The Great Disconnect: The Decoupling of Wage and Price Inflation in Japan*

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Abstract

We take some well-known observations about the structure of the Japanese labor market and add new evidence about how it has evolved to study inflation in Japan. Our key finding is that labor market dynamics shifted after 1998 so that correlations between labor market tightness and wages weakened noticeably. This change was accompanied in a break in the relationship between wages and prices, so wage inflation has become a much less important determinant of price inflation.

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1. Introduction

Japan's persistently low inflation is puzzling in two respects. On the one hand, the Bank of Japan (BoJ) since 2013 has engaged in unprecedented monetary stimulus. This began with a massive asset purchase program (concentrated on Japanese government bonds), which was followed by driving short term interest rates below zero and ultimately targeting the yield on the 10 year bond rate. Despite these efforts, and the conventional view that a determined central bank can raise the price level, inflation has remained below the BoJ's target of 2% per year.

On the other hand, the labor market in Japan has been relatively tight. There is no broadly accepted estimate of the natural rate of unemployment in Japan. However, speeches by BoJ officials often indicate that they believe that once the unemployment rate reaches about 3%, the only people unemployed are in that situation because of search frictions. With unemployment rate below 2.5 percent, one would expect to see rising wage and price inflation (even if the monetary policy stance were neutral). Likewise, standard estimates of potential growth in Japan are about 0.5 percent. The growth rate for the economy has regularly been above this level since early 2013. Thus, adherents of the Phillip's curve might also find the subdued inflation puzzling.

In this paper we explore the role of Japan's dual labor market in driving the low inflation outcomes in Japan. Economists have long studied the differences in employment conditions between full-time regular workers and part-time employees in Japan. As the Bank of Japan (2017) notes, there has been a steady rise in part-time workers and their wages are more sensitive to market conditions than full-time workers. However, the level of part-time workers' wages is far below those for full time workers. This change in composition has depressed firm's wage bills. We investigate the effects of this factor on inflation outcomes in Japan.

We begin our analysis in 1981, just after the second global oil shock, which marked the beginning of Japan's relatively low inflation era. Starting in 1981, inflation gradually trended down before rising a bit and then settling around zero by the middle of the 1990s. This pattern holds for both headline measures of inflation and those that exclude food and energy prices. We show that the behavior of wages and prices in this period is very conventional. Wages are reliably connected to labor market tightness and wage inflation has important explanatory power for prices.

Sometime in the late 1990s, these patterns begin to change. We date the shift as starting in 1998. While ability to statistically distinguish the exact break point is limited, there are several good reasons to impose a break in 1998. One is that the Bank of Japan gains its legal independence then. A second is that the acute phase of the banking Japanese banking crisis begins in late 1997. A third, most importantly, is that past research has found that a number of other structural relations in the economy changed around this time (Hamada, Kashyap, and Weinstein (2011)).[1] Thus, our analysis focuses on a number of differences between the pre and post-1998 eras.

We organize our investigation into five parts. First, we briefly review the literature on inflation in Japan. Broadly, past work can be separated into two broad approaches. One begins with the kind of Phillips curve that has been estimated in many countries and then tries to modify it to account for particular factors in Japan. The other is closer to our approach and puts the structure of the labor market at the center of the story.

Section 3 presents the evidence that supports our contention that it is wise to analyze inflation separately before and after 1998. We include both our own statistical analysis and review relevant related prior work that argues for the important structural break around 1998.

The fourth section of the paper covers our summary of the labor market facts. One novel aspect of our analysis is to study separately the determination of regular, overtime and bonus wages. We find that the different types of wages exhibit different dynamics and that their responsiveness to labor market tightness also varies. More importantly, we find that there were important shifts in the connection between the unemployment rate and wage inflation after 1998.

Section 5 investigates the joint links between prices and wages. We show how the trends in wages and prices changed in 1998 and how the trend breaks also correspond to shifts in the dynamic relations between the two series.

Section 6 presents our conclusions.

2. Literature Review

There is an enormous literature on the Japanese inflation experience over the last two decades. Since the BoJ was given formal independence in 1998, many of these papers have focused on the operating tactics and strategies of the BoJ. Many observers criticized the BoJ for being ambivalent about whether it should fight the ongoing deflation and if so whether it in fact had the necessary tools.

One influential analysis by Bernanke (2000) argued that the BoJ had been insufficiently aggressive in using the tools at its disposal to combat deflation. In a 2003 speech, Bernanke (2003) followed up this analysis and gave a number of suggestions about steps that could be taken to raise the price level in Japan. Svensson (2003) offered what has come to be known as the "foolproof" way to overcome deflation by relying on monetary induced changes in the exchange rate to eventually drive prices up.

[1] For instance, one widely studied question is the connection between monetary policy and the economy. Many studies have found a large shift at some point during the 1990s, although they differ in the variables they examine and the exact timing of the break. See, for example, Arai and Hoshi (2006), Kimura, Kobayahi, Muranaga, and Ugai (2003), Kuttner and Posen (2001), and Miyao (2000).

These diagnoses were in part a reaction to the BoJ's contention that deflation was occurring for reasons outside of its control. For example, in January 2002 BoJ Governor Hayami gave a speech describing recent BoJ policy decisions (Hayami (2002)). One key passage was (with emphasis included by us):

> "We changed the main operating target from call rates to a quantitative indicator of liquidity, that is, the outstanding balance of current accounts at the Bank of Japan, and we have substantially increased the balance.
>
> Because this was a very drastic easing measure and was unprecedented in the history of central banking worldwide, we had to consider various issues very carefully before deciding it. *Above all, it was uncertain whether and how expansion of liquidity provision in a situation where the rate is virtually zero percent would influence the economy. Needless to say, the mechanism through which such an expansion affects the economy has not been demonstrated either theoretically or empirically.*"

As late as 2011, the Bank of Japan was still making these kinds of arguments. For instance, Governor Shirakawa gave a speech (with a nearly identical title to Hayami's) in which he claimed (Shirakawa (2011)):

> "The prolonged, albeit moderate, deflation since the end of the 1990s cannot be explained only by short-term and cyclical factors. A more fundamental cause is the long-term downtrend in the growth potential of Japan's economy. When the growth rate continues to decline for a protracted period, people's expectations for future income growth are reduced and firms and households restrain their spending. As a result, downward pressure on prices continues (Chart 8).
>
> It is sometimes said that deflation will be solved only if the central bank provides liquidity more aggressively. Provision of ample liquidity is important, of course, but this alone does not solve the problem of deflation."

These arguments were met with continued criticisms from external observers. See, for example, Ito and Mishkin (2006) for a detailed assessment of the first few years of the BOJ independence and IMF (2012) and Kuttner, Iwaisako and Posen (2015) for subsequent critiques.

Yet, starting in 2013, when Governor Kuroda took the helm at the BoJ, these critiques no longer apply. The BoJ has become very aggressive and implemented many of the ideas advocated by its critics. It has stopped questioning its responsibility for inflation outcomes and has disavowed the idea that it is impossible to end deflation. The recent literature, therefore, has shifted to try to explain why, even with extremely accommodative monetary policy, inflation in Japan has remained below 2 percent.

One strand of research takes a Phillips curve approach and seeks to relate inflation to measures of slack in the economy and expectations. Bernanke (2017) surveys much of this work and adds his own conjectures about the reasons for persistently low levels of Japanese inflation. The conventional view is that the sensitivity of inflation to measures of slack have declined in many advanced economies including Japan. The Bank of Japan (2017) gives a specific example of this argument, contrasting the estimated slope of the Phillips curve before and after 2013 and concluding that the curve is much flatter after 2013.

This reduced sensitivity is supplemented with the view that expectations for inflation in Japan are unanchored. Kuroda (2017) argues that expectations in Japan are much more adaptive or backward looking in other countries, so that factors such as oil price swings that change realized inflation can be particularly important in Japan. Bernanke (2017) adds that one reason why expectations in Japan may not be closely pegged to the BoJ's inflation target is the long-period when inflation undershot the target. In this sense, the BOJ may still be suffering from the past performance despite the change in leadership and philosophy.

Not everyone accepts the idea that the Phillips curve is broken in Japan. Gagnon (2017) argues instead that potential output and full-employment have been chronically mis-measured in Japan. As he notes, standard measures of potential output are constructed under the assumption that over the sample being considered, output is both above and below potential. If instead, the economy was consistently depressed so that potential output was never reached (and the economy was never at full employment), then standard statistical approaches to deduce potential are doomed. Gagnon argues that this was likely the case in Japan between 1995 and 2016, so the more puzzling issue is why there was not more deflation. He conjectures that downward wage rigidity prevented an acceleration of deflation. He predicts that as the economy continues to recover, it will soon pass the level of full-employment and inflation will appear when it does. This explanation seems less persuasive standing in 2019, after two more years of steady growth, than at the time he was writing.

Some researchers have focused on the wage Phillips curve rather than the price Phillips curve, and have emphasized the role of the labor market structure in influencing wage and price dynamics. An excellent collection of the essays on this topic is Genda (2017). The 16 chapters in this volume explore a variety of reasons why wages have stagnated in the presence of a tight labor market. Three common themes emerge from these essays. One is that the dual labor market is important and that full-time workers (or regular workers) and part-time workers (or non-regular workers) are paid and treated very differently. The increasing share of part-time workers in the recent decades is highlighted in many of the chapters. A second theme is the prevalence of downward wage rigidity and the extent to which firms hesitate to cut wages. One essay by Yamamoto and Kuroda notes that there are many firms that never cut wages over a ten year period. These same firms also fail to raise wages when the economy improves. Some authors call this "upward wage rigidity."

A third consideration is the supply side of the labor market. One aspect of labor supply is the steady demographic shift in Japan. As the society has aged, many elderly people continue to want to work past the mandatory retirement age, and have stayed in the labor market often by taking part-time positions. This trend has perhaps been supplemented by a collapse in training within firms. On-the-job-training was once an important factor in raising skill-levels and the decline in this practice has reduced the supply of certain types of high-skilled workers. In cases where there is a mismatch between the hiring needs of firms and the supply of suitable workers, wage increases may not be very effective in clearing the market and the wage can stagnate even with a tight labor market.

The hypothesis that we pursue in this paper is very much in line with the arguments found in Genda (2017). While none of the essays specifically match our story, we see our story as a convex combination of the different pieces of evidence in the book. The main difference in our work relative to these essays is to explicitly connect inflation developments to the wage developments.

3. Structural Breaks in Japanese Inflation

This paper examines two price inflation indicators and three wage inflation indicators. Figure 1 shows the two price series from the first quarter of 1971 to the last quarter of 2018: the so-called "core-core" inflation rate which is the consumer price index excluding food and energy (the solid red line in the figure) and the headline inflation rate as computed from the total consumer price index (the dashed blue line in the figure). For both of the CPI measures we adjusted the series to remove the mechanical effects of the three increases in the consumption tax on April 1 in 1989, 1997, and 2014. To eliminate seasonal fluctuations, the figure shows the four quarter change in the natural logarithm of series. Throughout our analysis, we will measure wage and price inflation this way.

We construct the wage series by dividing a measure of earnings by a measure of hours worked. We distinguish three components of earnings for a worker: regular pay, overtime pay, and bonuses. The source of the data is *Monthly Labour Survey* https://www.mhlw.go.jp/toukei/list/30-1.html, English page: http://www.mhlw.go.jp/english/database/db-l/monthly-labour.html).[2] The regular wage is calculated by dividing the regular pay by the number of regular hours worked. The overtime wage is calculated by dividing the total overtime pay by the number of overtime hours. Finally, the bonus "wage" is calculated by dividing the bonus payments received in the last 12 months by the total number of hours worked (including overtime) for the last 12 months. We look at the last 12 months because the bonus is typically paid only twice a year: once in June or July and then in December. We use series that relate to establishments with 30 or more

[2] Errors in calculating some series in *the Monthly Labour Survey* were revealed in January 2019. See the Appendix 1 for more details of the problem and how we have corrected the series.

employees. Appendix 1 (missing in this draft) contains the detailed description of wage data construction. Figure 2 shows the three wage inflation indicators: regular wage inflation in the solid green line, overtime wage inflation in the dashed red line, and bonus wage inflation in the dotted blue line. The bonus wage inflation series starts at the fourth quarter of 1971, but the other two wage inflation series are available only from the second quarter of 1980 due to the availability of original data in *Monthly Labour Survey*.

