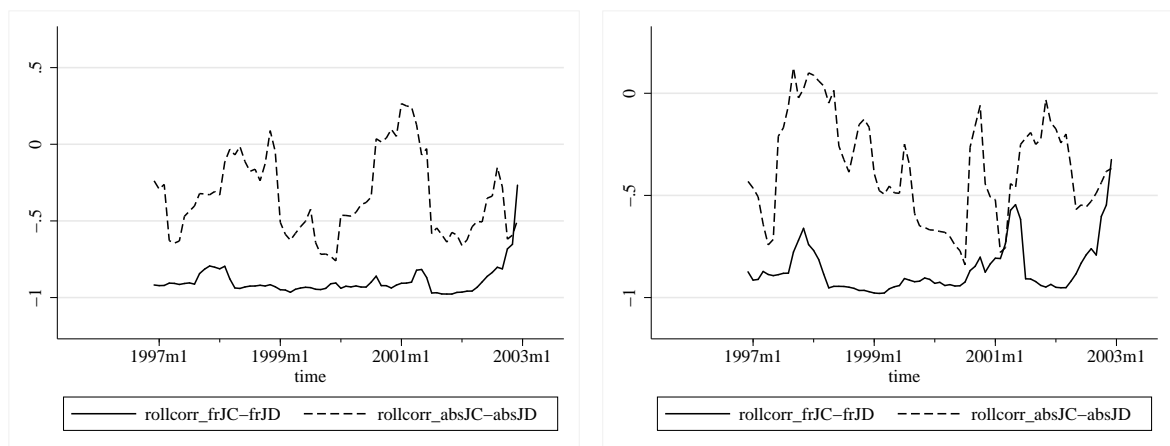


(a) Full sample

(b) Adjusted sample

Code of the manufacturing sub-industries according to the German Classification of Economic Activities, Edition 1993 (WZ93). Seasonally-adjusted first-of-month data.

**Figure 4.22:** Rolling correlation (12 months), LIAB LM1, manufacturing 15-37 D, first-of-month aggregation



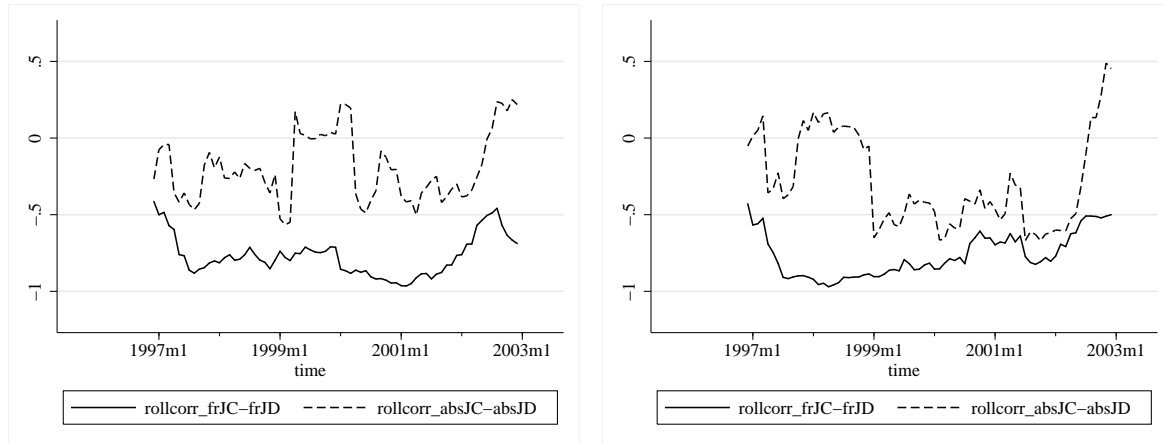
(a) Full sample

(b) Adjusted sample

Code of the manufacturing sub-industries according to the German Classification of Economic Activities, Edition 1993 (WZ93). Seasonally-adjusted first-of-month data.



**Figure 4.23:** Rolling correlation (12 months), LIAB LM1, manufacturing 27-28 DJ, first-of-month aggregation

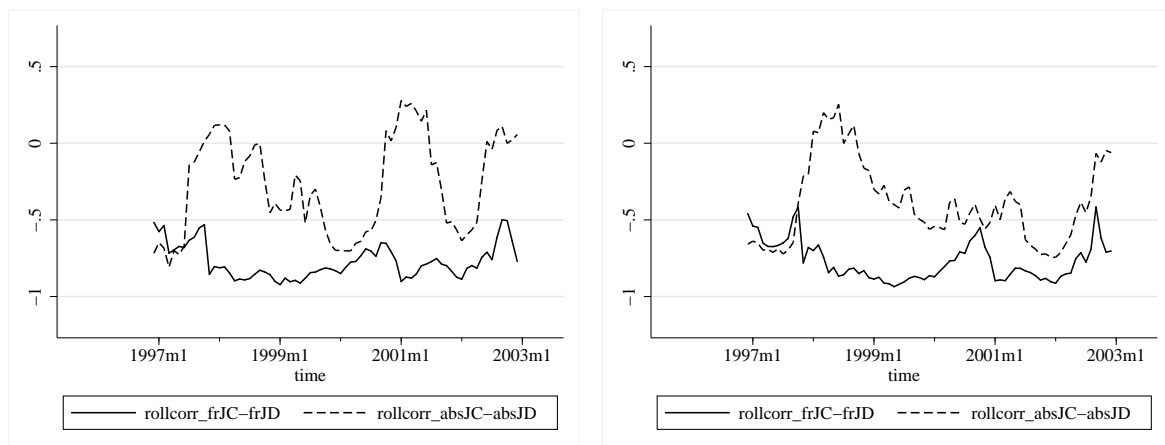


(a) Full sample

(b) Adjusted sample

Code of the manufacturing sub-industries according to the German Classification of Economic Activities, Edition 1993 (WZ93). Seasonally-adjusted first-of-month data.

**Figure 4.24:** Rolling correlation (12 months), LIAB LM1, manufacturing 29 DK, first-of-month aggregation

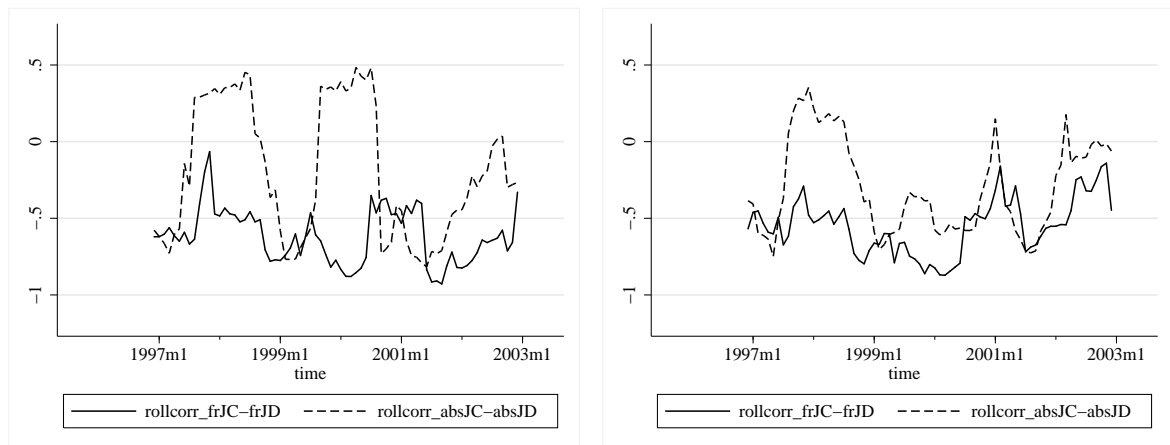


(a) Full sample

(b) Adjusted sample

Code of the manufacturing sub-industries according to the German Classification of Economic Activities, Edition 1993 (WZ93). Seasonally-adjusted first-of-month data.

**Figure 4.25:** Rolling correlation (12 months), LIAB LM1, manufacturing 30-33 DL, first-of-month aggregation

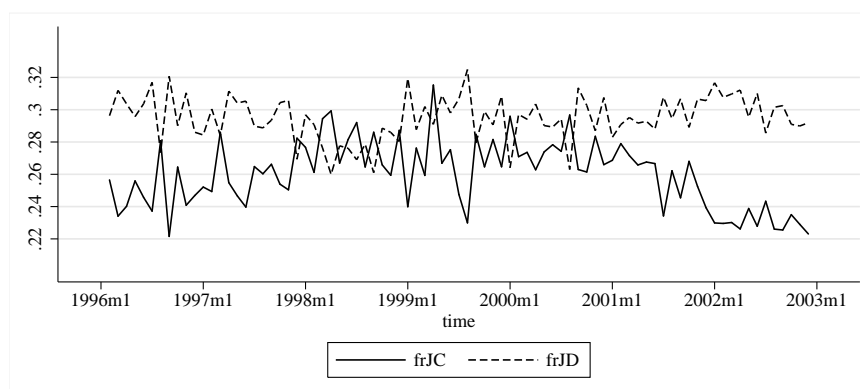


(a) Full sample

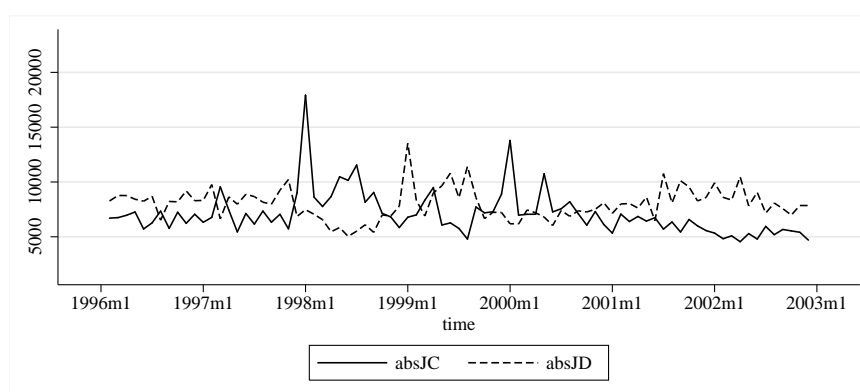
(b) Adjusted sample

Code of the manufacturing sub-industries according to the German Classification of Economic Activities, Edition 1993 (WZ93). Seasonally-adjusted first-of-month data.

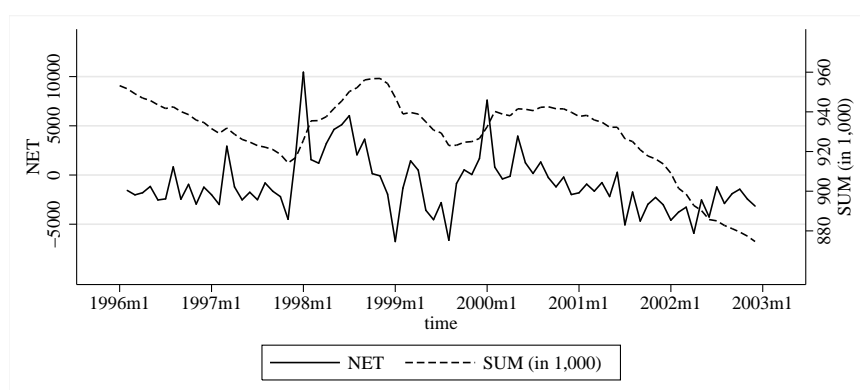
**Figure 4.26:** Development of job and employment flows, LIAB LM1, all industries, full sample, first-of-month aggregation



**(a)** Fraction of job creating and job destructing establishments



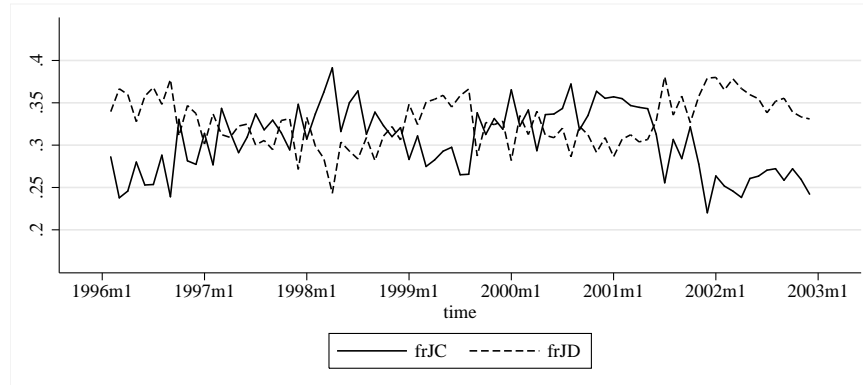
**(b)** Absolute job creation and destruction



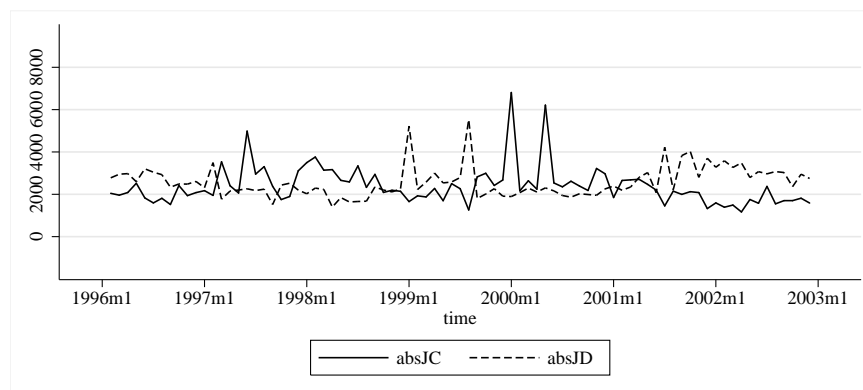
**(c)** Aggregate employment and employment change

Seasonally-adjusted first-of-month data.

