WILL THE "TRUE" LABOR SHARE STAND UP? AN APPLIED SURVEY ON LABOR SHARE MEASURES

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Abstract. Labor's share of income is a key variable in economics. It plays a leading role in analysis of (in)equality, globalization, technical change, growth theories, etc. Notwithstanding this broad application, there are many different definitions of the labor share. Understanding and synthesizing those differences is the purpose of this applied survey. Empirical measures may vary reflecting the allocation of income components that cannot be directly ascribed to capital or labor. We examine the alternative assumptions made in the literature in this regard and quantify and motivate the resulting discrepancies. Focusing (mostly) on US data, we show that different measures can have very distinct properties in terms of the observed stochastic trends, shares of short-, medium-, and long-run variation and volatilities, persistence and mean-reversion properties, and susceptibility to structural breaks. For instance, while "short-run" properties of the surveyed labor share measures are relatively consistent across all definitions (and countercyclical), their "medium-" and "long-run" trends may diverge substantially (and are procyclical). To substantiate our analysis, we document the implications of discrepancies in the empirical labor share definition for growth accounting, analyzing the effect of technology shocks, and for estimating inflation dynamics.

Keywords. Applications; Labor share; Labor share taxonomy; Mixed income; Stylized facts

1. Introduction

The labor share of national income, once a focal point of political economy debates, has been rather neglected throughout the recent half century. The classical economists – Smith, Ricardo, and Marx – regarded labor shares as inherently variable, even in the long run. In stark contrast, the empirical observations of Cobb and Douglas (1928), Bowley (1937), Johnson (1954), Kaldor (1961), and others established the wide-spread constancy of such shares. This "stylized" fact of stability arguably led to a neglect of the issue.

The recent revival of interest is probably due to at least two reasons. First, it has been argued that the labor share has exhibited a protracted decline since 1970s (Arpaia *et al.*, 2009; Elsby *et al.*, 2013;

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Karabarbounis and Neiman, 2014). Second, it has also been observed that the labor share is subject to substantial countercyclical short-run volatility that cannot be explained by time-varying markups (Young, 2004; McAdam and Willman, 2013a).

A key problem in such discussions, however, is the fact that there is no consensus as to how the labor share should be defined. The ambiguity arises from the fact that although total compensation of employees as well as companies' aggregated operational surplus are observable, the labor share is not, because a sizable share of the total value added is generated by the self-employed. This *mixed income* cannot be unambiguously understood as either the remuneration of capital or labor. In consequence, the measured labor share necessarily depends on the assumptions made in relation to the division of mixed income. Another caveat is related to the treatment of taxes on capital and labor incomes that may or may not be included in the computation of factor remuneration and total output (Gollin, 2002).

Although assigning ambiguous income to capital or labor is ultimately a matter of choice, it is rarely appreciated that this conceptual ambiguity has empirical consequences. These consequences still seem not to have been sufficiently surveyed thus far, further deepening the confusion. For example, it is customary in the business-cycle literature to adjust the labor share by proprietors' income as in Young (2004), whereas the structural analysis econometrics literature prefers to adjust by the fraction of self-employed in total employment (Klump *et al.*, 2007; Arpaia *et al.*, 2009; Raurich *et al.*, 2012). Yet, neither of these literatures confronts the role of the assumed definition. Thus, while many papers (for example, Gollin's, 2002, seminal contribution) promote discussion on how labor shares *could* be measured, there is none which systematically examines and tries to understand differences *across* various measures that, to recall, are meant to measure the same thing: namely the share of US national income that accrues to labor. Such differences, though, are likely to have consequences for the conclusions reached regarding the relationships between the labor share and other variables, and other empirical exercises (as we demonstrate in Online Appendix Section A).

This survey is intended to fill that important gap. We provide a systematic exploration of the dynamic properties of a range of alternative labor share measures.[1] Our investigation is based on annual US labor share series spanning 1929–2012 and quarterly series from 1947. We concentrate on the US data series because these data have been most extensively researched in the literature, making our discussion of consequences of the alternative measurement approaches relatively most transparent. We document that these measures are not only divergent in terms of the implied time trends, which are visible to a naked eye, but also in terms of their other dynamic properties, such as the shares of short-, medium-, and long-run variation in total volatility of the series, degree of persistence, mean-reversion properties, and susceptibility to structural breaks.