Simple inspection of Figures 1 and 2 reveals the three main points that are important for our subsequent analysis. First, the period from the start of the sample for price inflation series (and bonus wage inflation) through 1980 looks qualitatively different than the rest of the data. This period contains the end of the “high growth era” when Japan’s economy averaged more than 9 percent growth, and the two spikes in price inflation that accompanied the disruptions in global oil markets in 1974/75 and 1980, although the spike for 1980 is smaller than that for 1974/75 and is nearly absent for bonus wage inflation. Price inflation, even excluding food and energy, is much higher and more volatile than the rest of the sample. Both our measures of inflation, and bonus wage growth, rise sharply and then fall during this period.

The episode of the 1970s is so different from what followed after the 1980s that any econometric exercises to examine the connections between the variables would be driven by the events of the 1970s (even though they are not representative of the rest of the sample). We do not believe the experience from the 1970s is relevant for our question about why inflation has been so low for the last two decades. So for the remainder of the paper we begin the analysis in 1981. This decision is also driven by the fact that only bonus wage data are available before 1980.

The second important observation is that starting in 1981 inflation begins falling and declines gradually through 1988 before rising a bit. Even then, inflation remains low. For the entire time through 1997 inflation sits below four percent. Headline inflation moves more than the core-core measure, but the two variables track each other closely. Wages also move along with the price measures, but are more volatile.

Finally, note that all three measures fall to about zero by 1998. Starting in 1998 all price and wage inflation rates hover around zero. Price inflation measures also become more stable after 1998 than in the prior sample.

To confirm these visual impressions that the periods before and after 1998 are different, we conduct two formal statistical tests. First, we used Augmented Dickey Fuller (ADF) tests to assess the degree of integration for the underlying series graphed in Figures 1 and 2. Over the period from 1981 to 1997 for all the series except for the core-core inflation rate, the test cannot reject the hypotheses that the inflation rates are non-stationary. In contrast, after 1998 for the wage inflation indicators (except for bonus wage inflation), the test fails to reject stationarity. For the price inflation, the test continues to reject stationarity (including the core-core inflation rate).

As a second diagnostic, we estimated Box-Jenkins style time series models for each of the five series in Figures 1 and 2 and tested for the stability of the models. Table 2 consists of five panels showing the best fitting models for each of the five series. The models were selected to fit the 1981 to 1997 sample as parsimoniously as possible. The model was then re-estimated over the post-1998 sample to investigate whether the dynamics of the series were stable.

For the headline CPI inflation rate, the best fitting model had one autoregressive term and lagged moving average terms at quarters three and five. For the core-core inflation rate, the best fitting model also had one autoregressive term, and a lagged moving average term at quarter two. The regular wage series was modeled as having two lagged autoregressive terms, at quarters one and two. The overtime wage series had the same structure as the regular wage series with two lagged autoregressive terms. The best fitting model for the bonus series had a single autoregressive term at quarter one.

We draw four conclusions from these estimates. First, for the two price inflation series, there is a substantial degree of persistence as shown by the coefficient on the autoregressive term that is close to one. This is consistent with the unit root test results that suggested that inflation series (especially headline CPI) was I(1). As Cecchetti et al (2017) observe in many countries, a relatively good model for inflation assumes that the first difference of inflation follows a first-order moving average process. Our result suggests that this characterization applies for Japan. Second, for both of the price inflation series, the levels of persistence fall after 1998. Both the autoregressive coefficients and the moving average coefficients are smaller in magnitude and have lower degree of statistical significance. For the headline series, one of the MA coefficients flips sign.

Third, the three wage series are also highly persistent. The models have large coefficients on the autoregressive terms, although the model for the overtime wage has negative coefficient on the second autoregressive term that partially offset the large coefficient on the first autoregressive term. Fourth and finally, as with the price inflation measures, the persistence declines after 1998, although for the bonus wage series the drop is inconsequential.

Formal tests for coefficient stability show that for all five series, the coefficients across the two samples are significantly different. For example, a Chow test that supposes a break date of the first quarter of 1998 rejects the equality of coefficients at levels of significance below 1 percent for four of the five series. The exception is the core-core inflation rate, for which the standard Chow test using F-statistics fails to reject the null hypothesis that the coefficients are equal across the two sample periods. In that case, the test using the likelihood ratio rejects the null at 5 percent level and the test using the Wald statistic rejects the null at below 1 percent.

Alternatively, a Quandt-Andrews test allows for a potential break at any date (other than those that are too close to the beginning or the end of the sample period). We consider a potential break in the middle 85% of the sample (1986Q4 to 2013Q2). This test also generally rejects the null hypothesis that there were no break points. Again the exception is the core-core inflation rate. According to the likelihood ratio test, the most likely breakpoint of 1995Q2 is not statistically significant, while the Wald statistic suggests the breakpoint of 1993Q4 and is statistically significant. For headline inflation, the break date that is mostly likely is 1999Q4 according to the likelihood ratio test and 2008Q3 for Wald test. For regular wage inflation, both likelihood ratio and Wald tests select 1998Q1 as the most likely breakpoint. For overtime wage inflation, suggested breakpoints by two tests are 1998Q4 and 1996Q1. Suggested breakpoints are a little bit earlier for bonus inflation and are 1995Q2 and 1992Q2.

Combining all of this direct evidence, with the aforementioned analysis in Hamada, Kashyap and Weinstein suggesting that a number of other macro relations changed around 1998, leads us to examine separately the pre- and post-1998 data for the remainder of the paper. Our focus now shifts to trying to understand what might be responsible for the shift.

4. Wages and the Labor Market

The structure of the labor market began to shift following the Japanese banking crisis. Figure 3 shows annual data for the levels of average hourly wages (as opposed to rates of changes in Figure 2) in Japan from 1993 to 2018. The starting point for the graph is dictated by data availability because the full-time and part-time distinction only becomes available in 1993. Each panel of the figure shows the wage rate for full-time and part-time workers along with the average for the economy that accounts for both types (the green solid line) for each of the three measures of wages: regular wages (panel A), overtime wages (panel B), and bonus wages (panel C). To calculate the wage series, we start with an estimate for the level of earnings in yen (and number of hours worked) for full-time, part-time and average workers in 2018, which is reported in the *Monthly Labour Survey*. We then project these series back in time using indices of various types of earnings and hours worked by different types of workers at establishments with 30 or more employees. The wage series plotted here are calculated by dividing each measure of earnings in yen by the appropriate number of hours worked. More details in the construction of the dataset for our analysis is explained in Appendix 1.

Panel A of Figure 3 shows the movements of the level of regular wages. Note that the left axis is the scale for regular wage series for full-time workers and all workers and it differs from the scale on the right axis that measures regular wage for part-time workers. The average level of regular wages peaked in 1999 and stopped growing. By 2009 the level finally exceeded the 1999 peak, but the average regular wage dropped for the next 3 years, and did not exceed the 2009 level again until 2017. The patterns for full-time and part-time wages are very different. The wage for full-time workers has been remarkably steady sitting around 2,100 yen per hour and have only slightly increased during the last 20 years. The part-time wage has risen by about 20 percent from below 1,000 yen to close to 1,200 yen per hour between 1999 and 2018. The part-time wage also has been more sensitive to improved business conditions since 2013.

The different trends in full-time wage and part-time wage is even clearer for overtime wages, which are shown in Panel B. The average level of overtime wages also peaked in 1999 and as of 2018 has yet to exceed that level. The average level of overtime wages for full-time workers shows very similar dynamics. It also peaked in 1999 and has not exceeded that level. For part-time workers, the average overtime wage increased by about 19 percent from about 1,150 yen to close to 1,400 yen per hour between 1999 and 2018.

Bonus earnings divided by total hours worked is very different than the other wage measures. The average bonus peaked in 1997 and then trended down as Panel C of the figure shows. The level has been recovering since 2014, but the 2018 level is less than 80 percent of the 1997 level. The movements of the bonus for full-time workers are essentially the same as those of the average. This is because few part-time workers receive bonuses. As we can see from Panel C, the level of bonus divided by total hours worked has been very low (and trending down) for part-time workers.

Figure 4 shows that the main reason for the flat average regular and overtime wages despite rising regular and overtime wages for part-time jobs and (to a lesser degree) for full-time jobs is the changing composition of the workforce. We use the employment index for each type of job at establishments with 30 or more employees in *Monthly Labour Survey* and convert it into actual number using the ratio of the index value to the actual value in year 2018. Here we show the annual average of each series. The number of full-time workers is measured on the left axis (in millions) while the level of part-time workers is measured on the right axis (in millions). The number of full-time workers peaked in 1994, dips a bit afterwards, before it began a precipitous decline in 1998 that continued through 2003. The number of part-time workers was relatively stable until 1996 and then began a climb that continued over the next 20 years. The replacement of high cost full-time employees with much less expensive part-time workers is a major reason why average regular and overtime wages in 2018 are almost the same as in 1997.

The last section documented changes of dynamics for both prices and wages. For wages, the reason for the changing dynamics is specifically attributable to the interaction of the sharp recession that began in 1997 and the dual labor market. Unfortunately, data on wages for part-time and regular workers in *Monthly Labour Survey* is only available starting in 1993. This prevents us from being able to directly show that there was a break in the link between the labor market conditions and the wages for full-time as well as part-time workers. Consequently, we proceed indirectly, building up evidence in three steps.

First, using data on average wages for all workers, we show that the connection between average wages and labor market tightness changed around 1997. We do this by augmenting the ARMA models for the three measures of wage inflation that we considered in the last section with the unemployment rate, which is the most widely used measure of labor market slack (or tightness) and checking whether the response of wage to labor market conditions changed before and after 1997.

This analysis is presented in Table 3. We use the same autoregressive specifications that we used in the last section for each wage measure. Panel A of Table 3 examines the regular wage inflation. The panel shows the estimation results for two different sample periods: 1981-1997 and 1998-2018. For both samples, one period lag of the seasonally adjusted unemployment rate is statistically significant, but the size of the coefficient in the later period is less than one-fourth of the earlier period. Thus, the average regular wage does respond to the labor market condition in the expected direction in both periods, but the magnitude of the effect drops substantially after 1998. These estimates imply that all else equal, between 1981 and 1997, when unemployment rose by 0.5 percentage points in one quarter, inflation would fall by about 1.3 percentage point in the next quarter. A similar increase after 1998 would predict about a 0.3 percentage point reduction in the next quarter.

Panel B reports the results for overtime wage inflation. In the pre-1998 period, the coefficient estimate on the unemployment rate is negative and statistically significant. However, the strength of the effect drops noticeably after 1998. The point estimate of the coefficient drops to about one-tenth of the pre-1998 level and also loses statistical significance.

The results for bonus wage inflation in Panel C are very different. For the bonus, the responsiveness to the unemployment rate increased after 1998. The estimated coefficient on the unemployment rate for the pre-1998 period is not statistically significant. The point estimate suggests that a 0.5 percent reduction in the unemployment rate would raise bonuses by about 1 percent before 1998 while the reduction in the same magnitude would lead to 1.5 percent increase in bonuses in the post-1998 period.

Given the fraction of total compensation that comes from the three types of earnings, the overall sensitivity of earnings to labor market conditions is much lower after 1998. For instance, in 2018 the fraction of overall earnings from regular and overtime wages over the course of a year was 80%. So the fact that these wages have decoupled from labor market conditions is much more relevant than the increase in sensitivity for bonus wages.

The flattening of the wage Phillips curve in Japan has been noted in various studies including the paper by Muto and Shintani (2017). So the estimates in Table 3 can be read as confirming the observation that average wages now seem only weakly connected to excesses in the labor market.

To investigate what might be behind this change, we turn to data on market conditions for full-time workers. We do this by looking at how the proportion of enterprises that report excess full-time workers changed over time using data from *Rodo Keizai Doko Chosa (Survey of Labour*

Economy Trend) conducted by the Ministry of Health, Labour and Welfare in February, May, August, and November of each year.

Figure 5 shows the proportion of enterprises that express they have excessive full-time workers. This variable is clearly cyclical, and the level of excess workers jumps in 1998 and stays elevated till 2004, even though there is a partial economic recovery in 2000. By 2005, the excess employment indicator is back to the 1997 level and it remains there for 2 more years, before spiking again during the global financial crisis. Looking back at Figure 4, it is clear that the periods of excess correspond to times when full-time employment falls. Our contention is that this adjustment was incomplete, and if firms had not hoarded workers the number of full-time employees would have fallen much more sharply and presumably would have recovered more quickly.

This hunch leads to our third piece of evidence that explores whether the labor market condition has been equally important for full-time and part-time wages. To do this we estimate ARMAX models for wages separately for full-time and part-time workers. Because the wages data for full-time and part-time jobs separately are available only from 1993, we conduct the analysis for the post-1998 period only.