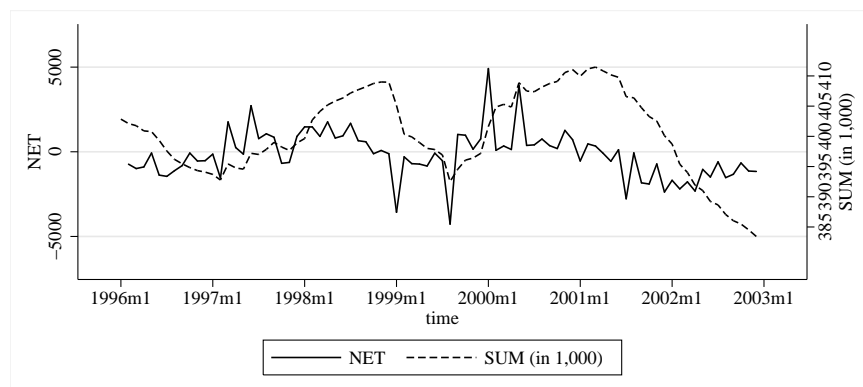
**Figure 4.27:** Development of job and employment flows, LIAB LM1, manufacturing 15-37 D, full sample, first-of-month aggregation



**(a)** Fraction of job creating and job destructing establishments



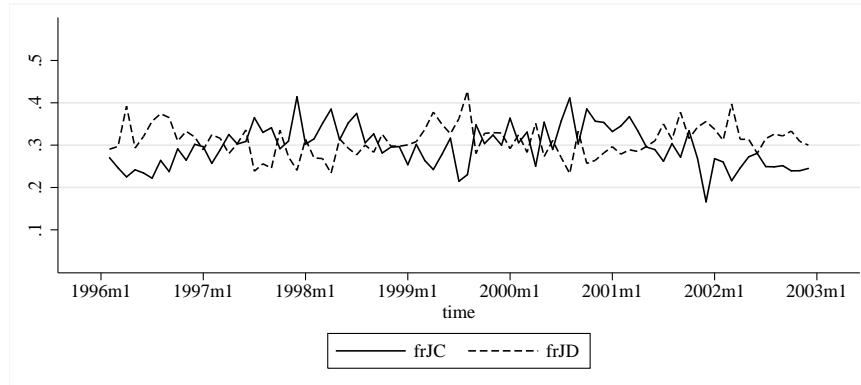
**(b)** Absolute job creation and destruction



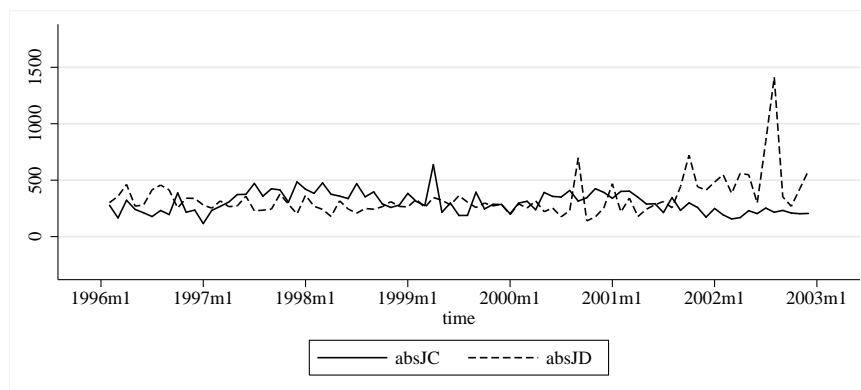
**(c)** Aggregate employment and employment change

Code of the manufacturing sub-industries according to the German Classification of Economic Activities, Edition 1993 (WZ93). Seasonally-adjusted first-of-month data.

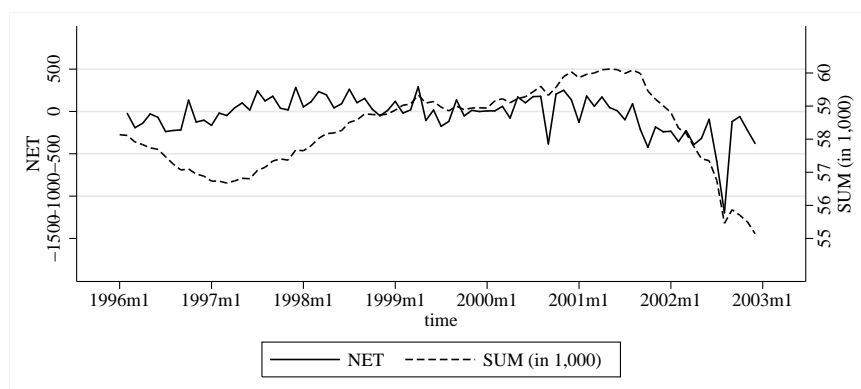
**Figure 4.28:** Development of job and employment flows, LIAB LM1, manufacturing 27-28 DJ, full sample, first-of-month aggregation



**(a)** Fraction of job creating and job destructing establishments



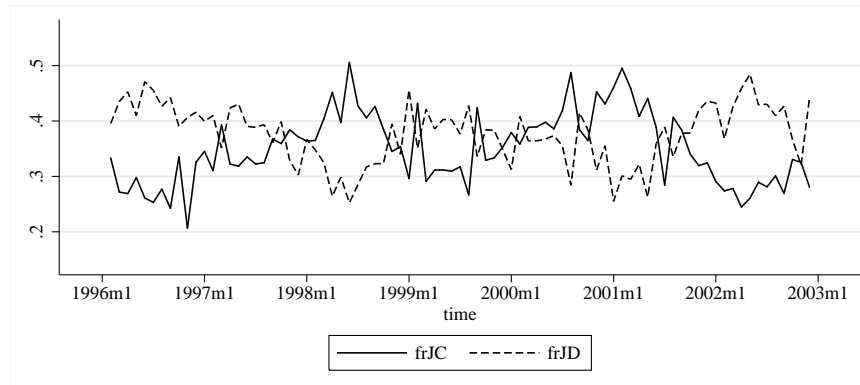
**(b)** Absolute job creation and destruction



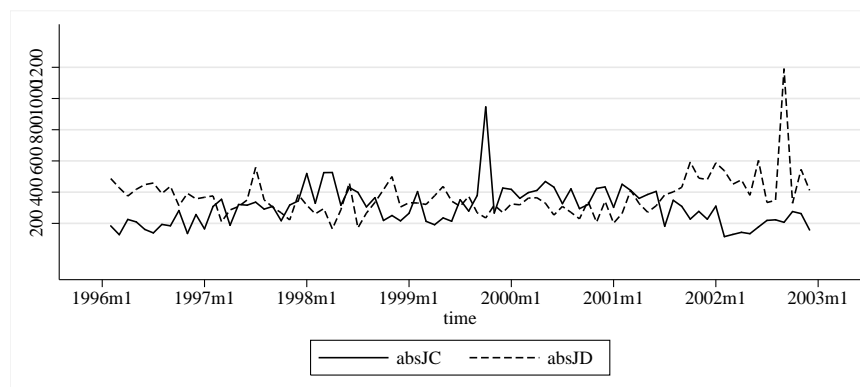
**(c)** Aggregate employment and employment change

Code of the manufacturing sub-industries according to the German Classification of Economic Activities, Edition 1993 (WZ93). Seasonally-adjusted first-of-month data.

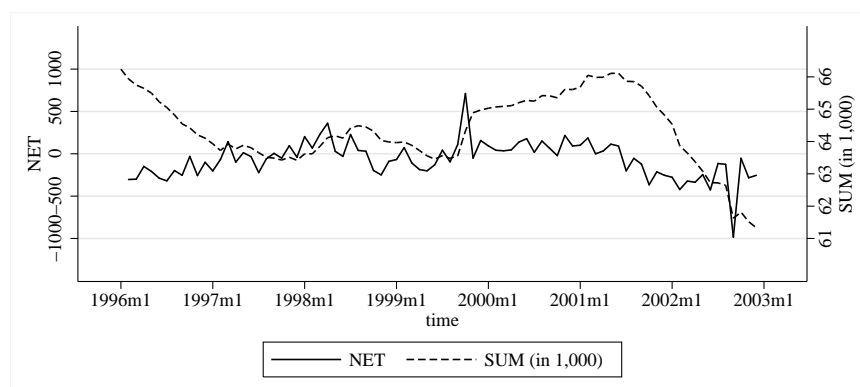
**Figure 4.29:** Development of job and employment flows, LIAB LM1, manufacturing 29 DK, full sample, first-of-month aggregation



**(a)** Fraction of job creating and job destructing establishments



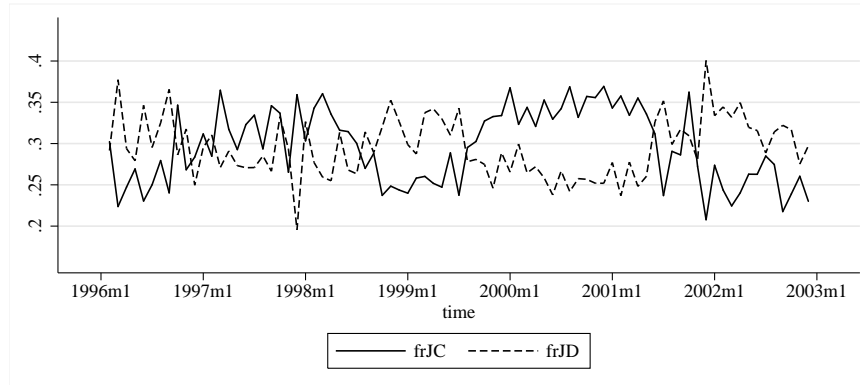
**(b)** Absolute job creation and destruction



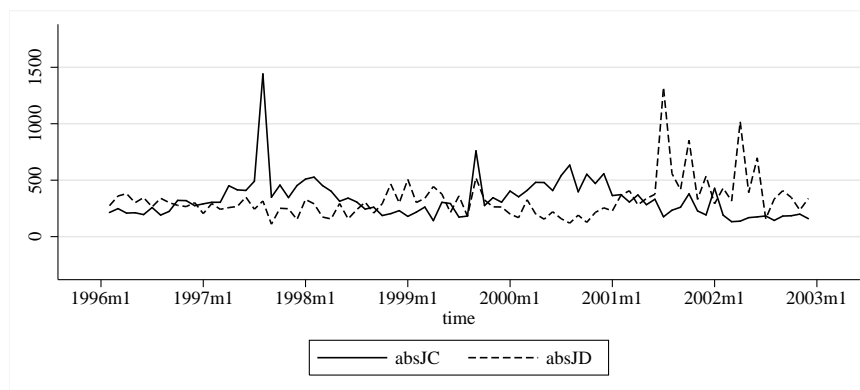
**(c)** Aggregate employment and employment change

Code of the manufacturing sub-industries according to the German Classification of Economic Activities, Edition 1993 (WZ93). Seasonally-adjusted first-of-month data.

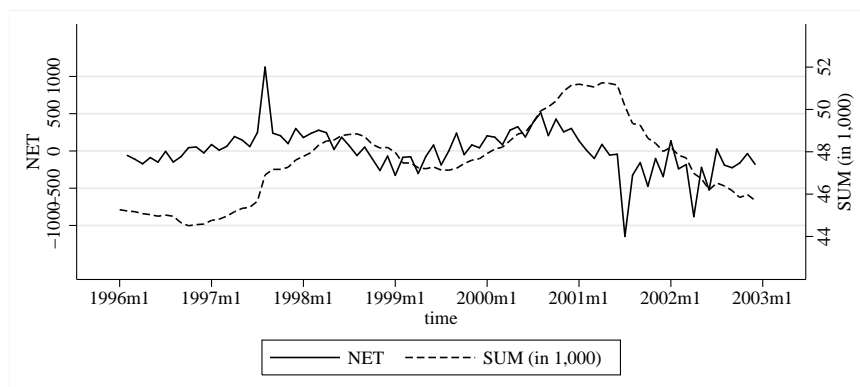
**Figure 4.30:** Development of job and employment flows, LIAB LM1, manufacturing 30-33 DL, full sample, first-of-month aggregation



**(a)** Fraction of job creating and job destructing establishments



**(b)** Absolute job creation and destruction



**(c)** Aggregate employment and employment change

Code of the manufacturing sub-industries according to the German Classification of Economic Activities, Edition 1993 (WZ93). Seasonally-adjusted first-of-month data.