Our results point to the general conclusion that while "short-run" properties of the labor shares are relatively consistent across all definitions, their "medium-run" swings and "long-run" trends diverge substantially. Therefore, it is indeed important to "get factor shares right," especially if one is interested in the medium and long run. We also emphasize that while the labor share is countercyclical in the short run, in the medium run it becomes procyclical.

Having considered the alternatives, we argue that the US series on the share of employees' compensation in GDP, adjusted for proprietors' income following Cooley and Prescott (1995) and Gomme and Rupert (2007) procedure (which we call PI_2-GDP) is probably the most sound theoretically, and also has intuitive, economically interpretable empirical properties. It provides the relatively most consistent message across a range of diverse exercises and applications while remaining in agreement with known "stylized facts" formulated elsewhere in the literature (e.g., it is mean-reverting but highly persistent, countercyclical over the short run, and has recorded a secular decline since 1970). This measure suggests, however, that the US labor share has not only declined after 1970, but also *substantially increased* before that, exhibiting a hump-shaped pattern over the last 84 years. Hence, instead of mostly concentrating on the decline in the labor share since the 1970s, one could also embrace the larger time span of available data; the

profile as a whole is suggestive of a long cycle of activity (reminiscent of the work of Kondratieff and Schumpeter).

In Section 8 and Online Appendix Section A, we concentrate on three interesting and well-motivated applications: (i) growth accounting exercises, (ii) examination of the effect of technology shocks on the labor share, and (iii) (which is the application given in the main text) the estimation of New Keynesian Phillips curves (which use the labor share directly). The properties of the labor share series used can help shed light on the empirical properties of the associated NKPCs.

To summarize, our survey is intended to accomplish the following:

(i) A taxonomy of different labor share measures.
(ii) A synthesis of the various measures: how and why they differ.
(iii) Delineation of stylized facts of the various series: for example, their moments, persistence, structural breaks, and frequency characteristics.
(iv) A series of applications illustrating the effects these different measures have in common exercises that rely upon labor-share measures.

The remainder of our survey is structured as follows. In Section 2, we construct the time series of the US labor share under a range of its alternative empirical definitions. Section 3 provides a synthesis of these different definitions – pointing out how and why they differ. In Section 4, we discuss their basic dynamic properties, including their degree of persistence and mean-reversion properties. In Section 5, we document the evidence for structural breaks. In Section 6, we carry out a spectral decomposition of these series into their short-, medium-, and long-run components. In Section 7, we provide a broad historical view on the observed labor share trends and swings. Section 8 gives a brief application, namely, the estimation of New Keynesian Phillips curve under different assumptions about the labor share used as the driving variable. Section 9 concludes.

2. Alternative Measures of the Labor Share

Formally, the aggregate labor share is defined as the proportion of total remuneration of the labor force (wL) in aggregate output of the economy (GDP or total value added, Y):

$$LS = \frac{wL}{Y}$$

While such a definition appears theoretically unambiguous, both the numerator and the denominator of the above ratio can be measured empirically in various ways (Gollin, 2002), with potentially diverging implications.

The simplest, "Naive" way to construct an empirical series of the labor share based on this definition is to use total *compensation of employees* (*CE*) for the numerator of equation (2). According to the System of National Accounts, compensation of employees contains the sum of both wages and other payments to employees. Thus, to derive the labor share, nominal *CE* can be simply divided by nominal output Y. Thus, one computes a measure which we label "Naive GDP":

$$\textbf{Naive} - \textbf{GDP} : LS = \frac{CE}{Y} \tag{1}$$

where Y is a generic measure of output. Typically, it is GDP; however, in sectoral studies, gross value added (GVA) is often used (see Bentolila and Saint-Paul, 2003; Young, 2010, 2013).

Although straightforward to compute and easily interpretable, this method (the "payroll share," cf. Elsby *et al.*, 2013) has a few crucial empirical disadvantages – the most important of which is that compensation of employees *CE* does not include *mixed income*, that is, the ambiguous income earned by the self-employed, which cannot be directly ascribed to capital or labor. Since at least part of mixed

income remunerates proprietors' labor, this leads to a systematic underestimation of the labor share at the aggregate level. There are at least three ways to deal with this issue: (1) assuming that the self-employed (proprietors) face identical average wage as the non-self-employed, (2) assuming identical labor shares in both groups, and (3) assuming an arbitrary rule of thumb to divide proprietors' income. We elaborate on these options below.

