Original Article

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Reevaluating the German labor market miracle

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Abstract: From 2003 to 2018, employment in Germany increased by 7.3 million, or by 19.3 % – growth not observed since unification. This "labor market miracle" was marked by a persistent and significant expansion of both part-time and low-wage jobs and a deterioration in pay for these jobs, while total hours hardly increased; overall wage growth returned only after 2011. These developments followed in the wake of the landmark Hartz reforms (2003–2005). A modified framework of Katz and Murphy (1992) predicts negative correlation of wages with both relative employment and participation across cells in the period following these reforms. In contrast, wage moderation alone should generate positive association of wages and participation. Our findings are most consistent with a persistent, positive labor supply shock at given working-age population in a cleared labor market. An alternative perspective of labor markets, the search and matching model, also points to the Hartz IV reforms as the central driver of the German labor market miracle.

Keywords: German labor market miracle, Hartz reforms, part-time work, wage inequality

JEL Classification: E24, J21

1 Introduction

The German labor market has witnessed a series of radical changes over the past two decades. The 1990s and early 2000s were characterized by labor market malaise, with rising unit labor costs, stagnant employment, and high unemployment rates, prompting the *Economist* in 1999 to describe Germany as "the sick

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man of Europe". The mid-2000s saw a reversal of this labor market malaise; unemployment rates declined year after year in the aftermath, even in the Great Recession. Although employment growth slowed in the crisis, it recovered soon thereafter, with low frequency movements dominating business cycle fluctuations. Furthermore, a labor market recovery driven initially by part-time work made way for full-time employment growth after 2011, with real wages rising across the wage distribution. By 2017, employment had returned to levels not seen since reunification – a "labor market miracle" unmatched by any other OECD country over the period, yet one accompanied by unspectacular economic growth.[1]

This paper takes a closer look at Germany's labor market miracle. First, we find that more than half of the employment expansion since 2005 can be attributed to the participation margin; that is, to an increased supply of workers given working-age population, as opposed to a reduction of unemployment. Until 2011, net overall employment growth originated in an unprecedented expansion of part-time employment and a reduction of average working hours. While employment rose from 37.8 to 43.6 million or 15.3 percent from 1993 to 2016, the total sum of hours worked stood only 1.9 percent higher in 2016 than in 1993, implying a 12.3 percent reduction in average hours per employed person.[2]

Second, we confirm findings of other researchers that slow GDP and productivity growth was accompanied by a increase in wage inequality across the employed labor force. Compensation, measured as gross hourly pay of employees, has grown more unevenly across different types of labor, leading to a significant increase in wage dispersion. While this finding is already well-established for full-time workers (Gernandt and Pfeiffer, 2007; Goos et al., 2009; and Dustmann et al., 2014), we use an imputation procedure to show that it holds even more strongly when part-time workers are considered.[3]

Third, we contribute new evidence to an ongoing debate over the role of sweeping labor market reforms implemented during the years 2003–2005. These

1 See Möller (2010), Burda and Hunt (2011), Rinne and Zimmermann (2012; 2013), Krause and Uhlig (2012), Krebs and Scheffel (2013), and Balleer et al. (2016).

2 After hitting a trough in 2003, total hours have risen cumulatively by 6.2 percent and employment by 11.3 percent. See IAB aggregate hours account (September 2017), Arbeitszeit Komponenten FB A2: IAB website.

3 This is evident from unadjusted registry data on daily earnings. While real daily wages of the median employee decreased by 4.5 percent over the period 1993–2010, those at the 75th percentile increased by 5.3 percent, and the 25th percentile fell by 12.1 percent (authors' calculations using the SIAB). For similar calculations using a different dataset, see Dustmann et al. (2014).

so-called "Hartz Reforms" reduced unemployment benefits, improved public job intermediation, and relaxed regulations of temporary help agency and marginal employment. A prime objective of the Hartz reforms was the enhancement of labor supply incentives, in particular at the extensive margin.[4] There is considerable debate over the role played by these reforms, as opposed to the flexibility of German collective bargaining, the inherent competitiveness of the German economy, a favorable business cycle, or simply good luck.[5] We show that a simple labor market clearing model responding to an exogenous increase in labor supply delivers the most coherent and plausible account of expanding employment, falling mean wages, increasing wage dispersion, and rising labor force participation observed in the course of the "German labor market miracle".[6]

2 A labor market miracle? Employment in Germany

Between 2003 and 2016, employment in Germany increased cumulatively by 12 percent, compared to 5 percent overall in the EU, 4 percent in the Eurozone, and only 1 percent in Italy (IMF World Economic Outlook, 2016). Even after a sharp GDP decline of 6–7 percent in the Great Recession, the German economy maintained a trend of declining unemployment and rising employment (Burda and Hunt, 2011). Figure 1 presents aggregate indicators since 1970 for Germany and, for comparison, France. The period encompasses the last pre-unification phase of strong growth (the mid-1980s), a unification boom and an overall longer-term post-unification growth slump punctuated by the dot-com boom (1997–2000). The first four panels present annual data for the standardized unemployment rate (ILO concept), the employment ratio, total hours worked, and the implied labor force participation rate; the last two panels display real GDP, expressed as an index equal to 100 in 2010 as well as in growth rates.

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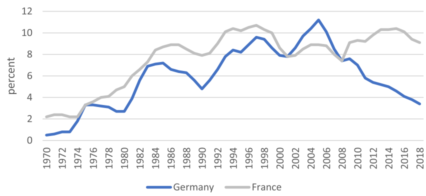
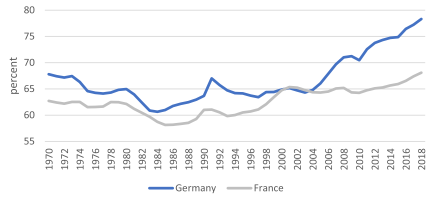
4 The Hartz reforms implemented some but not all recommendations of a blue-ribbon commission headed by Peter Hartz, the personnel director of Volkswagen at the time. See e. g. Jacobi and Kluve (2007), Burda and Hunt (2011).

5 See, for example, Dustmann et al. (2014), or Launov and Wälde (2014).

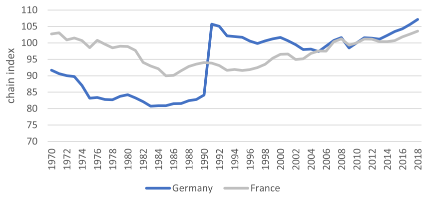
6 Fahr and Sunde (2005), Jacobi and Kluve (2007), Eichhorst and Marx (2011), Klinger and Rothe (2012), Launov and Wälde (2014), and Stops (2016) evaluate the effect of the Hartz reforms on gross flows and labor market dynamics but deemphasize the role of wage determination. Engbom et al. (2015) and Price (2016) find lower reemployment-wages, suggesting that benefit cuts associated with the Hartz IV reforms have worsened jobseekers' outside options.



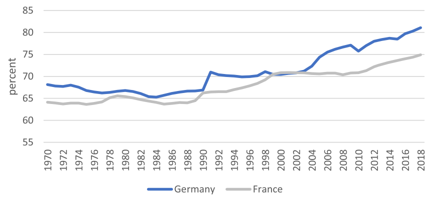
(a) Unemployment rate, OECD/ILO concept, Eurostat, as share of labor force



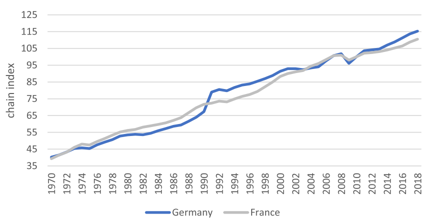
(b) Employment rate as share of working age population



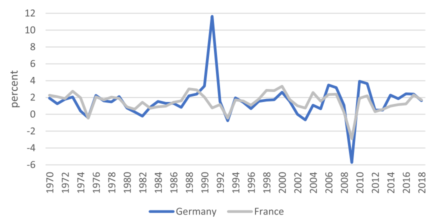
(c) Hours worked, index of Million hours, base year 2010



(d) Participation rate as share of working age population



(e) Real GDP, 2010 prices, index, 2010 = 100



(f) Real GDP growth rates, % per annum

Figure 1: Key labor and macro indicators, 1970–2016.

Note: Real GDP index, chained series, West Germany only until 1990. Participation rates are approximated as $e/(1-u)$, where e = employment rate and u = unemployment rate.
Source: Macro-economic database AMECO, European Commission, authors' calculations.

Taken together, the six panels of Figure 1 summarize the German labor "miracle": A sustained decline in the unemployment rate, a steady rise in the employment ratio, and rising labor force participation throughout and especially after 2003, despite stable total hours worked and trend economic growth similar to that in France. Coinciding with the return to growth, unemployment continued to fall throughout the next decade, despite the Great Recession. Simultaneously, total hours and especially the number of employees increased noticeably after 2005.

Table 1: The German labor market miracle deconstructed, 1993–2016.

Time Period	Annual average change (Δ) (in log points)					Total change (Δ) (in log points)	
	1993–1998	1998–2003	2003–2008	2008–2011	2011–2016	1993–2003	2003–2016
Δ ln (Working age population)	0.2	−0.1	−0.5	−0.7	0.4	−0.3	−2.6
+Δ ln (Participation rate)	0.1	0.7	0.8	0.8	0.2	5.2	8.0
+Δ ln (1-unemployment rate)	−0.5	0.3	0.1	0.5	0.3	−1.5	5.4
+Δ ln (Hours/employed)	−0.6	−1.1	−0.1	−0.6	−0.4	−7.9	−4.4
= **Δ ln (Total hours)**	−0.8	−0.3	0.4	0.0	0.5	−4.5	6.4

Note: Annual change in log-points for each period (1 log-point of $x = 100 * \Delta \ln(x) \approx$ % change). The sum of total hours worked is calculated such that it fits to the aggregate hours account by IAB (hours/employed) and the employment accounts by destatis.
Source: IAB Arbeitszeitrechnung (Aggregate hours accounts), destatis, authors' calculations.

In Table 1, we deconstruct the evolution of total hours worked over the period 1993–2016 into changes of underlying demographics, labor force participation, employment, and hours per employed. Relying on standard ILO concepts, we decompose annual changes in log hours worked according to the identity:

$$\begin{aligned}\text{Total hours worked} &= \text{working age population} \times \text{participation rate}\\ &\times (1 - \text{ILO unemployment rate})\\ &\times \text{hours worked per employed person.}\end{aligned}$$

The expansion of employment was not labor intensive. Real GDP rose by 38 percent over the period 1993–2016, total hours worked increased by less than 2 percent. At the same time, the working-age population shrank by 2.9 percent, ruling out demographics as a direct source of employment gains. Table 1 reveals a strong expansion of labor force participation, by 13.2 log points over the period. This substantial increase in participation of working age individuals is mirrored by a sharp rise in employment, while unemployment fell sharply. Hours per employed person fell continuously, with a slowdown in the period 2003–8.

Table 2 shows an expansion of employment and labor force participation across the economy, in particular for women and older age groups and after 2003. We consider four standard categories of employment: socially insured full-time employment, socially insured part-time employment, marginal employment, and self-employed.[7] While socially insured part-time employment grew steadily since

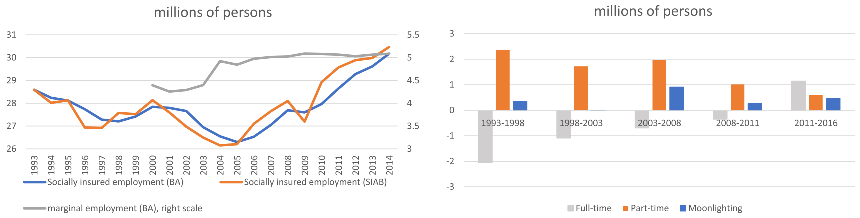
7 Moonlighters are only counted once, in the context of their primary job.