These results for three types of wages are shown in Table 4. The first panel compares the sensitivity of full-time regular wages to that of part-time regular wages. For both full-time and part-time wages, the specification with a second order autoregression is augmented by adding the (economy wide) unemployment rate. For both full-time workers and part-time workers the regular wage growth is negatively correlated with lagged unemployment rate and the coefficient estimates are statistically different from zero. The magnitude of the unemployment rate coefficient, however, is different. A one half of a percentage point increase in the unemployment rate would predict a 0.23 percentage point decrease in full-time worker regular wages in the next quarter while the same increase would lead to a 0.44 percentage point fall of part-time regular wages. Notice also that the R^2 is substantially lower for the model for full-time wages.

Panel B of Table 4 shows the results for overtime wages. The response of full-time workers' overtime wages is much more muted than that of part-time workers'. The point estimate suggests a one half of a percentage point increase in the unemployment rate would reduce full-time workers' overtime wage inflation by 0.14 percentage point while the same magnitude of increase would reduce the part-timers' wages by 0.71 percentage point, although neither estimate is statistically significant.

Panel C examines the bonus wage inflation. In this case, we use the specification with a single autoregressive term (as in Table 3). Here the full-time workers' bonuses show a response to the unemployment rate that is as large as the part-time workers' (though we need to note that the bonuses for part-time workers are much smaller than bonuses for full-time workers). A one half of a percentage point increase would reduce the bonuses for full-time workers by 1.57 percentage point and that for part-time workers by 1.77 percentage point.

In sum, Table 4 suggests that the regular wage (and overtime wage though the result is not statistically significant here) of full-time workers does not move as much as the wages for part-time workers in response to changes in labor market conditions. For bonuses, what full-time workers receive responds as much as what part-time workers get.

Given that the unemployment rate is not predictive of what happens to full-time regular wages (and overtime wages), and the evidence in section 3, we are led to the following account of the data. The market for full-time workers was often out of balance after 1998. This meant that labor market tightness did not influence full-time wages. Instead, the marginal equilibrating factor in the labor market occurs around part-time workers. When the market is relatively tight for full-time workers, wages respond for part-time workers. This is not so surprising since many people would prefer to work full-time, so to keep them in part-time positions their wages must rise.

On the other hand, the bonuses for both full-time workers and part-time workers do respond to labor market condition. This is consistent with the finding in Section 3 that the response of bonuses to changes in the unemployment rate did not decline in the post-1998 period (and actually increased).

5. Wages and Prices

We now turn to the implications of these facts for prices. In brief, the story we propose is that the break in the labor market helps us understand some, but not all of the puzzling features for inflation. In particular, prior to 1998 the labor market operated in a fairly conventional way: slack helped determine wage dynamics and wage changes were an important determinant of price changes. After 1998, there was a persistent excess supply of full-time workers and the marginal adjustments in labor came through the adjustment of part-time workers. Full-time wages were not an important factor in determining price changes and part-time wage changes were a statistical significant factor in affecting prices, but their quantitative impact was small. We proceed by first documenting the important pre-1998 facts before showing the post-1998 patterns.

Figure 7 plots the levels of headline CPI and core-core CPI with the indices for the regular wage for all workers, the part-time wage for all workers and the bonus wage for all workers. The structural break around 1998 that we found above is apparent in this figure as well. Before 1998, all the series were trending up, but they became stagnant or started to fall after 1998.

The bonus wage series stands out as a particularly extreme version of this pattern, as the level at the end of the sample is about 25% below the 1998 level. Recall that we had computed bonus wages by taking bonus payments over the last four quarters divided by total hours over that period. That smoothing is important because of the erratic timing of when bonus payments occur. If we measure bonus inflation as the simple four quarter change in bonuses, the resulting inflation is much, much more volatile. Figure 8 show the four quarter inflation rates for our preferred, averaged bonus series (shown in the blue solid line) and the four quarter inflation rate for the raw bonus series (shown in broken red lines). Not surprisingly any regressions with the raw series find much less explanatory power of the bonus wages.

We next compute a vector autoregression (VAR) of a 4 variable system that includes the core-core inflation rate and our three wage inflation series for the sample between 1981 and 1997. Given the ambiguity over degree of integration of the variables we also include a linear time trend in the system. The coefficients estimates are shown in Table 5. Rather than dwell on the coefficient estimates, we focus on the standard diagnostics for describing VARs: Granger causality tests, impulse response functions and variance decompositions. For the latter two diagnostics, we have ordered the series in the system so that the price inflation variable is first, regular wage inflation is second, overtime is third and bonuses are last. We then use a Choleski decomposition to impute the explanatory power of the different series. The standard deviations of the respective equations, which represent the size of the shocks for the impulse responses are shown at the bottom of Table 5.

Table 6 shows the Granger causality tests for core-core inflation. Both the regular wage inflation and bonus inflation rates are significant predictors of core-core inflation prior to 1997.

The impulse response functions are shown in Figure 9 for the response of the core-core inflation series to four types of shocks. The solid blue shows the mean response at each quarter and the dashed lines show 95% confidence intervals. By using the Choleski decomposition, the wage series are presumed to have no impact on price inflation in the first period. For regular wage inflation, the impact of the shock on core-core inflation grows and reaches a maximum between 5 and 8 quarters. The pass-through is meaningful, a one standard deviation shock to the regular wages moves prices by about half a standard deviation. For the part-time wages, the impulse responses are insignificantly different from zero at all horizons. For bonus wage inflation there is also a notable link to core-core price inflation. The impulse response shows that the maximum effect occurs at around 4 quarters and the quantitative effect is large. A one standard deviation increase in the bonus leads to about a 2/3 of a standard deviation in prices.

Table 7 shows the decomposition of the variance of core-core price inflation. Both regular wage and bonus wage inflation explain important amounts of the variance of prices. For instance, at the eight quarter horizon, together they explain over half the variation in price inflation.

Putting this all together, the results from Tables 5-7 and Figure 8 paint a very conventional view of inflation determination and the role of the labor market. When regular wages or bonus payments rise, these increases are passed on to prices and quantitatively this mechanism explains a lot of the movements in prices.

The linkage between wages and prices changed dramatically after 1998. Tables 8-10 and Figure 10 repeat the analysis of the same VAR system for the period 1998-2018. Table 8 shows the estimation results. One interesting observation is that the R^2 for regular and part-time wage inflation equations drop significantly in the later period; the core-core fit is also somewhat lower.

More importantly, the Granger causality tests in Table 9 suggest none of the three wage inflation series have any additional explanatory power for the core-core inflation process beyond what can be explained by the lagged core-core inflation rates. Even all three series combined have no incremental ability to predict core-core inflation during this period.

The impulse response functions in Figure 10 point to the same conclusion. An increase in regular wages or bonuses does not have any visible impact on core-core inflation. The decomposition of the variance of core-core inflation suggests that almost all the variation in core-core inflation is explained by its own shocks. For example, at the eight quarter horizon, three wage inflation series explains less than 7% of the core-core inflation variation.

The contrast between the 1981-1997 period and the 1998-2018 period is clear. Before 1998, both regular wages and bonuses had significant and sizable impact on prices. After 1998, those linkages between wages and prices were lost. Combined with the results from the last section, the VAR estimation suggests that around 1998, not only the response of wages to the labor market conditions got weaker but also prices also became disconnected from the wages.

In the last section, we found the regular wage response to unemployment was weaker for full-time workers. To see if we find similar differences between full-time workers and part-time workers in the relation between wages and prices, we estimated 7-variable VAR system consisting of (core-core inflation, regular wage inflation for full-time workers, regular wage inflation for part-time workers, overtime wage inflation for full-time workers, overtime wage inflation for part-time workers, bonus inflation for full-time workers, and bonus inflation for part-time workers. Because the wage series separately for full-time workers and part-time workers are only available after 1993, we cannot estimate the system for pre-1998 period. Thus, we estimated the system for the post-1998 period only. In the interest of saving space, we do not report all the estimates, but we find the disconnect for both full-time and part-time wages in general. The only exception is the overtime wages for part-time workers, which is shown to Granger cause core-core inflation at 7% significance level, but the variance decomposition suggests the overtime wages for part-time workers are not a quantitatively important driver of inflation. This wage series explains no more than 1.4% of the variation of core-core inflation (over the 10 periods we considered).

We also tried another approach to examine how the connection between price inflation and wage inflation changed over time. We start by estimate an unobserved components model of the following form for each of the four series: core-core inflation, regular wage inflation for all workers, overtime wage inflation for all workers, and bonus wage inflation for all workers.

$$y_t = \mu_t + \sigma^y \varepsilon_t$$

$$\mu_t = \mu_{t-1} + \sigma^\mu \nu_t$$

where y is the series, μ is the unobserved trend, and ε and ν are identical and independently distributed normal random variables with mean zero and variance one.

We then compute the correlations between the estimated μ*'s* for the price series and each of the wage series for rolling windows of 25 quarters. Figure 11 shows the evolution of the correlation between the core-core inflation and the regular wage inflation for all workers. Here each point shows the correlations calculated for 25 quarters centered on the date. For example, the observation for 1995q1 is the correlation calculated over [1992q1, 1999q1].

The correlation is positive and quite stable between 1989 and 2000, which covers rolling windows moving from [1986q1, 1993q1] to [1997q1, 2004q1]. As the rolling windows ceases to include the pre-1998 period (which first occurs in 2001q1), the correlation drops substantially. The correlation seems to move up again in the late 2000s, but it never reaches the level of the 1990s. The result is again consistent with the idea that prices and wages disconnected around 1998.

6. Conclusion

This paper looks at why Japan's inflation has not changed much despite the extremely aggressive monetary easing and the expansion of the real economic activity under Abenomics. Our explanation focuses on the role of dual labor market that made wages less sensitive to the labor market conditions. Japan's labor market has become increasingly segmented into full-time workers, many of whom are on lifetime employment and hence rarely fired, and part-time workers, whose employment can be adjusted more flexibly over business cycles. Following the recession in the late 1990s, many firms ended up hoarding an excessive number of full-time workers. Attempts by many firms to increase the proportion of part-time workers to gain the ability to adjust their employment more effectively in globally competitive markets, which preceded the recession, intensified the surplus of regular full-time workers.[3] The surplus of regular workers meant that there was no pressure on their wages. The wages for part-time workers do depend on business conditions, but since the level of their wages is much lower than

[3] For example, see Abe and Hoshi (2007) for some evidence on increased adjustment of employment and reduced emphasis on lifetime employment.

full-time workers, the substitution of part-time for full-time employees has meant that the average wage for the economy has stagnated even as economic conditions have improved.

While these broad trends are known, especially for labor economists, their role in understanding inflation has been less studied. We provide some evidence on aspects of the story that bear on inflation.

We find that the link between labor market conditions and regular and overtime wages that existed before 1998 substantially weakened after 1998. Looking at wages for full-time workers and part-time workers separately in the period after 1998, we find that the response of the wages for full-time workers to tightness of the labor market is much weaker than that of the wages for part-time workers. The increasing proportion of part-time workers, who are paid much less than full-time workers, during the period also dampened the wage increases that might have occurred as unemployment fell. Since the response of the wages for part-time workers after 1998 itself is weaker than the response of the average wage for all workers before 1998, the excess of full-time workers (and reduced sensitivity of their wages to the labor market condition as a result) is not likely to explain all of the weakening of wage responses to labor market conditions.

For bonuses, we do not find any weakening in their link to labor market conditions. The average bonuses for all workers respond more strongly to the unemployment rate after 1998. Moreover, the bonuses for both full-time workers and part-time workers (although they receive much less of this kind of compensation than full-time workers) respond to the labor market conditions.

Thus, one reason why Japanese inflation does not seem to have responded to economic recovery is the decoupling of average regular and overtime wages and labor market conditions. Looking at the relationship between wages and prices, however, shows that this is not the whole story. We find that the link between wages (including bonuses) and prices changed also around 1998. Before 1998, regular wage inflation and bonus inflation were important determinants of price inflation. The link, however, seems to have disappeared after 1998. Further understanding the causes of the disconnect between wages, bonuses, and prices after 1998 is an important topic for future research.

