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What Can We Learn from Asynchronous Wage Changes?

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Abstract

I document eight novel facts about wage changes and provide a theoretical framework to rationalize them. I then illustrate how this new treatment of data and theoretical framework speak to important secular and cyclical features of the macroeconomy. The evidence put forth in this paper, suggests that a theory of wage setting in which wages respond to idiosyncratic competition is an important complement to the more conventional macroeconomic view in which wage rigidity is induced by deliberately divorcing the timing of wage changes from innovations in firms' and workers' opportunities.

JEL Classifications:
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J33/M52: Compensation and Payment Methods
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This study uses the weakly anonymous Sample of Integrated Labour Market Biographies (1975-2014) and the IAB Establishment Panel (1993-2014). Data access was provided via on-site use at the Research Data Centre of the German Federal Employment Agency at the IAB in Nuremberg, Germany; Ann Arbor, MI; Cambridge, MA; Los Angeles, CA; Berkeley, CA; and Princeton, NJ; and remotely via JoSuA.

1 Introduction

The timing of pay changes is important for our understanding of the macroeconomy and of labor markets. Indeed, many questions in these areas lead to and from attempts to decipher and discipline the covariance between pay changes, employment, and macroeconomic shocks and their lags. Findings of missing or mild pro-cyclicality of wages have motivated theories of labor contracting that deliver wage rigidity, and these, along with data availability and quality, have motivated past treatment of micro data on wages. This paper breaks from the beaten path and documents hitherto unstudied features of pay changes. In this fresh look, I find eight facts that corroborate a view of wage setting and labor market dynamics that—despite originating in the 1990's—has only recently entered mainstream macroeconomics. In addition, I offer a nuance to this model that improves the fit to the facts and offers a new interpretation of secular trends in the past several decades, cyclical dynamics, and the relationship between these.

This paper asks "What can we learn from asynchronous pay changes?" This question is novel in the context of a literature that has focused primarily on cyclical covariances using data at fixed frequencies, in part because of data constraints.[1] Indeed, the novel view of the data taken here—facilitated by administrative data that allow for observation of unconventional features—uncovers facts that are not easily reconciled with prevailing views of wage rigidity. Instead, they are consistent with a class of job-ladder models that have more recently entered the mainstream discussion of business cycles. Further, within this class of models, the facts revealed in the data shed light on the likely structures and aggregate composition of longer-term labor contracts.

The facts I document are revealed by the relatively unique structure of the data I use: the Sample of Integrated Labour Market Biographies (SIAB) made available by the Institute for Employment Research (IAB) of the German Federal Employment Agency. Under the provisions of the law that mandates reporting of employment and wages, employers are required to report the exact dates of employment for all employees at least once per year. Reports contain basic demographics and, importantly, the average daily wage in the reporting interval. In accordance with the law, the typical ongoing employment spell is reported once yearly and spans the time from January 1 to December 31. However, I document that a small minority of ongoing employment spells contain an additional, midyear report. After removing additional reports associated with changes in employment law, transition from

[1] This main stream treatment of the data has been lent credulity by the finding that wage-change hazards spike at 12 month frequencies (Lünnemann and Wintr, 2010; Sigurdsson and Sigurdardottir, 2011; Le Bihan, Montornès, and Heckel, 2012; Barattieri, Basu, and Gottschalk, 2014; Murray, 2019; Grigsby, Hurst, and Yildirmaz, 2021).

the Deutschmark to the Euro, industry-wide union wage agreements, and employee-initiated changes in health insurance (which induce employers to submit an additional report), I document eight novel properties of asynchronous pay changes.

I begin by documenting (fact 1) that asynchronous wage changes are procyclical: covarying negatively with unemployment and positively with job-to-job mobility. This suggests that their properties have import for business cycle models. I then document (fact 2) that asynchronous wage changes, while uncommon, are typically larger than wage changes occurring at fixed and synchronized frequencies. While the literature has appealed to the infrequency of asynchronous pay changes to support a staggered contracting hypothesis à la Taylor (1980) the relative size and dispersion of the changes I document are hard to reconcile with such models. That model suggests that if asynchronous pay changes are randomly assigned they should be smaller, not larger, than those occurring at fixed frequencies.[2] The tension could be resolved if asynchronous pay changes were non-randomly selected. A plausible mechanism of selection, which also conforms with the observed procyclicality of the incidence of asynchronous pay changes, is firm-to-firm competition for employed workers, e.g. a job ladder.

With this in mind, I document (fact 3) that the incidence of asynchronous pay changes evolves over workers' careers in a pattern consistent with a job-ladder model in which wages can update in the face competition, as in Postel-Vinay and Robin (2002b,a). Specifically, incidence of asynchronous pay changes decline with tenure and with length of a continuous employment spell with one or more employers. This pattern closely matches (apart from level) the covariation between tenure and continuous employment spell and job-to-job mobility, conforming with the hypothesis that a job-ladder is the root cause of both transitions and asynchronous pay changes.

To explore this hypothesis further, I document (fact 4) opposite signed covariance between incidence of job-to-job mobility and asynchronous pay changes and proxies for firm rank on the job-ladder. Higher rank implies a lower probability of job-to-job transition but a higher incidence of asynchronous pay changes. This pattern is consistent with higher quality firms being more able to retain employees *and* more able and willing to do so by updating wages if an employee receives an outside offer. Further, in a job-ladder model with renegotiation, future competition is expected to yield wage gains on the job. Thus, if a worker expects a prospective employer to negotiate and to be more competitive in future negotiations she views this as an amenity and, as such, it is priced into her starting wage (Postel-Vinay and Robin, 2002b,a). I test this hypothesis and document (fact 5) that a) starting wages

[2] Grigsby et al. (2021) document a similar pattern in US payroll processing data and make a similar assessment in their Online Appendix D.4.

are lower in jobs that subsequently yield more asynchronous pay changes per year and b) lower starting wages are offset by greater returns to tenure in such jobs, with the effect on starting wages being offset within four years. Facts 3, 4, and 5 are corroborated by (fact 6): a correlation between the share of firms who reported willingness to renegotiate wages in a 2011 survey with contemporaneous incidence of asynchronous pay changes at the industry level: a larger expected number of jobs per continuous employment spell and greater incidence of asynchronous pay changes relative to job-to-job mobility are both correlated with greater reported willingness to renegotiate.

With this cross-sectional evidence in favor of a job-ladder model, I turn back toward the macroeconomic literature and I investigate the comovement between wage growth and the business cycle. To this end, I replicate, extend, and shed light on a fact first documented by Moscarini and Postel-Vinay (2017): the wage growth of *job-stayers* is positively related to the aggregate job-to-job transition rate. I decompose the effect into wage growth for workers with and without asynchronous pay changes and document (fact 7) that wages of job-stayers both with *and without* asynchronous pay changes are sensitive to the aggregate job-to-job mobility rate and the wages of recipients of asynchronous pay changes are more sensitive (as are the wages of actual job-to-job movers). While it is possible that my data does not identify every asynchronous pay change and that the unidentified asynchronous pay changes contaminate the coefficient for the job-stayers without identified pay changes, the result may also suggest a mixture of contracting mechanisms. Specifically, a typical job-ladder model with wage posting posits that firms post state-contingent wage contracts that update when macroeconomic conditions change in order to optimize a firm's tradeoff between rents conditional on having an employee and flows of employees in and out of the firm. This contrasts with the renegotiable contract model in which firms may wait to respond to aggregate conditions until they face a new instance of firm-to-firm competition for an incumbent employee. Thus, a mixture of contracts suggests sensitivity of job-stayer's wages to job-to-job mobility but greater sensitivity for recipients of asynchronous pay changes, as observed in fact 7.

Finally, taking a longer run perspective, I document (fact 8) that the incidence of asynchronous pay changes has secularly increased even as aggregate wage growth has stagnated. The tension between this last fact and the preceding seven poses a puzzle: how can a phenomena linked to greater wage growth for individuals also be linked to secularly declining wages in the aggregate?

I begin to answer this question by considering two state-of-the-art business-cycle job-ladder models designed to explain the fact that job-stayers' wage growth covaries with the rate of aggregate job-to-job mobility: Faccini and Melosi (2019) and Moscarini and Postel-

Vinay (2019). Each builds a business-cycle job-ladder model in which the hazard of on-the-job wage offers is linked to the wage growth of job stayers. The link is both subtly and fundamentally different in the two models. Faccini and Melosi (2019) impose a wage-posting assumption. In this framework, a shock that induces a greater hazard of on-the-job wage offers induces all firms to increase wage offers, on impact, in order to preemptively stave off future competition. The result is an immediate increase in wages that is uniformly positive for all workers. This model is consistent with finding that increased job-to-job mobility increases the wages of job stayers (as in Moscarini and Postel-Vinay (2017) and fact 7) but cannot accommodate the existence of asynchronous pay changes or the differential sensitivity to job-to-job mobility that they imply. Meanwhile, Moscarini and Postel-Vinay (2019) assume that wages are set by sequential auction. In this framework, wages of job-stayers grow more rapidly when the hazard of on-the-job wage offers increases because some of these encounters lead to upward wage revisions with existing incumbents. On the other hand, the wage growth of job-stayers without asynchronous pay changes should be zero or fall since expected future wage growth has increased and, as noted before, the worker views this as an amenity. Again, this contradicts the findings in fact 7.

These observations, together with variation in the incidence of asynchronous pay changes across industries and covariation between that heterogeneity and reported willingness to renegotiate—as documented in fact 6—suggest that a model in which firms select between these two types of contracts—as in Postel-Vinay and Robin (2004); Doniger (2015); Flinn, Mabli, and Mullins (2017)—may account for all facts.[3] To this end, I consider the implications of allowing for mixed contracts as in Doniger (2015). That model nests the steady state versions of Faccini and Melosi (2019)—Burdett and Mortensen (1998); Bontemps, Robin, and van den Berg (2000)—and Moscarini and Postel-Vinay (2019)—Postel-Vinay and Robin (2002b,a)—as extreme cases and offers a simple and tractable cost structure for wage contracts that generates market segmentation: firms lower on the job-ladder post wages while firms higher use sequential auction.

This synthesis of models not only provides an explanation for fact 7 it also contains an explanation for the apparent contradiction contained in fact 8. When a firm is able to adjust wages in the face of future competition it sets starting wages to match the value of the worker's current outside option—either the value of unemployment or the value of the best wage offer her incumbent is willing or able to make. If instead a firm is unable to adjust wages later then it optimally sets wages in a way that yields a greater share of rents from the match to the worker (in order to not be outbid by less competitive firms later). If a greater share of firms utilize the renegotiable contract then fewer yield rent to new hires from unemployment

[3] All of these are steady state models.

or with weak outside options, driving down labor compensation in the aggregate. This provides an explanation for the apparent contractions in fact 8. I test for and find evidence of this mechanism in cross-industry time variation of labor compensation and the incidence of asynchronous pay changes: industries in which asynchronous pay changes have become more common more rapidly have experienced larger declines in labor compensation.[4]

The paper proceeds as follows. Section 2 describes the SIAB data. Section 3 lays out the eight facts. Section 4 discusses the model and tests the hypothetical relation between payroll share and incidence of asynchronous pay changes. Section 5 concludes. Appendix B documents additional details about the data. Appendix A provides details about the model and proofs. Online appendix C documents a small set of related facts using survey data from the United States.

2 High frequency data on wages and employment

The primary dataset I use is the SIAB. The SIAB is a 2 percent random sample of Germans with employment liable to social security or recipients of social insurance and is made available by IAB. These data are based on mandatory, yearly reports filed by employers for each public sector employee. Reports contain the exact dates of employment and the average daily wages during the employment period. The data also contain basic worker demographics such as age, sex, occupation, and schooling, as well as firm-level characteristics such as industry, age, size, moments of the within-firm wage distribution, in-flows, and out-flows. I restrict the sample to workers with full-time employment and, as is common in the literature, I restrict my sample to prime-age workers (ages 20 to 60).[5]

An unusual feature of these data is the high frequency of reporting. This quality is particularly important for this work because it enables tracking the worker's employment status to the exact day. Employers report each employee at least once each year, typically at year end. Thus, the typical record records a sub-part of a multi-year employment relationship. Such a record reports start and end dates on January 1 and December 31, average daily wages over that period, and the aforementioned employee and employer characteristics. Further, when employment relationships begin and end the exact start and end dates are recorded. This practice results in an employment record covering a sub-part of a year and enables the identification of separations to nonemployment, accessions from nonemployment, and job-to-job moves. I define three types of yearly spells: job-stayer, job-to-job mover, and job-loser. To

[4]The relation holds even after including controls for alternative hypotheses for the decline in labor compensation.

[5]The data also contain rich information on job seekers and those with officially regulated part-time employment that is not used in this paper.

do so, I begin with the sample of workers employed in the first two weeks of January. I then identify the highest paying incumbent employer during this period. Job stayers subsequently have a year long relation with this employer that may include gaps so long as they are less than 15 days. Job-to-job movers transit from this initial employer to another with a gap less than 15 days. Meanwhile job-losers experience a gap of 15 days or more.