The first approach to include the ambiguous income in the labor share is to use data on the number of self-employed (SE). The key assumption used in this adjustment is that labor compensation is equal on average for both employees (E) and self-employed workers (SE). Then, the "Naive" labor share is increased by the imputed compensation of the self-employed, as in:

$$\mathbf{SE-GDP}: LS = \frac{CE}{Y}\left(1 + \frac{SE}{E}\right) \tag{2}$$

The second way to adjust the labor share refers directly to the concept of mixed income. *Proprietors' income* (PI), as defined in the System of National Accounts, is the ambiguous part of output that cannot be treated as pure labor or capital income. Labor share estimates can then be adjusted by the means of a simple reduction of the output by PI:

$$\mathbf{PI-GDP}: LS = \frac{CE}{Y - PI} \tag{3}$$

This approach is equivalent to assuming that mixed income is split between labor and capital income in the same proportion as in the rest of the economy.

The third, similar in spirit but more comprehensive approach to dealing with mixed income has been proposed by Cooley and Prescott (1995), and developed by Gomme and Rupert (2007) and others. Its starting point is a decomposition of total income into two components: ambiguous (AI) and unambiguous (UI) income. Ambiguous income AI is the sum of proprietors' income, taxes on production less subsidies $\tau - s$, business current transfer payments ($BCTP$), and statistical discrepancies ($SDIS$):

$$AI = PI + (\tau - s) + BCTP + SDIS$$

Neither of these amounts is directly attributable to capital or labor.

Unambiguous income UI, on the other hand, is straightforwardly separated into unambiguous labor and capital income components:

$$UI = \underbrace{ULI}_{CE} + UKI$$

where the latter consists of rental income, net interests, current surplus of government enterprises, and corporate profits:

$$UKI = RI + NI + GE + CP$$

The share of capital in unambiguous income (KS_U) is obtained as

$$KS_U = 1 - LS_U = \frac{UKI + DEP}{UI} = \frac{RI + NI + GE + CP + DEP}{RI + NI + GE + CP + CE}$$

where DEP is the consumption of fixed capital (in the US case, Table 1.7.5 of NIPA-BEA).

The key assumption underlying the current adjustment method is that the shares of capital and labor in ambiguous income are the same as in unambiguous income, $AKI = KS_U \times AI$. Then, the labor share is computed as follows:

$$\mathbf{PI_2-GDP}: LS = (1 - KS) = 1 - \frac{UKI + DEP + AKI}{Y} \tag{4}$$

The theoretical arguments why PI_2-**GDP** is likely to be a relatively accurate representation of the "true" labor share are as follows. First, it covers the *entire* economy and carefully considers many distinct economic quantities, reported in NIPA, including the ambiguous income. Hence, from the macroeconomic perspective, it should be more robust to structural changes, such as changes in the sectoral or private versus public composition of value added, than, for example, the corporate labor share (Karabarbounis and Neiman, 2014). Second, its core assumption, that the ambiguous income is split between labor and capital income in the same proportion as in the rest of the economy, makes this measure much more accurate in the case of long-dated series when compared to series assuming that labor compensation is equal, on average, for both employees and self-employed workers (e.g., **SE-GVA**, see Elsby *et al.*, 2013): in the early 20th century in the United States, just like in less developed countries today, most self-employed workers were farmers who earned much less than the contemporaneous average wage in industry and services.

Finally, Gollin (2002) also proposes an adjustment where the entire proprietors' income is treated as compensation of labor. Such an approach likely leads to a sharp overestimation of the labor share. Accordingly, Johnson (1954) uses an equally simple rule of thumb: two-thirds of proprietors' income to labor.

Another issue in constructing the labor share is whether aggregate output Y in the denominator is identified with GDP or GVA. It turns out that empirically factor shares in value added differ systematically from factor shares in GDP (Valentinyi and Herrendorf, 2008). This argument ought to be borne in mind particularly when GVA is employed in more aggregated frameworks. For instance, Karabarbounis and Neiman (2014) document a global decline in the labor share, using data on corporate GVA, which accounts for 60% of overall GVA, instead of GDP.[2]

## 3. A Synthesis: Sources of Discrepancy

There are clear-cut theoretical indications under which assumptions the aforementioned labor share measures are equivalent. Failure to meet these conditions is then the reason for their discrepancy. We make four points in that regard.