Table 2: Participation rates and employment rates by region, gender, and age, 1993–2016 (in percent).

	1993–2016	1993–98	1998–2003	2003–08	2008–11	2011–16
Participation rate	73.7	70.5	72.4	74.4	76.4	77.3
West	73.2	70.7	71.5	73.8	75.7	76.7
East	77.4	76.5	76.4	77.0	79.2	79.3
Male	81.1	80.7	80.1	80.9	82.1	82.3
Female	66.8	62.6	64.5	67.7	70.6	72.2
Age group 15–19	30.4	29.5	31.7	31.0	31.3	29.1
20–24	70.7	69.5	72.9	70.9	70.9	69.7
25–29	80.9	78.4	82.0	80.9	82.3	82.8
30–34	84.8	80.2	86.9	86.2	86.2	86.8
35–39	86.5	82.3	88.2	88.3	87.9	87.9
40–44	88.5	85.2	89.0	89.8	89.9	89.9
45–49	87.8	84.9	87.9	88.9	89.2	89.5
50–54	83.5	80.2	82.4	84.7	85.7	86.6
55–59	72.6	67.9	69.4	73.5	76.8	79.6
60–64	34.0	27.8	23.7	32.6	42.7	51.4
	1993–2016	**1993–98**	**1998–2003**	**2003–08**	**2008–11**	**2011–16**
Employment rate	67.3	64.3	65.0	66.8	70.9	73.1
West	67.9	64.8	65.8	67.6	71.2	73.2
East	65.1	62.6	61.8	63.4	69.9	72.3
Male	74.1	73.2	72.1	72.5	76.0	78.7
Female	60.6	55.2	57.8	60.9	65.8	68.5
Age group 15–19	28.1	29.9	28.6	27.0	27.9	26.4
20–24	64.2	66.1	65.0	61.6	64.2	64.4
25–29	74.1	73.4	74.1	71.8	75.5	77.4
30–34	79.0	77.3	79.3	77.9	79.9	81.9
35–39	80.7	78.6	80.4	80.6	82.3	83.5
40–44	82.4	80.1	81.2	82.0	84.6	86.0
45–49	81.2	78.3	79.8	80.8	83.9	85.7
50–54	76.2	72.2	73.6	76.1	80.1	82.6
55–59	62.1	52.1	57.1	63.9	70.9	75.3
60–64	29.0	18.2	21.0	29.0	39.6	48.2

Note: All forms of employment, including self-employment. Participation rate is defined as labor force divided by working age population.
Source: Destatis (Mikrozensus), authors' calculations.

1993, full-time employment declined until 2010. Self-employment increased from 1993 until 2005 but has since oscillated around 4–5 million. Marginal employment has been recorded in official statistics since 1999 and has since increased to 5 million. The number of moonlighters ("Nebenjobs") also grew; in 2016, 8 percent of socially insured employees had a second job besides their primary



(a) Time trend, SIAB and BA, 1993–2014

(b) Change in Employment by Type, 1993–2016

Figure 2: Employment trends in Germany since 1993.

Note: Figure (a): Socially insured employment in millions includes full-time and part-time employees. Marginal employment and moonlighting jobs (Nebenjobs) are not included. Figure (b): Part-time includes marginal forms of employment. "Moonlighting" refers to marginal employment of those who already have a form of primary employment.
Source: BA ("Arbeitsmarkt in Deutschland – Zeitreihen bis 2014", Tabelle 3.2), SIAB, and Arbeitszeitrechnung (Aggregate Hours Accounts), IAB, authors' calculations.

employment. At 80 percent in 2016, socially insured employment continues to represent the largest component of employment in Germany. In the analysis that follows, we restrict our attention to socially insured part-time and full-time employees.

It is natural to suspect that the deregulation of marginal employment displaced some full-time employment. Figure 2(a) plots both socially insured employment (left scale), as well as marginal employment (right scale). Marginal employment reported by the Bundesagentur für Arbeit (BA) rose from 4.3 million in 2002 to 4.8 million in 2005 but remained at this stable level thereafter. In contrast, socially insured employment declined from 27.7 million in 2002 to 26.3 million in 2005. Subsequently, the number of socially insured employed increased year after year with the exception of the crisis year 2009. Since 2010, marginal employment remained stable by 5.1 million and socially insured employment increased above 30 million. Figure 2(b) shows that the expansion of part-time work (including marginal employment and part-time work with full social security contribution) was strongly associated with growth at the extensive margin of employment at given working age population.

In Table 3, we examine the heterogeneous dynamics of socially insured employment. Demographic change has affected employment levels in Germany for some time, as the population of older individuals increased while fewer young people entered the labor force. The baby boomer generation is now close to retirement. In addition, the education level of socially insured employees has increased significantly, shifting the structure of employment in Germany. West German so-

Table 3: Change in socially insured employment, 1993–2014 (in percent).

	1993–2014	1993–98	1998–2003	2003–08	2008–11	2011–14
Total change	5.4	−3.4	−3.9	3.8	5.0	4.1
West	9.9	−2.9	−1.3	4.5	4.9	4.6
East	−7.9	−5.8	−12.4	2.0	5.9	3.3
Male	−1.9	−4.2	−6.2	2.7	3.5	2.8
Female	15.3	−2.2	−0.7	5.3	6.8	5.6
Age group 15–19	−59.9	2.8	−43.2	−6.0	−12.8	−16.4
20–24	−39.8	−28.2	−5.8	−4.9	5.1	−11.0
25–29	−27.1	−22.8	−23.4	11.7	3.2	7.0
30–34	−22.6	−0.2	−23.3	−14.5	10.3	7.3
35–39	−16.0	15.2	−0.3	−19.8	−12.8	4.5
40–44	0.3	6.1	16.8	3.5	−7.2	−15.7
45–49	65.5	19.5	8.0	20.9	8.2	−2.0
50–54	34.0	−26.6	23.7	13.2	15.4	13.0
55–59	62.7	10.0	−26.4	40.4	18.4	20.9
60–64	276.1	26.3	14.0	18.1	51.9	45.8

Note: Socially insured employment includes only full-time and part-time employees, excludes marginal employment and moonlighting.
Source: SIAB, authors' calculations.

cially insured employment stagnated by 4 percent between 1993 and 2003, but increased thereafter. In East Germany, socially insured employment declined by almost 8 percent from 1993 to 2014, but recovered after 2003. Almost three decades after unification, East and West German labor markets have followed markedly different paths.

Consider the following shift-share decomposition of total hours H into full-time hours F and part-time hours P worked by full- and part-time workers L^F and L^P (see Appendix A for details):

$$H_t - H_{t-1} = \left(\frac{F_t}{L_t^F}\right)\Delta L_t^F + L_{t-1}^F \Delta\left(\frac{F_t}{L_t^F}\right) + \left(\frac{P_t}{L_t^P}\right)\Delta L_t^P + L_{t-1}^P \Delta\left(\frac{P_t}{L_t^F}\right). \tag{1}$$

The most salient fact that emerges from this decomposition, presented in Table 4, is a secular rise in part-time employment of almost 5.5 million over the entire period, with acceleration after 2004. Until then, average hours per work fell for both full-time and part-time workers. In the twelve years after 2004, hours per part-time worker rose. In contrast, the number of full-time workers fell until 2011, the year when employment of full-time workers began to expand as well. Over the entire period, employment rose by 5.5 million persons; of this net expansion, 95 percent was in the form of part-time employment.

Table 4: Shift-share decomposition of working hours in Germany (in millions), 1993–2016.

Time Period	Annual change					Total change	
	1993–1998	1999–2003	2004–2008	2009–2011	2012–2016	1993–2003	2004–2016
Change in hours due to:							
Change in full-time employment	−18	−9	−6	−5	9	−153	2
+ Change in hours/full-time worker	0	−2	3	−2	−5	−8	−12
+ Change in part-time employment	58	34	33	25	17	519	326
+ Change in hours/part-time worker	−11	−5	19	5	8	−91	148
= **Total change in millions of hours**	−628	−167	598	126	94	−4.605	3.839

Note: Part-time employment includes marginal and socially insured part-time employment.
Source: IAB Arbeitszeitrechnung (Aggregate hours accounts), authors' calculations.

Evidently, part-time work served an important adjustment mechanism that facilitated labor force re-entry for workers who had lost attachment to the labor force. Of these, older workers and women played a pivotal role (Weinkopf, 2014). The rise in part-time work was especially important for female labor market participation. In 2014, 46 percent of women in socially insured employment worked part-time, compared to 31 percent in 1993. Overall, the fraction of part-time workers increased from around 14 percent to 25 percent of all those paying social security contributions.[8]

As noted above, the strong recent German labor market performance can be characterized as reallocation of a relatively stable number of hours worked across many more workers. By merging information from the SIAB and the GSOEP, we can also study the evolution of this intensive margin in more detail. The disaggregated SIAB-time series from Figure 2(a) are decomposed into full-time employment, part-time employment and apprentices in vocational training. Second, we merge these count measures with the average hours worked from the GSOEP-data (including overtime) by their respective employment classes.

Combining these datasets, we can identify the following aggregate trends in total working hours of socially insured employees: From 1993 to 2014, the share of hours worked by part-time socially insured employees rose from 7.3 to 18.0 percent. In 1993, part-time employees worked on average 22.9 hours per week including overtime while full-time employees worked 40.4 hours. By 2014, average part-time had increased to 25.6 hours per week, compared to 41.1 hours for full-time workers, and 39.4 hours per week for apprentices, both relatively stable in comparison. Consistent with the aggregate hours account data, we find that the num-

8 Authors' calculations using the SIAB.

Table 5: Sample statistics of synthetic panel data.

Socially insured employment	1993–2014	1993–98	1999–2002	2003–08	2009–14
SIAB: Nominal daily wage					
75th percentile	104.0	88.8	99.5	107.8	118.5
	(12.0)	(3.3)	(3.1)	(2.5)	(4.5)
Median	76.4	68.3	74.8	78.5	83.5
	(6.3)	(2.3)	(2.2)	(0.8)	(3.1)
25th percentile	52.2	49.2	51.8	52.7	55.2
	(2.6)	(1.3)	(1.0)	(0.5)	(2.0)
Sample size (thousands per year)	462.0	464.0	458.5	443.4	481.0
	(18.5)	(9.2)	(6.7)	(9.9)	(18.7)
GSOEP:					
Weekly working hours	37.8	38.1	37.7	37.7	37.9
	(0.3)	(0.1)	(0.3)	(0.3)	(0.3)
Sample size (thousands per year)	7.4	5.8	8.5	8.0	7.5
	(1.3)	(0.1)	(1.8)	(0.5)	(0.5)

Note: Nominal daily wages in Euro as a mean of the relevant time interval, standard deviations in parenthesis. Socially insured employment including full-time and part-time, only.
Source: SIAB and GSOEP, authors' calculations.

ber of hours in socially insured employment is roughly two percent higher in 2014 than in 1993.