Crucially important for this work, for a small proportion of employees with ongoing spells the employer has submit multiple contiguous reports within a single year.[6] I call a pair of contiguous employment reports with a single employer within a year a "reregistration." Note that while stayers, movers, and losers are mutually exclusive each has an intersection with reregistrations. In particular, so long as the reregistration occurs before the move or job loss a mover or loser may be counted as a reregistrant as well. In the following, I focus on the subset of asynchronous reregistrations that do not coincide with legal reforms, redenomination of contracts from the Deutschmark to the Euro, or a large number of reregistrations within the same industry (indicative of a change in the industry contract), and are not triggered by an employee-initiated change in health insurance coverage.[7]

One drawback of these data is the presence of top-coding. Administrative data record the daily wage up until a maximum contribution limit, which varies by year and region (East/West). Overall, top-coding effects 8 percent of observations and 9 percent of asynchronous registrations. However, for those who are not censored asynchronous reregistrations are associated with an on-impact pay change 95 percent of the time and an on-impact raise 70 percent of the time. Given the high degree of correlation between asynchronous reregistrations and pay changes I refer to asynchronous reregistrations as asynchronous pay changes (APC) going forward but note that all results are robust to restricting to reregistrations for which coincident pay changes are also observable and observed.

In addition to these data, I use data on official unemployment statistics, unionization, labor share, and import exposure from the IAB, the EU KLEMS project (European Union level analysis of capital (K), labour (L), energy (E), materials (M), and service (S) inputs), official unemployment statistics constructed from the Mikrozensus and the Organisation

[6] Analogous to job-to-job moves I define "contiguous" as two reports from the same employer with 15 days or less elapsing between.

[7] Specifically, I focus on reregistrations that do not coincide with more than 15 percent of workers within the same industry. In Germany many labor unions are organized by industrial sector. This restriction excludes changes in industrial labor contracts that affect many workers simultaneously. From 1999 onward the administrative data include reporting on health insurance coverage. Before 1996 Germans had little discretion over their health insurance coverage. After, Germans are able to make adjustments to their health insurance coverage if they meet certain requirements and from 1999 onward changes in health insurance coverage are required to be reported and trigger asynchronous reregistrations. Changes in health insurance coverage account for roughly half of asynchronous reregistrations after 1999. I exclude them from the main analysis and examine their properties separately in appendix B.

for Economic Co-operation and Development (OECD) and World Input-Output Database (WIOD). Details of these data are discussed in the sections where they are used.

3 Eight facts about asynchronous pay changes

Asynchronous pay changes are uncommon, affecting roughly 1-2 percent of job spells in any given year. Yet the following eight facts document that these pay changes are correlated in economically meaningful ways with the business-cycle and with worker's career trajectories. These facts provide evidence in favor of a job-ladder model in which wages can be renegotiated in the face of outside offers—a la ?Moscarini and Postel-Vinay (2019)—and contradict ubiquitous theories in macroeconomics that posit synchronized wage negotiations—as in (Taylor, 1980; Calvo, 1983). Indeed, Facts 1-5 can be explained by this type of model alone. Facts 6-8, however, call for further nuance. Incidence of APC varies over time and across industries, suggesting that multiple contracting mechanisms may coexist, as in Doniger (2015).

3.1 Incidence of asynchronous pay change is procyclical

Table 1 reports coefficients from regressing an indicator equal to one if the observed individual received an APC within the year on the unemployment rate and quarterly job-to-job mobility, job finding (from unemployment), and separation (to employment) rates that prevailed on average in the observations' German state in each year, while controlling for a quadratic in the individuals' tenure and experience, proxies for match quality as in Hagedorn and Manovskii (2013), four skill requirements categories, and indicator for employment in East or West Germany, trend breaks in 1983 (when bonuses were first included in the register data) and 1992 (when East Germans are first included), and an individual fixed effect.[8]

Columns (I) and (II) report that a one percent decrease in the unemployment rate or a one percent increase in the average quarterly job-to-job mobility rate increases the incidence of APC by about one and two tenths of a percent, respectively. Since unemployment and job-to-job mobility are strongly negatively correlated, column (III) runs the horse race and finds a one percentage point deviation in each yields roughly equal magnitude responses of opposite signs. Controlling additionally for the separation and job finding rate in column (IV) returns coefficients on unemployment and job-to-job mobility of magnitude and significance

[8]Experience is measured as time since first appearance as employed in the data and, consequently, calendar time, experience, and the individual fixed effect are co-linear. In other words, the controls effectively include a control for calendar time as well. I exclude individuals for whom tenure or experience begin in 1975 (the year records begin for West Germans) or in 1992 (the year records begin for East Germans).

Table 1: Incidence of asynchronous pay change is procyclical

Dependent Variable:	Asynchronous Pay Change			
	(I)	(II)	(III)	(IV)
Unemployment rate[a]	-0.09***		-0.087***	-0.091***
	(0.006)		(0.006)	(0.007)
Job-to-job mobility rate		0.17***	0.069**	0.178***
		(0.026)	(0.027)	(0.034)
Separation rate				-0.019
				(0.020)
Job finding rate (from nonemployment)				0.137***
				(0.024)
R-squared	0.15	0.15	0.15	0.15
Observations	5,847,963	5,847,963	5,847,963	5,847,963

Source: Sample of Integrated Labour Market Biographies (SIAB) and author's calculations.
Note: ***, ** and * indicate significance at the 1, 5, and 10 percent level. Standard errors, in parentheses, are clustered at the individual.
Controls: quadratic in tenure, quadratic in experience (measured as time since first appearance in the data if not censored), proxies for match quality as in Hagedorn and Manovskii (2013), indicator for East/West Germany, four skill requirements categories, indicator for *year* $\geq$ 1983 (when bonuses begin to be recorded in the wage data) and for *year* $\geq$ 1992 (when east Germans begin to be included in the data), industry fixed effects (3-digit), and individual fixed effect. Note that, as measured, experience, calendar time, and the individual fixed effect are co-linear.
[a] HP filtered at the quarterly frequency using smoothing parameter 100,000.

similar to that of columns (I) and (II).

In sum, the result suggests that understanding APC is important for understanding the labor market effects of business cycles. Yet, as discussed in the next subsection, key facts about APC fall outside the conventional business cycle theories.

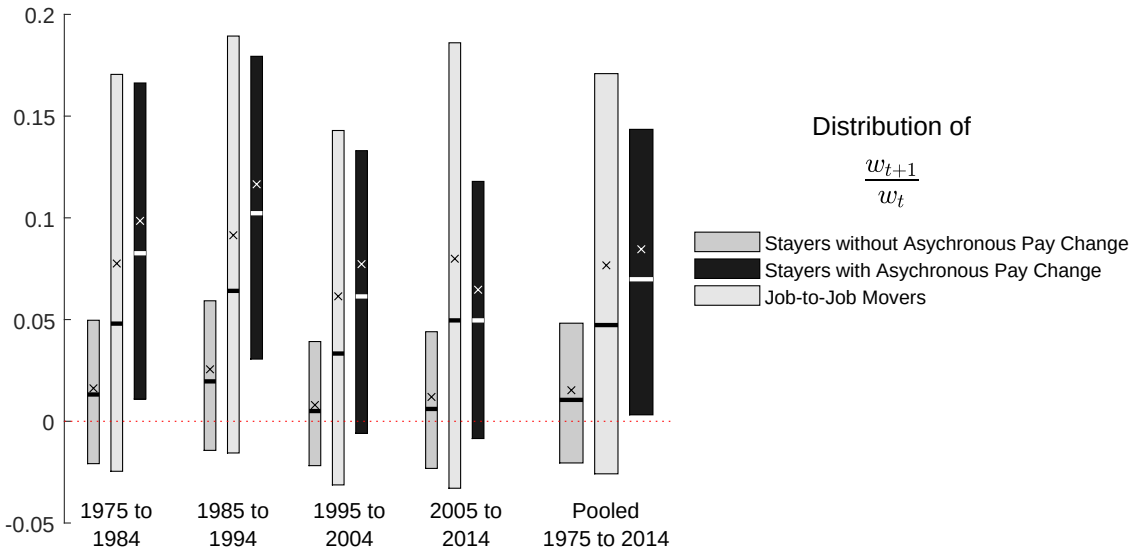
3.2 Asynchronous pay changes are large and dispersed

Figure 1 records the mean, median, and interquartile ranges of year-over-year pay changes for years that contain APC by decade starting with 1975 to 1984. APC are on average large and are dispersed.[9]

To compare these changes with those of workers with other labor market histories figure 1 also records the year-over-year pay changes of job stayers without asynchronous pay changes in the intervening year and job-to-job moves in the intervening year by decade starting with 1975 to 1984.[10] Workers with APC have year-over-year earnings growth far in excess of

[9] A similar pattern has been documented in data from the United States by Grigsby et al. (2021).
[10] As mandated by law, all ongoing employment relationships are reregistered at year end. At these year end reregistrations, just over 90 percent contain a nominal pay change while the remaining continue at the same nominal daily wage.

Figure 1: Asynchronous pay changes are large and dispersed



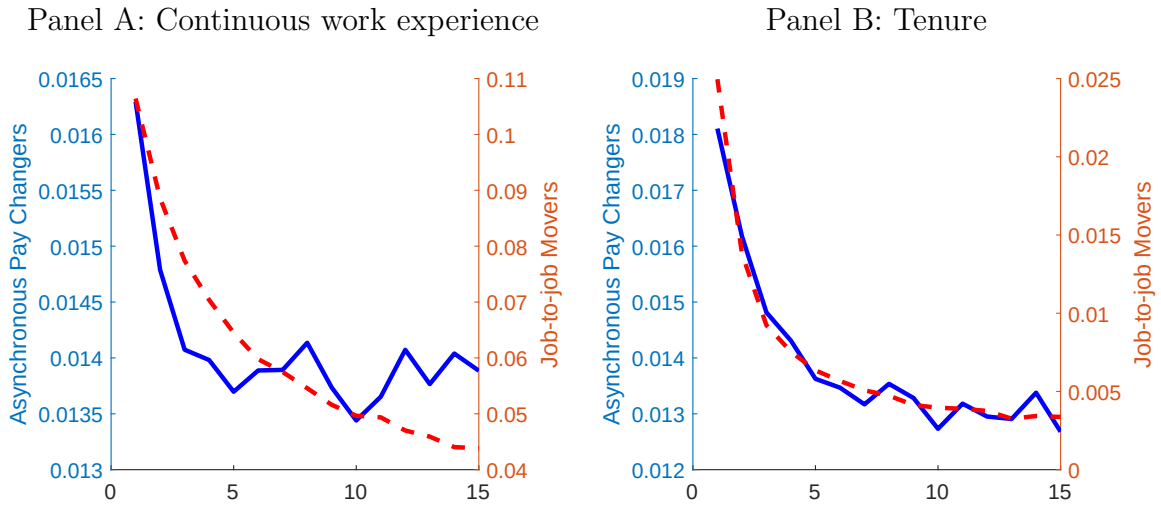
Source: Sample of Integrated Labour Market Biographies (SIAB), author's calculations.

other job stayers. Indeed, the mean, median, and distribution of year-over-year wage growth for these workers resembles that of job-to-job movers more closely than that of other job stayers.[11]

While the small share of workers with APC supports the popular Taylor (1980) hypotheses of staggard wage contracts the size and dispersion of those asynchronous wages changes that do occur contradict the hypothesis. In particular, Taylor's 1980 model suggests that if matches were randomly allocated an additional asynchronously timed wage change opportunity then the resulting wage revision should, on average, should be smaller and less dispersed than synchronized changes since, for these, there has been less time for the existing wage level and newly optimal wage level to diverge. The Calvo (1983) hypothesis suggests similar conclusions: wages revised after shorter intervals should yield smaller, not larger, revisions. Of course, this could be reversed if the asynchronous change were not randomly assigned, but rather occurred as a result of selection on a large shock to match productivity. Given the

[11]Potentially, part of these phenomena are driven by the typical timing of "Christmas" bonuses. Because most APC and job-to-job moves occur before December, the average daily wage in the initial year may be artificially depressed. However, the noted pattern is equally strong, if not stronger in the 1975-1984 period in 9 out of 10 years of which bonuses were excluded from the record. To additionally address this potential bias, I compute analogues to the figure 1 using the starting wage in the year before the year in which the asynchronous pay changes or job-to-job mobility is observed. Results are reported in figure 7 and yield broadly the same conclusions.

Figure 2: Incidence of asynchronous pay change declines with seniority



Source: Sample of Integrated Labour Market Biographies (SIAB), author's calculations.

similarity between the distribution of the magnitude of asynchronous pay changes and those following job-to-job transitions, the follow sections investigate a particular hypothesis regulating the shock process: a job ladder with on-the-job wage competition as in Postel-Vinay and Robin (2002b,a).

3.3 Incidence of asynchronous pay change declines with seniority

Figure 2 plots the relationship between continuous work experience—time since the most recent nonemployment—and tenure relative to job-to-job mobility and asynchronous pay changes.[12] As has been well documented in a long literature beginning with Topel and Ward (1992), job-to-job mobility declines in each measure of seniority (red hashed lines, right axis). Turning to asynchronous pay changes, a pattern similar to what has been documented here and in the literature for job-to-job mobility emerges. The data show an increasing hazard in age and an initially decreasing but later increasing hazard in experience. Asynchronous pay changes are most common for workers early in the job-cycle and at low tenures. As job-cycle and tenure increase the hazard of asynchronous pay change steadily decreases (solid blue lines, left axis).