## Appendix 4.C Additional tables and results

**Table 4.11:** Additional descriptive statistics, all industries, LIAB LM1

		total sample	adj. sample
daily variables			
# of establishments		4,264	2,769
<i>frJC</i>	mean	0.03	0.03
	s.d.	0.04	0.04
<i>frJD</i>	mean	0.04	0.03
	s.d.	0.04	0.04
<i>absJC</i>	mean	373.92	200.82
	s.d.	1,163.10	543.48
<i>absJD</i>	mean	400.99	214.87
	s.d.	1,299.13	656.42
<i>SUM</i>	mean	929,261.50	595,759.90
	s.d.	19,590.33	10,478.88
<i>NET</i>	mean	- 27.23	- 14.13
	s.d.	923.42	475.00
corr( <i>frJC</i> , <i>frJD</i> )		0.67	0.67
corr( <i>absJC</i> , <i>absJD</i> )		- 0.72	- 0.70
monthly-averages, seasonally adjusted			
# of establishments		4,264	2,769
<i>frJC</i>	mean	0.32	0.31
	s.d.	0.02	0.02
<i>frJD</i>	mean	0.36	0.34
	s.d.	0.01	0.01
<i>absJC</i>	mean	6,768.26	3,627.3
	s.d.	1,936.00	896.56
<i>absJD</i>	mean	7,710.19	4,129.33
	s.d.	1,446.63	746.29
<i>SUM</i>	mean	930,006.2	596,538.9
	s.d.	19,486.53	10,750.26
<i>NET</i>	mean	-941.93	-502.06
	s.d.	2,913.25	1,392.30
corr( <i>frJC</i> , <i>frJD</i> )		-0.64	-0.77
corr( <i>absJC</i> , <i>absJD</i> )		-0.47	-0.43



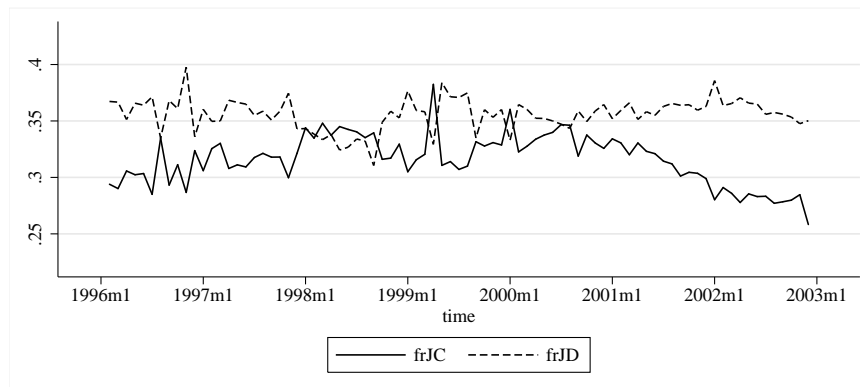
**Table 4.12:** Additional descriptive statistics, manufacturing, LIAB LM1

		total sample	adj. sample
15-37, D			
# of establishments		1131	857
<i>frJC</i>	mean	0.37	0.38
	s.d.	0.04	0.04
<i>frJD</i>	mean	0.39	0.39
	s.d.	0.03	0.03
<i>absJC</i>	mean	2,277.60	1,575.96
	s.d.	857.16	513.28
<i>absJD</i>	mean	2,466.62	1,690.88
	s.d.	691.48	470.06
<i>SUM</i>	mean	403,093.90	327,937.00
	s.d.	6,935.65	4,561.05
<i>NET</i>	mean	-189.02	-114.92
	s.d.	1,321.72	821.23
corr( <i>frJC</i> , <i>frJD</i> )		-0.89	-0.92
corr( <i>absJC</i> , <i>absJD</i> )		-0.45	-0.39
27-28, DJ			
# of establishments		228	184
<i>frJC</i>	mean	0.37	0.38
	s.d.	0.05	0.05
<i>frJD</i>	mean	0.37	0.38
	s.d.	0.04	0.04
<i>absJC</i>	mean	291.36	238.31
	s.d.	98.08	75.68
<i>absJD</i>	mean	324.53	246.04
	s.d.	163.35	127.64
<i>SUM</i>	mean	58,643.83	51,586.05
	s.d.	1,303.99	1117.07
<i>NET</i>	mean	-33.17	-7.73
	s.d.	214.77	168.27
corr( <i>frJC</i> , <i>frJD</i> )		-0.77	-0.81
corr( <i>absJC</i> , <i>absJD</i> )		-0.31	-0.33

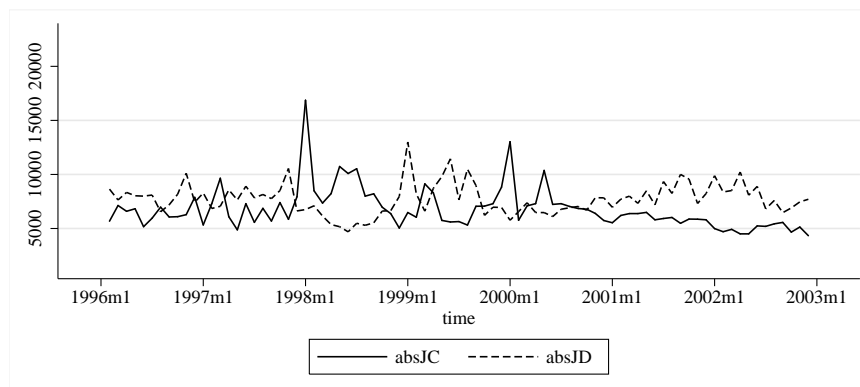
		total sample	adj. sample
		29, DK	
# of establishments		139	111
<i>frJC</i>	mean	0.41	0.43
	s.d.	0.07	.07
<i>frJD</i>	mean	0.44	0.44
	s.d.	0.06	0.06
<i>absJC</i>	mean	298.29	226.15
	s.d.	164.04	63.52
<i>absJD</i>	mean	359.43	242.13
	s.d.	163.83	82.66
<i>SUM</i>	mean	64,545.29	52,500.46
	s.d.	1,174.06	845.95
<i>NET</i>	mean	-61.14	-15.98
	s.d.	262.20	130.61
corr( <i>frJC</i> , <i>frJD</i> )		-0.90	-0.92
corr( <i>absJC</i> , <i>absJD</i> )		-0.28	-0.59
		30-33, DL	
# of establishments		154	117
<i>frJC</i>	mean	0.35	0.34
	s.d.	0.05	0.05
<i>frJD</i>	mean	0.35	0.33
	s.d.	0.04	0.05
<i>absJC</i>	mean	317.77	220.03
	s.d.	177.53	135.07
<i>absJD</i>	mean	314.90	186.97
	s.d.	190.31	93.21
<i>SUM</i>	mean	47,423.36	34,173.22
	s.d.	1,827.81	1,730.53
<i>NET</i>	mean	2.87	33.06
	s.d.	289.00	189.86
corr( <i>frJC</i> , <i>frJD</i> )		-0.79	-0.78
corr( <i>absJC</i> , <i>absJD</i> )		-0.23	-0.36

Code of the manufacturing sub-industries according to the German Classification of Economic Activities, Edition 1993 (WZ93). Monthly data seasonally adjusted.

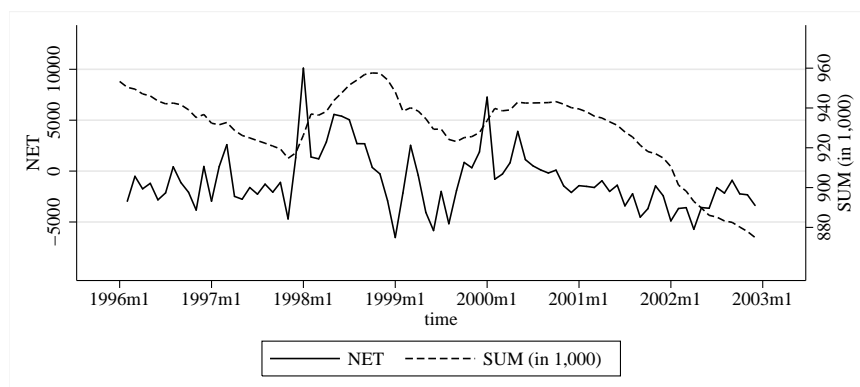
**Figure 4.31:** Development of job and employment flows, LIAB LM1, all industries, full sample



(a) Fraction of job creating and job destructing establishments



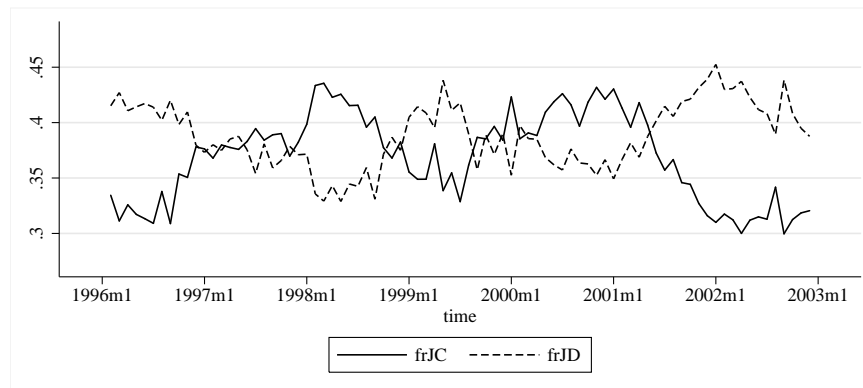
(b) Absolute job creation and destruction



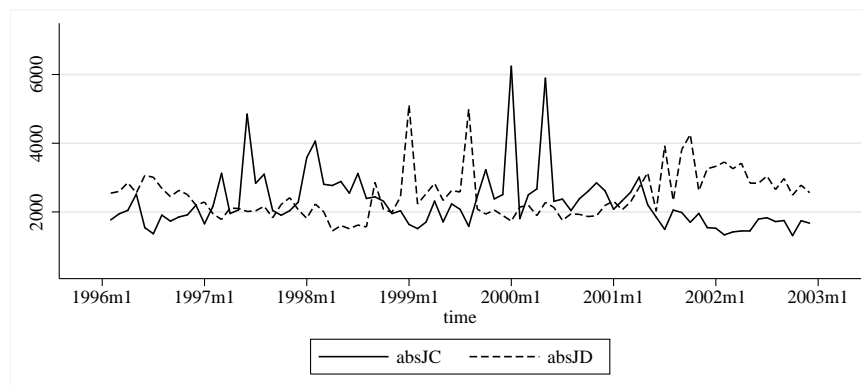
(c) Aggregate employment and employment change

Seasonally-adjusted monthly averages.