3 The price of the miracle: Wage stagnation and increasing wage dispersion

To understand market forces that could give rise to the reallocation of hours across employees, we look to the price of labor, in particular, the gross hourly wage. Yet official measures do not exist for part-time employees. One contribution of this paper is the construction of hourly wage estimates for both full-time and part-time employees. All socially insured employees in two micro-data sets, the SIAB and the GSOEP, are aggregated into representative groups by age, gender, region, and qualification. Daily wage information from the SIAB is then merged with average hours worked from the GSOEP of corresponding groups. Appendix B gives a brief summary of the data set and its construction; for more details on external validity, see Seele (2019).[9] Table 5 summarizes sample means of this synthetic GSOEP-SIAB panel.

9 At the time of this writing, data availability restricts our analysis to the years 1993–2014.

Table 6: Change in real median hourly wages, 1993–2014.

	1993–2014	1993–98	1998–2003	2003–08	2008–11	2011–14
Total change	−0.6	−0.1	5.5	−8.4	−1.6	4.8
West	−4.8	−2.5	4.7	−8.9	−0.6	3.0
East	7.4	3.5	6.8	−8.1	−0.6	6.3
Male	0.0	0.0	4.8	−7.3	−0.1	3.0
Female	−0.4	0.5	6.3	−9.3	−2.8	5.8
Age group 15–19	−11.2	−13.8	9.6	−14.7	4.6	5.5
20–24	−5.7	−6.8	2.6	−7.3	2.0	4.4
25–29	−3.7	−1.8	2.0	−10.5	1.0	6.3
30–34	−7.8	−1.9	4.5	−10.6	−3.5	4.2
35–39	−2.0	3.2	6.1	−7.4	−3.4	−0.0
40–44	−4.8	−3.5	7.4	−7.8	−2.2	1.9
45–49	−2.5	−2.0	4.0	−5.2	−1.7	2.6
50–54	0.5	2.4	3.4	−8.2	−1.0	4.5
55–59	−4.7	−4.6	2.8	−8.1	1.7	4.0
60–64	−15.8	−1.7	−0.6	−10.6	−6.5	3.0

Note: Socially insured employment includes full-time and part-time employees, only, excluding all types of marginal employment and moonlighting.
Source: SIAB, GSOEP, Destatis (CPI), authors' calculations.

Figure 3 tracks cumulative growth of hourly wages at different points in the earnings distribution over time. Once vaunted for its low wage inequality in the 1980s (Krugman, 1994), Germany has seen an increase in pay dispersion since unification since 2003, and we confirm the findings of Dustmann et al. (2014), who examined full-time West German workers only. Moreover, we find an increase in inequality that began at the upper end in the mid-1990s, but was delayed at the bottom of the distribution, beginning only after 2003. Although no statutory minimum wage was operative in Germany during this period, generous social welfare payments and unemployment benefit durations can create a lower bound on wages (OECD, 1994; Siebert, 1997; Nickell and Layard, 1999; and Sinn, 2003). Furthermore, the sharpest decline in hourly wages after 2003 occurred for part-time work, in the West and at the low end of the wage distribution. The expansion of part-time employment coincides with a sharper decline in effective real wages for these employees and represents prima facie evidence for a labor supply shift.

Table 6 shows that real median pay increased only modestly between 1993 and 2014. In fact, some groups experienced negative median wage changes. While real hourly median wages for almost all groups increased between 1998 and 2003, they decreased from 2003 to 2008 for all groups. Comparing real median hourly wage

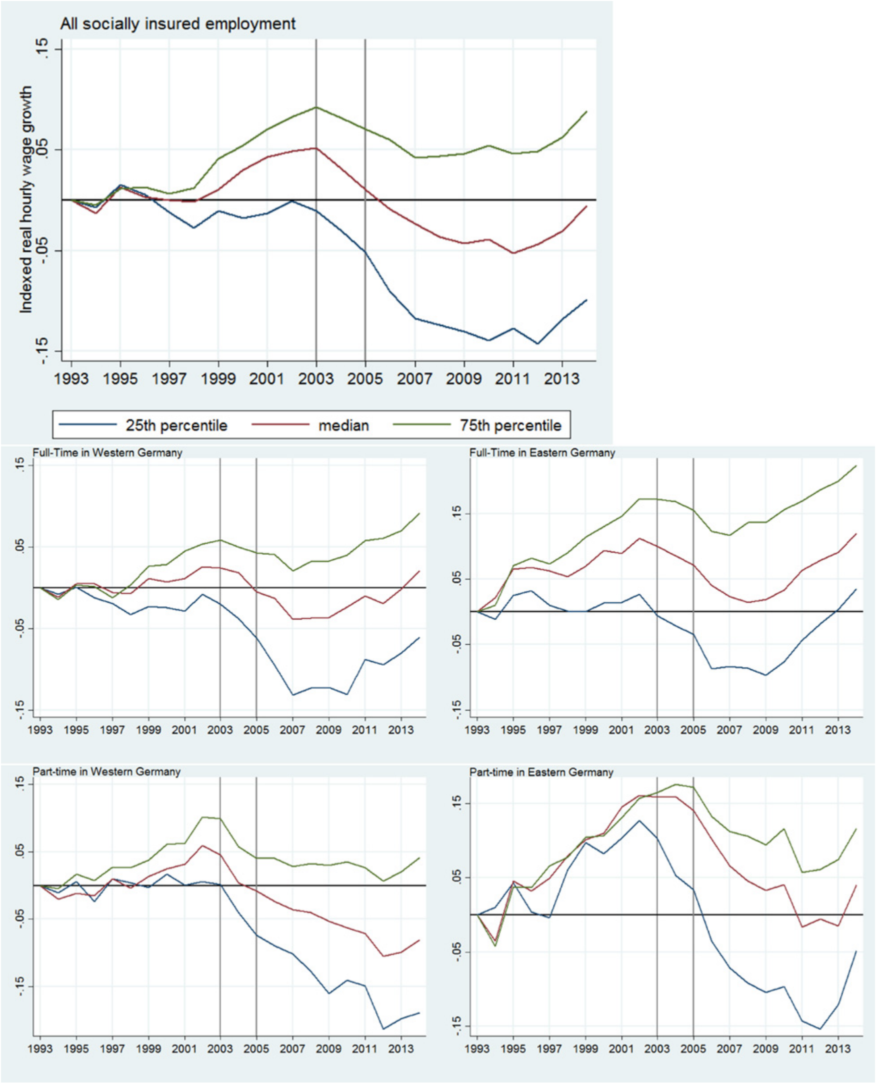


Figure 3: Indexed cumulative real wage growth, by employment status and region in Germany, 1993–2014.

Note: Gross hourly wages for full-time and part-time employees, excluding marginal employment. Source: SIAB, and GSOEP, authors' calculations.

Table 7: Employment growth at different segments of the hourly wage distribution, change in percentage points, 1993–2014.

	1993–1998	1998–2003	2003–2010	2010–2014
Full-time				
Western Germany				
Lowest segment	1.7	−0.9	7.3	−4.3
Middle segment	−2.2	−3.6	−5.5	0.9
Upper segment	0.4	4.5	−1.8	3.4
Eastern Germany				
Lowest segment	−0.4	−0.4	5.9	−8.3
Middle segment	−7.5	−5.5	−3.3	3.2
Upper segment	7.8	5.9	−2.6	5.1
Part-time				
Western Germany				
Lowest segment	1.2	1.6	9.3	1.5
Middle segment	−1.9	−4.2	−4.5	−1,7
Upper segment	0.7	5.7	−4.8	0.2
Eastern Germany				
Lowest segment	−5.5	−0.1	10.6	−1.2
Middle segment	1.1	−7.9	−4.8	1.2
Upper segment	4.4	8.1	−5.8	−0.1

Note: Employment in the lowest segment is characterized by real hourly wages below the 25th percentile of the 1993-wage distribution. Employees in the middle segment earn wages between 25th and 75th percentile, and employees in the upper segment receive higher wages than the 75th percentile.
Source: SIAB, GSOEP, and destatis (CPI), authors' calculation.

changes of East and West German employees from 1993 to 2014, the wage gap between the two regions declined yet remains significant. In 2014, the median West German full-time employee earned 25.5 percent more per hour than the median full-time employee in East Germany. At the 15th percentile the comparable figure was 21.1 percent; at the 85th percentile, 24.0 percent.

The German labor market mobilized inactive workers and reallocated a relatively stable level of working hours across a shrinking working age population, but at the same time, the dispersion of wages increased sharply. That these changes coincided with the Hartz reforms is documented in Table 7, which displays employment growth in three segments, by position in the wage distribution of 1993, for three sub-periods of the post-reunification era. The third column confirms that the strongest growth in part-time employment coincides with the labor market segments in which declines in wages were the largest. This finding is suggestive of an important, if not central role for labor supply shifts associated with the Hartz reforms, as we discuss below.

The aftermath of the German labor market reforms are associated with different regional outcomes. In the western half of the country, the labor market shifted from contracting employment with increasing real wages to growing employment, especially part-time employment, with falling real wages. In East Germany, more pronounced reductions in employment coincided with rising real earnings prior to 2003, but were followed after 2003 by employment growth and wage decline. In both East and West Germany, the importance of part-time employment rose, in particular in the aftermath of the Hartz reforms. It is natural to regard those labor market reforms as a surprise exogenous policy shock and the aftermath as a consequence of the reforms. In the next two sections, we investigate how different labor market models can account for these outcomes.

4 The labor market seen through the lens of supply and demand

The last section showed that a break in employment, wages and participation occurred around 2003–5, the years in which the Hartz reforms were announced and implemented. An interruption of median wage growth, an increase in wage dispersion especially at the lower end of the distribution, a reduction in unemployment, and increases in both employment and labor force participation characterized the period following the reforms. What is the most appropriate model for understanding these changes?

4.1 Market clearing

The analysis in this and the following section takes a standard system of labor demand and supply as a starting point.[10] Assume a representative firm that employs a linearly homogenous and concave aggregate production function of K different labor inputs. Expressed in vector notation, the system of factor demands resulting from profit maximization reads

$$L^D = D(W, X) \tag{2}$$

10 Katz and Murphy (1992) use this model to account for changes in employment and wages of full-time US workers in the period 1963–87. They find increasing wage dispersion due to shifting demand for skill in the 1980s, in contrast to labor supply shifts of the previous decade. The beauty of their approach is that it need not identify particular sources of supply or demand shifts in labor markets.

where L^D is a $(K \times 1)$ vector of labor inputs demanded, W is a $(K \times 1)$ vector of market prices of those inputs, X is a $(M \times 1)$ vector of exogenous demand shift variables, e. g. technology, product demand or other input prices.[11]

The production function giving rise to (2) is strictly concave, continuous and differentiable, so labor demand can be expressed in terms of small changes as

$$dL^D = D_W dW + D_X dX \tag{3}$$

where profit maximization and concavity of the production function imply that D_W is a $(K \times K)$ negative definite matrix. Rearranging (3) and premultiplying by dW' results in a quadratic form in the vector of wage changes dW:

$$dW'(dL^D - D_X dX) = dW' D_W dW < 0 \tag{4}$$

where the inequality follows from the fact that the Jacobian matrix D_W is negative definite. Expressed net of demand changes, observed changes in factor supplies and changes in wages must co-vary negatively.