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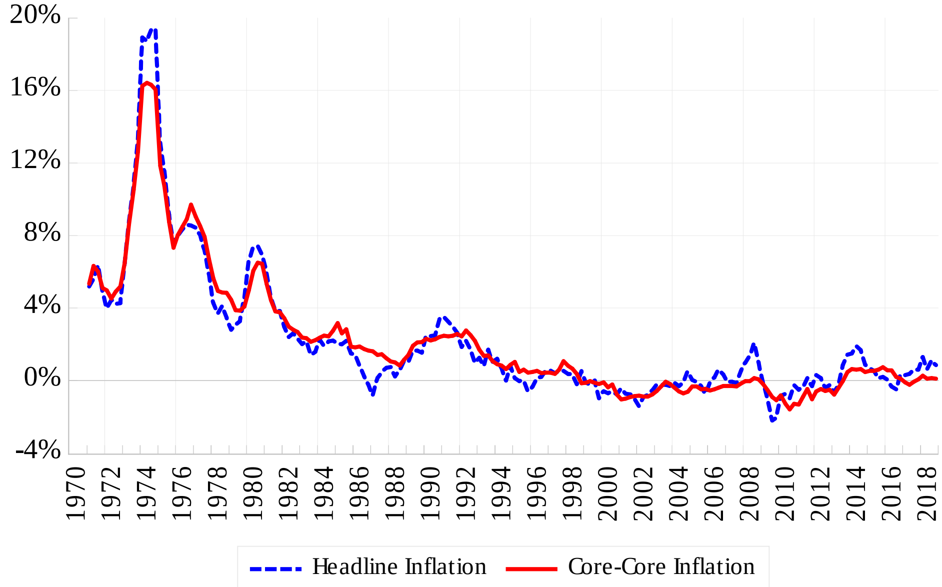
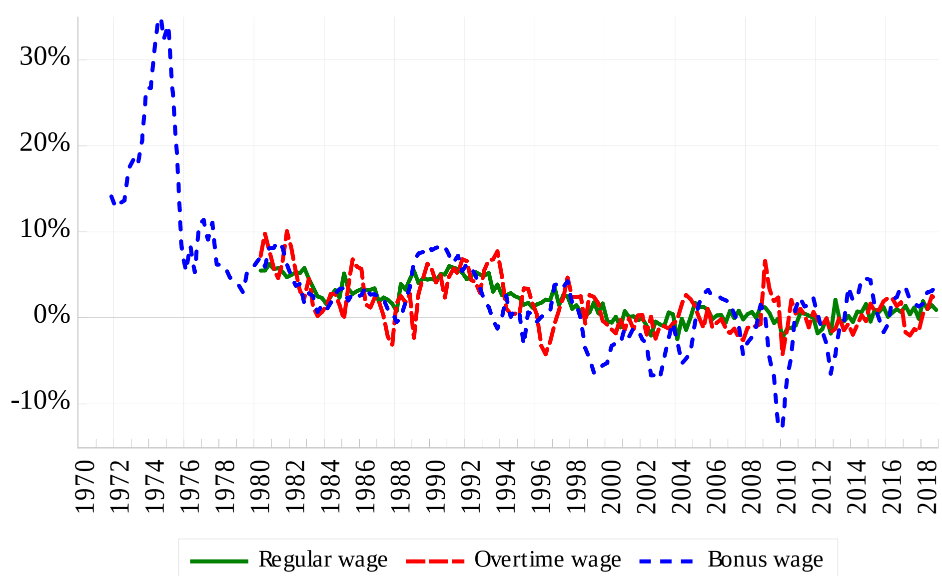
Figure 1: Japanese Price Inflation: 1971-2018



Source: Authors' calculation based on Ministry of Internal Affairs and Communications, Statistics Bureau, *Consumer Price Index*.

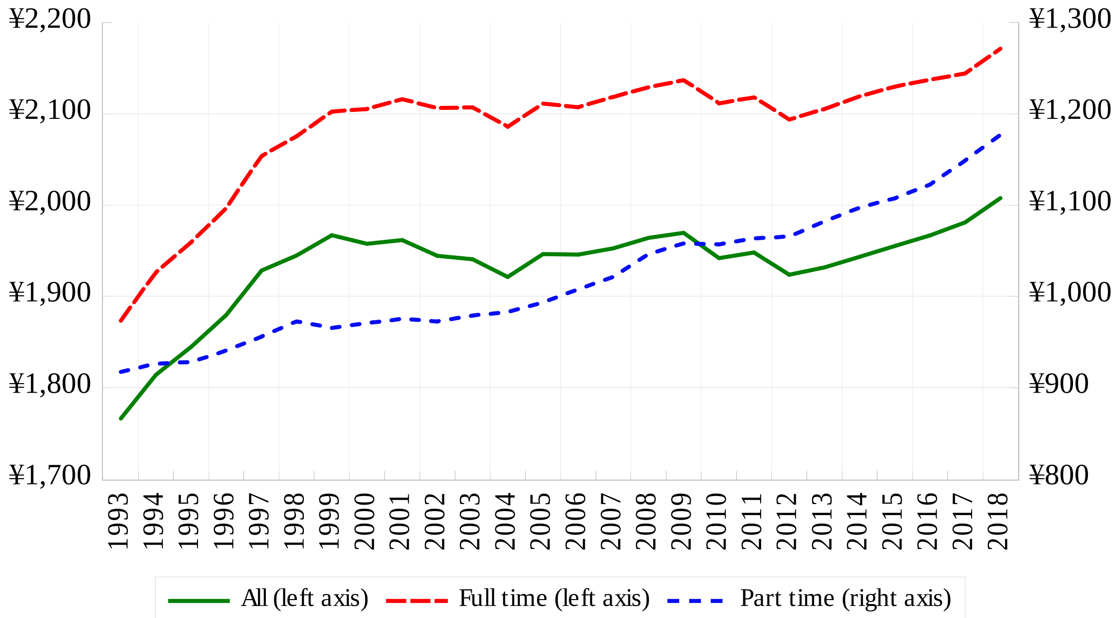
Figure 2: Japanese Wage Inflation: 1971-2018



Source: Authors' calculation based on Ministry of Health, Labour and Welfare, *Monthly Labour Survey*.

Figure 3: Wages in Japan, 1993-2018

A. Regular wages



B. Overtime wages

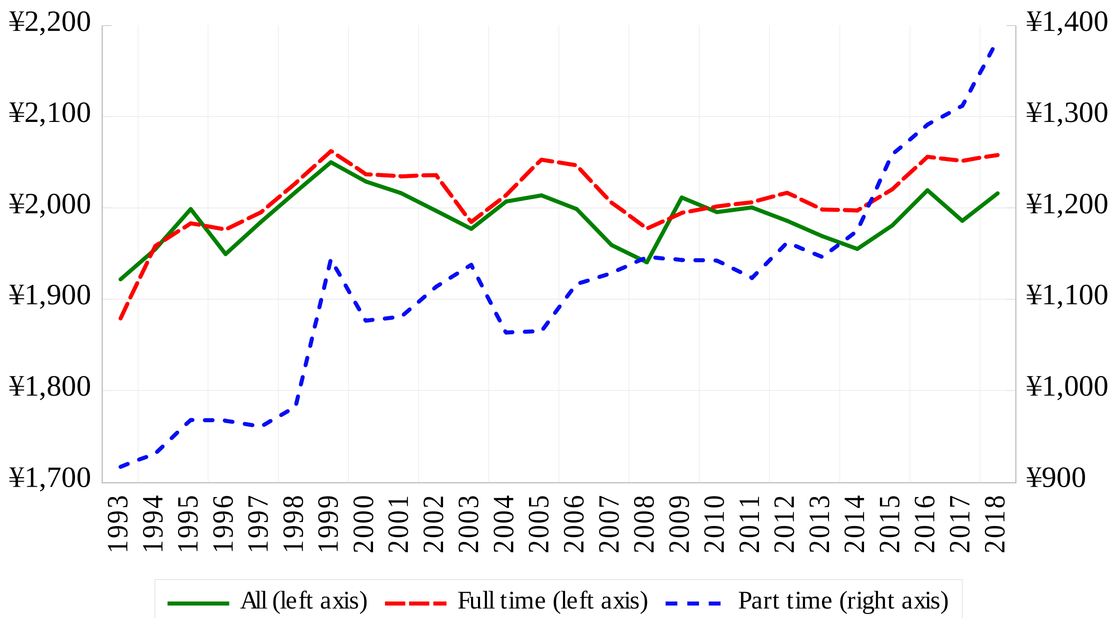
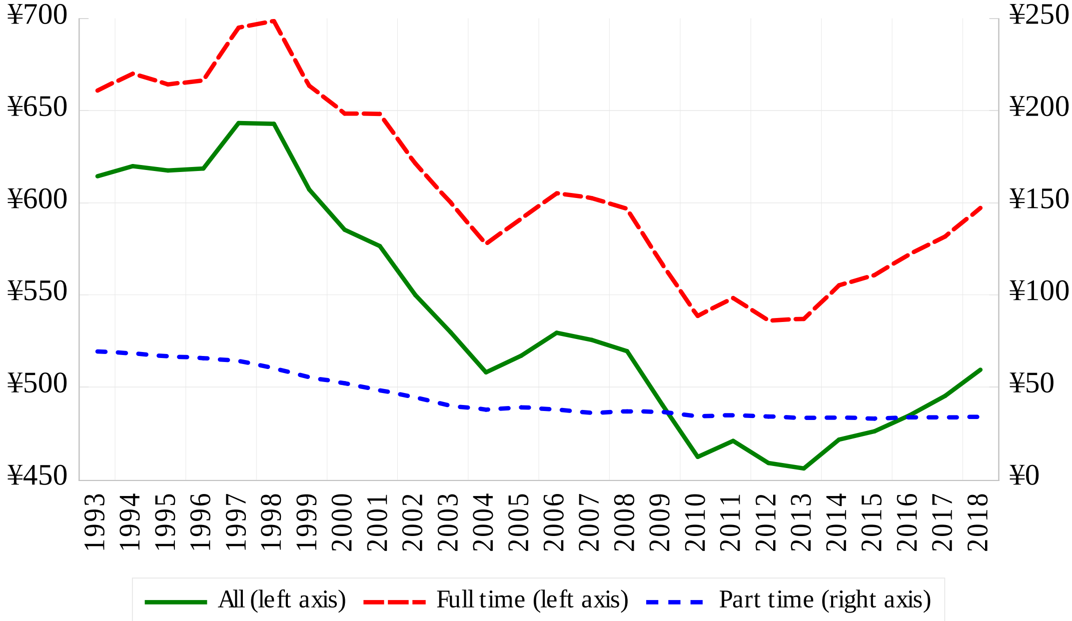


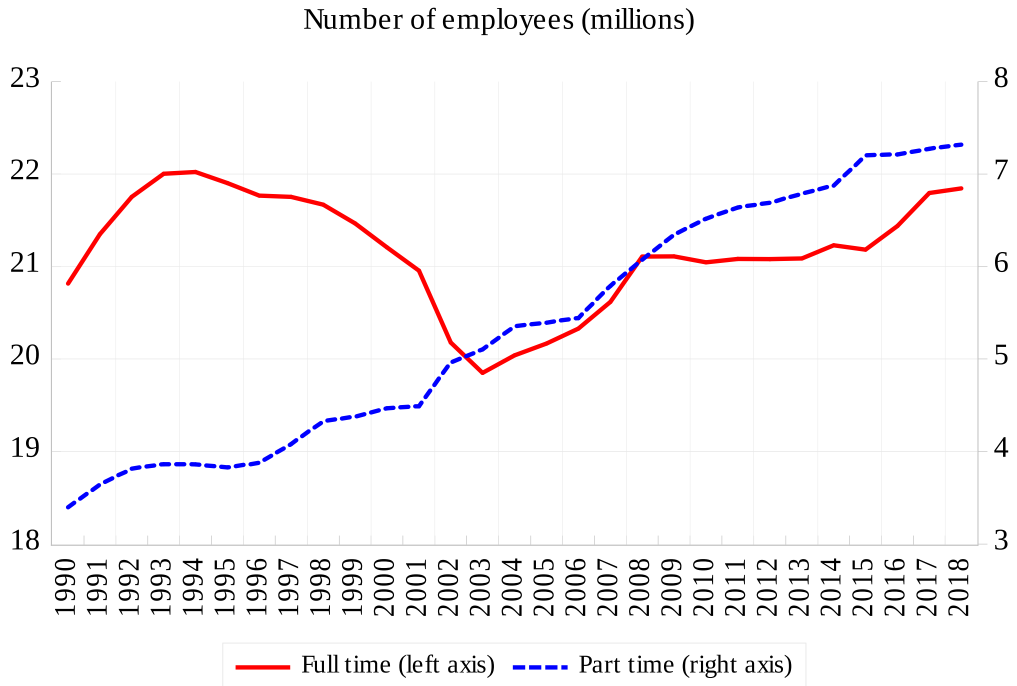
Figure 3 (Continued)