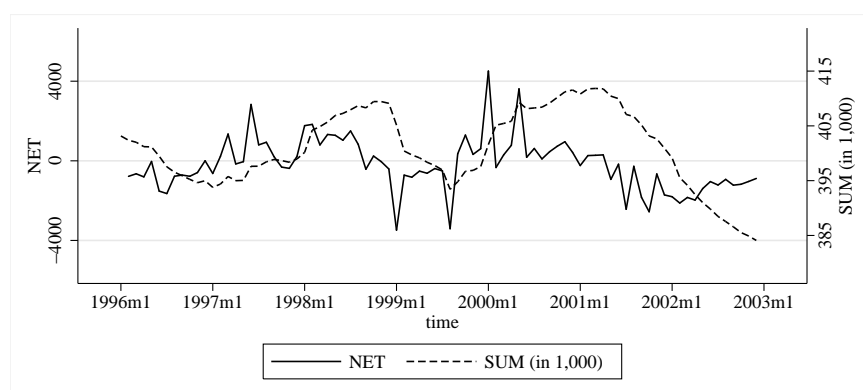
**Figure 4.32:** Development of job and employment flows, LIAB LM1, manufacturing 15-37 D, full sample



(a) Fraction of job creating and job destructing establishments



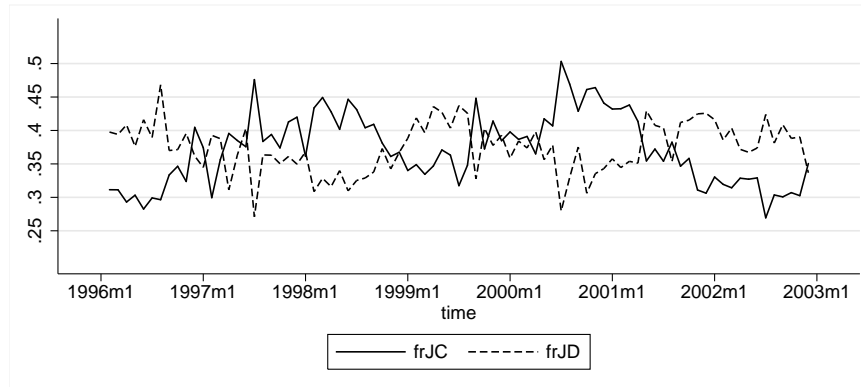
(b) Absolute job creation and destruction



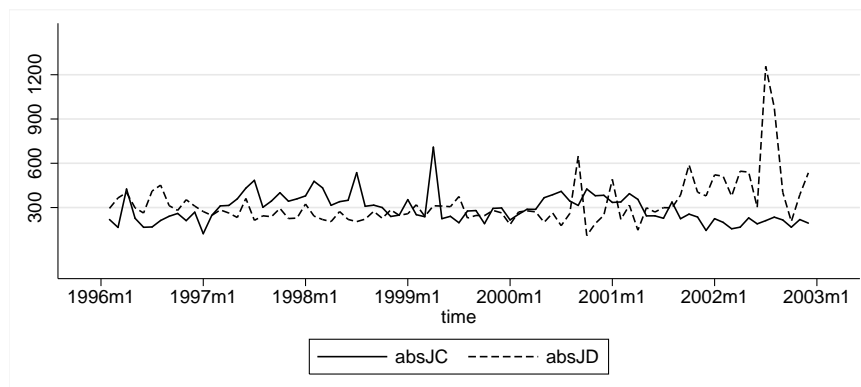
(c) Aggregate employment and employment change

Code of the manufacturing sub-industries according to the German Classification of Economic Activities, Edition 1993 (WZ93). Seasonally-adjusted monthly averages.

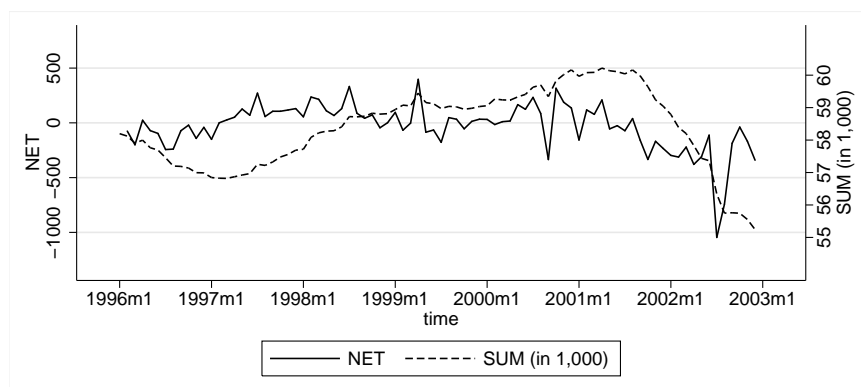
**Figure 4.33:** Development of job and employment flows, LIAB LM1, manufacturing 27-28 DJ, full sample



**(a)** Fraction of job creating and job destructing establishments



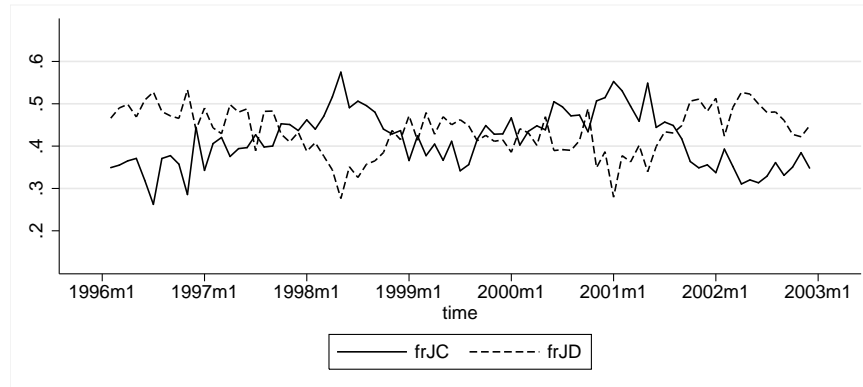
**(b)** Absolute job creation and destruction



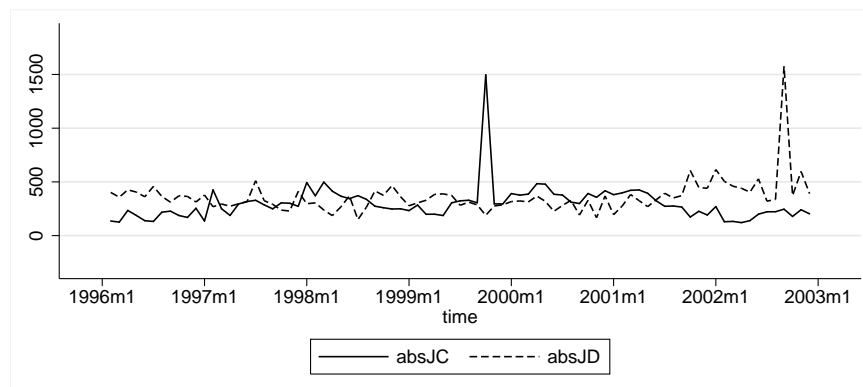
**(c)** Aggregate employment and employment change

Code of the manufacturing sub-industries according to the German Classification of Economic Activities, Edition 1993 (WZ93). Seasonally-adjusted monthly averages.

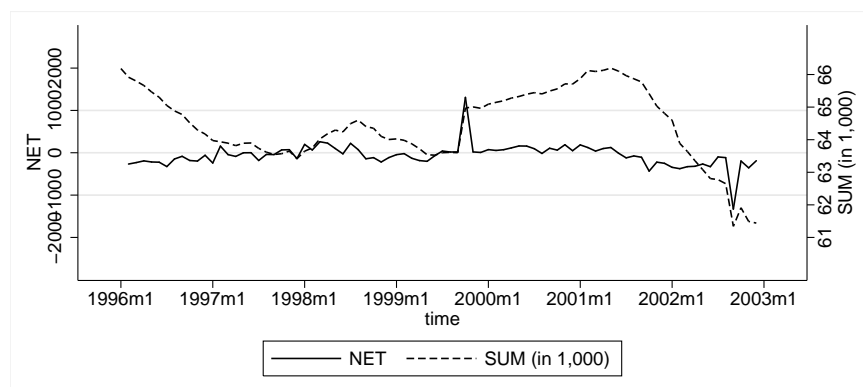
**Figure 4.34:** Development of job and employment flows, LIAB LM1, manufacturing 29 DK, full sample



(a) Fraction of job creating and job destructing establishments



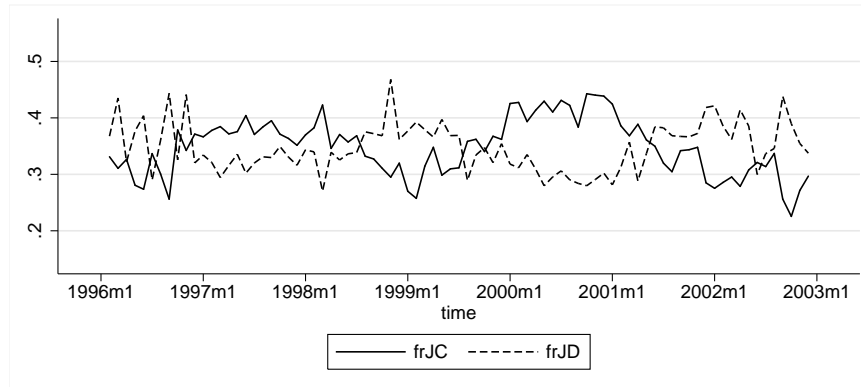
(b) Absolute job creation and destruction



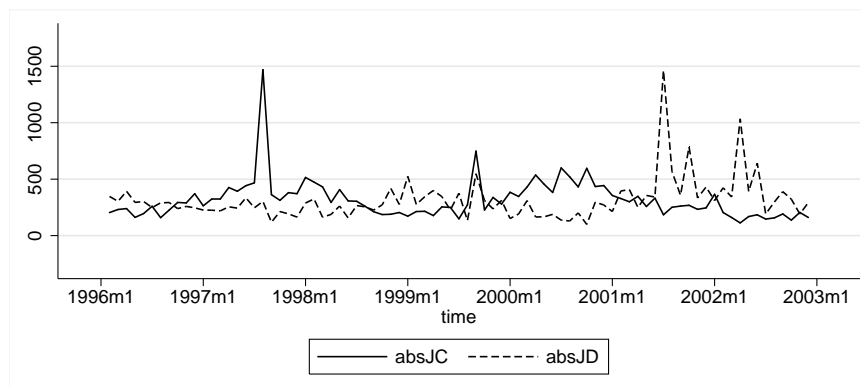
(c) Aggregate employment and employment change

Code of the manufacturing sub-industries according to the German Classification of Economic Activities, Edition 1993 (WZ93). Seasonally-adjusted monthly averages.

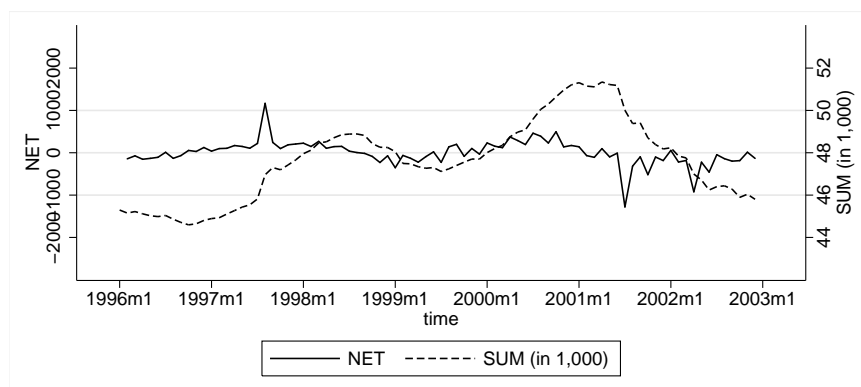
**Figure 4.35:** Development of job and employment flows, LIAB LM1, manufacturing 30-33 DL, full sample



**(a)** Fraction of job creating and job destructing establishments



**(b)** Absolute job creation and destruction



**(c)** Aggregate employment and employment change

Code of the manufacturing sub-industries according to the German Classification of Economic Activities, Edition 1993 (WZ93). Seasonally-adjusted monthly averages.





## Chapter 5

# Union Membership, Employment Dynamics and Bargaining Structure

## 5.1 Introduction

The seminal work on intertemporal union behaviour by Jones (1987) and Kidd and Oswald (1987) (henceforth JKO) states that conventional static models overrate the distortions caused by monopoly unionism. This result stems from the assumption that unemployed workers leave their union, which makes that union membership depends on employment. Therefore, a union actually faces an intertemporal optimization problem and needs to balance the gains from higher wages not only against immediate lower employment but also against the resulting shrinkage of the union. Hence, in comparison with static models, the union has an extra incentive to keep up employment.

Considering membership dynamics is important to better understand intertemporal union behaviour. JKO implicitly make two nontrivial assumptions, though. First, wage setting takes place at the firm level. This assumption implies a large number of small unions each of which has a negligible impact on the workers' outside option. Second, JKO assume that all unemployed workers immediately leave the union after losing their jobs in the unionized sector.

These assumptions, however, do not necessarily meet the empirical facts. It is well-known that OECD countries differ in their degree of bargaining centralization. While there is decentralized bargaining at the firm level in Canada, Japan, the United States, and the United Kingdom, we find centralized wage setting, for example, in Belgium and Norway (see Visser, 2011, for a recent survey). Moreover, there is an intermediate form of wage bargaining at the branch level that is typical for some continental European countries. The macroeconomic

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\* This chapter is based on joint work with Jun.-Prof. Dr. Marcus Dittrich (address: Chemnitz University of Technology, Department of Economics, Junior Professorship of European Economics, Thueringer Weg 7, D-09126 Chemnitz). It is in particular based on Dittrich, Marcus and Beate Schirwitz, 2011a, "Union membership and employment dynamics: A note," *Economics Letters* 110(1):38–40, but extended and modified borrowing partly from Dittrich, Marcus and Beate Schirwitz, 2011b, "Union – the bigger, the worse?" *Journal of Economic Research* 16(3):231–255.

importance of differing degrees of bargaining centralization was first highlighted by Calmfors and Driffill (1988). They postulate that the stage at which wage setting takes place is crucial for the labour market outcome of union-firm negotiations.<sup>1</sup> The second assumption rests upon observations that changes in union membership move with changes in unemployment (Booth, 1983; Carruth and Disney, 1988). However, recent empirical evidence shows that a significant fraction of workers stay in the union even after having lost their union jobs. In countries like Belgium, Denmark, Finland or Sweden, for instance, 80 % of the unemployed keep organized in unions (Visser, 2006).