1. The **Naive-GDP** measure could equal any other measure only in the counterfactual case where there was no proprietors' income in the economy. Hence, it is *always downward biased*. The difference between the payroll share and adjusted labor share measures is the larger, the greater is the actual share of mixed income in total output.

2. **SE-GDP** coincides with **PI-GDP** if and only if the share of the self-employed in the total labor force is equal to the share of proprietors' income in GDP:

$$\frac{SE}{E + SE} = \frac{PI}{Y} \tag{5}$$

Otherwise, the **SE-GDP** labor share measure exceeds **PI-GDP** if and only if, on average, employees obtain a proportionally larger share of output than the self-employed: $\frac{SE}{E+SE} > \frac{PI}{Y}$.

Figure 1 illustrates that after the peak in the self-employed share during the Great Depression, and a following period of its sharp decline in the 1930s, both sides of equation (5) declined in a roughly parallel way between World War II and the 1970s. The high share of self employed in the prewar period reflected the importance of Agriculture and the substitution to self-employment during the Great Depression. Thereafter, both as a share of output and employment, Agriculture declined reflecting the rise of Manufacturing with its scale economies and of the public sector that attracted and absorbed resources from Agriculture.
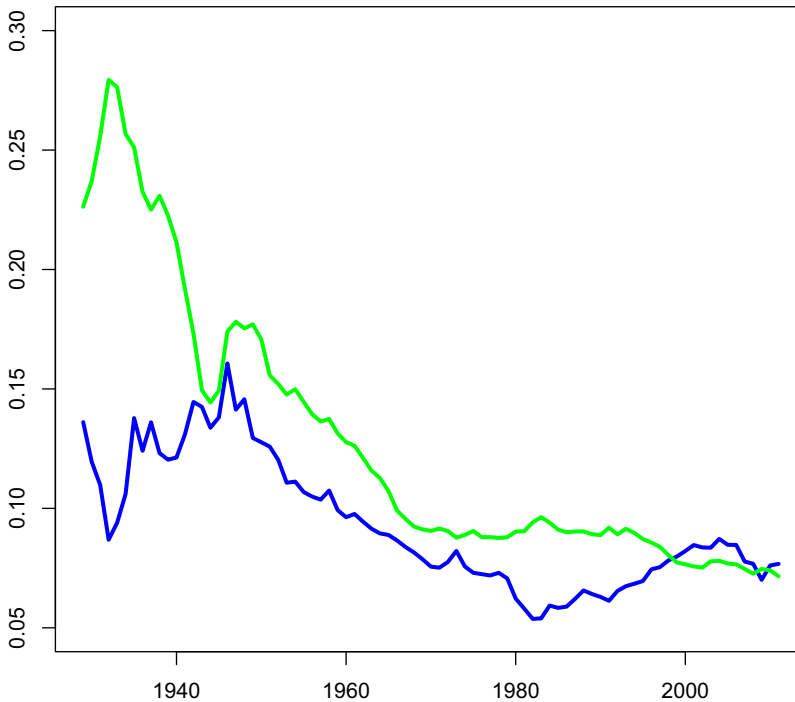
Figure 1. The Ratio of the Self-Employed to Total Employment and the Share of Mixed Income in GDP.
Notes: The blue line denotes the share of the proprietors' income in GDP (*PI/GDP*). The green line represents
for the ratio of the self-employed to total employment (*SE/(E + SE)*).
[Colour figure can be viewed at wileyonlinelibrary.com]

From the 1970s onward, that rapid decline in self-employment comes to a halt. This reflected factors such as technological changes that helped cut operating costs and reduce the importance of scale in favor of smaller scale enterprises, a greater use of contracting out, demographic shifts, and so on. The share of proprietors' income has a similar overall dynamic to that of the self-employed share. After 1980, however, the share of proprietors' income in GDP began to rise despite bottoming out of the share of the self-employed in the labor force. Both lines crossed in late 1990s. Now it is the self-employed who earn a proportionally larger share of the GDP than employees (which can be partly due to statistical error, Elsby *et al.*, 2013), and thus the **PI-GDP** exceeds the **SE-GDP** labor share.