The job-to-job mobility data suggest the presence of a job ladder that contains a common component. (In other words, most workers rank firms similarly.) Consistent with a job ladder theory, the ladder is revealed by the decline in job-to-job mobility as continuous work

[12]To account for left-censoring, I omit workers whose continuous work experience or tenure begins in 1975 (the year records begin for West Germans) or in 1993 (the year records begin for East Germans).

experience and tenure increase. The decline in asynchronous pay changes as these measures of seniority increase suggests that competition between firms on the job ladder is at least one of the mechanisms leading to these pay changes.

Taken together, these facts suggest a job ladder model in which both allocations and wages depend on workers' labor market histories (see, for example, the sequential auction model proposed by Postel-Vinay and Robin 2002b,a). In a model of this type, on-the-job contacts between workers and new firms generate job-to-job mobility when workers would be more productive working for the new firm. In addition, on-the-job contacts produce pay increases when workers would be less productive with the new firm than the incumbent but they would be more productive working for the new firm than their previously best outside option. Further, embedding such a model in a business cycle—as in Robin (2011) or Moscarini and Postel-Vinay (2019)—delivers the cyclical covariation in asynchronous pay changes and job-to-job mobility observed in Table 1.

3.4 Asynchronous pay changes are more common in firms higher on the job ladder

To evaluate the covariation between firm characteristics and job-to-job mobility and asynchronous pay changes, I exploit the quasi-employer-employee link between the SIAB and firm-level objects measured in the IAB Establishment History Panel (BHP). Specifically, while the SIAB is a panel of workers and not a linked employer-employee data set, the data include particular firm-level covariates that the job ladder literature considers to be correlated with a firm's rank: size and moments of the within-firm wage distribution.[13]

Figure 3 plots the share of yearly job spells including a job-to-job transition or an asynchronous pay change by firm size bins (panel A), inter-quartile range of the within-firm wage distribution (panel B), median wages (panel C), and the 75th percentile (panel D).[14] Despite the coarseness of the measures, the pattern predicted by a job-ladder model is evident in the generally declining incidence of job-to-job transitions as the proxy for firm quality increases (red lines, right axis). Meanwhile, the incidence of asynchronous pay changes is rising (blue lines, left-axis). This finding is, again, consistent with the predictions of a job-ladder model with wages set and updated under a sequential auction protocol and in which workers rank firms similarly (at least according to these measured characteristics).

[13]Inflows and outflows are also observed, but unfortunately, coarsely and without information about employees prior or future job status, which, makes it impossible to construct metrics suggested by the literature, e.g. the poaching index proposed by Lentz and Bagger 2009.

[14]Increasing inter-quartile range is associated with higher rank on the job-ladder under the sequential auction contract studied in Postel-Vinay and Robin (2002b,a) and the literature that follows. Note that, due to censoring, the mean wage is imputed while the median is observed. Thus, I focus on the median.

Figure 3: Asynchronous pay changes are more common in firms higher on the job ladder

Source: Sample of Integrated Labour Market Biographies (SIAB), IAB Establishment History Panel (BPH), author's calculations.
[a] Firm size bins: 1-4, 5-9, 10-19, 20-49, 50-99, 100-199, 200-499, and greater than 500.
[b] Deciles computed within each year.

3.5 Asynchronous pay changes mediate the return to tenure

I now turn to the impact of asynchronous pay changes on returns to tenure and experience. To this end, I construct the number of asynchronous pay changes in the average year of each worker-firm match.[15] In column (I) of Table 2, I document that workers in matches with a higher yearly probability of asynchronous pay changes have lower starting wages but greater return to tenure. The magnitudes are such that the effects offset, on average, within the first

[15] Again, I exclude matches starting in 1975 or 1993, when the data begin being collected for West and East Germans, respectively.

Table 2: Asynchronous pay changes mediate the return to tenure

Dependent Variable:	ln(Wage)		
	(I)	(II)	(III)
Tenure	0.008***	0.005***	0.005***
	(0.000)	(0.000)	(0.000)
Tenure^2	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)
Asynchronous pay changes per year	-0.079***	-0.058***	-0.066***
	(0.032)	(0.036)	(0.036)
×Tenure	0.020***	0.024***	0.023***
	(0.002)	(0.002)	(0.002)
×Tenure^2	0.000	-0.000	0.000
	(0.000)	(0.000)	(0.000)
Controls[a]	X	X	X
Altonji and Shakotko (1987)[b]		X	
Hagedorn and Manovskii (2013)[c]			X
R-squared	0.90	0.90	0.90
Observations	4,805,127	4,805,127	4,805,127

Source: Sample of Integrated Labour Market Biographies (SIAB) and author's calculations.

Note: ***, ** and * indicate significance at the 1, 5, and 10 percent level. Standard errors, in parentheses, are clustered at the job level.

[a] *Controls:* quadratic in tenure, quadratic in experience (measured as time since first appearance in the data if not censored), indicator for East/West Germany, four skill requirements categories, indicator for *year* $\geq$ 1983 (when bonuses begin to be recorded in the wage data) and for *year* $\geq$ 1993 (when east Germans begin to be included in the data), industry fixed effects (3-digit), and individual fixed effect. Note that, as measured, experience, calendar time, and the individual fixed effect are co-linear.

[b] Control for completed tenure in the current job as a proxy for match quality, as in Altonji and Shakotko (1987)

[c] Control for cumulative job-to-job mobility during contenuous period of employment preceding the current job and during the completed tenure in the current job as a proxy for match quality, in the spirit of Hagedorn and Manovskii (2013)

few years of tenure. Similarly, the return to experience is larger in a match which features a greater yearly frequency of asynchronous pay changes. Results are robust to the inclusion of proxies for match quality as in Altonji and Shakotko (1987) or Hagedorn and Manovskii (2013).

This result is predicted by a job-lader model with wages set under sequential auction, as in Postel-Vinay and Robin (2002b,a). In particular, from the worker's perspective, wage growth is an amenity. Meanwhile, firms make take-it-or-leave it starting wage offers. While these are strategically chosen to reflect a worker's outside options at the time of hiring—and

Table 3: Incidence of asynchronous pay changes is correlated with survey-reported willingness to renegotiate wages

Dependent Variable:	Share Reporting Negotiation		
	(I)	(II)	(III)
Incidence of APC	4.67	6.76	
	(5.45)	(5.57)	
Incidence of JTJ		1.12	
		(1.06)	
Incidence of Sep.		-1.10	
		(0.69)	
Incidence of APC relative to JTJ			0.50**
			(0.23)
Incidence of JTJ relative to Sep.			0.55**
			(0.24)
Constant	0.28	0.34**	-0.024
	(0.12)	(0.13)	(0.17)
R-Squared	0.03	0.14	0.23
Observations	23	23	23

Source: Sample of Integrated Labour Market Biographies (SIAB), Brenzel (2014), author's calculations.
Note: ** indicates significance at the 5 percent level. Observations weighted by industry employment.

therefore are higher for workers already employed in a better employer—they extract all of the remaining rent. This means that, all else equal, firms that can offer greater returns to experience can *as a result* offer lower starting wages for any given worker history.

3.6 Incidence of asynchronous pay changes is correlated with survey-reported willingness to renegotiate wages

While survey-based longitudinal data on the characteristics and composition of wage contracts does not exist for Germany, or elsewhere, I am able to test the relationship between the asynchronous pay changes and cross-sectional survey data on the negotiability of wage contracts using data collected in the early 2010's. Specifically, in the 2011 German Job Vacancy Survey conducted by the IAB, employers were asked "Did you negotiate with the applicant about remuneration (basic salary and further components if applicable)?" Brenzel, Gartner, and Schnabel (2014) document substantial variation across industries in the

probability of an affirmative response.

In table 3, column (I) records the relationship, at the industry level, between the share of affirmative survey responses—as reported by Brenzel et al. (2014)—and the incidence of asynchronous pay changes. The relationship has the expected sign, but is not statistically significant. Column (II) includes the incidence of job-to-job mobility and of separations. Each has the expected sign, but again, no statistical significance. Finally, column (III) transforms the data to test the predictions of a job ladder model in which some but not all wages are set under sequential auction as in Doniger (2015). This model is described in greater detail in section 4.

In a job-ladder model in which all wages are set under sequential auction, the ratio of the hazard of on-the-job contact with a new firm to the separation hazard determines the expected number of jobs per job cycle. A higher value implies a higher incidence of direct competition among firms for already employed workers. Thus, the expected relationship with the surveyed incidence of negotiations is positive. In addition, if only the firms higher on the ladder set wages under sequential auction, this pattern is reinforced. Industries in which the expected number of jobs per cycle is larger have more workers sorted toward the higher end of the job ladder, which is where the model predicts wage renegotiations occur. Indeed, the coefficient on this ratio is positive and statistically significant, as predicted.

In addition, in a model in which all wages are set under sequential auction, the incidence of pay changes and of job-to-job mobility is tightly linked. The first depends on the evolution of the best-to-date job offer and the second depends on the evolution of the best-to-date outside option, both of which are simple functions of the on-the-job offer arrival rate. Thus, if all wages in all industries are set under sequential auction, one would expect the ratio of asynchronous pay changes to job-to-job mobility to be roughly constant across industries and, therefore, to have no predictive power. Admitting a choice of wage setting mechanisms to the model, as in Doniger (2015), admits the possibility of variation in the ratio of asynchronous pay changes to job-to-job mobility across industries and predicts a positive relation between this ratio and the incidence of wage negotiations. Again, the coefficient on this ratio is positive and statistically significant, as predicted.

3.7 Asynchronous pay changes mediate wage cyclicality

Table 4 documents the relationship between wages, the unemployment rate, and the aggregate job-to-job transition rate, and how this relationship depends the worker's labor market history. The first two columns document the sensitivity of wage growth to the job-to-job mobility rate and unemployment rate measured at the level of the German state. As has

Table 4: Asynchronous pay changes mediate wage cyclicality

	LHS = ln(real wage)		
	(I)	(II)	(III)
Job-to-job rate	3.52***	1.91***	1.82***
	(0.064)	(0.076)	(0.077)
Unemployment rate[a]	-0.79***	-0.56***	-0.56***
	(0.014)	(0.015)	(0.014)
Job finding rate		2.62***	2.61***
		(0.055)	(0.055)
Separation rate		0.067***	0.067***
		(0.042)	(0.042)
Job-to-job rate ×			
Asynchronous pay change			0.23***
			(0.035)
Job to job move			0.58***
			(0.016)
Observations	4,633,877	4,633,877	4,633,877
R-squared	0.87	0.87	0.87

Source: Sample of Integrated Labour Market Biographies (1977-2014) and author's calculations. Sample restricted to continuously employed individuals.

Note: ***, ** and * indicate significance at the 1, 5, and 10 percent level. Standard errors, in parentheses, are clustered at the individual.

Controls: quadratic in tenure, quadratic in experience (measured as time since first appearance in the data if not censored), proxies for match quality as in Hagedorn and Manovskii (2013), indicator for East/West Germany, four skill requirements categories, indicator for *year* $\geq$ 1983 (when bonuses begin to be recorded in the wage data) and for *year* $\geq$ 1993 (when east Germans begin to be included in the data), industry fixed effects (3-digit), and individual fixed effect. Note that, as measured, experience, calendar time, and the individual fixed effect are co-linear.

[a] HP filtered at the quarterly frequency using smoothing parameter 100,000.

been documented for the United States by Moscarini and Postel-Vinay (2017) and others, higher rates of aggregate job-to-job mobility and low unemployment rates yield higher wage growth. The second two columns follow Moscarini and Postel-Vinay (2017) and decompose the effect of aggregate job-to-job mobility based on recent labor market history. Specifically, following their regression, I include interactions between the aggregate job-to-job mobility rate and an indicator for workers who are job-stayers with asynchronous pay changes and

workers who are job-to-job movers.[16] In this augmented regression the coefficient on the aggregate job-to-job mobility rate should be interpreted as the marginal effect of aggregate job-to-job mobility on the wage growth of *job stayers without asynchronous pay changes*. The coefficients on the two interaction terms are the marginal increase in cyclically due to the realization of that labor market history. Higher aggregate job-to-job mobility increases wages for job-to-job movers and job stayers both with *and without* asynchronous pay changes. Recipients of asynchronous pay changes and job-to-job movers enjoy a return to the aggregate job-to-job mobility rate about 15 and 30 percent larger than job-stayers without asynchronous pay changes.

In order to discuss these results further, it is useful to fix ideas regarding the predictions of a model featuring wage posting, as in Faccini and Melosi (2019), and one featuring renegotiable contracts, as in Moscarini and Postel-Vinay (2019). In the former asynchronous pay change is non-existent and thus suggests that what I measure as asynchronous pay change is orthogonal to the wage growth of job-stayers (I have already provided ample evidence that this is unlikely the case). In other words the model of Faccini and Melosi (2019) predicts that the coefficient on the interaction between an individuals history of asynchronous pay change and aggregate job-to-job mobility should be zero. The latter model suggests the opposite: decomposing job stayers into those with asynchronous pay change and those without should result in a null coefficient for stayers without APC and the entirety of the pooled coefficient being explained by the large pay changes of the recipients of APC.