C. Bonus wages



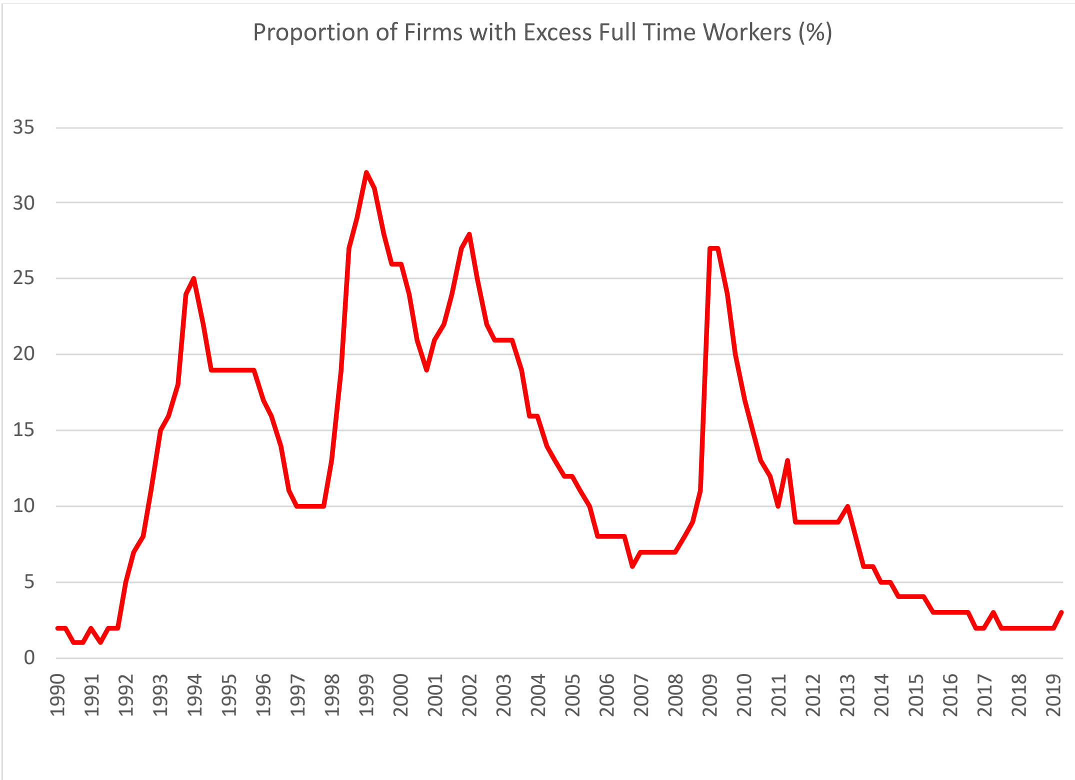
Source: Authors' calculation based on Ministry of Health, Labour and Welfare, *Monthly Labour Survey*.

Figure 4: Composition of the Japanese Workforce (Establishments with more than 30 employees)



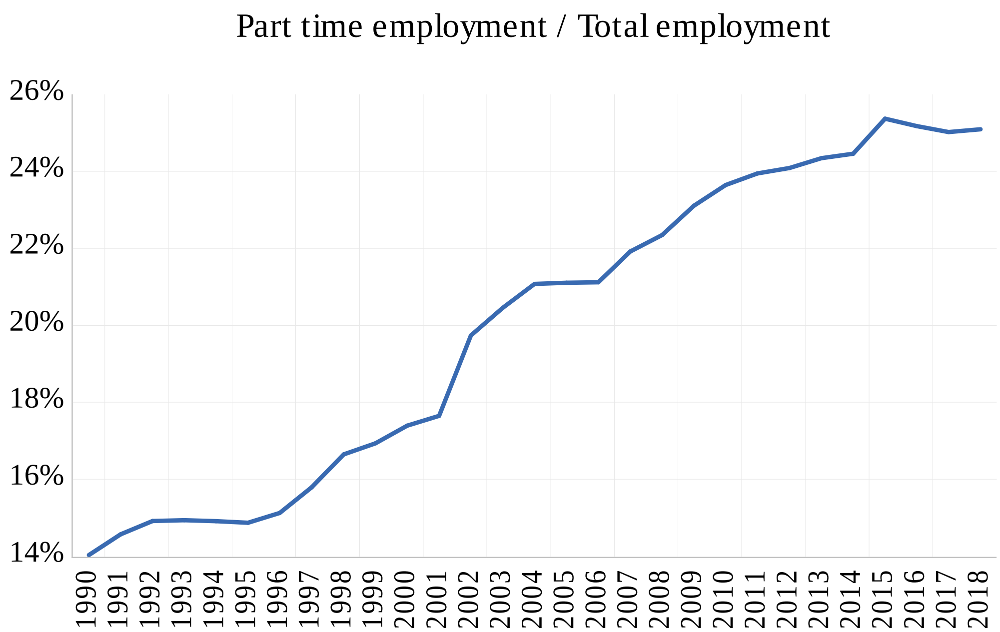
Source: Authors' calculation based on Ministry of Health, Labour and Welfare, *Monthly Labour Survey*.

Figure 5. Proportion of Firms with Excess Full Time Workers (%)



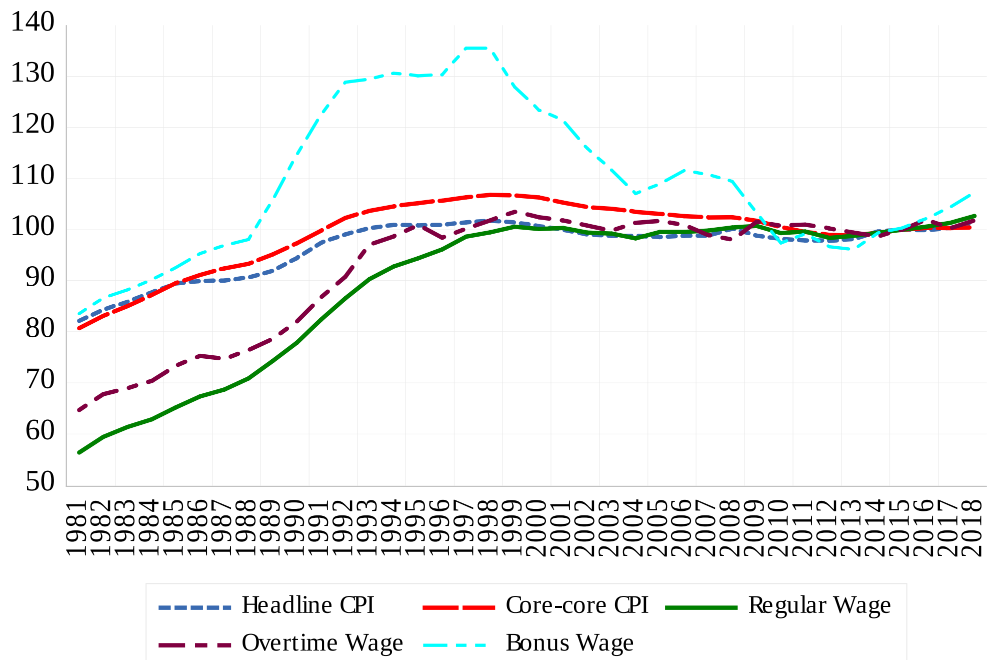
Source: Ministry of Health, Labour and Welfare, *Survey of Labour Economy Trend*.

Figure 6: Proportion of Part-time Employment to Total Employment: 1990-2018



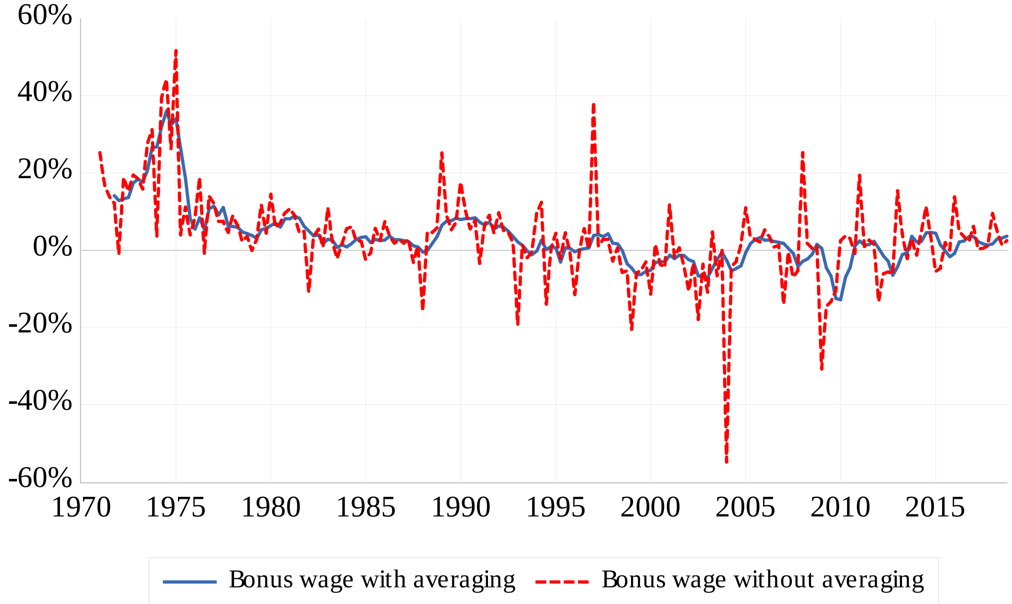
Source: Authors' calculation based on the *Monthly Labour Survey*

Figure 7: Japanese Price and Wage Level: 1981-2018 (2012=100)



Source: Ministry of Internal Affairs and Communications, Statistics Bureau, *Consumer Price Index*, and Ministry of Health, Labour and Welfare, *Monthly Labour Survey*.

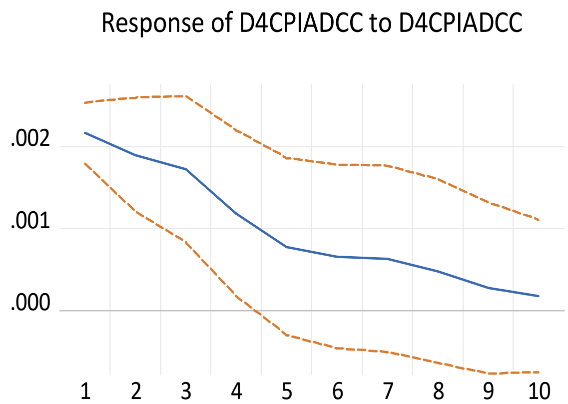
Figure 8. Bonus Wage Inflation for All Workers With and Without Averaging



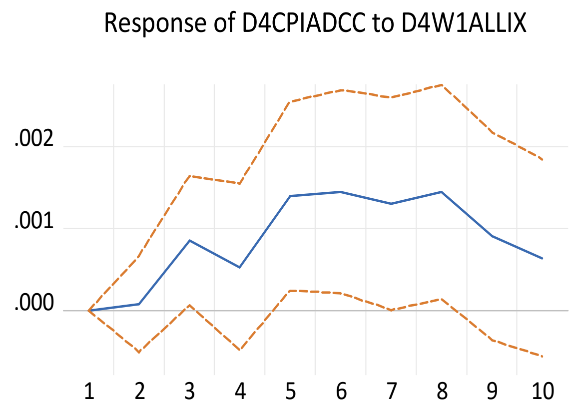
Source: Authors' calculation based on Ministry of Health, Labour and Welfare, *Monthly Labour Survey*.