3. **PI$_2$-GDP** coincides with **PI-GDP** as long as ambiguous income that is not directly proprietors' income (i.e., taxes on production τ and business current transfer payments, *BCTP*) is positive and attributed fully to capital. If factually, this income is also partly generated by labor, however, then **PI$_2$-GDP** should be relatively higher, while **PI-GDP** (and, by the same token, **SE-GDP**) should be an unambiguously downward-biased measure of the true labor share.

4. The discrepancy between labor share measures based on GDP and GVA follows from the difference between both denominators, driven by taxes on production and imports, minus subsidies.

4. Properties of the US Labor Share Series

To construct long historical labor share series for the US economy employing all the aforementioned measurement methods, we used annual data from National Income and Product Accounts (NIPA) tables

of the Bureau of Economic Analysis (BEA), and quarterly data from the Bureau of Labor Statistics (BLS). This choice of data sources stems from our wish to construct as long series as possible; the annual and quarterly series span 1929–2012 and 1947q1–2013q1, respectively. A detailed description of the constructed series is included in Table C.5 in the Online Appendix.

Apart from the aforementioned series **Naive-GDP**, **SE-GDP**, **PI-GDP**, and **PI$_2$-GDP**, we also calculate the "Naive" annual labor share in GVA in the private sector (**Naive-GVA**, the payroll share of GVA), and in the nonfarm private sector (**Naive-GVA-NF**). The next two variants are constructed by adjusting the above series by the number of the self-employed in the corresponding sectors (denoted as **SE-GVA** and **SE-GVA-NF**, respectively).[3] The last version of the labor share used in the current study is taken from the BLS. The **BLS** labor share series is a quarterly index, whose initial level is not determined.

4.1 Graphical Analysis

Figures 2 and 3 show the annual and quarterly labor income share time series, respectively. Note first the level differences between the series. For instance, **PI$_2$-GDP** exceeds **Naive-GDP** on average (i.e., almost 1/5th of its level). Systematic differences are substantial also for other pairs of measures. Such differences, as discussed in Online Appendix Section A, will, for instance, have implications for growth-accounting exercises and the retrieval of TFP. Eyeballing the historical series suggests that over the long run, differences between the variants often systematically diverge. Thus, the factors that drive a wedge between the series – number of self-employed, proprietors' income, taxes, and subsidies – are persistent and *time-varying*. This applies in particular to the comparisons between adjusted series and their "Naive" counterparts.[4]

Visible discrepancies, however, also relate to dynamics. Most importantly, the "Naive" series as well as series adjusted by mixed income exhibit hump-shaped trajectories, whereas the labor share modified by the share of the self-employed records a consistent, strong downward tendency throughout the period. This particular behavior is likely driven by (a) the sharp fall in the share of the self-employed in total employment until around 1970 (recall Figure 1), and (b) an overestimation of incomes among the self-employed in the immediately following period, as identified by Elsby *et al.* (2013).
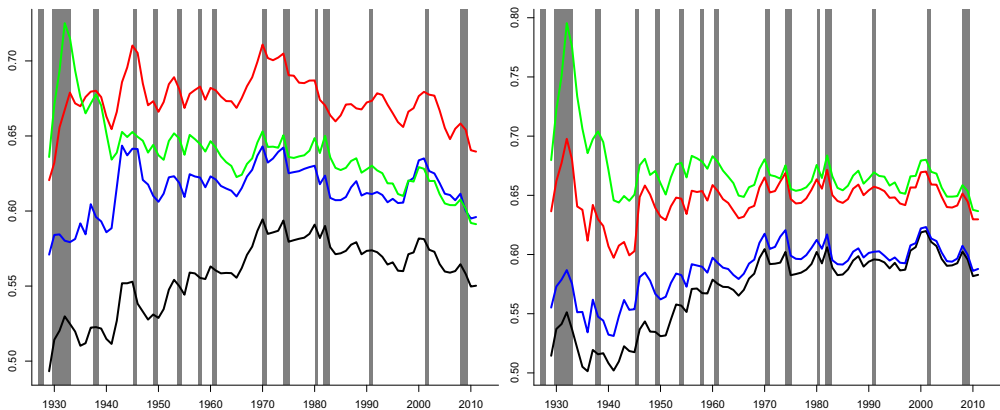
Figure 2. Annual US Labor Share.