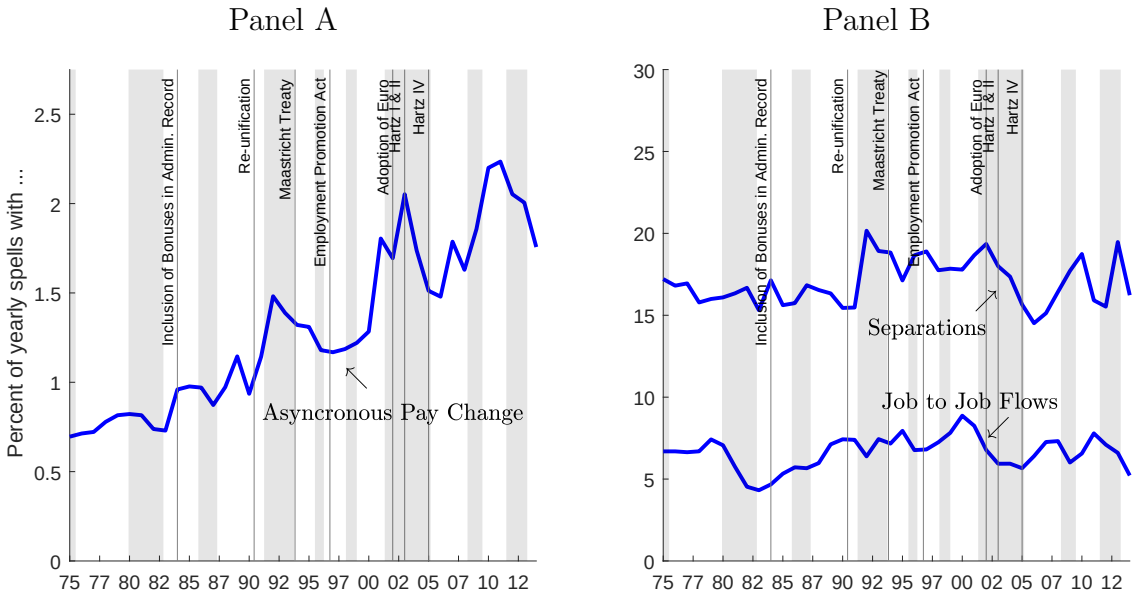
While it is possible that I fail to observe all APC and, thus, the pool of job stayers without observed APC is contaminated, the results, taken at face value, are supportive of the presence of both contracting models in a unified environment. The presence of posted wages reconciles the positive relationship between aggregate job-to-job mobility and the wages of job stayers without APC. Meanwhile, recipients of APC enjoy higher wages in all times with the difference accentuated when there is evidence of a higher rate of on-the-job competition for workers.

3.8 Asynchronous pay changes are rare but increasingly common

Finally, I turn to secular trends. Figure 4 plots the percent of spells in progress in the first two weeks of January of each year since 1975 that exhibit an asynchronous pay change, separation to nonemployment, and/or job-to-job transition before year end. As previously noted, separations and job-to-job transitions are distinguished by the elapsed time in nonemployment. Apart from the expected cyclical patterns, separations and job-to-job flows in Germany are

[16]Note, for ease of exposition, I exclude workers who are not continuously employed in the year from the sample. I obtain very similar results if these workers are included and histories appropriately controlled for.

Figure 4: Asynchronous pay changes are rare but increasingly common



Source: Sample of Integrated Labor Market Biographies (SIAB), author's calculations.

remarkably stable over the horizon.[17]

In contrast, a smaller and growing proportion of yearly employment spells contain an asynchronous pay change. Such asynchronous changes occur in less than 0.75 percent of yearly spells at the series start in 1975. By 2014, the last of my data, they occur in nearly 1.75 percent of spells, having peaked above 2 percent in the late 2010s expansion.

4 A job-ladder with heterogeneous wage contracts

The documented secular trend poses an interesting puzzle: how can a rising share of renegotiable contracts—which I have documented are associated with greater earnings growth—be reconciled with declining labor share of output—as has been documented in Karabarbounis and Neiman (2014) and elsewhere? In this section, I describe a job-ladder model with heterogeneous wage contracts that reconciles these facts.[18]

[17] This stability stands in sharp contrast to the documented decline in dynamism in the United States (Fallick and Fleischman (2004); Davis, Faberman, and Haltiwanger (2012); Davis and Haltiwanger (2014)) Although recently Fujita, Postel-Vinay, and Moscarini (2019) offer nuance to this view.

[18] For a more detailed exposition of the model see Doniger (2015).

4.1 Environment

The model assumes the basic structure of a random-search job ladder model à la Burdett and Mortensen (1998) and Postel-Vinay and Robin (2002b), both of which are nested cases. Identical workers search on and off the job for employers. Employers produce using a constant returns to labor technology, p, which is distributed across employers according to a differentiable distribution, $\Gamma(p)$. Search is random and balanced, meaning that the probability of drawing a job offer from an employer with technology p corresponds to its weight in the distribution $\Gamma(p)$. Balanced matching is equivalent to assuming that all firms, regardless of their steady state size and profitability, maintain exactly one vacancy at all times and workers have equal probability of being matched with any of these vacancies.[19] For workers, job offers arrive according to exogenous Poisson processes with hazards $\lambda_e < \lambda_u$ on and off the job. Separations occur according to an exogenous Poisson process with parameter δ.

I diverge from the nested models by allowing employers to choose between a non-negotiable wage contract—as in the posted-wage model of Burdett and Mortensen (1998)—or a contract that can be re-negotiated as the worker's outside option evolves through further search—as in the sequential Bertrand auction of Postel-Vinay and Robin (2002b).

Definition 1. *An equilibrium in this environment is such that*

- *given the opportunity, workers accept employment in the firm offering the highest value contract.*
- *firms employ using the contract and wage schedule set under said contract that yields the greatest rents in steady state.*
- *labor supply to a firm of type p is pinned down in steady state by the equilibration of flows of workers in from unemployment and from other firms and out to unemployment and other firms.*

4.2 Equilibrium

Proposition 1. *When the cost of maintaining a vacancy featuring a renegotiable contract exceeds that of a vacancy for a non-negotiable contract the equilibrium is* ***segmented*** *and only more-productive employers re-negotiate.*

[19] I assume balanced matching for tractability and comparability with the nested models but acknowledge that alternative assumptions may better fit the distribution of firm sizes. Segmentation, as described here, persists so long as the number of vacancies per firm does not increase too rapidly in productivity.

I derive the wage equations and employment distributions and present formal proof of segmentation in appendix A of this paper. They can also be found in Doniger (2015). Intuition rests on three (sets of) observations.

First, balanced matching, assumed in both nested models, implies that all firms maintain an equal mass of vacancies and the relative size of firms is determined ex-post by the probabilities of hiring and retention conditional on these equal masses of vacancies. Thus, balanced matching implies that relative cost of the two wage contracts is independent of equilibrium firm size.

Second, under segmentation, labor flows are efficient, meaning that no worker rejects an offer from an employer that is more productive than their incumbent. To see this, note that if $q < p$ are the productivity of two firms then the posited segmentation implies that either both q and p do not negotiate; both negotiate; or q does not negotiate while p does. In the first two cases Burdett and Mortensen (1998) (resp. Postel-Vinay and Robin (2002b)) demonstrate that optimal posted (resp. renegotiated) wages imply that the worker will flow from q to p if given the chance. To consider the final case it is useful to define the non-negotiable wage offered by an employer with labor productivity p as $w^n(p)$ and the renegotiable wage as $w^r(p,q)$ where q is the labor productivity of the worker's best-to-date outside option. Since any profit maximizing wage choice for q implies $w^n(q) < q$ and $q < p$ there exists a profitable wage offer from p that will trigger the worker to flow from q to p.[20] Thus, under optimally set wage offers, the worker always flows from q to p in equilibrium. In addition, let $\check{p}$ be the most productive firm that does not negotiate and consider the impact on worker flows if this firm deviates to renegotiating. As just discussed, this firm can hire from all firms with $q < \check{p}$ under the renegotiable contract. Meanwhile under the posited segmentation, all firms with $p > \check{p}$ renegotiate and therefore workers always flow from $\check{p}$ to p if given the opportunity. Thus, the marginal firm may change its wage bill but not increase its size by changing its wage setting rule.

Third, in Appendix A, I show that optimally set wages have the following properties:

$$(3.1)\ \frac{dw^n(p)}{dp} > 0, \qquad (3.2)\ \frac{dw^r(q,p)}{dq} > 0,$$

$$(3.3)\ \frac{dw^r(q,p)}{dp} < 0, \text{ and} \qquad (3.4)\ w^r(p,q) < w^n(q)\ \forall\ q \leq \check{p} < p.$$

Properties (3.1) and (3.2) are intuitive. The first, property (3.1), states that under a non-negotiable contract, wages are increasing in an incumbent's productivity. Burdett and Mortensen (1998) and Bontemps et al. (2000) document this property in their wage-posting

[20] Indeed, as noted in the following $w^r(p,q) < w^n(q)$.

models, which are nested in the present model.[21] The intuition follows from noting that, conditional on selecting the nonnegotiable contract, a more productive employer is willing to pay more for an employee because the output it forgoes if it is rejected is larger. That this property carries through to the segmented equilibrium follows from noting that labor flows are constrained efficient under segmentation. The second, property (3.2), states that under a renegotiable contract wages are increasing in a worker's best-to-date outside option. Postel-Vinay and Robin (2002b) prove this in their sequential Bertrand auction which is also nested in the present model.[22] The intuition follows by noting that a larger wage offer is required to beat out a more competitive offer from a more productive employer. That this holds even if that employer's offer is non-negotiable follows from property (3.1).

Property (3.3), which states that more-productive employers that use the renegotiable contract employ workers at lower wages conditional on their best-to-date outside options, appears counterintuitive. However, by noting two things this can be made intuitive. First, the cost-minimizing wage offer from the renegotiating employer is a wage equal to the worker's current reservation given the worker's current best-to-date outside offer. A lower wage offer would not be accepted and, because the employer can renegotiate wages, the prospect of future competition provides no incentive to offer a higher wage. Second, as in Postel-Vinay and Robin (2002b), the option value of search—and the resulting pay increases with this and future incumbents—is an amenity associated with the job offer specifying a renegotiable wage and is thus priced into the wage paid at hiring. Because the option value stems from the expectation of future wages and a more productive employer will place higher wage bids in the future, employment in a high productivity employer now locks in a longer tail of the expected wage distribution in the future. In other words, the option value of search is increasing in the incumbent's productivity whenever the incumbent employs under a renegotiable contract. This mechanism gives rise to property (3.3).

Finally, property (3.4), which states that an employer that renegotiates can hire from a employer that does not renegotiate at a wage cut, also appears counterintuitive. However, the logic also stems from comparing the option value of search in a nonnegotiable contract at a q-productivity employer which does not renegotiate, with that in a renegotiable contract at a p-productivity employer which renegotiates. Because the renegotiating employer will increase the wage offer in an attempt to retain the worker, the renegotiating employer offers a larger option value of search. As in the logic of property (3.3), the value of this expected competition is an amenity that is priced into the wage that induces transition from the

[21] An economy identical to that considered by Bontemps et al. (2000) is recovered when the relative cost of maintaining a renegotiable vacancy is sufficiently large.

[22] An economy identical to that considered by Postel-Vinay and Robin (2002b) is recovered when the relative cost of maintaining a renegotiable contract falls weakly below zero.

q-productivity employer to the p-productivity employer and results in the noted wage cut.

Constrained efficient labor flows and properties (3.1) through (3.4) can be used to establish that the benefit of switching from not negotiating to renegotiating is increasing in the firms productivity. Meanwhile the assumptions of balanced matching and relative vacancy costs imply that the relative costs of the two contracts are independent of productivity. This is sufficient to show single crossing and the existence of a segmented equilibrium.[23]

4.3 Secular trends

This model is consistent with the facts 1-6.[24] Meanwhile, trend in the incidence of asynchronous pay changes, documented in 3.8 begs the question, can the proposed model rationalize secular trends observed in the macroeconomy? Further this question arises naturally, given the unique ability to look into history with the SIAB data.

Admission of dual contracting methods allows for the trend in the incidence of asynchronous pay changes observed in 3.8 to correspond with a higher share of firms employing under the renegotiable contract, as described in more detail in subsection 3.8 with, all else equal, a higher incidence of APC corresponding to a higher share of firms employing under the renegotiable contract, as described in more detail in subsection 4.5. This fact suggests a decrease over time in the costs associated with renegotiable contracts. Such a decrease is consistent with a backdrop of weakening unionization in Germany through this period—particularly after reunification—which has both triggered and occurred in parallel to labor market reforms—such as introduction of fixed term contracts and preferential tax status for certain part time jobs—which have tended to increase the fluidity of the German labor market. However, the steady progression of the prevalence of asynchronous pay changes documented in figure 4 suggests that none of these events is singularly responsible.