Katz and Murphy assume that labor supply is exogenous, i. e., $dL^S = d\overline{L^S}$ and that labor markets clear, so $dL^S = d\overline{L^S} = dL^D$. If relative demands for labor are stable ($dX = 0$) then Equation (4) reduces to

$$dW' dL < 0. \tag{5}$$

The smaller dX is relative to observed employment dL, the more predominant supply shifts become, rendering the correlation negative. Katz and Murphy (1992) write: *"Periods of time in which the inequality [...] is satisfied (i. e., the inner product of changes in wages and changes in factor supplies is non-positive) have the potential to be explained solely by supply shifts. When this inequality is not satisfied, no story relying entirely on supply shifts is consistent with the data."* (p. 48). A necessary and sufficient indicator that supply shifts predominate in a particular period is negative correlation of wages and employment.

The model can be extended in a straightforward way to include endogenous labor supply, leading to an analogue of Equation (4), and this is done in Appendix C. Let labor supply be $L^S = S(W, Z)$, where Z represents exogenous shifts to labor supply; further assume that it is "upward-sloping" in the sense that S_W is positive definite and contains only substitution effects (i. e., Z includes the

11 In principle, the analysis can be generalized to a conditional formulation of the demand curve that would include other exogenous non-labor inputs that affect the demand for labor inputs or the level of output.

marginal utility of wealth, the Lagrange multiplier from the canonical labor supply problem). Market clearing ($dL^S = dL^D = dL$) and stability of demand ($dX = 0$) implies $dW'dL < 0$. In words, changes in wages and changes in employment remain negatively correlated when demand is stable and labor supply shocks are operative ($dZ \neq 0$).

The Marshallian paradigm of supply and demand also contains implications for labor force participation when the shock originates in household behavior at the extensive margin, holding population constant. Define P as the fraction of the total potential supply that is actually supplied to the market at wage W. Restricting Z to exclude demographic factors (immigration, ageing), we show in the Appendix that $dZ \neq 0$ and $dX = 0$ implies $dW'dP < 0$. Participation and wages are negatively correlated when supply shocks predominate.

4.2 Non-clearing labor markets with rigid wages

The Katz-Murphy framework can also be modified to reflect non-clearing of the labor market in the sense described early on by Pigou (1933). In particular, unemployment is seen as excess labor supply due to wage rigidities, with the working assumption $L = \min(L^D, L^S) = L^D$. Downward wage rigidity due to intransigent unions was often blamed for the German labor market malaise in the 1970s and 1980s (Lindbeck and Snower, 1986; 1987; Calmfors and Driffill, 1988). Dustmann et al. (2014) argue that increasingly cooperative collective bargaining, i. e. wage moderation, is largely responsible for the German labor market recovery.

For simplicity, we begin by assuming that labor supply is perfectly inelastic. The change of the market-clearing wage W^* is given by

$$dW^* = D_W^{-1}(dL^S - D_X dX), \tag{6}$$

where dL^S denotes changes in labor supply at constant population of working age. Let wages observed in the market be a weighted sum of changes in market-clearing wages and exogenous (rigid) levels, $\overline{W}$:

$$dW = (1 - \phi)dW^* + \phi d\overline{W}, \tag{7}$$

where the scalar ϕ ($0 < \phi < 1$) operationalizes wage rigidity; $\phi = 0$ corresponds to market-clearing or the Marshallian paradigm of the previous section and $\phi = 1$ represents the case of complete wage rigidity. If firms are on the short side of the market, $L = L^D < L^S$ and

$$dL = dL^D = (1 - \phi)d\overline{L^S} + \phi D_W d\overline{W} + \phi D_X dX \tag{8}$$

and

$$dW = (1 - \phi)D_W^{-1}d\overline{L^S} + (1 - \phi)D_W^{-1}D_X dX + \phi d\overline{W}. \tag{9}$$

The level of (involuntary) unemployment U is given by $U = \overline{L^S} - L^D$. The change in unemployment dU across the types of labor is

$$dU = \phi d\overline{L^S} - \phi D_W d\overline{W} - \phi D_X dX \tag{10}$$

and change in labor force participation dP at given demographics simply equals $d\overline{L^S}$.

The inclusion of wage rigidity ($\phi > 0$) leads to a role for changes in the degree of wage rigidity as well as demand and supply factors in the evolution of employment and compensation. In Appendix C, we augment the setup to include both some degree of wage rigidity as well as endogenous labor supply. In the extreme case in which the market-clearing wage is of negligible relevance and shocks to wage rigidity predominate, a central correlation implied by the Marshallian supply-demand paradigm is reversed. In particular, measures of labor force participation (defined as the ratio of labor supply to working-age population) will be positively correlated with wage changes. In contrast, in the market clearing case, the correlation between wage changes and the participation rate in the absence of demand shifts is negative.

These extreme cases illustrate the utility of our framework for distinguishing among potential sources of the German labor market miracle. Naturally, in intermediate cases, correlations will shed little or no light on sources of changes – labor demand, labor supply or shocks to wage rigidity and a structural econometric approach is required. In contrast, if one of these shocks should predominate, we can derive qualitative predictions that are presented in Table 8.

4.3 Marshall v. Pigou: Evidence from the Hartz reform episode

Sections 2 and 3 established that the outsize changes in the German labor market – increasing employment, increasing wage dispersion at the bottom of the wage distribution, increasing labor force participation, and declining unemployment – began in 2003–2005. Thus, the candidate cause of these changes is the Hartz reforms. The Hartz reforms came as a surprise to labor market participants and can be seen as a shock. In this light we evaluate the period following 2003. Given the discussion in the previous sections, we emphasize two potential mechanisms:

1) **An outward shift of labor supply given wages.** Hartz IV and to some extent Hartz III increased labor supply for standard neoclassical reasons. The aggregate willingness of workers to supply labor at given wages increased due to

Table 8: Predicted correlations of wage changes, employment changes, and participation changes.

	Demand shift ($dX \neq 0; dZ = d\overline{W} = 0$)	Supply shift ($dZ \neq 0; dX = d\overline{W} = 0$)	Wage rigidity shift ($d\overline{W} \neq 0; dX = dZ = 0$)
Implied correlations between $\Delta\omega$ and $\Delta\ell$			
Market clearing (Marshall, $\phi = 0$)	+	–	Not applicable
Wage rigidity (Pigou, $\phi = 1$)	0	0	–
Implied correlations between $\Delta\omega$ and Δp			
Market clearing (Marshall, $\phi = 0$)	+	–	Not applicable
Wage rigidity (Pigou, $\phi = 1$)	0	0	+

stricter work requirement associated with unemployment benefits and receipt of social welfare, the increased effectiveness of the labor offices, and a reduction in non-labor income associated with benefit reductions. In the model of Section 4.1, the exogenous cause is $dZ > 0$. Mechanisms associated with the Hartz III reforms, which restructured employment offices and increased the rate of employment offers (Fahr and Sunde, 2009, Klinger and Rothe, 2012; Launov and Wälde, 2016) can also be seen as increasing the supply of labor at given wages.

2) **Reduced fallback of workers.** A second transmission channel is the effect of the Hartz reforms workers' fallback position in wage bargaining. With a level of unemployment benefits set, collective and individual bargaining reflected a lower threat point for workers. This explains the accommodative stance of unions and an increasing acceptance of decentralized bargaining and wage outcomes especially in the lower percentiles of the wage distribution. In the rigid-wage model of Section 4.2, this corresponds to $d\overline{W} < 0$.

A central point of contention in the debate surrounding the Hartz reforms is whether they really induced increases in labor supply in the face of stable demand, leading to more employment and more dispersed wages. Alternatively demand shifts predominated which would attenuate or reverse the correlation. Another possibility is that market clearing incorrectly describes German labor markets and that the shift in wages was rather due to an exogenous collapse of union power or increase in local wage flexibility (Dustmann, et al., 2014). Using

Table 9: Correlation of changes in relative wages with changes in relative employment (1993–2014).

a) age-gender-region cells					**b) age-gender-region-qualification cells**				
		2000	2005	2010			2000	2005	2010
Germany	1995	0.16	0.04	−0.14	Germany	1995	−0.16 (96)	−0.18 (96)	−0.17 (107)
(n=37)	2000		−0.46	−0.57		2000		−0.22 (106)	−0.37 (108)
	2005			−0.66		2005			−0.43 (111)
		2000	2005	2010			2000	2005	2010
Western	1995	0.10	0.33	0.46	Western	1995	−0.29 (61)	−0.23 (61)	−0.10 (61)
Germany	2000		0.4	0.52	Germany	2000		0.21 (67)	−0.34 (67)
(19)	2005			−0.28		2005			−0.43 (69)
		2000	2005	2010			2000	2005	2010
Western	1995	0.14	0.1	0.74	Western	1995	−0.07 (33)	−0.01 (33)	0.20 (33)
German	2000		0.2	−0.26	German	2000		−0.12 (34)	−0.00 (34)
Men (9)	2005			−0.61	Men	2005			−0.36 (35)
		2000	2005	2010			2000	2005	2010
Western	1995	0.18	0.51	0.61	Western	1995	−0.46 (28)	−0.49 (28)	−0.37 (28)
German	2000		0.59	0.75	German	2000		−0.26 (33)	−0.44 (33)
Women (10)	2005			−0.32	Women	2005			−0.48 (34)
		2000	2005	2010			2000	2005	2010
Eastern	1995	0.28	−0.32	−0.85	Eastern	1995	0.23 (35)	0.08 (35)	−0.20 (36)
Germany	2000		−0.54	−0.87	Germany	2000		−0.21 (39)	−0.47 (41)
(18)	2005			−0.85		2005			−0.50 (42)
		2000	2005	2010			2000	2005	2010
Eastern	1995	−0.69	−0.57	−0.88	Eastern	1995	0.29 (20)	−0.03 (19)	−0.49 (20)
German	2000		0.03	−0.80	German	2000		−0.17 (20)	−0.56 (21)
Men (9)	2005			−0.85	Men	2005			−0.45 (21)
		2000	2005	2010			2000	2005	2010
Eastern	1995	0.66	−0.23	−0.8	Eastern	1995	0.27 (15)	0.45 (16)	0.43 (16)
German	2000		−0.66	−0.89	German	2000		−0.22 (19)	−0.41 (20)
Women (9)	2005			−0.88	Women	2005			−0.53 (21)

Note: Table a) – Balanced panel, cell categories by age group, region, and gender. Table b) – Unbalanced panel, cell categories by qualification, age group, region, and gender. Number of observations in parenthesis. Source: SIAB, and GSOEP, authors' calculations.

results from Section 4.1, the "stable demand hypothesis" implies the predominance of supply shifts in the period between year t and year τ to the extent that the following inequality holds:

$$(W_t - W_\tau)'(L_t - L_\tau) < 0. \tag{11}$$

Table 9 presents cross-cell correlations between relative hourly wage changes and relative employment changes across four different time intervals defined by

Table 10: Correlation of changes in relative hourly wages with changes in relative labor force in hours (1993–2014).

a) age-gender-region cells				
		2000	2005	2010
All (n=36)	1995	0.15	−0.23	−0.60
	2000		−0.16	−0.54
	2005			−0.65
Males (n=18)	1995	−0.33	−0.25	−0.67
	2000		−0.06	−0.72
	2005			−0.85
Females (n=18)	1995	0.52	−0.33	−0.59
	2000		−0.22	−0.51
	2005			−0.62

Note: There is a structural break in 2005 for the variables of the micro census by region: Before 2005, West-Berlin is considered as part of Western Germany. Since 2005, West-Berlin is considered as part of Eastern Germany.
Source: SIAB, Destatis, and GSOEP, authors' calculations.

five years surrounding the years 1995, 2000, 2005, and 2010. Panel a), examines the same correlations for a smaller set of cells defined on the basis of age (10), region (2), and gender (2). It conducts the same analysis on stratified samples: East versus West, male versus female. It is important to emphasize that wage convergence between Eastern and Western Germany continued until the mid-2000s so that the underlying behavior of the two regions is likely to be different. In the second part of Table 10, panel b), we expand the number of cells to include educational attainment.