This chapter expands the JKO framework to meet these empirical facts. We construct a general model where we analyse the employment effects resulting from both decentralized and centralized union behaviour. In this latter scenario, a large centralized union takes into account that employment decisions in the unionized sector directly influence the workers' outside option. Furthermore, we assume that only a fraction of those workers who lose their jobs in the unionized sector quit union membership. Employing these extensions, we find that the results of JKO are not universally valid. They only apply unconditionally if employment setting takes place by decentralized monopoly unions at the firm level. In an economy with centralized employment setting, however, static models may even underrate distortions caused by monopoly unions. The employment effects then depend on both the wage elasticity in the competitive sector and the union's time preference rate. In extension to Dittich and Schirwitz (2011a) we expand our analysis also to efficient bargaining where employment and wages are set simultaneously. We find that despite corresponding employment effects the influence of membership dynamics on labour market distortions is quite inverse in both frameworks. Additionally comparative static examinations complement our analysis. In particular, we examine the effects of endogenous union membership on wages and employment and show that a higher exit rate of union members has mixed employment effects depending on the degree of centralization.

The chapter is organized as follows: Section 5.2 sets up the model. Sections 5.3 and 5.4 analyse the labour market outcome in a monopoly union and an efficient bargaining approach, respectively. Section 5.5 discusses the economic intuition behind our main results. In Section 5.6, a comparative static analysis is conducted while Section 5.7 concludes.

## 5.2 The model

### 5.2.1 Firms and unions

We consider an economy with a unionized and a competitive sector. There is a large number  $\gamma$  of identical union-firm pairs in the unionized sector. The number of firms in the competitive

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<sup>1</sup> Other strands of the trade union literature have shown that the stage of bargaining also matters beyond employment decisions, see, e.g., Donado and Wälde (forthcoming) for a recent work on occupational health and safety.

sector is normalized to unity. The economy is inhabited by  $z$  identical, risk-neutral workers,<sup>2</sup> each of them inelastically supplying one unit of labour. For each period  $t$ , the number of workers in a union-firm is given by  $n_t$ . Those  $c_t = z - \gamma n_t$  workers who are not employed in the unionized sector move to the competitive sector operating as residual labour market. The respective isoelastic production functions of a representative firm in the unionized and the competitive sector are denoted by  $f(n_t)$  and  $g(c_t)$ .<sup>3</sup> The exogenous output price is normalized to one. Firms' profit maximizing labour demand in the unionized sector follows from the marginal productivity condition

$$f'(n_t) = w_t. \quad (5.1)$$

Furthermore let  $\eta_n^w \equiv \frac{\partial w}{\partial n} \frac{n}{w} \in ]-1, 0[$  indicate the constant elasticity of the resulting wage with respect to employment.

Since labour supply in the competitive sector is given by the residual workers not employed in any unionized firm, the competitive wage  $b_t$  adjusts such that

$$b_t = g'(z - \gamma n_t). \quad (5.2)$$

The constant elasticity of the competitive wage with respect to changes in employment there is denoted with  $\eta_c^b \equiv \frac{\partial b}{\partial c} \frac{c}{b} \in ]-1, 0[$ .

Utilitarian unions maximize the utility sum of their members, which for risk-averse workers equals the wage sum. With  $m_t$  denoting membership, union's utility in  $t$  is described by

$$u_t = n_t[w_t - b_t] + m_t b_t. \quad (5.3)$$

In accordance with JKO, a union does not only care about current but also about future utility. Union's objective function is hence the intertemporal notation of (5.3):

$$v = \int_0^\infty u_t e^{-rt} dt, \quad (5.4)$$

with  $r$  representing the time preference rate.

Given the assumptions of  $\gamma$  identical firms and unions and  $z$  as the total number of workers in the economy,  $\tilde{m} \equiv \frac{z}{\gamma}$  denotes the exogenous potential labour force in each union-firm. Hence,  $\tilde{m}$  represents the maximum number of a single union's members. To meet the empirical facts discussed above, we consider that some of the workers not employed in the unionized sector

<sup>2</sup> Assuming risk-aversion would not change the qualitative results of our analysis but introduce additional terms into the derivatives, therewith complicating the evaluation.

<sup>3</sup> Dittrich and Schirwitz (2011a) in particular employed the Cobb-Douglas specifications  $f(n_t) = n_t^\alpha$  and  $g(c_t) = c_t^\beta$ .

quit their membership, that is,  $m_t \leq \tilde{m}$ . However, while JKO assume that all these workers leave the union, we instead suggest that only a fraction of them quit their membership. In particular, we denote the fraction of workers that stick to the union even if losing their jobs in the unionized sector with  $\sigma \in [0, 1[$ .<sup>4</sup> Accordingly, the evolution in union membership over time is described as

$$m_t = n_{t-1} + \sigma[\tilde{m} - n_{t-1}]. \quad (5.5)$$

That is, union membership in  $t$  results from previous period's number of employed workers in the unionized sector ( $n_{t-1}$ ) plus a fraction  $\sigma$  of the remaining workers ( $\tilde{m} - n_{t-1}$ ) in the competitive sector. As shown in Appendix 5.A, with transition to continuous time membership dynamics becomes

$$\dot{m} = [1 - \sigma]n - m + \sigma\tilde{m}, \quad (5.6)$$

where the time index is suppressed for notational reasons.

### 5.2.2 Employment and wage determination

We employ the dynamic formulation of the standard monopoly union model (McDonald and Solow, 1981) proposed by JKO as well as that of the efficient wage bargains additionally found in Kidd and Oswald (1987). For each case, we develop a general framework from which we can derive two different scenarios: First, following JKO, employment determination takes place at the firm level. As there is a large number of union-firm pairs in the unionized sector, each small union neglects the consequences of its decision on wage and employment in the competitive sector. Second, taking into account the empirical evidence for a sizeable number of countries, we consider centralized employment determination for the whole unionized sector. In this case, one large union represents all  $\gamma$  firm-unions. This union explicitly takes into account that setting a lower employment level in the unionized sector increases labour supply in the competitive sector which decreases the competitive wage and therefore lowers its remaining members' outside option. Accordingly, both scenarios differ in two respects: (i) the number of firm-unions included, and (ii) the considered functional relationship between employment in the unionized sector and the wage in the competitive sector.

We define  $\phi_i$  representing the different number of unions included in the analysis, where  $i = \{d, c\}$  denotes the decentralized and the centralized case, respectively. In particular,

$$\phi_i = \begin{cases} 1 & \text{if } i = d \\ \gamma & \text{if } i = c. \end{cases}$$

<sup>4</sup> To keep the analysis simple we assume  $\sigma$  to be exogenous. Endogenising union density, as proposed by Chang and Lai (1997), would not change our results qualitatively.

The second difference between decentralized and centralized unions rests upon their considered influence on the competitive sector. In particular, in the decentralized case each firm-union takes the competitive wage as given. The centralized union, however, explicitly considers the relationship between wages and employment in both sectors expressed by (5.2):

$$b_i(n) = \begin{cases} \bar{b} & \text{if } i = d \\ g'(z - \gamma n) & \text{if } i = c. \end{cases}$$

### 5.3 Employment setting by a monopoly union

Monopoly unions set the wage or employment in the unionized sector considering the firms' marginal productivity condition (5.1), that is, wage and employment determination are interchangeable. For ease of comparison with JKO, we set up the model in terms of employment. Hence, we formulate the union's general maximization problem:

$$\begin{aligned} \max_n \int_0^\infty \phi_i [n[w - b_i(n)] + mb_i(n)] e^{-rt} dt \\ \text{s. t. } w = f'(n) \\ \dot{m} = [1 - \sigma]n - m + \sigma \tilde{m}. \end{aligned} \quad (5.7)$$

Let  $\lambda$  be the co-state variable. The present value Hamiltonian for (5.7) is given by

$$\mathcal{H} = \phi_i [n[f'(n) - b_i(n)] + mb_i(n)] e^{-rt} + \lambda [[1 - \sigma]n - m + \sigma \tilde{m}],$$

and the first order conditions include

$$\mathcal{H}_n = \phi_i [f'(n) + nf''(n) - b_i(n) + [m - n]b'_i(n)] e^{-rt} + \lambda [1 - \sigma] = 0 \quad (5.8)$$

$$\mathcal{H}_m = \phi_i b_i(n) e^{-rt} - \lambda = -\dot{\lambda} \quad (5.9)$$

Using (5.8) to eliminate  $\lambda$  and  $\dot{\lambda}$  in (5.9), as shown in more detail in Appendix 5.B the optimal time path for employment is given by

$$\dot{n} = \frac{1+r}{\delta(n)} \left[ f'(n)[1 + \eta_n^w] - \frac{\sigma+r}{1+r} b_i(n) + [m-n]b'_i(n) \right], \quad (5.10)$$

with  $\delta(n) = f''(n)[1 + \eta_n^w] - 2b'_i(n) + [m-n]b''_i(n)$ . In the steady state,  $\dot{n} = 0$  holds. The corresponding equilibrium employment – subject to the respective centralization regime  $i$  –

is therefore implicitly represented by

$$f'(n_i) = \left[ \frac{\sigma + r}{1 + r} b_i(n_i) - [m_i - n_i] b'_i(n_i) \right] \frac{1}{1 + \eta_n^w}. \quad (5.11)$$

The focus in this chapter is on these steady state results in the various scenarios, but there is a discussion on the dynamics towards these long-run equilibria in Appendix 5.C.

We can now derive equilibrium employment with decentralized unions as a special case of (5.11). Considering  $b'_d(n) = 0$  from each union's viewpoint if employment is determined on the firm level, in accordance with JKO we end up in:

$$f'(n_d) = \frac{\sigma + r}{1 + r} \frac{1}{1 + \eta_n^w} b_d. \quad (5.12)$$

The mark-up  $\frac{\sigma + r}{1 + r} \frac{1}{1 + \eta_n^w} > 1$  set on the competitive wage indicates the distortion that unions generate on labour allocation compared to a pure competitive framework.<sup>5</sup> To see this, note that although each small union considers  $b_d$  to be exogenous, in a macroeconomic perspective also the wage in the competitive sector is determined endogenously, that is,  $b_d = g'(z - \gamma n_d)$ . It is well-known that efficiency in terms of optimal resource allocation requires the equality of the marginal product of labour in both sectors. Apparently this is only warranted then if  $f'(n_d) = b_d$ . Any mark-up which exceeds unity implies inefficiently low employment in the unionized sector. Because the marginal productivity condition (5.1) holds in the monopoly union framework, the mark-up also indicates that the union wage exceeds the competitive wage.<sup>6</sup>

The equivalent static solution of an employment setting monopoly union, which can be derived by maximizing (5.3) and ignoring membership dynamics, is given by  $f'(n_d^{stat}) = \frac{1}{1 + \eta_n^w} b_d^{stat}$ . Compared to (5.12), it is easy to see that with decentralized unions JKO's finding that static models overrate the distortions caused by unionism also holds in our more general case with  $0 \leq \sigma < 1$ .

Analysing a centralized union representing all firm-unions, however, we have to take into account the competitive wage as a function of unionized employment. A change in this wage due to a change in unionized employment is expressed by the derivative

<sup>5</sup> In line with JKO we only focus on this employment allocating effect of union behaviour. There is a rich strand of literature on additional efficiency effects unions generate. See, e.g., Boeri and van Ours (2008, Chap. 3.4.1) for an introductory discussion and literature survey.