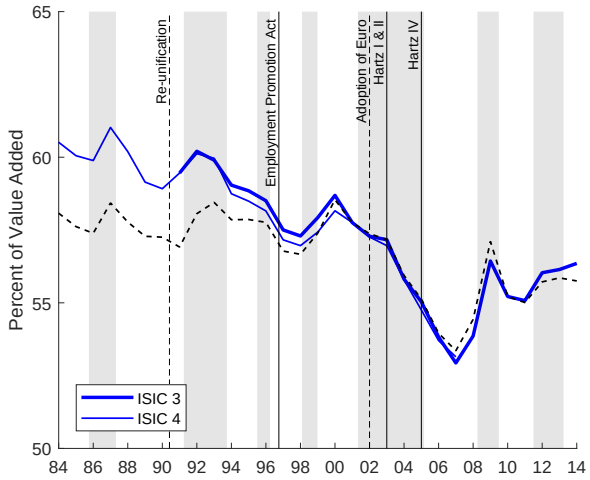
In this section, I investigate whether the data, viewed in light of the model, speak to the trend in labor share that has been well documented in developed economies.[25] Elsby et al. (2013) and Karabarbounis and Neiman (2014), among others, have highlighted a secular decline in labor share in the United States and internationally, respectively. Germany is

[23] Uniqueness requires that the difference in wage bills $\check{p}$ under non-negotiating and negotiating for the firm is monotonically increasing in $\check{p}$. This is guaranteed if the rate of job-to-job mobility relative to separations is sufficiently small. See appendix A.3.2 for details.

[24] Note, the model and nested models are defined in steady state. Facts 1 and 7 describe cyclical phenomena. The model is consistent with the phenomena if booms are states of the world where job offer arrival rates increase relative to separation rates.

[25] A host of theories have been put forth to explain the remaining trend: Elsby, Hobijn, and Şahin (2013) Karabarbounis and Neiman (2014) Autor, Dorn, Katz, Patterson, and Reenen (2017) Autor, Dorn, Katz, Patterson, and Van Reenen (2020) Gouin-Bonenfant (2018) Edmond, Midrigan, and Xu (2015) Eggertsson, Robbins, and Wold (2018) Kehrig and Vincent (2018) This analysis is intended to complement, rather than compte with, this literature.

Figure 5: Payroll Share



Source: EU KLEMS project, author's calculations.
Note: black dashed line holds the industrial composition fixed at the 2010 mix.

among the countries documented by Karabarbounis and Neiman (2014), and the solid blue line in figure 5 documents Germany's declining labor share. The data come from EU KLEMS, which synchronize national accounts data and definitions for a large set of countries. From 1984 to 2014, payroll share declined 5 percentage points.

The trend in payroll share is in part driven by changes in industry composition over this period. To address this, I adjust the data to hold constant the shares of employment in each industry at the 2010 share. The dotted black line in figure 5 plots the adjusted series. It is readily apparent that much of the early trend is accounted for by composition. In contrast, starting in the late 1990s, trend in payroll share transitions to a within-industry phenomenon. From 1984 to 2000, composition-adjusted payroll share holds steady at approximately 58 percent. Thereafter, it falls nearly 5 percent to a trough in 2007 before partially recovering 2.3 percent by 2014.

4.4 Comparative Statics

To begin, the model delivers the following:

Proposition 2. *All else being equal, increasing the share of employers offering the re-negotiable contract reduces labor share.*

As before, proof can be found in Appendix A. Here I provide intuition.

Three forces act upon the compensation of employees when the composition of contracts shifts. First, some marginal employer switches from the non-negotiable contract to the renegotiable contract. From property (3.4), we know that this employer reduces its average wage bill. Second, wages necessary to hire from this marginal employer increase. A key insight is that these first two forces offset perfectly. This offsetting occurs because the promise of higher wages in light of future renegotiations is exactly the amenity that the marginal employer is able to price into its wage schedule when it switches to the renegotiable contract.

The third force delivers the equilibrium result. Notice that renegotiating employers yield no rent at hiring, because they can adjust later in the face of future competition, while non-negotiating employers offer wages above the history dependent reservation wage of a prospective employee because they cannot adjust later to ward off future competition. Indeed, nonnegotiable wages are optimally set to balance the lost rent against the hazard of attrition (Burdett and Mortensen, 1998; Bontemps et al., 2000). As the share of renegotiating employers rises the equilibrium result is that the rent yielded at hiring by all firms falls.[26]

To see that falling compensation of employees implies falling labor share in the present context requires specifying a national accounting framework that includes a treatment of rents and the costs of the labor contracts. There are two reasonable options. The first is to treat contracting costs as an intermediate input. This assumption gives rise to

$$labor\ share = \frac{compensation\ of\ employees}{output - contracting\ costs}.$$

The second imagines that the microfoundation of contracting costs are payments to employees in a human resources department. In this case

$$labor\ share = \frac{compensation\ of\ employees + contracting\ costs}{output}.$$

It is straightforward to show that declining cost of the renegotiable contract implies falling labor share under either accounting framework whenever the conditions for uniqueness are

[26]Indeed, it falls to zero as the game approaches Postel-Vinay and Robin (2002b) making that game subject to the Diamond (1971) Paradox. Doniger (2015) discusses how contract heterogeneity serves to break the Diamond (1971) Paradox, restoring a relation between wage dispersion and search incentives among the unemployed. The problem of the Diamond (1971) Paradox could also be alleviated by introducing bargaining power on the part of workers as in Cahuc, Postel-Vinay, and Robin (2006). As compared with Cahuc et al. (2006), which offers a reduced form incentive for search on the part of the unemployed, the present model provides a microfounded incentive that leaves observable tracks in the data: the incidence of asynchronous pay changes relative to job-to-job transitions.

met.[27]

4.5 Measurement

In the previous sections, I have provided suggestive evidence that the ratio of asynchronous pay changes to job-to-job transitions measured in a given interval of time is related to the share of firms using the renegotiable contract in the model economy. This intuition corresponds cleanly with the model's clear predictions about the incidence of job-to-job mobility and on-the-job wage growth.

Job-to-job mobility occurs whenever on-the-job search leads to an innovation in the best-to-date job offer. Thus, the likelihood that a job survives t periods and ends in job-to-job mobility is:

$$\int_{\underline{p}}^{\bar{p}} [\lambda_e[1 - F(p)]e^{-[\delta+\lambda_e[1-F(p)]]t}]dG(p) \tag{4.1}$$

where $[\underline{p}, \bar{p}]$, $\bar{p}$ potentially infinite, is the support of the distribution of firms' productivity; λ_e and δ are the exogenous, Poisson arrival rate of job offers on the job and job separations; $F(p)$ is the cumulative distribution of wage offers originating from firms with productivity p or less; and $G(p)$ is the cumulative distribution of workers across firms with productivity p or less.

Raises occur in a more specialized set of circumstances: whenever on-the-job search leads to 1) an innovation in the best-to-date outside option, 2) no innovation in the best-to-date job offer, *and* 3) the incumbent best-to-date job offer is at an employer who renegotiates. Thus, the likelihood that a wage survives t periods and ends in a raise is:

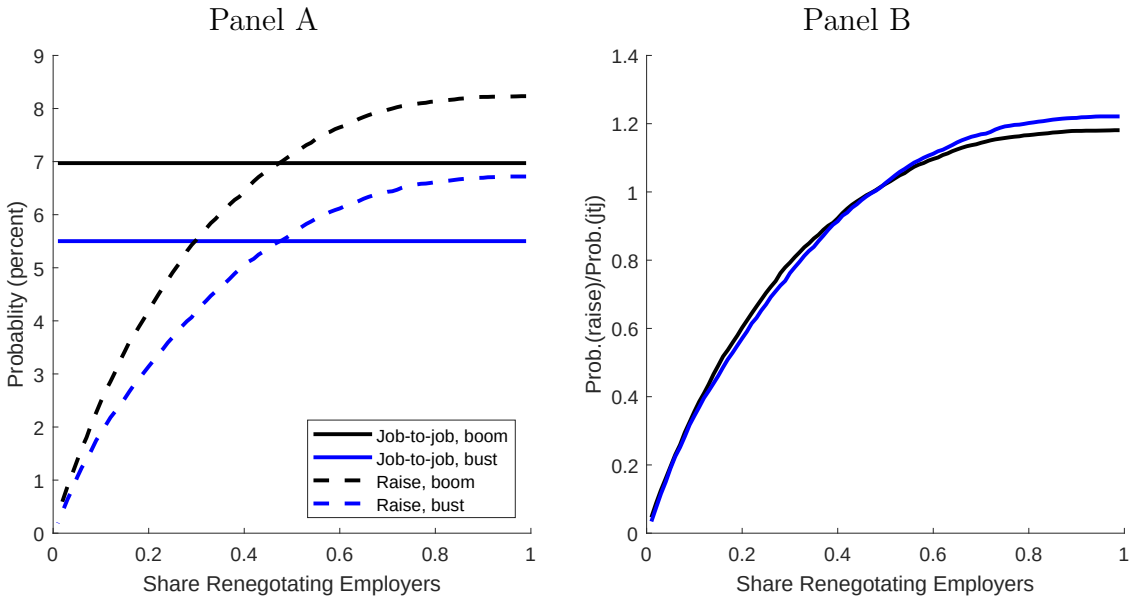
$$\int_{\tilde{p}}^{\bar{p}} \int_{\underline{q}}^{p} [\lambda_e[F(p) - F(q)]e^{-[\delta+\lambda_e[1-F(q)]]t}]dG(q|p)dG(p) \tag{4.2}$$

where $G(q|p)$ is the cumulative distribution of best-to-date outside options originating from firms with productivity q or less conditional on employment in a firm with productivity p. It is straightforward to observe that, all else equal, both the model-implied incidence of a raise and the share of firms employing under a renegotiable contract are decreasing in $\tilde{p}$.

Figure 6, Panel A illustrates the steady state probability of a job-to-job transition and a raise in the model as the share of firms utilizing the renegotiable contract rises from zero to one. The y-axis records the probability of each event occurring in a given interval as the simulated share of renegotiating employers increases from zero to one. As discussed above

[27] As noted previously, uniqueness requires that the difference in wage bills $\check{p}$ under non-negotiating and negotiating for the firm is monotonically increasing in $\check{p}$. This is guaranteed if the rate of job-to-job mobility relative to separations is sufficiently small. See appendix A.3.2 for details.

Figure 6: Simulated incidence of job-to-job mobility and asynchronous pay change



Source: Author's simulations.

and in Appendix A, the allocation of labor is constrained efficient under all compositions of contract types, thus the probability of observing a job to job transition (solid lines) depends only on the models hazards and is independent of the fraction of employers utilizing the renegotiable contract. In contrast, the probability of observing a raise is increasing, not surprisingly, in the fraction of firms which renegotiate.

Further, panel A illustrates these hazards under a high probability of on-the-job offer arrival and low probability of separation as would be the case in an expansion (black) and a low probability of offer arrival and high probability of separation as would be the case in a contraction (blue). In the contraction simulation, both job-to-job transition and raise probabilities fall short of those simulated in the expansion. However, these scale approximately proportionately–a drop in the job-to-job transition probability of half coincides with a drop in the raise probability of about half–when the share of firms that renegotiate is not too large. The ratio is illustrated in Panel B. In the data documented in this paper, the ratio fluctuates between 0.07 and 0.3, well within the region in which the mapping from the ratio of these to the share of firms which renegotiate is approximately linear and acyclical.[28]

[28]While there may be reason to think that some asynchronous pay changes are not observed in the SIAB, since reporting is not legally mandated, the approximate linearity and acyclicity covers almost twice this range.

Table 5: Determinants of Payroll Share

Dependent Variable: Payroll Share	Levels						Stacked 5-year Differences
	(I)	(II)	(III)	(IV)	(V)	(VI)	
APC / JTJ	-0.083*	-0.094**	-0.064**	-0.062**	-0.087**	-0.044*	-0.035**
	(0.0480)	(0.044)	(0.030)	(0.027)	(0.043)	(0.023)	(0.016)
Year FE	X	X	X	X	X	X	
Industry FE	X	X	X	X	X	X	
JTJ/separations		X	X	X	X	X	
Demographics[a]			X			X	
Unionization[b]				X		X	
Import Exposure[d]					X	X	
R-Squared	0.154	0.159	0.305	0.293	0.177	0.402	0.332
Observations	544	544	544	544	544	544	544

Source: Sample of Integrated Labor Market Biographies (SIAB), EU KLEMS project, OECD and WOID input-output tables, IAB Establishment Panel (BH), author's calculations.

Note: ***, ** and * indicate significance at the 1, 5 and 10 percent level. Observations weighted by industry employment. Standard errors clustered at the industry level.

[a] *Share West German, sex composition, establishment age (5-year bins), employee age (5-year bins).*

[b] *Quadratic fit in time to concentration of union types by industry. Author's calculations based on the IAB Establishment Panel (BH).*

[d] *Percentage difference between total domestic requirements and total requirements constructed from the OECD and WIOD input-output tables. Following the methodology of Elsby et. al (2013).*

4.6 Evidence

Here I exploit heterogeneity across industries to explore the relationship between trends in the incidence of re-negotiable contracts and payroll share.[29] Specifically, I document a relationship between within-industry changes in payroll share and the incidence of asynchronous pay changes relative to job-to-job transitions. As discussed in the previous sections, if one has in mind a job ladder model in which some firms post wages while others renegotiate according to a sequential auction, variation across industries in this ratio is correlated with the share of firms setting wages according to sequential auction.