Figure 9. Impulse Response of Core-Core Inflation to Cholesky One Standard Deviation Innovations: 1981q1-1997q4

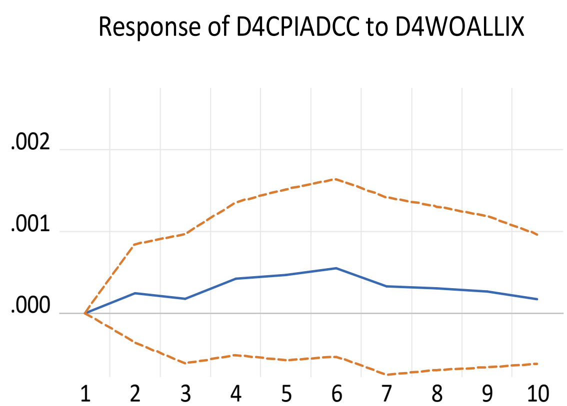
To Core-Core Inflation



To Regular Wage Inflation



To Overtime Wage Inflation



To Bonus Wage Inflation

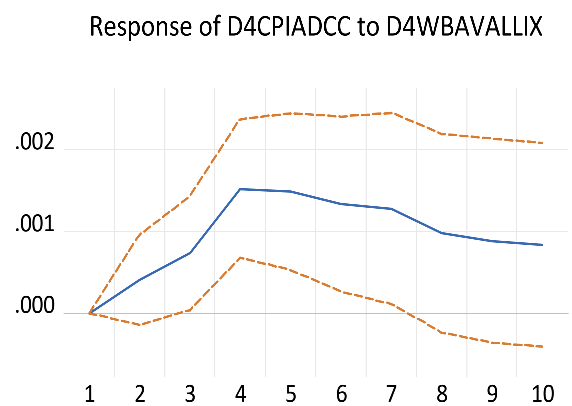
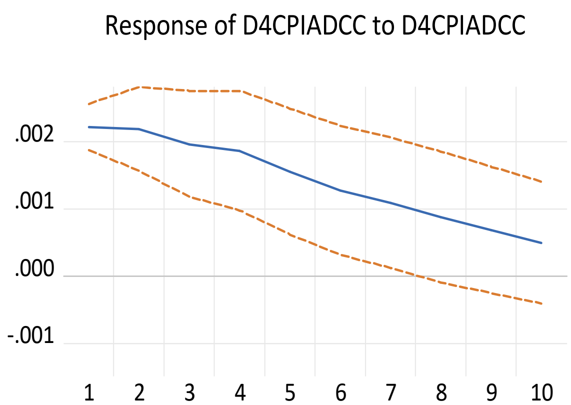
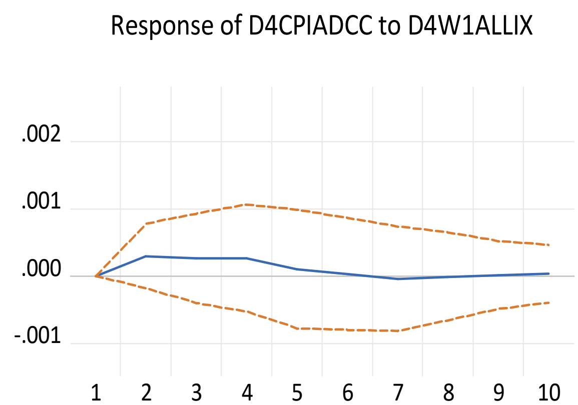


Figure 10. Impulse Response of Core-Core Inflation to Cholesky One Standard Deviation Innovations: 1998q1-2018q4

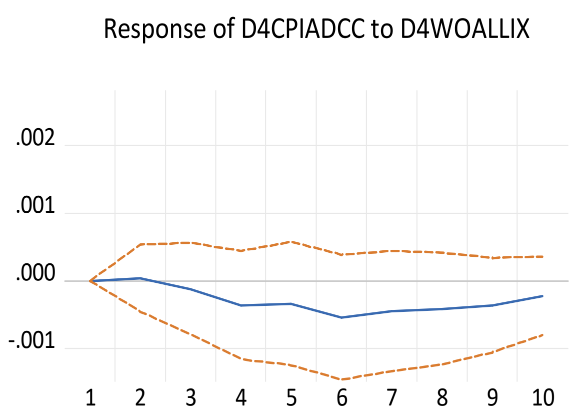
To Core-Core Inflation



To Regular Wage Inflation



To Overtime Wage Inflation



To Bonus Wage Inflation

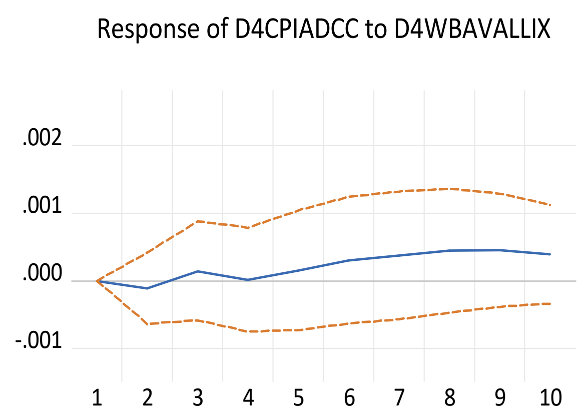
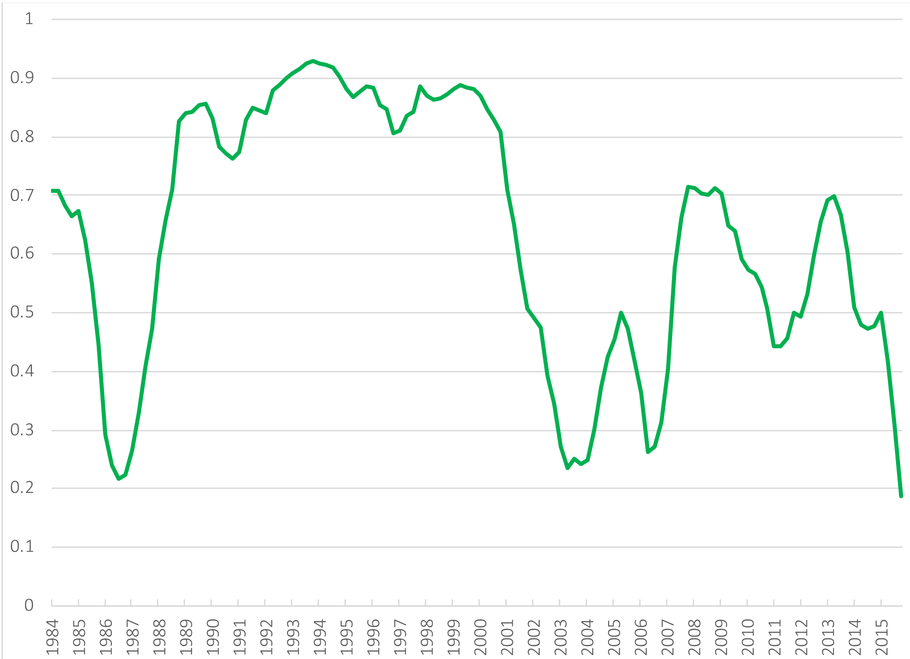


Figure 11. Correlation between Unobserved Trends for Core-core CPI Inflation Rate and Regular Wage Inflation Rate for All Workers



Source: Authors' estimation

Table 1: Augmented Dickey Fuller Tests for Orders of Integration

Series	1981-1997		1998-2017	
	Order of Integration	P value (H0: I(1))	Order of Integration	P value (H0: I(1))
Four Quarter Log Difference of Headline Consumer Price Index	I(1)	0.0938	I(1)	0.0810
Four Quarter Log Difference of Core-Core Consumer Price Index	I(0)	0.0230	I(1)	0.1502
Four Quarter Log Difference of Average Regular Wages	I(1)	0.3915	I(0)	0.0162
Four Quarter Log Difference of Average Overtime Wages	I(1)	0.6101	I(0)	0.0277
Four Quarter Log Difference of Average Bonus "Wages"	I(1)	0.3620	I(1)	0.1155

Augmented Dickey Fuller regressions with four lags as well as intercept and trend are estimated. The column "order of integration" shows the order of integration suggested by the tests. The column "P-value" shows the p-value for test of the null hypothesis that the series has unit root.

Table 2: ARMA Models for Price and Wage Inflation

Headline CPI Inflation

	Sample: 1981 - 1997			Sample: 1998 - 2018		
Variable	Coefficient	Standard Error	T statistic	Coefficient	Standard Error	T statistic
Constant	0.0240	0.0124	1.9328	0.0003	0.0023	0.1322
AR(1)	0.9473	0.0451	20.9889	0.7986	0.0757	10.5515
MA(3)	0.3772	0.1190	3.1693	0.1406	0.1217	1.1545
MA(5)	0.4360	0.1488	2.9302	-0.1945	0.1096	-1.7747
R^2	0.88			0.67		
Approximate P-value Q statistic	0.7823 (at lag 17)			0.0056 (at lag 19)		

Core-Core Inflation

	Sample: 1981 - 1997			Sample: 1998 - 2018		
Variable	Coefficient	Standard Error	T statistic	Coefficient	Standard Error	T statistic
Constant	0.0291	0.0135	2.1482	-0.0014	0.0023	-0.6033
AR(1)	0.9802	0.0333	29.4294	0.8968	0.0483	18.5498
MA(2)	0.3842	0.1019	3.7694	0.2015	0.1070	1.8827
R^2	0.93			0.84		
Approximate P-value Q statistic	0.9483 (at lag 17)			0.5818 (at lag 19)		

Regular Wage Inflation for All Workers

	Sample: 1981 - 1997			Sample: 1998 - 2018		
Variable	Coefficient	Standard Error	T statistic	Coefficient	Standard Error	T statistic
Constant	0.0371	0.0062	5.9556	0.0023	0.0022	1.0329
AR(1)	0.5457	0.1257	4.3396	0.2065	0.1146	1.8025
AR(2)	0.3165	0.1278	2.4768	0.3116	0.1154	2.6995
R^2	0.6584			0.1748		
Approximate P-value Q statistic	0.09 (at lag 17)			0.00 (at lag 19)		

Overtime Wage Inflation for All Workers

	Sample: 1981 - 1997			Sample: 1998 - 2018		
Variable	Coefficient	Standard Error	T statistic	Coefficient	Standard Error	T statistic
Constant	0.0310	0.0076	4.0862	0.0014	0.0036	0.3791
AR(1)	0.9079	0.1152	7.8790	0.4411	0.1820	2.4238
AR(2)	-0.2223	0.1527	-1.4559	0.0715	0.1350	0.5296
R^2	0.5760			0.2237		
Approximate P-value Q statistic	0.29 (at lag 17)			0.42 (at lag 19)		

Bonus Wage Inflation for All Workers

	Sample: 1981 - 1997			Sample: 1998 - 2018		
Variable	Coefficient	Standard Error	T statistic	Coefficient	Standard Error	T statistic
Constant	0.0391	0.0130	3.0066	-0.0065	0.0170	-0.3832
AR(1)	0.8997	0.0482	18.6748	0.8517	0.0556	15.3307
R^2	0.8000			0.7236		
Approximate P-value Q statistic	0.53 (at lag 17)			0.00 (at lag 19)		

Table 3: ARMAX Models for Wage Inflation with Unemployment Rate (UNEMP)

A. Regular Wage Inflation for All Workers

	Sample: 1981 - 1997			Sample 1998- 2018		
Variable	Coefficient	Standard Error	T statistic	Coefficient	Standard Error	T statistic
Constant	0.1060	0.0131	8.12	0.0290	0.0084	3.44
AR(1)	0.2880	0.1071	2.69	0.0428	0.1041	0.41
AR(2)	0.1916	0.1434	1.34	0.1844	0.1078	1.71
Lagged UNEMP	-0.0267	0.0049	-5.48	-0.0064	0.0019	-3.40
R^2	0.71			0.28		

B. Overtime Wage Inflation for All Workers

	Sample: 1981 - 1997			Sample 1998- 2018		
Variable	Coefficient	Standard Error	T statistic	Coefficient	Standard Error	T statistic
Constant	0.1338	0.0260	5.14	0.0189	0.0206	0.92
AR(1)	0.7125	0.1173	6.07	0.4308	0.1673	2.58
AR(2)	-0.2469	0.1701	-1.45	0.0734	0.1322	0.55
Lagged UNEMP	-0.0398	0.0099	-4.03	-0.0042	0.0048	-0.87
R^2	0.62			0.23		

C. Bonus Wage Inflation for All Workers

	Sample: 1981 - 1997			Sample 1998- 2018		
Variable	Coefficient	Standard Error	T statistic	Coefficient	Standard Error	T statistic
Constant	0.0888	0.0473	1.88	0.1334	0.0394	3.39
AR(1)	0.8635	0.0822	10.50	0.7708	0.0716	10.76
Lagged UNEMP	-0.0195	0.0189	-1.03	-0.0342	0.0084	-4.07
R^2	0.80			0.76		

Table 4: ARMAX Models for Wage Inflation with Unemployment Rate: Full Time and Part Time Workers

Sample Period is 1998Q1-2018Q4

A. Regular Wage Inflation for Both Types of Workers

	Full time workers			Part time workers		
Variable	Coefficient	Standard Error	T statistic	Coefficient	Standard Error	T statistic
Constant	0.0221	0.0083	2.66	0.0471	0.0093	5.08
AR(1)	-0.0151	0.1076	-0.14	0.3802	0.1071	3.55
AR(2)	0.2189	0.1084	2.02	0.1253	0.1664	0.75
Lagged UNEMP	-0.0046	0.0019	-2.45	-0.0087	0.0022	-3.93
R^2	0.17			0.54		