The negative correlations can be interpreted as a movement along a stable labor demand curve. In all cases, the empirical evidence supports the stable demand hypothesis for German employment, as changes of wages and employment co-vary negatively and significantly in the period following 2003, the implementation of the Hartz reforms. In previous periods in contrast the correlations were positive or close to zero.

These findings alone are not sufficient, however, to establish that the Hartz reforms were more important than wage moderation for high employment growth. The stable demand hypothesis implies negative covariation between relative wage and employment changes both when labor markets clear (positive labor supply shifts) and when they do not (exogenous variation of rigid wages). The two labor market models presented in Sections 4.1 and 4.2 contain implications for labor force participation across cells which provide evidence that labor supply shifts were decisive.

Suppose that demand shocks are negligible ($dX \approx 0$), wage rigidity shocks are relevant ($\phi > 0$, $d\overline{W} \neq 0$). If wage rigidity shocks are dominant ($dZ \approx 0, d\overline{W} \neq 0$), it follows that $dW'dP > 0$ i. e. that relative participation and relative wages are positively correlated. In contrast, if labor supply shocks are significant in the period under consideration ($dZ > 0, d\overline{W} \approx 0$), then $dW'dP < 0$.[12] Jointly, the stable labor demand hypothesis and market clearing imply that $(W_t - W_\tau)'(L_t - L_\tau) < 0$ and $(W_t - W_\tau)'(P_t - P_\tau) < 0$ between years t and τ. In contrast, stable demand and supply with exogenous variability of wage rigidity (i. e. wage moderation) implies $(W_t - W_\tau)'(L_t - L_\tau) < 0$ with $(W_t - W_\tau)'(P_t - P_\tau) > 0$.

In Table 10, we present evidence on the correlation of wage changes and participation changes, measured in relative terms. For this purpose, it was necessary to construct a measure of labor force participation – hours potentially supplied to a particular labor market cell by persons in employment and unemployment following a standard ILO definition. For Germany, labor force data are published annually by the Federal Office of Statistics (destatis) based on the German census (Mikrozensus). It contains aggregates by age groups in five year intervals from 15–65, by gender, and by region in Eastern and Western Germany.[13] Corresponding grouped hourly wages are available in the synthetic panel based on SIAB and GSOEP data. The relative labor force is a measure of the total potential of labor supply in the economy (in hours). First, we multiply the labor force by average weekly working hours based on the GSOEP. Second, the labor force in hours p_{it} is relative to total sum of labor force in hours in each year t, weighted by the relative wage ω_{it}, which defines the relative participation π_{it}:[14]

$$\pi_{it} = \frac{p_{it} \cdot \omega_{it}}{\sum_{i=1}^{N}(p_{it} \cdot \omega_{it})} \tag{12}$$

As before, we consider the following time intervals: 1995 (1993–1998); 2000 (1999–2003); 2005 (2004–2008); 2010 (2009–2014). For averages of these time intervals, we construct first differences in levels of the variables relative hourly wages and the relative labor force in hours. The results, presented in Table 10, provide strong support for the "Hartz hypothesis," that labor supply shocks were predominant in a Marshallian market-clearing setting. Combined with the evidence

12 In the absence of other restrictions, coincidence of labor supply and wage rigidity shocks $d\overline{L^S} \neq 0, d\overline{W} \neq 0$ would unravel our identification strategy.

13 There is a structural break in 2005 for the variables of the German census by region: Before 2005, West-Berlin is considered as part of Western Germany. Since 2005, West-Berlin is considered as part of Eastern Germany.

14 The average relative wage is defined as $\omega_{it} = w_{it}/(\sum_{t=1}^{T}(\gamma_{it}/T) \cdot \sum_{i=1}^{N}(w_{it}/N))$, which is weighted by the relative employment $\gamma_{it} = L_{it}/\sum_{i=1}^{N} L_{it}$.

from Table 9, it is difficult not to conclude that increases at the extensive margin of labor supply was an essential element of the German labor market miracle.

5 An alternative perspective of the Hartz reforms: Labor markets with search and matching frictions

The search and matching model has become a prominent complement to – and sometimes a substitute for – Marshall's demand-supply framework for labor market analysis (Rogerson et al., 2005). Its emphasis on enhanced job finding, job take-up and labor force participation makes it an obvious lens for examining the German labor market turnaround. In this spirit, Krause and Uhlig (2012), Launov and Wälde (2014), Hartung et al. (2018), and Hochmuth et al. (2019) focus on two aspects of the reforms which affect labor market flows: increased efficiency of the employment offices (Hartz III) and cuts in eligibility, generosity, and duration of unemployment benefits and enhancement of in-work subsidies (Hartz IV). In what follows, we assess briefly the potential for a bare-bones search and matching model à la Mortensen and Pissarides (1994; 1999) or Pissarides (2000) to account for facts presented in Sections 2 and 3. We will show that, seen through the lens of this model, only the Hartz reforms – in contrast to wage moderation or increased matching efficiency taken alone – can account for the qualitative features of the German labor market turnaround in a coherent fashion.[15]

5.1 The MP Model with labor force participation

The working age population of measure one consists of homogeneous workers in one of three labor market states: unemployment u, nonparticipation ℓ, or employment $e = 1 - \ell - u$. Competitive firms produce at constant returns to scale and their activity can be reduced to the level of individual ex-post heterogeneous matches of individual workers. Matched with a worker, a firm produces value added px under constant returns to scale, where p is a constant and $x \in [0, 1]$ is a random draw from a time-invariant distribution with c. d. f. $F(x)$. When the match is ini-

15 A detailed derivation of the model and comparative statics results can be found in the Appendix D.

tially formed, $x = 1$, after which changes in productivity arrive over time following a Poisson process at exogenous rate λ.

Firms and workers are risk-neutral and discount at rate r. After paying wage w, a firm earns profit and, if the match survives, a prospect of future production with that worker in the future. Without a worker, firms can enter the labor market costlessly, posting vacancies at periodic cost c; the mass of vacancies, a measure of firm search intensity, is v. They are assumed to do so until the present value of entry with a vacancy equals zero (zero profit condition for vacancy posting). Unmatched workers are either engaged in unemployed search and receive flow income b, e. g. unemployment benefits, or are out of the labor force (leisure, retirement, training) and receive εb with $\varepsilon \in (0,1)$. All individuals of working age have a heterogeneous valuation of nonparticipation summarized by the cumulative distribution function G; ordering them by decreasing valuation of leisure time implies that the index of the individual with the valuation ℓ is also the mass of nonparticipation in the labor market. Labor force participation is determined by indifference between the value of nonparticipation and unemployment, the latter which incorporates the probability of finding a job. The single labor market friction in this model is a finite arrival rate of workers to vacancies, due to a constant returns matching function $Ax(u,v)$, where A parametrizes matching efficiency. The arrival rate of matches at firms posting vacancies is $q(\theta) \equiv Ax(\theta^{-1},1)$, and for workers $\theta q(\theta)$, with $\theta = v/u$ measuring labor market tightness. Jobs separate when match surplus has nonpositive present value.

Four core equations summarize the MP model:

$$\text{(JC)} \qquad \frac{c}{q(\theta)} = (1-\beta)\left(\frac{1-R}{r+\lambda}\right)p, \tag{13}$$

$$\text{(JD)} \qquad Rp + \frac{\lambda p}{r+\lambda}\int_R^1 (z-R)dF(z) = rU, \tag{14}$$

$$\text{(RU)} \qquad rU = b + \frac{\beta c}{1-\beta}\theta, \tag{15}$$

$$\text{(LP)} \qquad 1-\ell = G(rU - \varepsilon b). \tag{16}$$

They jointly determine four variables: the reservation or threshold productivity for a viable match (R), labor market tightness (θ), the value of unemployment (U), and the mass of working-aged individuals in nonparticipation (ℓ). The following parameters are exogenous to the analysis: c (vacancy posting costs), β (worker bargaining power), A (efficiency of job matching), r (interest rate), λ (Poisson incidence parameter for productivity changes), p (base match productivity), b (unemployment income/benefit), ε (monetary income in nonparticipation relative to unemployment).

The first equation is represented in panel a) of Figure 4 as the downward-sloping job creation (JC) curve relating reservation match productivity R to labor market tightness θ. As labor markets become tighter, the difficulty of finding workers increases, as does the wage needed to employ them, and any acceptable match must be more productive to justify the higher expected search costs necessary to locate that worker. The upward-sloping job destruction condition (JD) in (θ, R) space links tighter labor markets to higher reservation utility for unemployed workers, which in equilibrium consists of the reservation productivity plus an option value of future improvement. The last two equations capture the labor force participation margin and are traced out below in (θ, ℓ) space (the LP curve). The outcome of free entry of vacancies and voluntary participation of unemployed searching for a job (RU) determines the reservation level of utility rU as the sum of the periodic unemployment benefit b plus the effect of labor market tightness on the worker's fallback position. All other things equal an increase in θ raises the value of unemployed search and thereby the value of labor force participation. The last equation determines the marginal labor force participant in the economy and thereby the mass of nonparticipation ℓ.

The rest of the model's endogenous variables are derived from θ, R, and ℓ. Given labor market tightness θ, the wage is

$$w = (1 - \beta)\, b + \beta\, (p + \theta c)\,. \tag{17}$$

Given the reservation level of productivity R, the rate of inflow into unemployment from employment is the product of an incidence probability λ and the probability that the new level of x is less than the threshold level R, $F(R)$. Since employment is $1 - \ell - u$, the unemployment rate evolves as the difference between inflows and outflows:

$$\frac{du}{dt} = \lambda F(R)(1 - \ell - u) - \theta q(\theta) u \tag{18}$$

and in the steady state $u = \frac{\lambda F(R)(1-\ell)}{\lambda F(R)+\theta q(\theta)}$. The mass of vacancies v can be recovered as the product of θ and u.

5.2 Comparative statics

This compact model delivers several robust qualitative predictions relevant for assessing the Hartz reforms.[16] In the interest of brevity, we employ a diagrammatic

16 For quantitative assessments of the Hartz reforms see Krause and Uhlig (2012), Launov and Wälde (2014), Hartung et al. (2018), and Hochmuth et al. (2019).

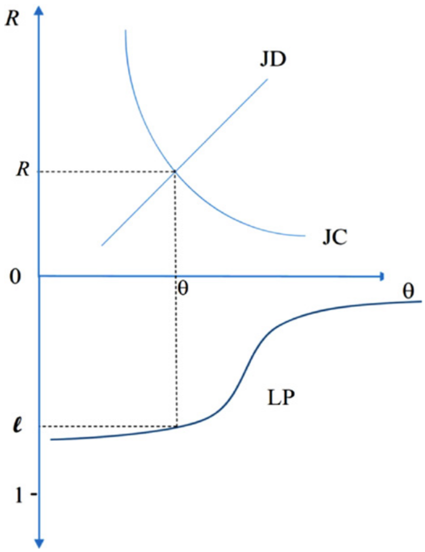
representation of the predicted effects of competing causes of the labor market recovery in Germany: 1) a comprehensive, efficiency-enhancing reform of employment agencies, $dA > 0$ (Hartz III), 2) a reduction of unemployment benefits $db < 0$ (Hartz IV), and 3) a reduction in worker bargaining power, $d\beta < 0$ following Dustmann et al. (2014). The formal comparative statics analysis is presented in the Appendix D. We present the qualitative outcomes in Figure 4 for the reservation productivity R, a measure of the fragility of matches; labor market tightness θ, the ratio of job openings to unemployed job seekers; and labor force participation $(1 - \ell)$.