I focus on 1999 and onward because, during this period, shifts in payroll share occurred within industry. To test the relationship between asynchronous raises and payroll share, I

[29]Following Elsby et al. (2013), I focus on the ratio of compensation of employees to total value added to avoid issues stemming from imputing the contribution of sole proprietor income to labor versus capital share. In addition, the model that I discuss in the following section pertains to an employer employee relation, not a sole proprietor.

run the following industry-level regression:

$$labor\ share_{i,t} = \beta\{\frac{APC}{JTJ}_{i,t}\} + year\ fixed\ effects + industry\ fixed\ effects + \varepsilon_{i,t}$$

where $\frac{APC}{JTJ}_{i,t}$ is the ratio of asynchronous pay changes to job-to-job transitions in an industry $\times$ year. Regressions are weighted according to the average value added over the period 1999 to 2014 and standard errors are clustered at the industry level. I consider the 34 broad industries in the International Standard Industrial Classification of All Economic Activities 4. Table 5 presents the result. However, across specifications, increasing the incidence of an asynchronous raise relative to job-to-job mobility decreases payroll share with statistical significance ranging between 5 and 10 percent. Alternative specifications include industry level demographics as well as measures of competing theories—notably, declining unionization and increasing trade exposure.[30]

5 Conclusion

This paper provides a novel look at wage-change data and uncovers new stylized facts. In particular, I focus on asynchronous rather than the synchronized pay changes that have been taken as evidence of the Taylor (1980) hypothesis of infrequently but synchronously renegotiated wage contracts. In contrast to much of the existing empirical literature, the new facts that I document are inconsistent with the Taylor (1980) mechanism and instead point toward microfoundations for wage changes that have recently been introduced into the macroeconomics main-stream in particular, a job ladder model with in which wages are renegotiable in the event of an innovation in a worker's alternative employment prospects. I describe a steady state version of such a model due to Doniger (2015) and discuss the ways it is consistent with the novel facts about wage changes and reconciles apparently contradictory

[30]Unionization: To study the effects of unionization I construct estimates of industry level concentration of the various union types extant in Germany during this time—industry wide, plant level, works council and "other" representation—as well as the share without representation of any kind, using the IAB Establishment Panel. Because of small cell sizes for some industry-years estimates are as industry specific flexible time trends. These are then merged to industry level aggregates constructed from the SIAB. Regression coefficients, not shown, suggest that an industry wide agreement or a works council is positively correlated with payroll share as compared to no collective representation. Plant level and "other" representation have no effect. Import Exposure: Following Elsby et al. (2013) I measure import exposure as the ratio of final value added accounted for by imported inputs, by industry. To construct the measure, I use the OECD input-output tables. Coefficients, not shown, suggest that a 1 percentage point increase in import exposure decreased payroll share by approximately 0.3 percentages points, implying that over the horizon considered variation in import exposure accounts for approximately 2 percentage points of the decline in payroll share.

secular trends.

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A Structural Model

A.1 *Equilibrium distributions.*

The following are standard in the literature deriving from the nested Bontemps et al. (2000) and Postel-Vinay and Robin (2002b) models. It is straightforward to show, using the method of mass balance, that the unemployment rate is

$$u = \frac{\delta}{\delta + \lambda_u}$$

and that the distribution of firm types across employed workers is

$$L(p) = \frac{\Gamma(p)}{1 + k_e \bar{\Gamma}(p)}$$

where $\bar{\Gamma}(p) = 1 - \Gamma(p)$ and $k_e = \lambda_e / \delta$ is the average number of jobs held during an employment spell. The density of $L(p)$ is:

$$\ell(p) = \frac{1 + k_e}{1 + \bar{\Gamma}(p)}$$

Finally, within a non-negotiating firm the distribution of wages is a point mass at the posted wage. Within a renegotiating firm the distribution of wages is

$$G(w|p) = \left(\frac{1 + k_e \bar{\Gamma}(p)}{1 + k_e \bar{\Gamma}(q(w,p))} \right)^2.$$

A.2 *Wage contracts.*

Noting that renegotiating employers offer the history-contingent reservation wage at all times deriving wage schedules under each contract type is also straightforward:

$$w^n(p) = p - [1 + \kappa_1 \bar{\Gamma}(p)]^2 \int_{\underline{w}}^{p} [1 + \kappa_1 \bar{\Gamma}(x)]^{-2} dx$$

$$w^r(q,p) = \begin{cases} w^n(q) - k_e \bar{\Gamma}(\check{p}) \left[\check{p} - w^n(q) - \int_q^{\check{p}} \frac{k_e [\Gamma(\check{p}) - \Gamma(x)]}{1 + k_e [\Gamma(\check{p}) - \Gamma(x)]} \frac{dw^n(x)}{dx} \right] - k_e \int_{\check{p}}^{p} \bar{\Gamma}(x) dx & \text{for } q \leq \check{p} \\ q - k_e \int_q^p \bar{\Gamma}(x) dx & \text{for } \check{p} < q. \end{cases}$$

where p is the incumbent employer's productivity, q is the productivity of the best-to-date outside offer, k_e is the ratio of the arrival rate of offers on-the-job to the separation rate, Γ is the distribution of employer types, $\underline{w}$ is the reservation wage of a worker to take employment in a non-negotiable contract, and $\check{p}$ is the least productive employer utilizing the re-negotiable contract. Comparative statics (3.1) through (3.4) follow. Existence of an invertible mapping

$q(w,p)$ can be checked by noting that $w^r(q,p)$ is increasing in q for $q < \tilde{p}$ and $q > \tilde{p}$ and that $w^r(\tilde{p}^-,p) < w^r(\tilde{p}^+,p)$. Further details and value functions can be found in Doniger (2015).

A.3 *Market Segmentation.*

A.3.1 Existence

Current operating surplus from the proposed strategies exceed current operating surplus from each firm's best deviation.

Suppose non-negotiating is prescribed: If non-negotiating (n) is prescribed then it must be that $p < \check{p}$.

For such a p-productivity firm, current operating surplus from playing optimal wage under the prescribed wage contract, n, and the best deviation (bd) to renegotiating (r) can be written as

$$\pi^n(p) = [p - w^n(p)]\ell(p)$$

and

$$\pi^{bd}(p) = [p - w^r(\underline{p},p)]\ell(\underline{p}) + \int_{\underline{p}}^{\grave{p}} [p - w^r(q,p)]d\ell(q) - c(\check{p})$$

where $\grave{p}$ is the productivity of the most productive firm that offers a posted wage less than p (for example, the most productive firm that the p-type firm can outbid by switching to SA).

Substituting in $c(\check{p}) = [w^n(\check{p}) - \mathbb{E}[w|\check{p}, r]]\ell(\check{p})$ and rearranging gives,

$$\begin{aligned}
\pi^{bd}(p) =& [p - w^r(\underline{p}, p)]\ell(\underline{p}) + \int_{\underline{p}}^{\grave{p}} [p - w^r(q, p)]d\ell(q) - \underbrace{[w^n(\check{p}) - \mathbb{E}[w|\check{p}, r]]\ell(\check{p})}_{=c(\check{p})} \\
=& [p - w^r(\underline{p}, p)]\ell(\underline{p}) + \int_{\underline{p}}^{\grave{p}} [p - w^r(q, p)]d\ell(q) \\
& - \underbrace{\left\{ [w^n(\check{p}) - w^r(\underline{p}, \check{p}]\ell(\underline{p}) + \int_{\underline{p}}^{\grave{p}} [w^n(\check{p}) - w^r(q, \check{p}]d\ell(q) + \int_{p}^{\check{p}} [w^n(\check{p}) - w^r(q, \check{p})]d\ell(q) \right\}}_{=c(\check{p})} \\
=& [p - w^n(\check{p}) + \underbrace{w^r(\underline{p}, \check{p}) - w^r(\underline{p}, p)}_{<0, \text{ since } \frac{dw^r(p,p)}{dp}<0}]\ell(\underline{p}) \\
& + \int_{\underline{p}}^{\grave{p}} [p - w^n(\check{p}) + \underbrace{w^r(q, \check{p}) - w^r(q, p)}_{<0, \text{ since } \frac{dw^r(q,p)}{dp}<0}]d\ell(q) \\
& - \int_{p}^{\check{p}} [\underbrace{w^n(\check{p}) - w^r(q, \check{p})}_{\geq 0}]d\ell(q) \\
<& [p - w^n(\check{p})]\ell(\grave{p}) \\
<& [p - w^n(\grave{p})]\ell(\grave{p}) \\
<& \pi^n(p).
\end{aligned}$$

Where the second to last line follows from noting that $w^n(p)$ is increasing in p and the last line follows from noting $w^n(p)$ is the unique profit-maximizing non-negotiable wage choice for the p-type firm.

In other words, the non-negotiating firm could increase its labor supply by deviating to renegotiating. However, the firm could also increase its labor supply by the same amount by deviating to a larger non-negotiable wage. Willingness to pay for the right to renegotiate is then strictly less than the difference between the wage bill under the deviation to renegotiating and the deviation to a higher non-negotiable wage, which in turn is strictly less than the cost of renegotiating in the posited $\check{p}$ equilibrium.

Suppose renegotiating is prescribed: If renegotiating (r) is prescribed then it must be that $\check{p} < p$. For such a p-productivity firm, current operating surplus from playing the

prescribed r wage schedule and deviating to the best n wage are

$$\begin{aligned}\pi^r(p) =&[p - w^r(\underline{p}, p)]\ell(\underline{p}) + \int_{\underline{p}}^{\check{p}} [p - w^r(q,p)]d\ell(q) \\ &+ \int_{\check{p}}^{p} [p - w^r(q,p)]d\ell(q) - c(\check{p})\end{aligned}$$

and

$$\pi^{bd}(p) = [p - \grave{w}]\ell(\grave{w}).$$

Note that $\grave{w} \geq w^n(\check{p})$ since $p \geq \check{p}$. Simplifying,

$$\begin{aligned}\pi^{BD}(p) =&[p - \grave{w}]\ell(\underline{p}) + \int_{\underline{p}}^{\check{p}} [p - \grave{w}]d\ell(q) + \int_{\check{p}}^{\grave{w}} [p - \grave{w}]d\ell(q) \\ <&[p - \underbrace{w^n(\check{p})}_{\leq \grave{w}}]\ell(\underline{p}) + \int_{\underline{p}}^{\check{p}} [p - \underbrace{w^n(\check{p})}_{\leq \grave{w}}]d\ell(q) + \int_{\check{p}}^{\grave{w}} [p - \underbrace{w^r(q,p)}_{< \grave{w}}]d\ell(q) \\ <&[p - w^r(\underline{p}, p) - \underbrace{w^n(\check{p}) + w^r(\underline{p}, \check{p})}_{>0, \text{ since } \frac{dw^r(\underline{p},p)}{d\underline{p}} < 0}]\ell(\underline{p}) \\ &+ \int_{\underline{p}}^{\check{p}} [p - w^r(q,p) - \underbrace{w^n(\check{p}) + w^r(q, \check{p})}_{>0, \text{ since } \frac{dw^r(q,p)}{dp} < 0}]d\ell(q) \\ &+ \int_{\check{p}}^{p} [p - w^r(q,p)]d\ell(q) < \pi^r(p).\end{aligned}$$

The best deviation to n involves a reduction in the r firm's labor supply. I can find a bound on the minimum willingness to pay for the right to r by considering only the labor supply that would arise under the *smallest possible* best deviation the r firm might select: $w^n(\check{p})$. Willingness to pay for the right to r is then larger than the difference between the wage bill under the deviation to n and the wage bill for these employees under the prescribed r contract, which in turn is strictly greater than the cost of r.

Since no firm wishes to unilaterally deviate, the pair $\{c, \check{p}\}$ form an equilibrium.