<sup>6</sup> Note that our parameters' domain principally could cause  $\frac{\sigma + r}{1 + r} \frac{1}{1 + \eta_n^w} < 1$ , which indicated inefficiently high employment in the unionized sector. Anyway, because the marginal productivity conditions (5.1) and (5.2) hold, this would imply that wages in the unionized sector are lower than in the competitive sector. Because workers are free to move to the competitive sector (but the other way around is liable to unions' job rationing) that was no stable result; unions' market power is negligible in this parameter constellation. In the monopoly union framework we therefore refrain from mark-ups which fall below unity.

of (5.2):

$$b'_c(n) = -\gamma g''(z - \gamma n) > 0. \quad (5.13)$$

Since in long-run equilibrium also  $\dot{m} = 0$  holds, we find from (5.6) that  $m - n = \sigma[\tilde{m} - n]$ . Inserting into (5.11) and using  $\tilde{m} \equiv \frac{z}{\gamma}$  together with (5.13) allows to calculate employment set by a centralized union:

$$f'(n_c) = \left[ \frac{\sigma + r}{1 + r} + \sigma \eta_c^b \right] \frac{1}{1 + \eta_L^w} g'(z - \gamma n_c). \quad (5.14)$$

**Proposition 5.1.** *If monopoly unions consider membership dynamics in their employment setting decision, then employment in the unionized sector is higher with a centralized union than with firm-level unions.*

*Proof.* With (5.14), (5.12) and (5.2), Proposition 5.1 implies that

$$\frac{\sigma + r}{1 + r} \frac{1}{1 + \eta_n^w} g'(z - \gamma n_d) > \left[ \frac{\sigma + r}{1 + r} + \sigma \eta_c^b \right] \frac{1}{1 + \eta_L^w} g'(z - \gamma n_c). \quad (5.15)$$

Given the parameters' domain it holds that

$$\frac{\sigma + r}{1 + r} \frac{1}{1 + \eta_n^w} > \left[ \frac{\sigma + r}{1 + r} + \sigma \eta_c^b \right] \frac{1}{1 + \eta_n^w}.$$

Hence, for (5.15) to be false, that is,  $n_c < n_d$ , we had that

$$g'(z - \gamma n_c) > g'(z - \gamma n_d).$$

With diminishing returns to labour in turn, this implies the contradiction  $n_c > n_d$ , though. The same reasoning applies if we assumed  $n_c = n_d$ . Only if we consider (5.15) to be true, no inevitable contradiction applies.  $\square$

A second, more important result is found comparing static and dynamic optimization results. While JKO clearly state that (decentralized) unions maximizing an intertemporal utility function set higher employment, we find that centralized employment setting yields ambiguous results.

**Proposition 5.2.** *In case of centralized employment setting by monopoly unions conventional static models overrate the distortions caused by unions only if  $\eta_c^b > -\frac{1}{1+r}$ .*

*Proof.* Similar to the decentralized case, a central union's static utility maximization can be

derived employing an adapted version of (5.3) and ignoring membership dynamics,

$$\begin{aligned} & \max_n \gamma [n(w - b)] + mb \\ \text{s. t. } & w = f'(n) \\ & b = g'(z - \gamma n). \end{aligned}$$

If we additionally consider that in the static case without membership quits  $m = \frac{z}{\gamma}$ , we find that

$$f'(n_c^{stat}) = [1 + \eta_c^b] \frac{1}{1 + \eta_n^w} g'(z - \gamma n_c^{stat}), \quad (5.16)$$

see also Dittrich (2008). Comparing the mark-up on the competitive sector's marginal labour product in (5.16) and (5.14), respectively, shows that the latter is smaller than the former only if

$$-\eta_c^b < \frac{1}{1 + r}. \quad (5.17)$$

□

Hence, if the absolute value of the wage elasticity in the competitive sector  $\eta_c^b$  is high enough compared to the union's time preference rate  $r$ , conventional static models may even underrate the distortions caused by unions.

**Proposition 5.3.** *For the decentralized monopoly union, employment in the unionized sector is higher in the dynamic compared to the static framework, while this holds for the centralized monopoly union only if  $\eta_c^b > -\frac{1}{1+r}$ .*

*Proof.* This follows adapting the reasoning which proved Proposition 5.1 and considering the proof of Proposition 5.2. □

## 5.4 Bargaining over employment and wages

In an alternative setup wage and employment decisions are made separately, hence the solution is not restricted to the marginal productivity condition (5.1). However, it must be warranted that the firm realizes some minimum profit level  $\bar{\Pi}$  (Kidd and Oswald, 1987). Otherwise in this efficiency bargaining set-up the same assumptions apply like in the monopoly



union framework. The maximization can thus be formulated as follows:

$$\begin{aligned} \max_n \int_0^\infty \phi_i [n[w - b_i(n)] + mb_i(n)] e^{-rt} dt \\ \text{s. t. } \phi_i \int_0^\infty [f(n) - wn] e^{-rt} dt \geq \phi_i \bar{\Pi} \\ \dot{m} = [1 - \sigma]n - m + \sigma \tilde{m}. \end{aligned} \quad (5.18)$$

The corresponding Hamiltonian which reflects the dynamic part of the maximization is given by

$$\mathcal{H} = \phi_i [n[w - b_i(n)] + mb_i(n)] e^{-rt} + \mu \phi_i [f(n) - wn] e^{-rt} + \lambda [[1 - \sigma]n - m + \sigma \tilde{m}],$$

where  $\mu$  is a multiplier that does not depend on time. Hence, we end up with the following first order conditions:

$$\frac{\partial \mathcal{H}}{\partial n} = \phi_i [w - b_i(n) + [m - n]b'_i(n)] + \mu \phi_i [f'(n) - w] + \lambda [1 - \sigma]e^{rt} = 0 \quad (5.19)$$

$$\frac{\partial \mathcal{H}}{\partial w} = \phi_i n e^{-rt} - \mu \phi_i n e^{-rt} = 0 \quad (5.20)$$

$$\frac{\partial \mathcal{H}}{\partial m} = \phi_i b_i(n) e^{-rt} - \lambda = -\dot{\lambda}. \quad (5.21)$$

Differentiating (5.19) with respect to time and combining with (5.19), (5.20) and (5.21) yields an equation defining the optimal employment movement (consult Appendix 5.D for the details):

$$\dot{n} = \frac{1+r}{\kappa(n)} \left[ f'(n) - \frac{\sigma+r}{1+r} b_i(n) + [m-n]b'_i(n) \right], \quad (5.22)$$

with  $\kappa(n) = f''(n) - 2b'_i(n) + [m-n]b''_i(n)$ . Accordingly, in the steady-state where  $\dot{n} = 0$  we have

$$f'(n_i) = \frac{\sigma+r}{1+r} b_i(n) - [m-n_i]b'_i(n_i), \quad (5.23)$$

again subject to the respective centralization regime  $i$ . Note that (5.23) is equivalent to the contract curve known from the efficient bargaining literature (McDonald and Solow, 1981).<sup>7</sup>

We can employ (5.23) to derive equilibrium employment with decentralized unions considering  $b'_d(n) = 0$  from each union's viewpoint:

$$f'(n_d) = \frac{\sigma+r}{1+r} b_d. \quad (5.24)$$

<sup>7</sup> Our focus is on optimal employment but note that the complete wage-employment combination is determined by the intersection of the contract curve and the rent division curve not derived here. It is a weighted average of the marginal and the average product of labour which depends on the bargaining strengths of both parties (Booth, 1995). In our model the solution is implicitly given combining (5.23) with the firms' minimum profit constraint of the maximization problem (5.18).

The equivalent static solution is found by maximizing (5.3) with respect to  $w$  and  $n$ , subject to the minimum profit constraint. This yields  $f'(n_d^{stat}) = b_d^{stat}$  – with risk-neutral agents and static optimization the derived employment level corresponds to the competitive solution. The dynamic result instead sets the mark-up  $\frac{\sigma+r}{1+r} < 1$  on the competitive wage.<sup>8</sup> Like already Kidd and Oswald (1987) noted for  $\sigma = 0$ , this indicates that employment is higher in the dynamic compared to the static case. Nonetheless, and not considered by these authors, in terms of efficiency the static solution outmatches the dynamic one. In the latter, employment in the unionized sector indeed is too high: The redundant workers' productivity would go up if they switched into the competitive sector. Hence we conclude that for decentralized simultaneous bargaining over employment and wages static models underrate both employment in the unionized sector as well as the distortionary effects of unionism.

Finally we examine the wage and employment setting of a large union covering all workers. As in the monopoly union case, (5.13) applies. In the long-run equilibrium also  $\dot{m} = 0$  which from (5.6) gives that  $m - n = \sigma[\tilde{m} - n]$ . Using additionally that  $\tilde{m} \equiv \frac{z}{\gamma}$ , (5.23) results in

$$f'(n_c) = \left[ \frac{\sigma + r}{1 + r} + \sigma \eta_c^b \right] g'(z - \gamma n_c). \quad (5.25)$$

We hence can confirm our first finding from the monopoly union also in the efficient bargaining framework:

**Proposition 5.4.** *If unions and firms bargain over both wage and employment, then employment in the unionized sector is higher with centralized than with decentralized bargaining.*

*Proof.* Equivalent to the proof of Proposition 5.1. □

Considering the efficiency effects, we find quite the opposite result of the monopoly union set-up:

**Proposition 5.5.** *In case of centralized wage and employment setting conventional static models overrate the distortions caused by unions only if  $\eta_c^b < -\frac{1}{1+r}$ .*

*Proof.* The equivalent static result is found solving

$$\begin{aligned} & \max_{n,w} \gamma [n(w - b)] + mb \\ \text{s. t. } & \gamma [f(n) - wn] = \gamma \bar{\Pi} \\ & b = g'(z - \gamma n), \end{aligned}$$

<sup>8</sup> Remember that in the efficient bargaining framework the unionized wage is determined separately and not dependent on the marginal productivity condition (5.1). Therefore also mark-ups which fall below unity are stable, contrary to the monopoly union set-up.

**Table 5.1:** Employment mark-ups compared to benchmark

	Static	Dynamic
Decentralized	1	$\frac{\sigma+r}{1+r}$
Centralized	$1 + \eta_c^b$	$\frac{\sigma+r}{1+r} + \sigma\eta_c^b$

which yields  $f'(n_c^{stat}) = [1 + \eta_c^b] g'(z - \gamma n_c^{stat})$ . Likewise to the decentralized framework this includes a mark-up which is smaller than one and therefore indicates an inefficiently high number of workers in the unionized sector. Hence for the static set-up to overrate unionism's distortions on the labour market outcome we need that

$$(0 <) \quad 1 + \eta_c^b < \frac{\sigma + r}{1 + r} + \sigma\eta_c^b \quad (< 1),$$

which is equivalent to

$$\eta_c^b < -\frac{1}{1+r}.$$

□

**Proposition 5.6.** *For decentralized bargaining of wage and employment, employment in the unionized sector is higher in the dynamic compared to the static framework, while this holds for centralized bargaining only if  $\eta_c^b > -\frac{1}{1+r}$ .*

*Proof.* This follows adapting the reasoning which proved Proposition 5.1 and considering the proof of Proposition 5.5. □

## 5.5 Discussion – static vs. dynamic optimization results

To understand the economic intuition behind our results, Table 5.1 summarizes the mark-ups on the competitive wage in the respective scenarios. The decentralized union's employment condition in the static case, that is,  $f'(n_d^{stat}) = \frac{1}{1+\eta_n^w}b$  in the monopoly union case as well as  $f'(n_d^{stat}) = b$  for simultaneous setting of employment and wages, are used as benchmark.

Decentralized unions obviously choose higher employment if they maximise a dynamic utility function taking membership dynamics into account. This result is driven by the “intertemporal” mark-up  $\frac{\sigma+r}{1+r} < 1$ . The more the union values future losses in membership, that is, if  $r$  is low, the more it is willing to prevent these losses by setting higher employment. For decentralized unions, (5.12) and (5.24) therefore replicate JKO's result.

However, the picture is less clear for a centralized union which considers its members' outside option. In general, the union's influence on the competitive wage depends on its elasticity with respect to changes in employment there.<sup>9</sup> For rather elastic wage elasticity, that is, for large values of  $|\eta_c^b|$ , a small decrease in competitive employment induced by a small increase in unionized employment yields a relatively large increase in the competitive wage. Taking this effect into account, the union has an incentive to increase unionized employment. In the static case, this effect is represented by the "centralization" mark-up  $1 + \eta_c^b$ . In the dynamic scenario, employment is driven by two mark-ups. The intertemporal mark-up  $\frac{\sigma+r}{1+r}$  is the same as in the decentralized case. The centralization mark-up  $\sigma\eta_c^b$ , however, differs from the static case: The more workers leave the union, the less the union cares about the competitive sector. For any given  $\sigma < 1$ , the centralization mark-up is thus less effective in the dynamic than in the static scenario because there are less members in the competitive sector.

A consolidated view indicates that, on the one hand, the intertemporal mark-up yields higher employment in the dynamic framework. On the other hand, the centralization mark-up is more effective in the static framework. Depending on  $\eta_c^b$ , unionized employment might already be high in the static framework. Hence, a static model understates unionized employment caused by centralized unions only if  $|\eta_c^b|$  or  $r$  are low enough. If  $r$  is high, however, the union's loss from membership quits takes place in the less valued future. Today's wage gain in the union sector resulting from lower employment might then be high enough to push employment in the dynamic case below the static one.