Consider first an increase in A, the efficiency of the matching function, associated with the Hartz III reforms (Launov and Wälde, 2014, Hochmuth et al., 2019). The comparative statics analysis implies positive signs of $\frac{d\theta}{dA}$ and $\frac{dR}{dA}$. In panel b) of Figure 4, the outcome is represented as an outward shift of the JC curve. Intuitively, an increase in matching efficiency increases employers' probability of finding a worker and reduces the expected vacancy costs associated with finding a worker from the point of view of the employer. Labor market tightness and the productivity threshold of matches increase in market equilibrium. The average fragility of job matches increases, implying a *higher* average separation rate, with an unambiguous increases in both, wage and participation. Taken alone, this qualitative prediction is inconsistent with the post-Hartz experience.

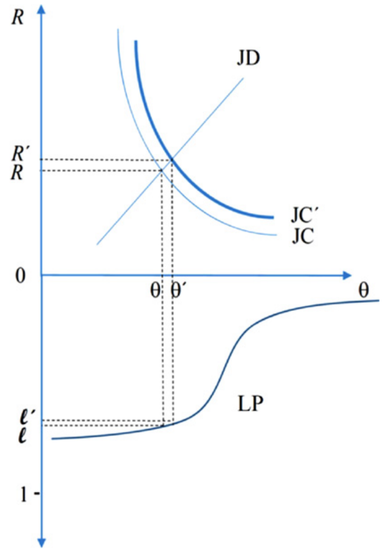
Panel c) of Figure 4 displays the impact of a cut in unemployment benefit b, while holding $(1 - \varepsilon)b$ constant, i. e. imposing $d\epsilon = \frac{1-\epsilon}{b} db$.[17] This implies also a reduction in unconditional income in nonparticipation. In the first instance, the reservation level of utility for unemployed declines at any level of labor market tightness, shifting the JD curve to the right; the JC and LP curves are not affected. Labor market tightness increases while reservation productivity for viable matches declines. A reduction in unemployment benefits implies falling wages, but also a *decline* in the fragility of job matches as separations decline.

Finally, the last panel of Figure 4 shows the effect of a reduction of worker bargaining power ($d\beta < 0$), which both elevates the share of the match for the employer and cuts the worker's fallback utility in unemployment. Both JD and JC curves are affected by β: The JD curve shifts to the right as increased labor market tightness is needed to maintain a constant reservation match productivity. At the

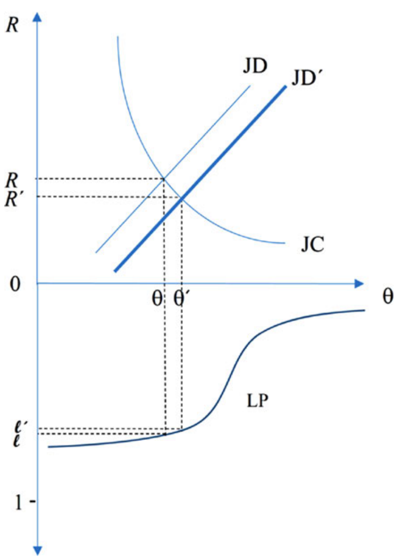
17 This restriction fixes the position of the LP curve in Figure 4 (holds constant the relationship between labor market tightness and participation). Cuts in unemployment income associated with the Hartz reforms was not matched by pari passu benefit reductions for nonparticipants, to the extent that pensions, welfare, disability and student income were not linked to the benefit b. In fact, the generosity of long term assistance for employable individuals was raised slightly (Hochmuth et al., 2019).



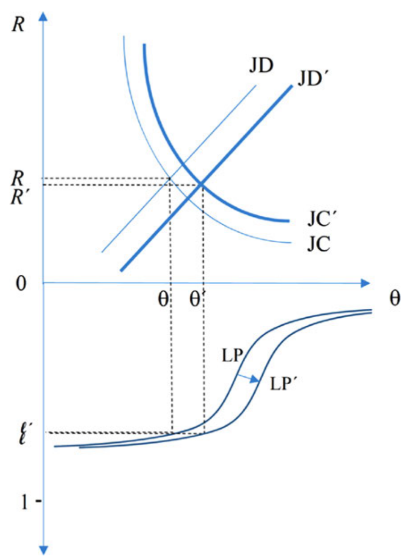
(a) Equilibrium



(b) Increase in matching efficiency ($dA > 0$)

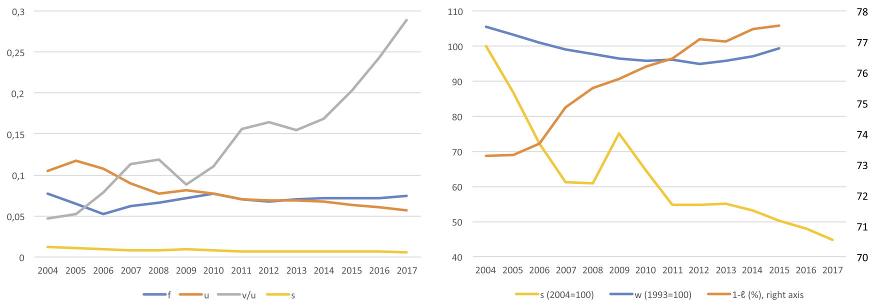


(c) Decrease in unemployment benefits, holding LP constant ($db < 0, d(1-\varepsilon)b = 0$)



(d) Decrease in worker bargaining power ($d\beta < 0$)

Figure 4: Equilibrium and comparative statics in the Mortensen-Pissarides Model.



(a) Finding rate (f), unemployment rate (u), labor market tightness ($\theta = v/u$), and separation rate (s)

(b) Separation rate (s), real hourly wage (w), and labor force participation ($1 - \ell$)

Figure 5: Search and matching indicators for Germany since 2004.

Note: The finding rate (f), the separation rate (s), and the unemployment rate (u), German definition (Sozialgesetzbuch). The real hourly wage index is based on the SIAB-GSOEP synthetic panel, deflated by CPI, and excludes all forms of marginal employment. Labor force participation ($1-\ell$) is based on the German Mikrozensus and includes unemployed by ILO definition and is expressed as an index.
Source: Federal Employment Agency (BA), Destatis, SIAB, and GSOEP, authors' calculations.

same time, the JC curve shifts rightward when β declines, as a higher equilibrium value of labor market tightness θ is implied to equate the enhanced attractiveness of creating jobs at constant R. While a reduction in bargaining power β increases labor market tightness unambiguously, it may either reduce or raise the job separation rate $\lambda F(R)$. More labor market tightness works towards increasing labor force participation, but a reduction in worker surplus will reduce it, so the net effect of less bargaining power on participation is ambiguous.[18]

5.3 Model predictions and post-Hartz outcomes

The two panels of Figure 5 plot annual values of the key flow and stock variables in the MP model for Germany for the period after 2004, the year the Hartz III reforms were implemented.[19] The first panel presents the outflow rate f (measured

18 For a formal demonstration of this result, see Appendix D.

19 This figure is taken from Seele (2019). Comparable data before 2004 using common definitions are unavailable. For this reason, data limitations preclude more ambitious testing or estimation of the model.

Table 11: Summary of comparative statics results in the MP model with a participation margin.

Exogenous change:	Effect on: u	θ	w	ℓ	f	R
Increase in matching efficiency, $dA > 0$ (Hartz III)	–	+	+	–	+	+
Decrease in unemployment income, $db < 0$, $d(1-\epsilon)b = 0$ (Hartz IV)	–	+	–	–	+	–
Decrease in worker bargaining power, $d\beta < 0$ (Memo)	–	+	–	?	+	?

as a fraction of unemployment), the inflow rate s into unemployment (measured as a fraction of employment), the unemployment rate u, and the measure of labor market tightness θ. The secular rise in both the job finding rate and labor market tightness document an unambiguous pattern of structural tightening in labor market in the ensuing 14 years, albeit punctuated by the business cycle, in which the measure of labor market tightness has increased by five-fold. Falling unemployment and rising outflow rates also characterize the evolution of the German labor market in the period. The second panel uses index numbers to document a cumulative decline in average real wages of 8.1 % between 2004 and 2011, a rise in labor force participation of 5.1 %, and most remarkably, a significant and secular decline of the inflow rate of more than 50 %.[20]

The MP model delivers robust qualitative predictions that are summarized in Figure 4 and Table 11. Of the three potential candidate explanations of the German labor market turnaround, only the reduction of unemployment benefits (b) associated with the Hartz IV reforms is consistent with long-run changes after 2005: falling unemployment, rising labor market tightness, declining wages, rising participation, and falling inflow rates into unemployment. Taken alone, enhanced efficiency (Hartz III) should have raised wages and increased the fragility of job-worker matches. Taken alone, a reduction in worker bargaining power à la Dustmann et al. (2014) has an ambiguous prediction on the stability of worker-firm matches, and more importantly, labor force participation. These qualitative findings militate unambiguously in favor of a central role for the Hartz IV reforms in the German labor market turnaround.

6 Conclusion

Two important findings characterize our study of the German labor market turnaround since 2005. First, part-time employment played an outsize role in

20 This decline in the separation rate has also been noted independently by Hartung et al. (2018).

reallocating a modest increase of total hours worked over a large number of new workers, leading to a significant expansion of employment. Until 2010, part-time work accounted for all employment growth; since then, full-time employment has increased more rapidly. In the most recent recovery, part-time employment represented a new and important adjustment mechanism for the German labor market.

Our second finding is that wage and employment correlations changed around the Hartz reforms in a way that is most consistent with a market-clearing model driven by shifts in the supply of hours at given wages. We adapt Katz and Murphy's (1992) framework to identify the sources of employment growth in full-time and part-time employment. Our findings indicate a reversal in the correlation between changes in wages and employment following the Hartz reforms in 2003–2005. Before 2003, employment across cells were showed mixed or little correlation with real wages. After 2005, this correlation turned uniformly and strongly negative, and also characterizes the relationship between participation and real wages. Cells with slower median wage growth experienced expansion of employment when compared with cells of slower wage growth. This reversal coincides with the Hartz reforms.

Our assessment is supported by stock and flow data and the qualitative implications of a standard search and matching model with a participation margin (e. g. Pissarides, 2000). From the set of potential comparative statics changes, only a decrease in unemployment benefit is consistent with qualitative changes observed after 2005: declining wages, increasing employment and participation, secularly rising labor market tightness and outflows out of unemployment, and increasing stability of matches (a declining separation rate).

The weight of the evidence presented in this paper suggests that the German labor market was dominated by labor supply shifts in the period 2003–2010, and that these shifts reflected increases in labor force participation at given demographic determinants of labor supply. In contrast, East Germany behaves somewhat differently, and it may be misleading to treat the two regions as a single labor market. Confounding demand factors – such as the ongoing industrial restructuring of the post-unification economy – also influenced the evolution of wages and employment in Eastern Germany. Structural change following unification and significant migration flows to the West are just two factors that could have affected local labor demand and supply differently. Future research should direct more attention to understanding how employment, wages and participation differed across specific demographic groups in the two regions.