A.3.2 Uniqueness

The mapping between c and $\check{p}$ is one-to-one if $\frac{dc}{d\check{p}} > 0$. $\forall \check{p}$ c can be written:

$$\begin{aligned}
c =& \pi^r(\check{p}) - \pi^p(\check{p}) \\
=& \Big[[\check{p} - w^r(\underline{p}, \check{p})]\ell(\underline{p}) + \int_{\underline{p}}^{\check{p}} [\check{p} - w^r(q, \check{p})] d\ell(q)\Big] - [\check{p} - w^n(\check{p})]\ell(\check{p}) \\
=& \big[k_e\bar{\Gamma}(\check{p})[\check{p} - w^n(\check{p})]\big]\ell(\check{p}) + \int_{\underline{p}}^{\check{p}} \ell(q) \frac{1 + k_e\bar{\Gamma}(q)}{1 + k_e[\Gamma(\check{p}) - \Gamma(q)]} \frac{dw^n(q)}{dq}
\end{aligned}$$

Since integrating by parts yields

$$\int_{\underline{p}}^{\check{p}} [\check{p} - w^r(q, \check{p}) d\ell(q) = [\check{p} - w^r(\check{p}, \check{p})]\ell(\check{p}) - [\check{p} - w^r(\underline{p}, \check{p})\ell(\underline{p})] + \int_{\underline{p}}^{\check{p}} \ell(q) \frac{1 + k_e\bar{\Gamma}(q)}{1 + k_e[\Gamma(\check{p}) - \Gamma(q)]} \frac{dw^n(q)}{dq}$$

and noting that

$$w^n(\check{p}) - w^r(\check{p}, \check{p}) = k_e\bar{\Gamma}(\check{p})[\check{p} - w^n(\check{p})]$$

Differentiating gives the result:

$$\begin{aligned}
\frac{dc}{d\check{p}} =& \frac{d\ell(\check{p})}{d\check{p}} \big[k_e\bar{\Gamma}(\check{p})[\check{p} - w^n(\check{p})]\big] + \ell(\check{p})\Big[k_e\bar{\Gamma}(\check{p})[1 - \frac{dw^n(\check{p})}{d\check{p}}]\Big] - \ell(\check{p})\Big[k_e d\Gamma(\check{p})[\check{p} - w^n(\check{p})]\Big] \\
&+ \ell(\check{p})(1 + k_e\bar{\Gamma}(\check{p})) \frac{dw^n(\check{p})}{d\check{p}} - k_e d\Gamma(\check{p}) \int_{\underline{p}}^{\check{p}} \ell(q) \frac{1 + k_e\bar{\Gamma}(q)}{(1 + k_e[\Gamma(\check{p}) - \Gamma(q)])^2} \frac{dw^n(q)}{dq} \\
=& k_e\bar{\Gamma}(\check{p})\ell(\check{p}) + k_e d\Gamma(\check{p})\Big[\ell(\check{p})[\check{p} - w^n(\check{p})] - \int_{\underline{p}}^{\check{p}} \frac{[q - w^n(q)](1 + k_e\bar{\Gamma}(p))}{(1 + k_e[\Gamma(\check{p}) - \Gamma(q)])^2} d\ell(q)\Big] \\
=& k_e\bar{\Gamma}(\check{p})\ell(\check{p}) - k_e d\Gamma(\check{p})\big[\ell(\check{p})[\check{p} - w^n(\check{p})] - 2\int_{\underline{p}}^{\check{p}} \frac{\ell(q)}{1 + k_e[\Gamma(\check{p} - \Gamma(q)} dx\Big] \\
=& k_e\bar{\Gamma}(\check{p})\ell(\check{p}) + k_e d\Gamma(\check{p})\Big[\int_{\underline{p}}^{\check{p}} \ell(q) \frac{1 - k_e[\Gamma(\check{p} - \Gamma(q)]}{1 + k_e[\Gamma(\check{p} - \Gamma(q)]} dx\Big]
\end{aligned}$$

Noting that:

$$\frac{d\ell(\check{q})}{d\check{q}} = \ell(q)\frac{2k_e d\Gamma(q)}{1+k_e\bar{\Gamma}(q)}, \text{ and}$$
$$\frac{dw^n(q)}{dq} = [q - w^n(q)]\frac{2k_e d\Gamma(q)}{1+k_e\bar{\Gamma}(q)}$$

So we have that $\frac{dc}{d\check{p}} > 0$ for sufficiently small k_e. How small depends on the distribution $\Gamma(p)$. As $\Gamma(p)$ approaches a point mass k_e must approach 1; however, for disperse $\Gamma(p)$, k_e can be large. Insufficiently small k_e will result in non-monotonicity as $\check{p}$ approaches $\bar{p}$.

A.4 Increasing in the share renegotiable decreases labor share.

$$\begin{aligned}
\textit{total wages} = &\int_{\underline{p}}^{\check{p}} w^n(p)\ell(p)d\Gamma(p) \\
&+ \int_{\check{p}}^{\bar{p}} \Big[w^r(\underline{p},p)\ell(\underline{p}) + \int_{\underline{p}}^{\check{p}} w^r(q,p)d\ell(q) + \int_{\check{p}}^{p} w^r(q,p)d\ell(q)\Big]d\Gamma(p) \\
= &\int_{\underline{p}}^{\check{p}} w^n(p)\ell(p)d\Gamma(p) \\
&+ \int_{\check{p}}^{\bar{p}} \Big[w^r(\check{p},p)\ell(\check{p}) - \int_{\underline{p}}^{\check{p}} \ell(q)\frac{1+k_e\bar{\Gamma}(q)}{1+k_e[\Gamma(\check{p})-\Gamma(q)]}\frac{dw^n(q)}{dq} \\
&\qquad + p\ell(p) - w^r(\check{p},p)\ell(\check{p}) - \int_{\check{p}}^{p} \ell(q)(1+k_e\bar{\Gamma}(q))dx\Big]d\Gamma(p)
\end{aligned}$$

Since integrating by parts yields:

$$\int_{\underline{p}}^{\check{p}} w^r(q,p)d\ell(q) = w^r(\check{p},p)\ell(\check{p}) - w^r(\underline{p},p)\ell(p) - \int_{\underline{p}}^{\check{p}} \ell(q)\frac{1+k_e\bar{\Gamma}(q)}{1+k_e[\Gamma(\check{p})-\Gamma(q)]}\frac{dw^n(q)}{dq}, \text{ and}$$
$$\int_{\check{p}}^{p} w^r(q,p)d\ell(q) = p\ell(p) - w^r(\check{p},p)\ell(\check{p}) - \int_{\check{p}}^{p} \ell(q)(1+k_e\bar{\Gamma}(q))dx$$

Differentiating:

$$\begin{aligned}
\frac{d(\textit{total wages})}{d\check{p}} =& \big[w^n(\check{p}) - w^r(\check{p},\check{p})\big]\ell(\check{p})d\Gamma(p) \\
&+ d\Gamma(\check{p})\int_{\underline{p}}^{\check{p}} \ell(q)\frac{1+k_e\bar{\Gamma(q)}}{1+k_e[\Gamma(\check{p})-\Gamma(q)]}\frac{dw^n(q)}{dq} \\
&+ \int_{\check{p}}^{\bar{p}} \Big[\frac{d\ell(\check{p})}{d\check{p}}\big[w^r(\check{p},p) - w^r(\check{p},p)\big] + \ell(q)\big[\frac{dw^r(\check{p},p)}{d\check{p}} - \frac{dw^r(\check{p},p)}{d\check{p}}\big] \\
&- (1+k_e\bar{\Gamma}(\check{p}))\ell(\check{p})\big[\frac{dw^n(\check{p})}{d\check{p}} - 1\big] \\
&+ k_e d\Gamma(\check{p})\int_{\bar{p}}^{\check{p}} \ell(q)\frac{1+k_e\bar{\Gamma}(q)}{(1+k_e[\Gamma(\check{p})-\Gamma(q)])^2}\frac{dw^n(q)}{dq}\Big]d\Gamma(p) \\
=&(1+k_e)d\Gamma(\check{p})\int_{\bar{p}}^{\check{p}} \frac{1}{(1+k_e[\Gamma(\check{p})-\Gamma(q)])^2}\frac{dw^n(q)}{dq} \\
>&0
\end{aligned}$$

Noting that:

$$\begin{aligned}
w^r(\check{p},p) - w^r(\check{p},p) &= (w^n(\check{p}) - \check{p})[1+k_e\bar{\Gamma}(\check{p})], \text{ and} \\
\frac{d\ell(\check{q})}{d\check{q}} &= \ell(q)\frac{2k_e d\Gamma(q)}{1+k_e\bar{\Gamma}(q)}
\end{aligned}$$

B Data Appendix

B.1 Christmas Bonus

Typically bonus pay in Germany is distributed at year end as a "Christmas Bonus." After 1984 such bonuses are included in the yearly pay reported in the IAB source data and are averaged into the average daily wage for the episode. It is possible, therefore, that the pattern recorded in Section 3.2 spuriously arises from comparing average daily wages from an episode that includes only the beginning of a year, up until the point when an asynchronous pay change or job ending occurred to average daily wages from a completed year (the year after).

Here, I make an alternative calculation which compares the average daily wage from the year before the year of the pay or job change to the year after. Specifically, figure 7 plots the mean and interquartile range of

$$\frac{w_{t+1}}{w_{t-1}} - \tfrac{1}{2}\frac{w_{t+1}}{w_{t-1}}|_{stay},$$

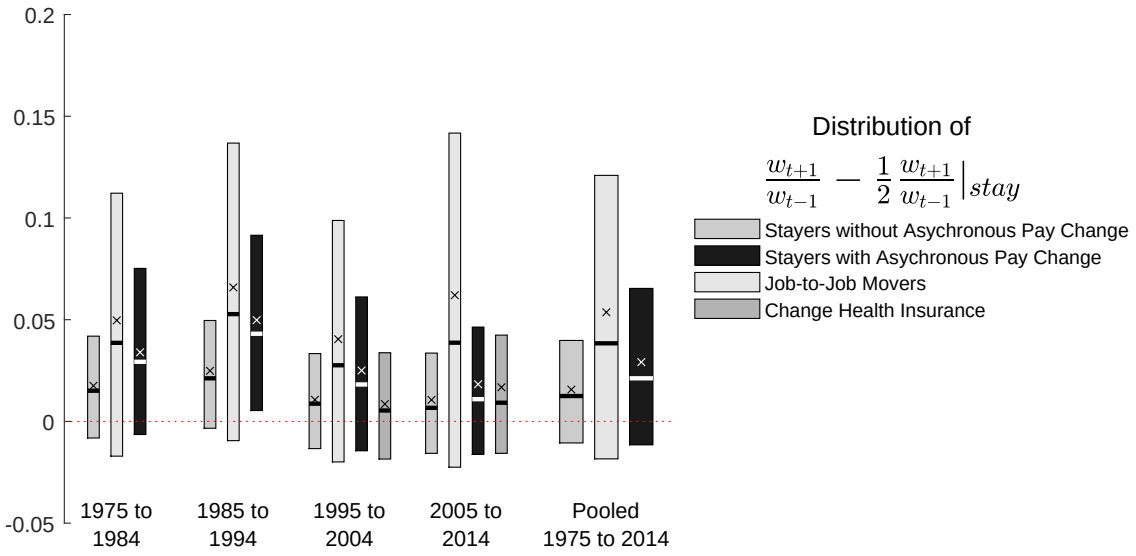
implicitly assuming that wage growth in the non-change year would have been identical to the wage growth for other non-changers. The upside to this calculation is that it excludes the year that is split by the change episode it is, on average, free from the "Christmas Bonus" bias. The downside, this skip-the-change-year analysis is selected on workers with longer tenure and—as I document in Section 3.3—incidence of both pay and job changes are negatively correlated tenure. Thus, the skip-the-change-year analysis is selected on workers with better existing match quality and remuneration conditional on that match quality and therefore, unsurprisingly, reveals smaller innovations in wages following changes.

An additional comment on the "Christmas Bonus" criticism: bonuses are excluded from the data prior to 1984 yet the pattern I document is as evident, if not more so, in those years as in later decades.

B.2 Health-care induced registrations

Figures 8 through 10 document the behavior of change of health care induced reregistrations in the lenses of section 3. From 1998 such changes are recorded as a reason for reregistration in the administrative record. Figure 8 documents a spate of health care changes during and after the Hartz reforms, after which such changes fall in frequency, affecting 1-1.5 percent of spells. Figure 9 documents that such changes follow a distribution between that of job

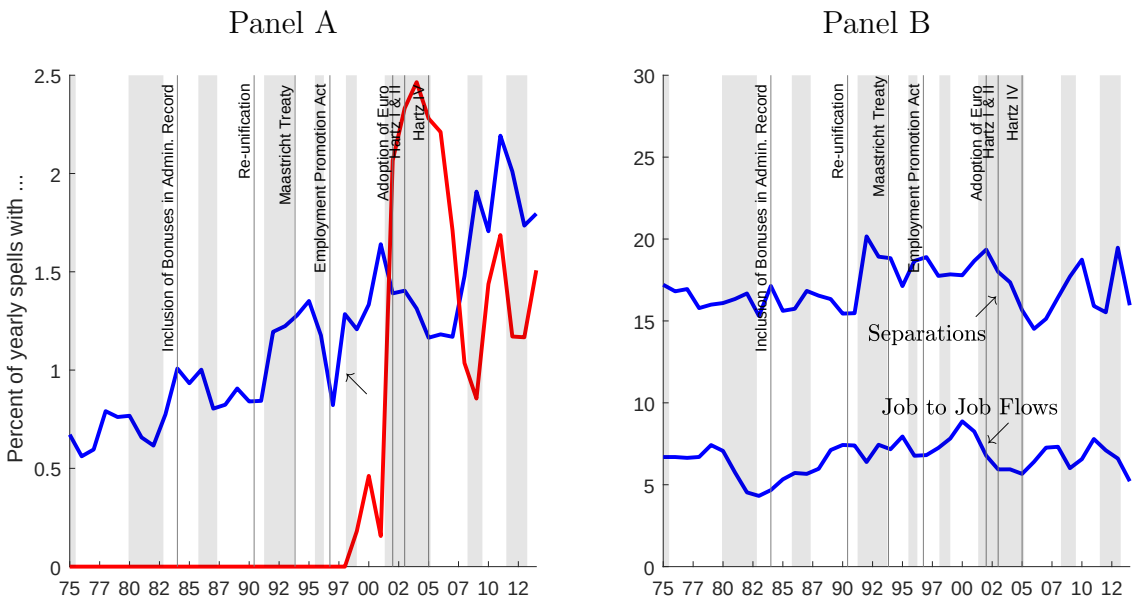
Figure 7: Asynchronous Pay Changes are Large And Dispersed (robustness).