The conclusions which follow from these findings to the evaluation of labour market distortions depend on the scope of bargaining. In the monopoly union framework distortions stem from inefficiently low employment in the unionized sector. Simultaneous bargaining over wage and employment in contrast tends to produce over-employment there. Therefore opposing results concerning the extent of distortions in the centralized vs. decentralized framework apply.

## 5.6 Comparative Statics

Finally we analyze the impact of exogenous changes in the membership loyalty rate ( $\sigma$ ), the time preference rate ( $r$ ) and the number of unionized firms ( $\gamma$ ) on the labour market outcomes. We present results for the monopoly union case only. As the optimal employment conditions for the monopoly union and efficient bargaining just differ by the positive factor  $\frac{1}{1+\eta_n^w}$ , the qualitative results are equal in both frameworks.

<sup>9</sup> For ease of comparison with Dittrich and Schirwitz (2011a) note that the wage elasticity with respect to employment is the inverse of the labour demand elasticity with respect to the wage.

## Decentralized Employment Setting

In response to marginal changes in the exogenous parameters, employment responses in the unionized sector with a monopoly union are given by

$$\frac{\partial n^d}{\partial \sigma} = \frac{\frac{1}{1+r} \frac{1}{1+\eta_n^w} g'(z - \gamma n)}{f''(n) + \frac{\sigma+r}{1+r} \frac{1}{1+\eta_n^w} g''(z - \gamma n)\gamma} < 0, \quad (5.26)$$

$$\frac{\partial n^d}{\partial r} = \frac{\frac{1-\sigma}{(1+r)^2} \frac{1}{1+\eta_n^w} g'(z - \gamma n)}{f''(n) + \frac{\sigma+r}{1+r} \frac{1}{1+\eta_n^w} g''(z - \gamma n)\gamma} < 0, \quad (5.27)$$

$$\frac{\partial n^d}{\partial \gamma} = -\frac{\frac{\sigma+r}{1+r} \frac{1}{1+\eta_n^w} g''(z - \gamma n)n}{f''(n) + \frac{\sigma+r}{1+r} \frac{1}{1+\eta_n^w} g''(z - \gamma n)\gamma} < 0. \quad (5.28)$$

Employing  $c = z - \gamma n$ , the corresponding reactions in the competitive sector are

$$\frac{\partial c^d}{\partial \sigma} = \frac{-\frac{1}{1+r} \frac{1}{1+\eta_n^w} g'(z - \gamma n)\gamma}{f''(n) + \frac{\sigma+r}{1+r} \frac{1}{1+\eta_n^w} g''(z - \gamma n)\gamma} > 0, \quad (5.29)$$

$$\frac{\partial c^d}{\partial r} = \frac{-\frac{1-\sigma}{(1+r)^2} \frac{1}{1+\eta_n^w} g'(z - \gamma n)\gamma}{f''(n) + \frac{\sigma+r}{1+r} \frac{1}{1+\eta_n^w} g''(z - \gamma n)\gamma} > 0, \quad (5.30)$$

$$\frac{\partial c^d}{\partial \gamma} = \frac{f''(n) \frac{c-z}{\gamma}}{f''(n) + \frac{\sigma+r}{1+r} \frac{1}{1+\eta_n^w} g''(z - \gamma n)\gamma} < 0. \quad (5.31)$$

From the marginal productivity condition in the monopoly union case and the fixed profit level  $\bar{\Pi}$  the firm obtains in the efficient bargaining framework, we find that there is an inverse relationship between wages and employment. Hence, negative responses of employment to a marginal change in an exogenous parameter are equivalent to a positive effect on the respective wage rate, and vice versa.

As (5.26) suggests, the number of workers per unionized firm falls in response to a higher  $\sigma$ . A rise in  $\sigma$  means that fewer workers in the competitive sector leave the union. Therefore, its future utility loss due to membership quits in reaction to reduced employment in the unionized sector declines. Correspondingly, the number of workers in the competitive sector goes up, as confirmed by (5.29). Note that  $\sigma \rightarrow 1$  effectively approaches the static case, as membership dynamics fade away.

The arguments concerning a rise in  $r$  are quite similar. The higher the time preference rate, the more the union appreciates present compared to future utility gains, which in the limit

again converges towards the static scenario. But the less the union weights later wage sum losses due to membership quits, the more it will appreciate a high current wage rate  $w$ . Accordingly,  $n$  is smaller leading to a higher  $c$ , see (5.27) and (5.30).

As (5.28) shows, a higher number  $\gamma$  of firms in the unionized sector leads to an employment decline in each of these firms. This is due to the fact that the individual firm's negative influence on the competitive sector wage rate  $b = g'(z - \gamma n)$  is dampened if more of them exist. Even if the single union ignores this effect in its optimizing behaviour, finally it adapts its employment demand to the resulting, endogenously determined  $b$ . But for higher  $\gamma$  it then is less costly in terms of union's utility to let workers switch sectors. This drives down employment per firm. However, as (5.31) indicates, residual employment in the competitive labour market likewise falls in response to a higher  $\gamma$ . This in turn implies that the firm-level employment decreases in the unionized sector are more than compensated by the according rise in the number of firms there, that is,  $\frac{\partial \gamma n}{\partial \gamma} > 0$ .

### Centralized Employment Setting

If unionized employment is determined centralized, the effects in response to changes in the exogenous parameters in particular for the monopoly union framework are as follows:

$$\frac{\partial n^c}{\partial \sigma} = \frac{\left[ \frac{1}{1+r} + \eta_c^b \right] \frac{1}{1+\eta_n^w} g'(z - \gamma n)}{f''(n) + \left[ \frac{\sigma+r}{1+r} + \sigma \eta_c^b \right] \frac{\eta_w^L}{1+\eta_n^w} g''(z - \gamma n) \gamma} \gtrless 0, \quad (5.32)$$

$$\frac{\partial n^c}{\partial r} = \frac{\frac{1-\sigma}{(1+r)^2} \frac{1}{1+\eta_n^w} g'(z - \gamma n)}{f''(n) + \left[ \frac{\sigma+r}{1+r} + \sigma \eta_c^b \right] \frac{1}{1+\eta_n^w} g''(z - \gamma n) \gamma} < 0, \quad (5.33)$$

$$\frac{\partial n^c}{\partial \gamma} = - \frac{\left[ \frac{\sigma+r}{1+r} + \sigma \eta_c^b \right] \frac{1}{1+\eta_n^w} g''(z - \gamma n) n}{f''(n) + \left[ \frac{\sigma+r}{1+r} + \sigma \eta_c^b \right] \frac{1}{1+\eta_n^w} g''(z - \gamma n) \gamma} < 0. \quad (5.34)$$

Employment in the competitive labour market changes in turn according to

$$\frac{\partial c^c}{\partial \sigma} = \frac{- \left[ \frac{1}{1+r} + \eta_c^b \right] \frac{1}{1+\eta_n^w} g'(z - \gamma n) \gamma}{f''(n) + \left[ \frac{\sigma+r}{1+r} + \sigma \eta_c^b \right] \frac{1}{1+\eta_n^w} g''(z - \gamma n) \gamma} \lesseqgtr 0, \quad (5.35)$$

$$\frac{\partial c^c}{\partial r} = \frac{- \frac{1-\sigma}{(1+r)^2} \frac{1}{1+\eta_n^w} g'(z - \gamma n) \gamma}{f''(n) + \left[ \frac{\sigma+r}{1+r} + \sigma \eta_c^b \right] \frac{1}{1+\eta_n^w} g''(z - \gamma n) \gamma} > 0, \quad (5.36)$$

$$\frac{\partial c^c}{\partial \gamma} = - \frac{f''(n) \frac{c-z}{\gamma}}{f''(n) + \left[ \frac{\sigma+r}{1+r} + \sigma \eta_c^b \right] \frac{1}{1+\eta_n^w} g''(z - \gamma n) \gamma} < 0. \quad (5.37)$$

In contrast to the decentralized framework, employment responses to a variation of  $\sigma$  are ambiguous for a centralized union. The inclusion of  $\eta_c^b < 0$  represents the centralization effect. From (5.32) we find that employment per unionized firm in accordance to the decentralized case will fall in response to a higher  $\sigma$  if  $-\eta_c^b < \frac{1}{1+r}$ . That is the same condition which ensured higher employment in the dynamic compared to the static case, see Section 5.5. For rather elastic wage elasticity, however, that is, for large values of  $|\eta_c^b|$  compared to  $r$ , a small decrease in competitive employment (induced by a small increase in unionized employment) yields a relatively large increase in the competitive wage. As this is even more valuable for larger  $\sigma$ , it becomes profitable for the union to subtract employment in the competitive sector and instead pocket the resulting strong increase in  $b$ . Accordingly, the reaction on  $c$  always is the opposite of that on  $n$ , see also (5.35).

For the remaining parameters, the qualitative results from the decentralized framework also hold for a centralized union. Differences in the optimal results between both set-ups are reflected in small quantitative variations of the derivatives. Table 5.2 summarizes the qualitative comparative static effects.

**Table 5.2:** Comparative static effects for decentralized and centralized bargaining

	$\gamma$	$\sigma$	$r$
$n^d$	-	-	-
$n^c$	-	?	-
$\gamma n^d$	+	-	-
$\gamma n^c$	+	?	-
$c^d$	-	+	+
$c^c$	-	?	+

## 5.7 Conclusion

The paper provides some new insights in the discussion on labour market distortions caused by unionism. In accordance with the seminal works of Jones (1987) and Kidd and Oswald (1987) and recent empirical findings we presented a dynamic framework with a rather general setting of union dynamics. We have shown that JKO's findings that conventional static models overrate monopoly unionism's distortions might also hold if only a part of the displaced workers leave the union. However, this is only valid if employment setting takes place at the

firm level. Otherwise, in an economy with centralized employment setting, static models even may understate distortions caused by unions. The employment effects in a central employment setting scenario depend on the relationship between the wage elasticity in the competitive sector and the time preference rate. Furthermore we found that employment in the unionized sector is higher if employment is determined centralized for the whole sector. In contrast to a firm-level union, a centralized union considers the consequences of its employment setting behaviour on the outcome in the competitive sector and hence recommends higher unionized employment. Standard models with exogenous outside option can not capture this effect.

In addition to the monopoly union framework we extended our analysis to simultaneous bargaining on wage and employment. We found that the scope of bargaining is irrelevant for most of the results derived in the monopoly union case. However, it plays a decisive role in the evaluation of distortions caused by unions in the different scenarios. Comparative statics and discussions of the results complemented the analysis.



## Appendix 5.A Derivation of continuous time membership dynamics

Adjust (5.5) to  $t - 1$  and subtract from (5.5) to find

$$m_t - m_{t-1} = [1 - \sigma][n_{t-1} - n_{t-2}]. \quad (5.38)$$

With time periods of length  $\Delta$  this becomes

$$m_t - m_{t-\Delta} = [1 - \sigma][n_{t-1} - n_{t-1-\Delta}]$$

and hence

$$\frac{m_t - m_{t-\Delta}}{\Delta} = [1 - \sigma] \frac{[n_{t-1} - n_{t-1-\Delta}]}{\Delta}.$$

As  $\Delta \rightarrow 0$  we end up in

$$\dot{m}_t = [1 - \sigma]\dot{n}_{t-1}. \quad (5.39)$$

An alternative representation of  $m_t - m_{t-1}$  is found if  $m_{t-1}$  is directly subtracted from (5.5):

$$m_t - m_{t-1} = n_{t-1} + \sigma[\tilde{m} - n_{t-1}] - m_{t-1}. \quad (5.40)$$

Equating (5.38) and (5.40) we find that

$$n_{t-2} = \frac{m_{t-1} - \sigma\tilde{m}}{1 - \sigma}$$

and therefore

$$n_{t-1} - n_{t-2} = n_{t-1} - \frac{m_{t-1} - \sigma\tilde{m}}{1 - \sigma}.$$

Repeating the procedure from above gives

$$\begin{aligned} \frac{n_{t-1} - n_{t-1-\Delta}}{\Delta} &= \frac{\Delta \left[ n_{t-1} - \frac{m_{t-1} - \sigma\tilde{m}}{1 - \sigma} \right]}{\Delta} \\ &\Leftrightarrow \\ [1 - \sigma]\dot{n}_{t-1} &= [1 - \sigma]n_{t-1} - m_{t-1} - \sigma\tilde{m}. \end{aligned}$$

We insert this result in (5.39) to find

$$\dot{m}_t = [1 - \sigma]n_{t-1} - m_{t-1} - \sigma\tilde{m},$$

which suppressing the time indices equals (5.6) and is the adjusted version of JKO's membership dynamics.