B. Overtime Wage Inflation for Both Types of Workers

	Full time workers			Part time workers		
Variable	Coefficient	Standard Error	T statistic	Coefficient	Standard Error	T statistic
Constant	0.0131	0.0203	0.65	0.0778	0.0725	1.07
AR(1)	0.6005	0.1229	4.89	0.6860	0.1136	6.04
AR(2)	0.0378	0.1182	0.32	-0.1282	0.1181	-1.09
Lagged UNEMP	-0.0027	0.0047	-0.56	-0.0142	0.0158	-0.90
R^2	0.40			0.42		

C. Bonus Wage Inflation for Both Types of Workers

	Full time workers			Part time workers		
Variable	Coefficient	Standard Error	T statistic	Coefficient	Standard Error	T statistic
Constant	0.1252	0.0376	3.32	0.1170	0.0633	1.85
AR(1)	0.7734	0.0714	10.84	0.7005	0.0913	7.68
Lagged UNEMP	-0.0313	0.0080	-3.90	-0.0354	0.0139	-2.55
R^2	0.75			0.62		

Table 5: VAR Estimates of (core-core inflation, regular wage inflation, overtime wage inflation, bonus wage inflation):1981q2-1997q4

Included observations: 67
Standard errors in ( )

	CORE-CORE INFLATION	REGULAR WAGE INFLATION	OVERTIME WAGE INFLATION	BONUS WAGE INFLATION
CORE-CORE INFLATION (-1)	0.845*** (0.142)	0.304 (0.535)	0.657 (1.105)	-1.027 (0.749)
CORE-CORE INFLATION (-2)	-0.014 (0.165)	-0.303 (0.623)	0.926 (1.287)	0.475 (0.872)
CORE-CORE INFLATION (-3)	-0.160 (0.162)	0.035 (0.609)	-2.280 (1.259)	1.469 (0.853)
CORE-CORE INFLATION (-4)	0.024 (0.105)	0.000 (0.395)	1.990** (0.816)	-1.536*** (0.553)
REGULAR WAGE INFLATION (-1)	-0.004 (0.037)	0.377*** (0.140)	0.278 (0.289)	0.388** (0.196)
REGULAR WAGE INFLATION (-2)	0.062 (0.041)	0.318** (0.153)	0.398 (0.315)	0.038 (0.214)
REGULAR WAGE INFLATION (-3)	-0.112*** (0.043)	-0.051 (0.163)	0.033 (0.337)	-0.426 (0.229)
REGULAR WAGE INFLATION (-4)	0.081 (0.042)	-0.373** (0.158)	0.223 (0.326)	0.092 (0.221)
OVERTIME WAGE INFLATION (-1)	0.019 (0.018)	0.062 (0.070)	0.588*** (0.144)	0.166 (0.097)
OVERTIME WAGE INFLATION (-2)	-0.015 (0.022)	0.015 (0.083)	-0.232 (0.172)	0.034 (0.116)
OVERTIME WAGE INFLATION (-3)	0.018 (0.020)	0.076 (0.077)	-0.189 (0.160)	-0.060 (0.108)
OVERTIME WAGE INFLATION (-4)	-0.010 (0.017)	-0.020 (0.066)	-0.144 (0.136)	0.020 (0.092)
BONUS WAGE INFLATION (-1)	0.039 (0.026)	-0.013 (0.100)	-0.107 (0.206)	0.793*** (0.139)
BONUS WAGE INFLATION (-2)	0.009 (0.033)	0.132 (0.125)	0.115 (0.259)	0.257 (0.176)
BONUS WAGE INFLATION (-3)	0.048 (0.032)	-0.007 (0.122)	0.014 (0.252)	0.042 (0.171)
BONUS WAGE INFLATION (-4)	-0.063** (0.025)	0.063 (0.093)	-0.026 (0.192)	-0.309** (0.130)
Constant	0.006*** (0.002)	0.016** (0.008)	-0.047*** (0.016)	0.020 (0.011)
TREND(1981Q1)	-7.620E-05*** (2.800E-05)	-1.020E-05 (1.000E-04)	4.630E-04** (2.100E-04)	-2.420E-04 (1.500E-04)
R-squared	0.961	0.758	0.762	0.881
S.E. equation	0.002	0.008	0.017	0.0114

Table 6: Granger Causality from Wages Inflation to Core-Core Inflation: 1981q1-1997q4

Included observations: 67

Dependent variable: Core-core inflation			
Excluded	Chi-sq	df	Prob.
Regular wage inflation	10.139	4	0.038
Overtime wage inflation	2.292	4	0.682
Bonus wage inflation	17.529	4	0.002
All	32.725	12	0.001

Table 7: Variance Decomposition of Core-Core Inflation Rate (%): 1981q1-1997q4

Quarter	Core-core inflation	Regular wage inflation	Overtime wage inflation	Bonus wage inflation
1	100.000	0.000	0.000	0.000
2	97.293	0.072	0.685	1.950
3	88.002	5.745	0.699	5.554
4	74.613	5.977	1.564	17.846
5	60.427	13.516	2.199	23.858
6	51.556	19.056	2.977	26.412
7	46.362	22.224	2.955	28.459
8	42.410	26.210	2.933	28.447
9	40.540	27.234	2.981	29.245
10	39.328	27.486	2.965	30.220

Table 8: VAR Estimates of (core-core inflation, regular wage inflation, overtime wage inflation, bonus wage inflation):1998q1-2018q4

Included observations: 84
Standard errors in ( )

	CORE-CORE INFLATION	REGULAR WAGE INFLATION	OVERTIME WAGE INFLATION	BONUS WAGE INFLATION
CORE-CORE INFLATION(-1)	0.986***	0.753	-1.246	1.676
	(0.120)	(0.441)	(0.777)	(0.893)
CORE-CORE INFLATION(-2)	-0.128	-0.462	1.883	-0.389
	(0.169)	(0.619)	(1.090)	(1.254)
CORE-CORE INFLATION(-3)	0.042	-0.447	-0.184	-1.312
	(0.169)	(0.619)	(1.091)	(1.254)
CORE-CORE INFLATION(-4)	-0.079	1.074**	0.268	0.939
	(0.118)	(0.433)	(0.763)	(0.877)
REGULAR WAGE INFLATION(-1)	0.041	-0.028	0.003	0.049
	(0.032)	(0.118)	(0.208)	(0.240)
REGULAR WAGE INFLATION(-2)	-0.012	0.261**	-0.177	0.077
	(0.032)	(0.117)	(0.207)	(0.238)
REGULAR WAGE INFLATION(-3)	0.005	-0.029	0.192	0.093
	(0.032)	(0.117)	(0.207)	(0.238)
REGULAR WAGE INFLATION(-4)	-0.024	-0.383***	0.052	-0.354
	(0.031)	(0.116)	(0.204)	(0.234)
OVERTIME WAGE INFLATION(-1)	0.003	0.050	0.372***	-0.179
	(0.018)	(0.065)	(0.115)	(0.133)
OVERTIME WAGE INFLATION(-2)	-0.016	-0.044	0.158	0.064
	(0.019)	(0.072)	(0.126)	(0.145)
OVERTIME WAGE INFLATION(-3)	-0.007	0.072	0.049	-0.205
	(0.019)	(0.068)	(0.121)	(0.139)
OVERTIME WAGE INFLATION(-4)	-0.001	-0.063	-0.341***	0.206
	(0.017)	(0.064)	(0.113)	(0.130)
BONUS WAGE INFLATION(-1)	-0.007	0.111	0.152	1.039
	(0.017)	(0.063)	(0.112)	(0.129)
BONUS WAGE INFLATION(-2)	0.019	-0.090	-0.218	-0.186
	(0.023)	(0.086)	(0.151)	(0.173)
BONUS WAGE INFLATION(-3)	-0.020	0.042	0.043	-0.169
	(0.024)	(0.086)	(0.152)	(0.175)
BONUS WAGE INFLATION(-4)	0.017	0.008	-0.011	-0.048
	(0.016)	(0.060)	(0.105)	(0.121)
Constant	-0.002	0.009	-0.001	-0.021
	(0.002)	(0.006)	(0.010)	(0.011)
TREND(1981Q1)	1.280E-05	-3.530E-05	2.050E-05	1.810E-04**
	(1.200E-05)	(4.500E-05)	(7.800E-05)	(9.000E-05)
R-squared	0.868	0.461	0.462	0.847
S.E. equation	0.002	0.008	0.014	0.016

Table 9: Granger Causality from Wages Inflation to Core-Core Inflation: 1998q1-2018q4

Included observations: 84

Dependent variable: Core-core inflation			
Excluded	Chi-sq	df	Prob.
Regular wage inflation	2.771	4	0.597
Overtime wage inflation	1.377	4	0.848
Bonus wage inflation	2.200	4	0.699
All	6.272	12	0.902

Table 10: Variance Decomposition of Core-Core Inflation Rate (%): 1998q1-2018q4

Quarter	Core-core inflation	Regular wage inflation	Overtime wage inflation	Bonus wage inflation
1	100.000	0.000	0.000	0.000
2	98.957	0.899	0.016	0.128
3	98.494	1.145	0.111	0.249
4	97.651	1.311	0.840	0.198
5	97.212	1.194	1.304	0.290
6	95.712	1.090	2.518	0.680
7	94.517	1.025	3.222	1.236
8	93.279	0.978	3.762	1.981
9	92.176	0.948	4.157	2.720
10	91.529	0.936	4.274	3.261

Appendix 1. Construction of data series from the *Monthly Labor Survey*

The wages and employment data that are used in this paper are constructed from the data series published by Japan's Ministry of Health, Labor, and Welfare (MHLW) in its *Monthly Labor Survey* A brief explanation of the survey in English is available at https://www.mhlw.go.jp/english/database/db-slms/dl/slms-01.pdf (accessed on July 15, 2019).

The survey was first conducted in July1923 when it was called the *Monthly Wage Survey of Production Workers and Miners*. The current form of the monthly survey that cover almost all major industries including services was established in January 1970. The survey aims to capture the fluctuations in employment, earnings, and working hours for various regions and industries in Japan. The survey consists of three parts: the National Survey, the Prefectural Survey, and a Special Survey that is conducted annually for tiny enterprises (that have between one and four employees). We use the data from the National Survey.

The National Survey covers enterprises with 5 or more employees. For this survey employees are workers who were (1) hired without a fixed term or for a term longer than one month or (2) hired by the day or for less than one month but for 18 days or more in each of the two preceding months of the survey. In January 1993, the survey began to distinguish between full-time workers and part-time workers, where part-time workers are defined to be those who are scheduled to work less hours per day or less days per week than the full-time workers.

National Survey samples the enterprises to be surveyed based on the latest *Economic Census (Establishments and Enterprises Census* before 2009), which has been conducted every 2 to 3 years. For the enterprises that have 500 or more employees, all of them are sampled. For the enterprises with the number of employees between 30 and 499, samples are drawn randomly with cells stratified by prefecture, industry and enterprise size. For the small enterprises, having between 5 and 29 employees, another sampling method is used, but we do not discuss that here, because we do not study enterprises with fewer than 30 employees. As we discuss below, the data are supposed to be aggregated using the sampling ratio as weights, but it was revealed this was not consistently done and we will explain how we corrected that problem.

The sample of National Survey changes every 2 or 3 years when the new results of *Economic Census* becomes available. Thus, the aggregate numbers are not comparable over time. Along with the raw data, the survey reports an index number that standardizes the data by dividing each observation by the average value of the series in certain year (2015 currently), but the index also would exhibit a break when the sample rotation occurs. To mitigate this problem, the survey adjusts the total number of employees to be equal to the actual number whenever the new results of the *Economic Census* come out and the sample rotation occurs. Then, the revised total number of employees are used to aggregate the numbers and re-calculate indices for all the series. For most of our analysis, we use these index data.

In January 2019, the MHLW revealed that they found biases in the *Monthly Labour Survey* data because of a faulty procedure that started in 2004. The survey is supposed to gather data from every enterprise with 500 or more employees, but starting in 2004 it turned out for Tokyo-based enterprises only about third of those large enterprises were sampled. The published aggregate data series were not properly corrected for this sampling mistake, so resulting the data from large companies in Tokyo were underweighted.

Since the employees of large enterprises tend to receive higher earnings than smaller enterprises, the underweighting of the large companies resulted in underestimation of the level of average earnings. This developed into a political scandal because the results of the *Monthly Labor Survey* are used to determine the level of benefits in some important government programs including for unemployment insurance.[1] By late January, the MHLW quickly re-estimated and published the data series using the original data for individual enterprises going back to 2012. Based on the corrected data, they started calculating how much they owe to the recipients of the unemployment insurance. For the period between 2004 and 2012, the MHLW contended that the original individual data cannot be found and hence the data correction cannot be made.