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Appendix A. Decomposition of total hours into full-time and part-time hours: A shift-share approach

Hours worked H are decomposed into full-time F and part-time P hours as follows:

$$H_t = F_t + P_t \tag{19}$$

$$= \frac{F_t}{L_t^F} L_t^F + \frac{P_t}{L_t^P} L_t^P \tag{20}$$

where the L^F and L^P are workers employed at full and part-time, respectively. Take first differences of H and rewrite:

$$H_t - H_{t-1} = \frac{F_t}{L_t^F} L_t^F - \frac{F_{t-1}}{L_{t-1}^F} L_{t-1}^F + \frac{P_t}{L_t^P} L_t^P - \frac{P_{t-1}}{L_{t-1}^P} L_{t-1}^P \tag{21}$$

$$= \frac{F_t}{L_t^F} L_t^F - \frac{F_t}{L_t^F} L_{t-1}^F + \frac{F_t}{L_t^F} L_{t-1}^F - \frac{F_{t-1}}{L_{t-1}^F} L_{t-1}^F + \frac{P_t}{L_t^P} L_t^P - \frac{P_t}{L_t^F} L_{t-1}^P + \frac{P_t}{L_t^F} L_{t-1}^P - \frac{P_{t-1}}{L_{t-1}^P} L_{t-1}^P \tag{22}$$

$$= \frac{F_t}{L_t^F} \left(L_t^F - L_{t-1}^F \right) + \left(\frac{F_t}{L_t^F} - \frac{F_{t-1}}{L_{t-1}^F} \right) L_{t-1}^F + \frac{P_t}{L_t^P} \left(L_t^P - L_{t-1}^P \right) + \left(\frac{P_t}{L_t^F} - \frac{P_{t-1}}{L_{t-1}^P} \right) L_{t-1}^P \tag{23}$$

So we have

$$H_t - H_{t-1} = \left(\frac{F_t}{L_t^F} \right) \Delta L_t^F + L_{t-1}^F \Delta \left(\frac{F_t}{L_t^F} \right) + \left(\frac{P_t}{L_t^P} \right) \Delta L_t^P + L_{t-1}^P \Delta \left(\frac{P_t}{L_t^F} \right). \tag{24}$$

The change in total hours over the interval is decomposed into 1) the change in full-time workers weighted by the average hours worked by a full-time worker in period t; 2) the change in the hours per full-time worker, weighted by the number of full-time workers in $t-1$; 3) the change in part-time workers weighted by the average hours worked by a part-time worker in period t; 4) the change in hours per part-time worker, weighted by the number of part-time workers in $t-1$.

Appendix B. Data description

B.1 German wages: Imputed hourly wages from SIAB and GSOEP

Previous studies analyzed hourly wages for Germany by using the earnings surveys, the micro census (both provided by the Federal Statistical Office), or, more commonly, the German Socio-Economic Panel (GSOEP). Unfortunately, at the individual-level, neither the quarterly earnings survey, nor the micro census are freely available for research. Social security records, namely the Sample of Integrated Labour Market Biographies (SIAB), contains an imputed daily wage at the individual level, but lacks information about working hours. The GSOEP is used frequently because it is freely accessible for research and it contains information about monthly wages and hours worked per week.

In both micro data sets, all socially insured employees in full-time or part-time work are grouped by the following categories: age groups, gender, place of residence, and qualification. In addition to the previously described differences in the two surveys, variables such as employment status, qualification or wage have different definitions. To aggregate both micro data sets in groups is meaningful only, if these aggregates are conditional on corresponding characteristics in both data sources.

The conceptual discrepancy, i. e. definitions of variables and respondents of the two data sources, lead to differences in the wage measures in levels and its growth rates.[21] However the two wage measures are highly correlated in levels as well as growth rates. An hourly wage measure is imputed in a synthetic panel based in group means of working hours from the GSOEP and median gross daily wages from the SIAB. The synthetic panel fills a lack in limited availability of hourly wage information for socially insured employees of all firm sizes.

21 See Seele (2019) for descriptives.

B.2 Construction of relative wages and relative employment

The relative wage is defined as:

$$\omega_{it} = w_{it}/(\sum_{t=1}^{T}(\gamma_{it}/T) \cdot \sum_{i=1}^{N}(w_{it}/N)), \tag{25}$$

which is weighted by the relative employment $\gamma_{it} = L_{it}/\sum_{i=1}^{N} L_{it}$. The relative, weighted employment is defined as:

$$\theta_{it} = (\bar{\omega}_i \cdot L_{it})/(\sum_{i=1}^{N}(\bar{\omega}_i \cdot L_{it})), \tag{26}$$

with average relative weighted wage of group i: $\bar{\omega}_i = \sum_{t=1}^{T} \omega_{it}/T$. For the description of relative participation, see Section 4.3 footnote 14.

Appendix C. Generalization of Katz-Murphy (1992) to endogenous labor supply, market clearing and rigid wage cases

C.1 Marshall: Market clearing

The model can be extended in a straightforward way to include endogenous labor supply with an analogue of Equation (5). Let labor supply be $L^S = S(W, Z)$ and assume that it is "everywhere upward-sloping" in the sense that Z contains the marginal utility of wealth (the Lagrange multiplier from the canonical labor supply problem), and that S_W contains only substitution effects. Market clearing $dL^S = dL^D = dL$ implies

$$dW = (D_W - S_W)^{-1}(S_Z dZ - D_X dX) \tag{27}$$

$$dL = D_W dW + D_X dX \tag{28}$$

$$= D_W (D_W - S_W)^{-1} S_Z dZ + \left(I - D_W (D_W - S_W)^{-1}\right) D_X dX \tag{29}$$

It follows that

$$dW' dL = (S_Z dZ - D_X dX)' (D_W - S_W)^{-1} \cdot \left[D_W (D_W - S_W)^{-1} S_Z dZ + \left(I - D_W (D_W - S_W)^{-1}\right) D_X dX\right] \tag{30}$$

and for the case of stable demand ($dX = 0$)

$$dW'dL = dZ'S_Z'(D_W - S_W)^{-1} D_W (D_W - S_W)^{-1} S_Z dZ \tag{31}$$

which is a quadratic form in the $k \times 1$ vector $(D_W - S_W)^{-1} S_Z dZ$. The fact that D_W is negative definite plus $dX = 0$ imply that $dW'dL < 0$.

C.2 Pigou: Introducing wage rigidity

The wage is a linear combination of market clearing and exogenous rigid wage $d\overline{W}$:

$$dW = (1 - \phi)dW^* + \phi d\overline{W} \tag{32}$$

where ϕ is a constant $0 < \phi < 1$ that controls the extent of wage rigidity in the economy. The change in the market-clearing wage W^* is the change in the Marshallian outcome, so after substitution

$$dW = (1 - \phi)(D_W - S_W)^{-1}(S_Z dZ - D_X dX) + \phi d\overline{W}. \tag{33}$$

Because labor force participation equals labor supply, we have

$$dP = S_W dW + S_Z dZ \tag{34}$$

$$= S_W \left[(1 - \phi)(D_W - S_W)^{-1}(S_Z dZ - D_X dX) + \phi d\overline{W}\right] + S_Z dZ \tag{35}$$

and

$$dW' = (1 - \phi)\left(dZ'S_Z' - dX'D_X'\right)(D_W - S_W)^{-1} + \phi d\overline{W}'. \tag{36}$$

The inner product $dW'dP$ is given by

$$\left[(1 - \phi)\left(dZ'S_Z' + dX'D_X'\right)(D_W - S_W)^{-1} + \phi d\overline{W}'\right] \cdot \left[(1 - \phi)S_W (D_W - S_W)^{-1}(S_Z dZ - D_X dX) + \phi S_W d\overline{W} + S_Z dZ\right] \tag{37}$$

This will form the basis of predictions regarding the correlation of wages and participation.

C.2.1 Case of wage rigidity shocks only $d\overline{W} \neq 0$ ($dX = dZ = 0$)

If $d\overline{W} \neq 0$ and $dX = dZ = 0$ then

$$dW'dP = \phi^2 d\overline{W}' S_W d\overline{W} > 0 \tag{38}$$

which is a quadratic form in the positive definite matrix S_W; as wage rigidity disappears ($\phi \to 0$), $dW'dP$ approaches zero (since no other shocks are active by assumption). In the rigid wage case with wage shocks operative, relative wages and relative participation should covary positively. Note that this effect exists only as long as wage rigidity is relevant ($\phi > 0$).

C.2.2 Case of labor supply shocks only $dZ \neq 0$ ($dX = d\overline{W} = 0$)

Suppose instead that shocks to wage rigidity are absent ($d\overline{W} = 0$) and labor demand is stable $dX = 0$, but labor supply shocks are operative ($dZ \neq 0$). Then $dP = [S_W(1-\phi)(D_W - S_W)^{-1} + I] S_Z dZ$ and $dW = (1-\phi)(D_W - S_W)^{-1} S_Z dZ$, so

$$dW'dP = (1-\phi)dZ'S_Z'(D_W - S_W)^{-1}\left[S_W(1-\phi)(D_W - S_W)^{-1} + I\right] S_Z dZ \quad (39)$$

$$= (1-\phi)dZ'S_Z'(D_W - S_W)^{-1}[S_W(1-\phi) + (D_W - S_W)](D_W - S_W)^{-1} S_Z dZ \quad (40)$$

$$= (1-\phi)dZ'S_Z'(D_W - S_W)^{-1}(D_W - \phi S_W)(D_W - S_W)^{-1} S_Z dZ \quad (41)$$

which is a quadratic form in $D_W - \phi S_W$, a negative definite matrix. Thus $dW'dP < 0$ unambiguously. If only labor supply shocks are operative, the correlation between wages and participation in the partially rigid wage case remains negative regardless of the degree of wage rigidity. As wage flexibility goes to zero $\phi \longrightarrow 1$, dZ has no effect on the wage and the effect vanishes.

Appendix D. Mortensen-Pissarides (1994; 1999) with a labor force participation margin

D.1 Basic structure and continuation values for labor force participants

The exposition follows Mortensen and Pissarides (1999) and Pissarides (2000) and omits well-established proofs. The mass of total working population is fixed at 1, and can be in one of three labor market states: unemployment (u), nonparticipation (ℓ) and employment ($e = 1-u-\ell$). When out of the labor force, the worker receives monetary equivalent flow $b\varepsilon$ at each point in continuous time. Each worker in the labor force $\ell \in [0,1]$ has a valuation of nonparticipation described by a continuous cdf $G(\,)$. b is the unemployment benefit paid to those searching for work (*Arbeitslosengeld I*), and ε measures the flow value of being outside of the labor force – leisure, value of education, social welfare (*Arbeitslosengeld II*), plus cost of active job search, all measured as a fraction of the unemployment benefit.