Source: Sample of Integrated Labor Market Biographies (SIAB), author's calculations.

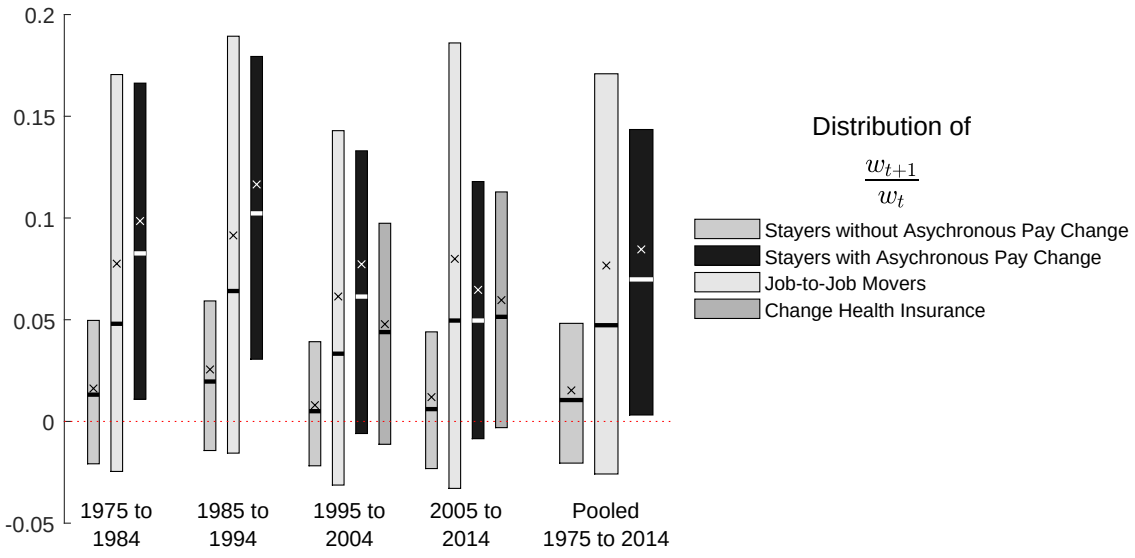
stayers with no reregistration and that of Asynchronous pay change recipients but resembles more the distribution of asynchronous pay change recipients. In contrast, figure 10 reveals a starkly different pattern than figure 2, with heath care changes growing in likelihood with all measures of increased seniority. Finally, figure **??** shows little relationship between measure of firm rank and health care changes.

Figure 8: Health care changes over time



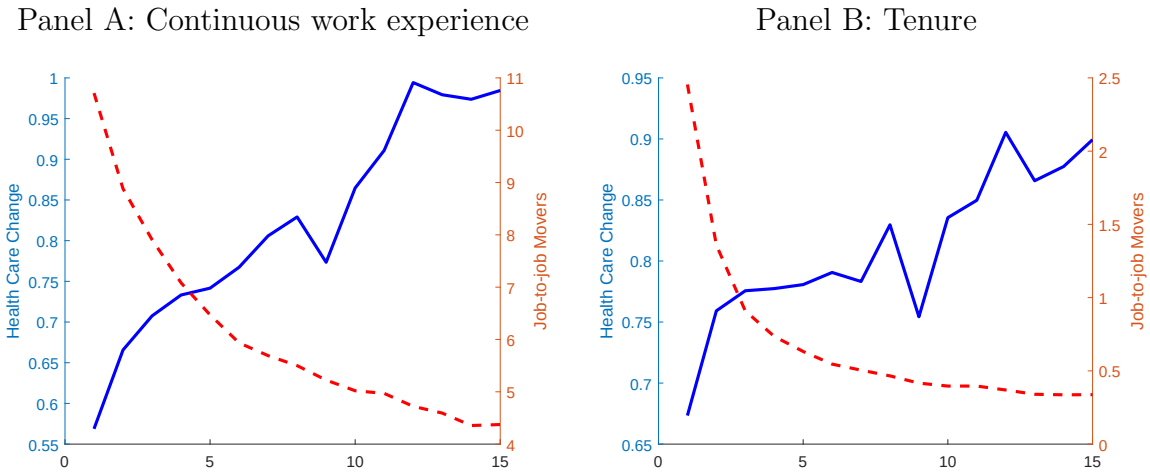
Source: Sample of Integrated Labor Market Biographies (SIAB), author's calculations.

Figure 9: Dispersion of health care changes



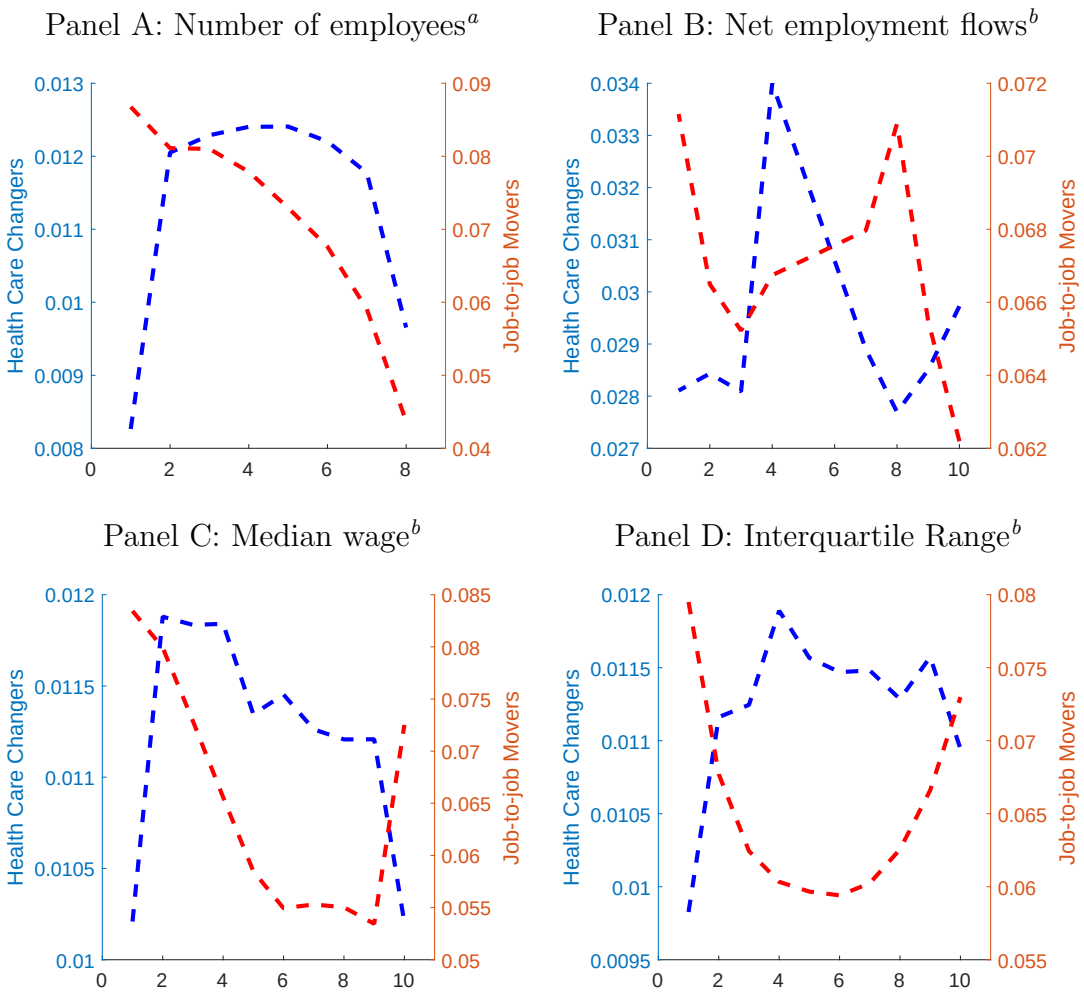
Source: Sample of Integrated Labor Market Biographies (SIAB), author's calculations.

Figure 10: Health care change and seniority



Source: Sample of Integrated Labor Market Biographies (SIAB), author's calculations.

Figure 11: Health care change and the job ladder



Source: Sample of Integrated Labor Market Biographies (SIAB), IAB Establishment History Panel (BPH), author's calculations.

[a] Firm size bins: 1-4, 5-9, 10-19, 20-49, 50-99, 100-199, 200-499, and greater than 500.

[b] Deciles computed within each year.

C Asynchronous pay changes in the US

C.1 Asynchronous pay changes in the SIPP

I now turn to The SIPP is composed of a series of short panels querying, among other things, labor market outcomes such as employment histories and wages. Panels running from 1996 to 2008 (spanning years 1996 to 2014) have the same design, facilitating pooled analysis of the data. In these years, data are collected every three months and retrospective questions fill in wage and employment histories in the intervening two months. Barattieri et al. (2014) propose an algorithm for identifying persistent wage change from the survey data. Simply described, the algorithm conducts a Bai-Perron 1998 test against the null hypothesis of constant nominal wages for each respondents wage history. The advantage of the algorithm over the raw wage data is that it addresses measurement errors due to survey design or response errors, which are assumed to be transitory. Barattieri et al. (2014) consider only the SIPP 1996 panel, but the commonality of structure through to the 2008 panel allows me to apply their algorithm forward.

A key finding of Barattieri et al. (2014) and others in the literature is a spike in the hazard for a wage change at intervals of 12 months. This finding guides my search for asynchronous changes. Having identified persistent pay changes, I identify the modal month in which a pay change occurs for each individual. I then identify asynchronous changes as pay changes occurring in other months.[31]

C.2 Asynchronous pay changes and U.S. business cycles

Table C presents the covariation between the incidence of pay changes, synchronized pay changes, and asynchronous pay changes with measures of cyclical variation in the labor market. Column (I) documents a negative relationship between pay changes (pooling synchronized and asynchronous pay changes) and the unemployment rate and a positive, but statistically insignificant, relationship with the rate of job-to-job mobility. Columns (II) and (III) separately consider synchronized and asynchronous pay changes. Both exhibit negative co-movement with the unemployment rate, but, interestingly, the sign of the relation with job-to-job mobility differs between the two. For synchronized pay changes the coefficient is negative, but economically and statistically insignificant. Meanwhile, asynchronous pay changes have a positive and statistically significant co-movement with job-to-job mobility.[32]

[31] Thus, if a respondent has only one identified pay change it is counted as asynchronous.

[32] A similar pattern can be casually observed for the German data from figure 1, omitting the Hartz recession.

Table 6: Cyclicality of the incidence of pay changes.

LHS=	(I) Any Pay Change	(II) Synchronized Pay Change	(III) Asynchronous Pay Change
unemployment rate	-0.81***	-0.27***	-0.53***
	(0.08)	(0.05)	(0.06)
job-to-job transition rate	0.23	-0.05	0.27**
	(0.17)	(0.11)	(0.14)
R-squared	0.20	0.24	0.21
Observations	652,901	652,901	652,901
Jobs	124,048	124,048	124,048

Source: SIPP Panels 96-08 and authors's calculations. Pay changes identified using the Barattieri, Basu, & Gottschalk (2014) algorithm. Pay changes are categorized as synchronized if a SIPP respondent has more than one pay change in that same calendar month.
Note: All regressions control for job fixed effects and cluster standard errors at the job. Standard errors, clustered at the individual, in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

This finding is particularly interesting in light of the empirical evidence provided in Moscarini and Postel-Vinay (2016, 2017). These papers document that wage growth for SIPP respondents is positively related to job-to-job mobility even if the respondents themselves are not job-to-job movers. Moscarini and Postel-Vinay's 2016; 2017 fact, in part, motivates the macroeconomic models proposed in Moscarini and Postel-Vinay (2019) and Faccini and Melosi (2019). In both, increased job-to-job mobility is correlated with increased wages of job-stayers through their employers' response to increased on-the-job contacts between employees and other firms. However, the mechanism driving wage growth is different, and the differences have non-trivial implications for the relative timing of the driving macroeconomic shock, growth in remitted wages, and price inflation. In Faccini and Melosi (2019) wages are set under wage posting. An implication of this assumption is that the entire wage schedule is revised at the time of the macroeconomic shock, making the shock, wage growth (as measured in both allocative and remitted wages), and inflation coincident.[33] Meanwhile, in Moscarini and Postel-Vinay (2019) wages are set under sequential auction. An implication of this assumption is that additional wage growth for job-stayers when the contact rate between firms and employees increases accrues in large part only after such a contact. This finding

[33]See Basu and House (2016) for a discussion of the differences between allocative and remitted wage measurements.

makes the timing of the shock and inflation coincident while wage growth as measured by remitted wages lags because firms anticipate increased allocative labor costs even though they do not immediately appear in remitted wages.

The evidence present in this section supports a wage setting convention similar to that embedded in the Moscarini and Postel-Vinay (2019) model. Meanwhile, the model present in section 4 provides a flexible intermediate capable of accounting for secular trends in the relative timing of the shock and wage and price reactions.[34]

[34]Such analysis is left for future work.