The opposition parties used this opportunity to attack the government for having manipulated the statistical data to make Abenomics economic policy look good, even though it does not make sense for the government to under-report the wage levels intentionally.

For our analysis, the problem is that we do not have proper data for 2004-2011. Before 2003, the data did not suffer from this incorrect procedure. After 2012, the corrected data have been published. So we make the corrections to the data series from January 2004 to December 2011 in the following way.

First, using the observations from January 2012 to December 2018, for which both the original series and the corrected series (published in January 2019) are available, we estimate a linear regression model of the corrected series on the original series, a constant term, and eleven monthly dummies. We have also experimented with specifications including liner trend, quadratic trend, or cubic trend, but none of those noticeably improved the fit, which is already very good with the simple model with just the original series and monthly dummies. Second, use the estimated model to predict the corrected series for January 2004 to December 2011. Finally, create the time series for our analysis by combining the three series: (i) original series up to December 2003, (ii) predicted series from January 2004 to December 2011, and (iii) corrected series from January 2012 to December 2018.

As mentioned above, we use mostly the index series for our analysis. The source data files (for both original data and corrected data) are available at https://www.e-stat.go.jp/stat-search/files?page=1&layout=datalist&toukei=00450071&tstat=000001011791&cycle=1&tclass1=000001035519. The data files are named "maikin-k.csv" (and "sai-maikin-k.csv" for corrected data). In particular, we use the following seven index series for three categories of workers (all workers, full-time workers, and part-time workers) at enterprises with 30 or more employees. The data are extracted by specifying Column A of maikin-k file to be "I M" (for monthly index series) and Column D to 0 (for 30 or more employees).

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[1] An early news on the problem is found in an article "Tens of Billions of Yen in Jobless Benefits Unpaid Due to Faulty Labor Ministry Data: Sources" *Japan Times*, January 10, 2019. (https://www.japantimes.co.jp/news/2019/01/10/national/tens-billions-yen-jobless-benefits-unpaid-due-faulty-labor-ministry-data-sources/#.XDgTH89KiMI)

- Employment index (Column I of maikin-k file)
- Regular working hours index (Column L of maikin-k file
- Overtime working hours index (Column M of maikin-k file)
- Contracted salary index (this includes overtime) (Column N of maikin-k file)
- Total hours worked index (Column Q of maikin-k file)
- Total salary index (this includes bonus as well as overtime) (Colulmn R of maikin-k file)
- Regular salary index (this does not include overtime) (Column S of maikin-k file)

In some figures, we show level data, such as number of workers in millions or wages in yen. We construct these series by converting the index data using the average level data for 2018 as following:

$$Number = Index * \frac{Average\ of\ Number\ during\ 2018}{Average\ of\ Index\ during\ 2018}$$

The level data are extracted by specifying Column A of maikin-k file to be "E1M" (for monthly level series) and Column D to 0 (for 30 or more employees). The level data that correspond to the seven series above are:

- Number of workers at the end of the current month (Column I of maikin-k file)
- Average number of regular hours worked per worker (Column L of maikin-k file
- Average number of overtime hours worked per worker (Column M of maikin-k file)
- Average contracted salary per worker (Column N of maikin-k file)
- Average number of total hours worked per worker (Column Q of maikin-k file)
- Average total salary per worker (this includes bonus as well as overtime) (Colulmn R of maikin-k file)
- Average regular salary per worker (this does not include overtime) (Column S of maikin-k file)

Let us go through how we calculate the series for the contracted salary index (for all workers) as an example. First, using both corrected series and original series for 2012-2018, we estimate the regression model. The estimation result is given by:

Corrected Contracted Salary Index = -0.269 + 1.002*(Original Contracted Salary Index)
(2.551) (0.025)
– 0.012*D1 – 0.027*D2 + 0.028*D3 – 0.002*D4 + 0.030*D5 – 0.0001*D6 + 0.0002*D7
(0.109) (0.107) (0.105) (0.109) (0.107) (0.105) (0.105)
+ 0.044*D8 + 0.044*D9 + 0.057*D10 + 0.014*D11
(0.107) (0.106) (0.106) (0.105)

$R^2 = 0.96$

The variables Di (i=1, …, 11) is the monthly dummy variables that takes one in the i-th month of the calendar year (1 for January, 2 for February, and so on) and zero otherwise. The numbers in the parentheses are the standard errors of the coefficient estimates. In this regression, none of the monthly dummies are significantly different from zero.

Figure A-1 shows the original values (blue broken line), the corrected values (red dotted line), and the fitted values (green solid line) for the contracted salary index. We can see the corrected series is not much different from the original series. This is generally the case for the index data. The fit of the simple regression model is quite good, and the fitted value (though not much different from the original values) trace the corrected values very well.

Figure A-2 shows the original series (blue broken line) and the estimated series (green solid line) that we use for this paper, which is a combination of (i) original series before 2003, (ii) predicted series from the regression between 2004 and 2012, and (iii) corrected series after 2012. The difference between the two series is very small.

Although we do not use level data directly in our analysis, we applied the same procedure to adjust the original series. For example, the regression estimation result for the average contracted salary per worker (for all workers) is given by the following equation.

Corrected Average Contracted Salary Per Worker = 12361.15
(10203.22)
+ 0.966*(Original Average Contracted Salary Per Worker) – 386.59*D1 – 392.52*D2
(0.035) (351.84) (337.23)
– 261.73*D3 – 91.65*D4 – 209.31*D5 – 166.95*D6 – 127.14*D7 – 126.19*D8
(322.69) (336.16) (331.93) (322.70) (323.39) (330.10)
– 77.56*D9 + 125.75*D10 – 7.49*D11
(326.00) (322.79) (322.68)

$R^2 = 0.95$

Again the numbers in the parentheses are standard errors, and none of the monthly dummies are significant in this regression.

Figure A-3 shows the original values (blue broken line), the corrected values (red dotted line), and the fitted values (green solid line) for the average contracted salary per worker. Now we see the corrected series is consistently larger than the original series, reflecting the (erroneous) under-representation of large firms that tend to have higher salaries. The fit of the simple regression model is still good, and the fitted value, which is now noticeably larger than the original values trace the corrected values very well.

Figure A-4 shows the original series (blue broken line) and the estimated series (green solid line), which is a combination of (i) original series before 2003, (ii) predicted series from the regression between 2004 and 2012, and (iii) corrected series after 2012. The estimated series is consistently above the original series after 2004, and the drop from 2003 to 2004 is less pronounced.

Figure A-1. Original values, corrected values, and fitted values: Contracted salary index (all workers)

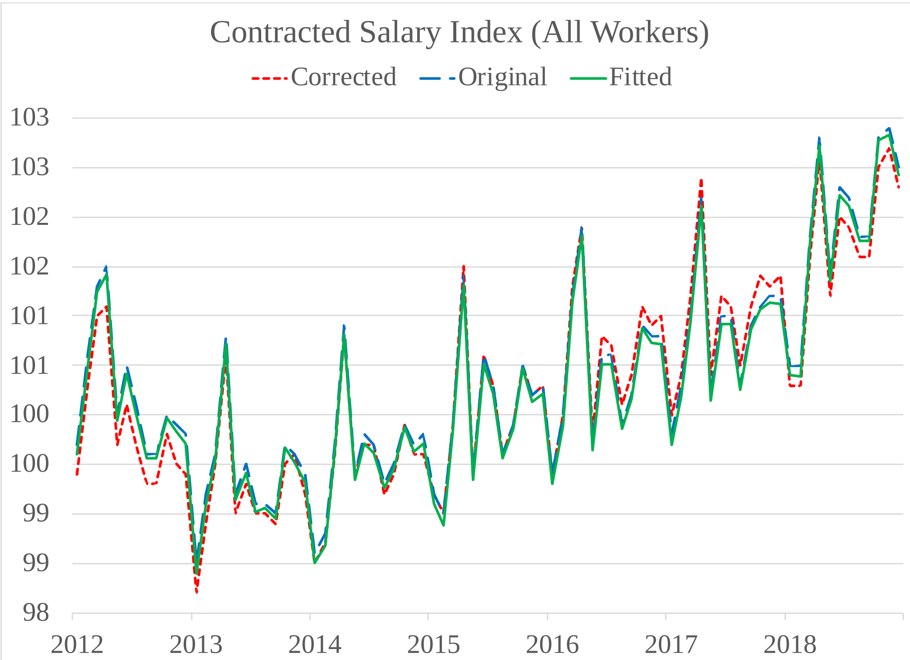

Figure A-2. Original series and estimated series: Contracted salary index (all workers)

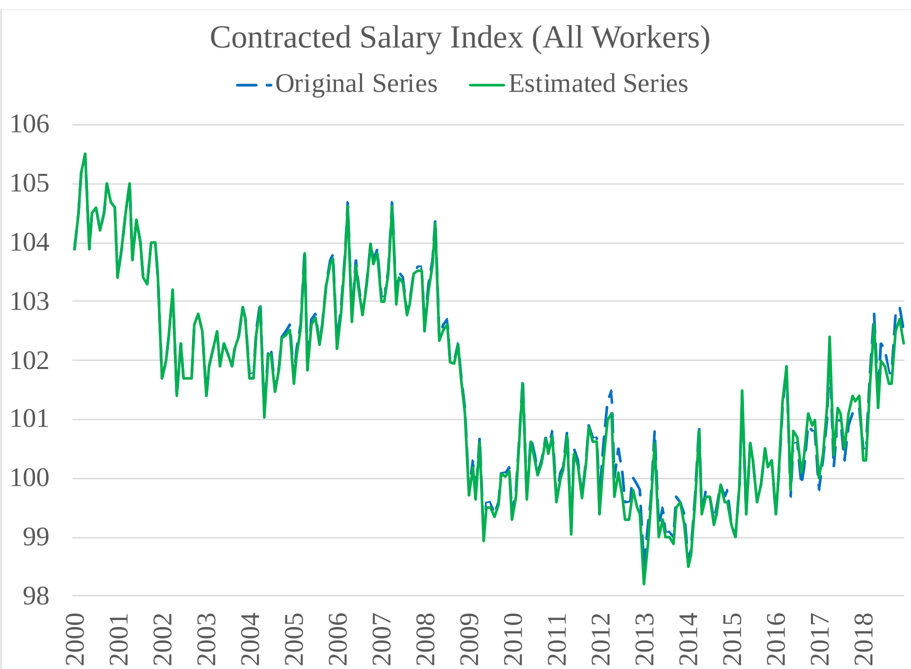

Figure A-3. Original values, corrected values, and fitted values: Average contracted salary per worker (all workers)

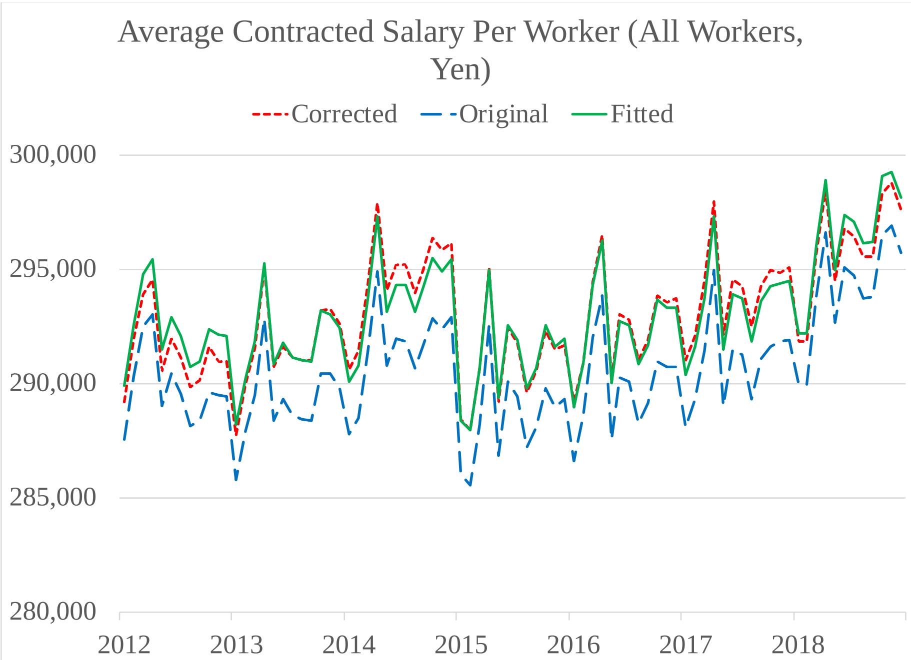

Figure A-4. Original values, corrected values, and fitted values: Average contracted salary per worker (all workers)