First, we study the sub-system conditional on labor force participation. In the steady state, the continuation valuations of the two possibilities for workers participating in the labor market (ILO definition) U and W are defined by functional equation

$$rW(x) = w(x) + \lambda \left[\int_0^1 \max(W'(z), U') dF(z) \right] \tag{42}$$

$$= w(x) + \lambda F(R) \left[U' - W(x)\right] + \lambda \int_R^1 \left[W'(z) - W(x)\right] dF(z) \tag{43}$$

for employed workers, conditional on the current state of idiosyncratic productivity $x \in [0, 1]$, and

$$rU = b + \theta q(\theta) \left[W'(1) - U'\right] \tag{44}$$

for unemployed workers. The prime ($'$) refers to the state in the next instant (after dt has transpired) conditional on a new draw of x (a shock actually having occurred). Similarly, for firms producing with a worker of productivity x

$$rJ(x) = px - w(x) + \lambda \int_0^1 \max(J'(z), 0) dF(z) \tag{45}$$

$$= px - w(x) + \lambda F(R) \left[V' - J(x)\right] + \lambda \int_R^1 \left[J'(z) - J(x)\right] dF(z) \tag{46}$$

and for firms posting a vacancy:

$$rV = -c + q(\theta) \left[J'(1) - V'\right]. \tag{47}$$

The reservation level of productivity R is the level of the idiosyncratic productivity shock x below which mutually agreed dissolution of the match occurs; there are no involuntary separations in this model. Shocks occur in the interval $(t, t + dt)$ with Poisson incidence rate λ and x is distributed according to a time-invariant c. d. f. $F(z)$.

The participation constraint implies

$$rU = b + \frac{\beta c}{1 - \beta} \theta. \tag{48}$$

The wage, which serves to divide the match surplus, is determined by Nash bargaining:

$$\max(W(x) - U)^{\beta} (J(x) - V)^{1-\beta} \tag{49}$$

with first order condition

$$(W(x) - U) = \beta(J(x) + W(x) - U - V). \tag{50}$$

The solution for the (state contingent) wage $w(x)$ is

$$w(x) = \beta px + (1 - \beta)\, rU, \tag{51}$$

which, given the reservation level of utility can be rewritten as

$$w(x) = (1 - \beta)\, b + \beta\, (px + \theta c)\,. \tag{52}$$

A free-entry condition for vacancy posting by firms:

$$V = 0. \tag{53}$$

Constant unemployment implies $du = 0$:

$$s(1 - u - \ell) - \theta q(\theta) u = 0, \tag{54}$$

which completes the model. The unemployment rate is $u = \frac{s(1-\ell)}{s+\theta q(\theta)}$, where the separation rate s and nonparticipation ℓ are yet to be determined.

D.2 Modeling the participation margin

Following Pissarides (2000, Chapter 7), stock equilibrium between states of nonparticipation and unemployment is determined by indifference between participation and unemployment for the marginal worker with identity $\ell \in [0, 1]$, there are no frictions between the two states.[22] While all workers value the state of unemployment at rU and receive identical income in nonparticipation (εb), each worker is heterogenous with respect to nonparticipation, described by a cumulative distribution function $G(.)$, which also gives the worker's unique identity on $[0, 1]$, with $\ell = 0$ having the highest, and $\ell = 1$ having the lowest (periodic) monetary valuation of nonparticipation. Aggregate equilibrium reflects indifference at the margin between participation and unemployment for the marginal worker, satisfying

$$1 - \ell = G(rU - b\varepsilon). \tag{55}$$

22 An alternative assumption is that new entrants face probability of employment $\frac{e}{1-\ell}$ and of unemployment $\frac{u}{1-\ell}$. While plausible, this variant is algebraically more challenging and does not add to the qualitative conclusions.

The mass of nonparticipation ℓ is thus given by

$$\ell = 1 - G((1-\varepsilon)b + \frac{\beta c}{1-\beta}\theta). \tag{56}$$

Workers with low values of ℓ have the highest valuation of non-work time and are least likely to participate. Note that the right hand side is either parametric (b, β, c) or is endogenous and determined by free entry and zero profit condition on vacancies (θ).

We consider comparative-static changes in parameters b, β, and A; b describes the monetary periodic flow value to job searchers *relative* to ε. Because $0 < \varepsilon < 1$, non-participation in equilibrium will be interior: $1 > \ell > 0$.

D.3 Equilibrium

In steady-state, $W = W'$, $U = U'$, $J = J'$ and $V = V'$. The firm's valuation equations for the two states plus the free entry/exit condition for vacancies $V = 0$ imply $J = \frac{c}{q(\theta)} = \frac{p-w}{r+s}$; labor market tightness θ is fully determined by model parameters and the matching function according to

$$\frac{c}{q(\theta)} = (1-\beta)\left(\frac{1-R}{r+\lambda}\right)p \tag{JC}$$

$$Rp + \frac{\lambda p}{r+\lambda}\int_R^1 (z-R)dF(z) = rU \tag{JD}$$

$$rU = b + \frac{\beta c}{1-\beta}\theta \tag{RU}$$

$$1 - \ell = G(rU - \epsilon b) \tag{LP}$$

Note that inserting RU into JD leads to the JD curve:

$$Rp + \frac{\lambda p}{r+\lambda}\int_R^1 (z-R)dF(z) = b + \frac{\beta c}{1-\beta}\theta \tag{JD}$$

and RU into LP leads to the LP curve.

D.4 Comparative statics

We seek expressions for the following derivatives of equilibrium reservation productivity R, labor market tightness θ, and labor force nonparticipation ℓ with respect to the "Hartz-parameters" matching efficiency A and income of searching unemployed b, as well as worker bargaining power β. Total differentiation of JD, JC and LP, eliminating rU using RU and substituting $q(\theta) = Ax(\theta^{-1}, 1)$, with $dA, db, d\beta \neq 0$ and all other model parameters held constant, yields the following linearized system in $d\theta$, dR, and $d\ell$:

$$\left(\frac{1-\beta}{r+\lambda}\right)pdR + \frac{c}{Ax^2}\frac{x_1}{\theta^2}d\theta = \frac{c}{A^2x}dA - \left(\frac{1-R}{r+\lambda}\right)pd\beta \tag{57}$$

$$\left[1 - \frac{\lambda(1-F(R))}{r+\lambda}\right]pdR - \frac{\beta c}{1-\beta}d\theta = db + \frac{c\theta}{(1-\beta)^2}d\beta \tag{58}$$

$$-d\ell - g\cdot\frac{\beta c}{1-\beta}d\theta = g\cdot\left[(1-\varepsilon)\,db - bd\varepsilon + \frac{c\theta}{(1-\beta)^2}d\beta\right] \tag{59}$$

or in matrix form:

$$\begin{bmatrix} \left(\frac{1-\beta}{r+\lambda}\right)p & \frac{c}{Ax^2}\frac{x_1}{\theta^2} & 0 \\ \left[1-\frac{\lambda(1-F(R))}{r+\lambda}\right]p & -\frac{\beta c}{1-\beta} & 0 \\ 0 & g\cdot\frac{\beta c}{1-\beta} & 1 \end{bmatrix}\begin{bmatrix} dR \\ d\theta \\ d\ell \end{bmatrix} = \begin{bmatrix} \frac{c}{A^2x}dA - \left(\frac{1-R}{r+\lambda}\right)pd\beta \\ db + \frac{c\theta}{(1-\beta)^2}d\beta \\ -g\cdot\left[(1-\varepsilon)\,db - bd\varepsilon + \frac{c\theta}{(1-\beta)^2}d\beta\right] \end{bmatrix} \tag{60}$$

where the functions g and x are evaluated at steady state values. Defining

$$\Delta \equiv -\left(\frac{\beta c}{1-\beta}\right)\left(\frac{1-\beta}{r+\lambda}\right)p - \left(\frac{c}{Ax^2}\frac{x_1(\theta^{-1},1)}{\theta^2}\right)\left[1-\frac{\lambda(1-F(R))}{r+\lambda}\right]p < 0 \tag{61}$$

we can use Cramer's Rule to derive the following comparative statics results:

$$\frac{dR}{dA} = -\frac{\left(\frac{c}{A^2x}\right)\left(\frac{\beta c}{1-\beta}\right)}{\Delta} > 0 \tag{62}$$

$$\left.\frac{dR}{db}\right|_{d\varepsilon=\frac{(1-\varepsilon)}{b}db} = \frac{-\frac{c}{Ax^2}\frac{x_1(\theta^{-1},1)}{\theta^2}}{\Delta} > 0 \tag{63}$$

$$\frac{dR}{d\beta} = \frac{\left(\frac{1-R}{r+\lambda}\right)p\left(\frac{\beta c}{1-\beta}\right) - \frac{c\theta}{(1-\beta)^2}\left(\frac{c}{Ax^2}\frac{x_1(\theta^{-1},1)}{\theta^2}\right)}{\Delta} \lesseqgtr 0 \text{ ambiguous} \tag{64}$$

$$\frac{d\theta}{dA} = \frac{-\left[1-\frac{\lambda(1-F(R))}{r+\lambda}\right]p\frac{c}{A^2x}}{\Delta} > 0 \tag{65}$$

$$\left.\frac{d\theta}{db}\right|_{d\varepsilon=\frac{(1-\varepsilon)}{b}db} = \frac{\frac{1-\beta}{r+\lambda}p}{\Delta} < 0 \tag{66}$$

$$\frac{d\theta}{d\beta} = \frac{\left(\frac{1-\beta}{r+\lambda}\right)p\frac{c\theta}{(1-\beta)^2} + \left[1-\frac{\lambda(1-F(R))}{r+\lambda}\right]p\left(\frac{1-R}{r+\lambda}\right)p}{\Delta} < 0 \tag{67}$$

$$\frac{d\ell}{dA} = \frac{g \cdot \frac{\beta c}{1-\beta}\left[1-\frac{\lambda(1-F(R))}{r+\lambda}\right] p \frac{c}{A^2 x}}{\Delta} < 0 \tag{68}$$

$$\left.\frac{d\ell}{db}\right|_{d\varepsilon=\frac{(1-\varepsilon)}{b}db} = -\frac{g \cdot \frac{\beta c}{1-\beta}\left(\frac{1-\beta}{r+\lambda}\right) p}{\Delta} > 0 \tag{69}$$

$$\frac{d\ell}{d\beta} = pc\left[1-\frac{\lambda(1-F(R))}{r+\lambda}\right] g \cdot \frac{1}{(1-\beta)^2}\left[\frac{-\beta p(1-\beta)\left(\frac{1-R}{r+\lambda}\right)+\frac{cx_1}{A\theta x^2}}{\Delta}\right] \lesseqgtr 0 \text{ ambiguous} \tag{70}$$

confirming the graphical analysis in the main text.

Using the JC curve $\frac{c}{q(\theta)} = (1-\beta)\left(\frac{1-R}{r+\lambda}\right)p$, the last expression can be rewritten as

$$\frac{d\ell}{d\beta} = pc\left[1-\frac{\lambda(1-F(R))}{r+\lambda}\right] g \cdot \frac{1}{(1-\beta)^2}\left[\frac{-\beta\frac{c}{q(\theta)}+\frac{cx_1}{A\theta x^2}}{\Delta}\right] \tag{71}$$

$$= pc\left[1-\frac{\lambda(1-F(R))}{r+\lambda}\right] g \cdot \frac{1}{(1-\beta)^2}\frac{c}{q(\theta)}\left[\frac{-\beta+\frac{\theta^{-1}x_1}{x}}{\Delta}\right] \tag{72}$$

Given that $\left[1-\frac{\lambda(1-F(R))}{r+\lambda}\right] > 0$ and $\Delta < 0$, a necessary and sufficient condition for $\frac{d\ell}{d\beta} > 0$ is $\beta > \frac{\theta^{-1}x_1}{x}$, or that worker bargaining power is strictly greater than the local elasticity of the vacancy posting rate (q) with respect to job tightness (θ) evaluated at the equilibrium.

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