## Appendix 5.B Derivation of optimal employment – monopoly union

To derive the optimal employment path with decentralized employment setting, we first solve (5.8) and (5.9) for  $\lambda$ ,

$$\begin{aligned}\lambda &= \phi_i \frac{e^{-rt}}{\sigma - 1} [f'(n) + n f''(n) - b_i(n) + [m - n] b'_i(n)] \\ &= \phi_i \frac{e^{-rt}}{\sigma - 1} [f'(n)[1 + \eta_n^n] - b_i(n) + [m - n] b'_i(n)] \\ \lambda &= \phi_i b_i(n) e^{-rt} + \dot{\lambda},\end{aligned}\tag{5.41}$$

where we employ  $-1 < \eta_n^w \equiv \frac{\partial w}{\partial n} \frac{n}{w} < 0$  and  $w = f'(n)$  for (5.41). Equating both results and in turn solving for  $\dot{\lambda}$  gives

$$\dot{\lambda} = \phi_i \frac{e^{-rt}}{\sigma - 1} [f'(n)[1 + \eta_n^n] + [m - n] b'_i(n) - \sigma b_i(n)].\tag{5.42}$$

A second equation for  $\dot{\lambda}$  is found by differentiating (5.41) with respect to  $t$ , considering that  $\eta_n^w$  is assumed to be constant and hence independent of  $n$ :

$$\begin{aligned}\dot{\lambda} &= \phi_i \frac{e^{-rt}}{\sigma - 1} [\dot{n} [f''(n)[1 + \eta_n^n] - 2b'_i(n) + [m - n] b''_i(n)] \\ &\quad - r [f'(n)[1 + \eta_n^n] - b_i(n) + [m - n] b'_i(n)]].\end{aligned}\tag{5.43}$$

Finally, equating (5.42) and (5.43), and solving for  $\dot{n}$  gives the optimal time path for the wage rate (5.10).

## Appendix 5.C Employment dynamics

For the monopoly union setup, (5.10) is a function  $\dot{n}_i(n_i)$  which describes the path of employment in a unionized firm towards its steady state (ss) value. Hence it holds that  $\dot{n}_i(n_i)|_{ss} = 0$ . Employing the implicit function rule we find that

$$\left. \frac{\partial \dot{n}_i}{\partial n_i} \right|_{\dot{n}_i=0} = [1 + r] \frac{f''(n_i)[1 + \eta_n^w] - [1 + \frac{\sigma+r}{1+r}] b'_i(n_i) + [m_i - n_i] b''_i(n_i)}{f''(n_i)[1 + \eta_n^w] - 2b'_i(n_i) + [m_i - n_i] b''_i(n_i)}\tag{5.44}$$

For the decentralized union  $b'_d(n_d) = 0$ , hence (5.44) becomes

$$\left. \frac{\partial \dot{n}_d}{\partial n_d} \right|_{\dot{n}_d=0} = 1 + r > 0,$$

which indicates that the adjustment path of  $n$  towards its steady state level is unstable. That is, if the number of employees starts outside this steady state value, employment would move ever further away from the optimal steady state level. To ensure that both the optimal steady state level as well as the optimal path condition are fulfilled, the employment level has to jump into its steady state level immediately.

For the centralized monopoly union in turn (5.13) holds, which disables any more appreciable simplification of (5.44). Note that nominator and denominator there differ only by  $\left[1 + \frac{\sigma+r}{1+r}\right] < 2$  in the middle term. Also note that the sum of the respectively first two terms unambiguously is smaller than zero, while the third term is indeterminated because of  $b''_i(n_i)$ . If nominator and denominator have equal signs, we end up with  $\left. \frac{\partial \dot{n}_i}{\partial n_i} \right|_{\dot{n}_i=0} > 0$  again, and the conclusions from the decentralized union case apply. A gradual adaptation towards steady state employment in contrast requires that  $b''_i(n_i) > 0$  as well as

$$-f''(n_i)[1 + \eta_n^w] + \left[1 + \frac{\sigma+r}{1+r}\right] b'_i(n_i) < [m_i - n_i] b''_i(n_i) < -f''(n_i)[1 + \eta_n^w] + 2b'_i(n_i),$$

which is equivalent to

$$\sigma < \frac{[1+r] \left[ f''(n_i)[1 + \eta_n^w] + [m_i - n_i] b''_i(n_i) \right] - b'_i(n_i)[1 + 2r]}{b'_i(n_i)} < 1.$$

Note that similar findings result considering the case of simultaneous bargaining for wage and employment.

## Appendix 5.D Derivation of optimal employment – bargaining over wages and employment

We start with reformulating (5.19) and inserting  $\mu = 1$  from (5.20):

$$\lambda = [f'(n) - b_i(n) + [m - n] b'_i(n)] \phi_i \frac{e^{-rt}}{\sigma - 1}. \quad (5.45)$$

Equating with (5.21) likewise solved for  $\lambda$  and rearrangements give

$$\dot{\lambda} = [f'(n) + [m - n] b'_i(n) - \sigma b_i(n)] \phi_i \frac{e^{-rt}}{\sigma - 1}. \quad (5.46)$$

Differentiating (5.45) with respect to  $t$  yields

$$\dot{\lambda} = \phi_i \frac{e^{-rt}}{\sigma - 1} [\dot{n} [f''(n) - 2b'_i(n) + [m - n]b''_i(n)] - r [f'(n) - b_i(n) + [m - n]b'_i(n)]] . \quad (5.47)$$

Equating (5.46) and (5.47) and solving for  $\dot{n}$  gives the optimal employment path with decentralized bargaining (5.22):

$$\dot{n} = \frac{1+r}{\delta} \left[ f'(n) - \frac{\sigma+r}{1+r} b_i(n) + [m-n]b'_i(n) \right] .$$

## Appendix 5.E Comparative statics

A higher number of firms in the unionized sector has a less stronger negative effect under centralized than under decentralized bargaining. In order to show that  $\frac{\partial n^d}{\partial \gamma} < \frac{\partial n^z}{\partial \gamma} < 0$  holds, we divide both (5.28) and (5.34) by  $-n \frac{1}{1+\eta_n^w} g''(z - \gamma n)$ . Comparing the results shows that

$$\frac{\frac{\frac{\sigma+r}{1+r}}{f''(n) + \frac{\sigma+r}{1+r} \frac{1}{1+\eta_n^w} g''(z - \gamma n) \gamma}} < \frac{\frac{\frac{\sigma+r}{1+r} + \sigma \eta_c^b}{f''(n) + \left[ \frac{\sigma+r}{1+r} + \sigma \eta_c^b \right] \frac{1}{1+\eta_n^w} g''(z - \gamma n) \gamma}} .$$

Rearranging gives  $\sigma \eta_c^b f''(n) > 0$ . This inequality always holds since both the elasticity and the second derivative of the production function have a negative sign.

## Chapter 6

### Concluding discussion

Virtually any economic number is constantly subject to change over time. This fact calls for the explicit consideration of such dynamics in economic research. On the one hand, this is necessary to understand the mechanism behind inherently dynamic phenomena: For example, growth and fluctuations of macroeconomic variables like an economy's output, productivity and employment strongly determine social as well as individual welfare. Despite much research, many questions remain on these topics. On the other hand, to neglect significant dynamics in economic analysis might quite simply lead to wrong results and conclusions. The papers which make up this thesis have contributed to both of these aspects with regard to a variety of specific research questions.

In particular, Chapter 2 has developed a business cycle chronology for the German economy. It hence offers a valuable reference series for further empirical research on such fluctuations and helps to collect additional insights in their sources, characteristics and conditions. The contribution of the chapter goes beyond the special application to the German case, though. Firstly, for portability: In many countries there is a lack of official business cycle chronologies. Given that all dating procedures included in this chapter are based on the gross domestic product – a widely available and standardized measure of economic activity –, furthermore are easily reproducible and recorded in software code, the analysis could be extended to other economies as well. Likewise a set of consistent business cycle chronologies could be built and used in further cross-national comparative research. Secondly, more generally: Prior to the concrete analysis the chapter contains a general overview on varying approaches to the business cycle found in the (empirical) literature. Awareness and consideration of these differences appears to be still limited, but is highly necessary in order to reasonably compare and integrate past and future contributions.

Indeed, while Chapter 3 likewise considered, among others, output fluctuations and periods of negative growth rates, its specific focus differed from the previous one. The chapter conducted a theoretical analysis of a possible mechanism which might lie behind such macroeconomic fluctuations that appear to produce rather ambiguous empirical observations. It was demonstrated how the introduction of already simple heterogeneities into a basic model helps to increase the variety of dynamics for aggregate variables in response to a productivity shock considerably. The suggested model also highlights the potential of

time-consuming reallocation activities to propagate, amplify and assimilate shocks in the economy. The novel focus on transitional dynamics emphasised the importance such adaptations, and not only the inducing shocks themselves, have on the observed macroeconomic fluctuations.

Clearly, to concentrate on the main idea, the model sketched in Chapter 3 was rather simple. But its findings point to the big potential that lies in particular in an increased consideration of heterogeneity in dynamic macroeconomic models in order to understand apparent ambiguity in aggregated variables. In case of the productivity shock-puzzle, for example, diversity in the empirical observations might be based on micro-differences hidden in aggregated variables. That example even more generally highlights another important implication for further research: The exclusive consideration of aggregate figures and homogeneous representative agents in the analysis of macroeconomic phenomena can miss important and effective dynamics which take place ‘below the surface’ but have extensive effects. Apparently, in order to further improve our understanding on business fluctuations, there is need for more evaluations of the relationships between micro-economic and macro-economic dynamics.

Finally, the model suggests that long-run growth might involve temporary fluctuations. Rational, forward-looking optimization might even induce time spells of higher unemployment and drops in total output in response to productivity-enhancing shocks. Indeed, the larger the jump in productivity, the more it is profitable to react with endogenous job destruction. That result might appear to be against intuition at first, and hence demonstrates the necessity of a thorough analysis.

Chapter 4 in turn initialized an evaluation of the occurrence of such heterogeneous productivity-enhancing shocks in a data set as suitable as possible. It turned out, though, that evidences appeared to be sparsely in a primarily descriptive approach. However, a number of alternative procedures intended to deepen the analysis have been discussed, despite they are beyond the scope of the thesis. In general, the chapter for a particular case has disclosed a number of typical challenges in the conduction of empirical research aiming to test theoretical findings: Firstly, theoretical models often are highly stylized, which enables them to be analytically traceable and concentrate on the main topic they are intended to show. Real data, on contrast, rather reflect a variety of influences additionally to those captured by the model. With a comparably simple theoretical underlying, a necessary separation in relevant and (for the time being) irrelevant influences in the data might not be straightforward. Secondly, there is the matter of availability of suitable data at all. Appropriate empirical measures for the theoretical parameters and variables must exist. They furthermore have to be collected in high quality and – particularly important if we analyse dynamic aspects – be available consistently for rather long time periods at sufficient frequency. Problems in both these aspects have hindered the empirical analysis in Chapter 4. They point to required improvements in terms of model adjustments prior to empirical testability, of adjustment in empirical methods and improved data facility in order to generate additional insights. Nonetheless, however, my data evaluation

allowed novel insights into the high-frequency, cyclical and seasonal characteristics of gross job and employment flows in German establishments. In particular, complementary to previous research mostly based on annual data, I could consider the dynamics of job creation and job destruction during the year and even during the month.

Finally, Chapter 5 has demonstrated that the consideration of changes in variables over time is not only necessary for the analysis of inherently dynamic phenomena like business cycles or economic growth. The focus instead has been on employment effects resulting from unions on the labour market. Conventional models have solved this question in static environments. Empirical evidence, however, pointed to the fact that membership in unions varies in response to employment. The inclusion of these dynamics in the optimization process indeed produces results which differ from their static counterparts, but due to their empirical base should beat those in terms of reliability. As shown in this chapter, the additional consideration of differing degrees in bargaining centralization into the dynamic framework revealed further important effects not evaluated in previous research.

The relevancy of the questions considered in this thesis are obvious: A comprehensive understanding of aggregated business fluctuations can help to identify its causes, amplification and propagation mechanisms. The evaluation of market imperfections like market power in trade unions in turn requires an analysis in an adequate structure which includes relevant influences. Only such knowledge and results enable us to draw appropriate consequences. These include the set-up of institutional frameworks and of necessary interventions in order to, for instance, minimize the social costs induced by excessive macroeconomic fluctuations and recessions, or by present market imperfections. As an example, evidence for important heterogeneous productivity shocks amplified by frictions in the labour market would demand to particularly promote research and development in rather easily transferable technologies, to improve technology transfer, and to reduce reallocation frictions. Policies which aim at other approaches to improve demand or supply, in contrast, would be misleading in this case.

The consideration of dynamics in the economy is of highest relevancy for the analysed but also many additional topics in economics. The chapters which make up this thesis contributed to this knowledge but also raised a number of new issues left to further research. Not only the economy is dynamic – our state of understanding on it is it, too.





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