Notes: Left panel: Naive-GDP, PI-GDP, PI$_2$-GDP, SE-GDP. Right panel: Naive-GVA, Naive-GVA-NF, SE-GVA-NF, SE-GVA. NBER recession periods are overlaid at the appropriate frequency.

[Colour figure can be viewed at wileyonlinelibrary.com]
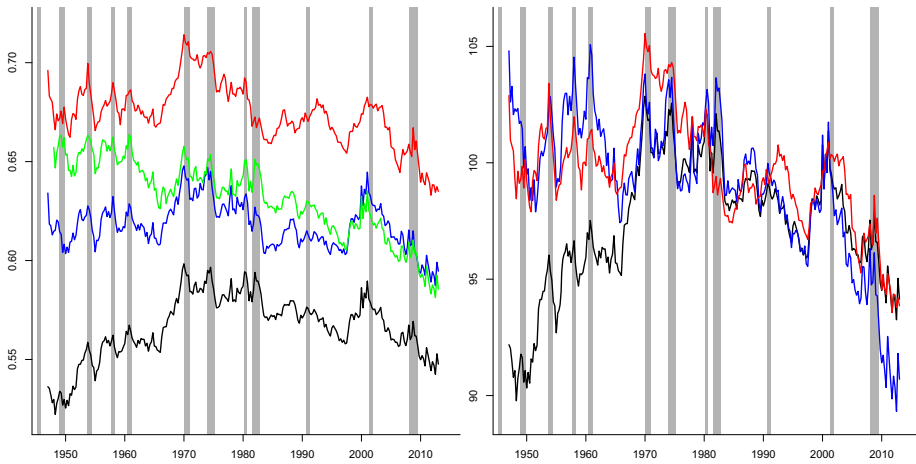
Figure 3. Quarterly US Labor Share.

Notes: Left panel: Naive-GDP, PI-GDP, PI$_2$-GDP, SE-GDP . Right panel: Naive-GDP, PI$_2$-GDP, BLS. For comparison, all series set at 2000 = 100.

[Colour figure can be viewed at wileyonlinelibrary.com]

Moreover, even the much heralded labor income decline since the 1970s is not universal. Series based on value added have been apparently stable since the 1940s, as has the PI-GDP variant (annual and quarterly). All series, though, *do* share a steep fall since the 2001 and 2007/09 recessions.

Notwithstanding, it is worth bearing in mind that all of these series are *meant* to measure the same thing: namely, the share of US national income that accrues to labor. Moreover, all of them have been widely used in various literatures. Yet, we have little understanding of the properties of these different series. For instance, in line with Kaldor's stylized facts, can we view the shares as stable or *quasi*-stable (e.g., stable after correcting for structural breaks)? Moreover, how persistent and volatile are they? What, in any given exercise, is the consequence of using one labor share measure rather than another? To illustrate, if income shares are not stable how would growth accounting exercises (which residually retrieve TFP) change? Would it alter the importance of TFP in accounting for economic growth? If labor's share of income cannot be uniquely measured, how would that change debates about income inequality?

4.2 *Summary Statistics*

Summary statistics of labor-share measures are presented in Tables 1 and 2 (where $\widetilde{x}$ is the logged then HP filtered series).[5] The table shows formally the differences in the levels (repeating what we observed in the previous graphs). In the annual case, **SE-GVA** indicates a mean labor share of 0.67 as against 0.56 for **Naive-GDP** (which, as we have remarked upon is always biased down). Indeed, the minimum of the former exceeds the maximum of the latter. A similar picture pertains to the quarterly series.

The volatility, relative to output, ranges from 23% to 36% for the long annual series (the **SE-GVA** series being the most volatile), and 36% to 48% for the postwar quarterly series (the **BLS** series is the most volatile). The numbers are relatively lower for annual series because they – as opposed to their quarterly counterparts – also include the period 1929–1946 when output was particularly volatile, and because quarterly data on the labor share may include more high-frequency noise. Systematic differences in volatility among the various labor share measures, in turn, appear because (i) self-employment has fallen precipitously between 1929 and 1970 (Figure 1) increasing the overall volatility of the annual series

Table 1. Annual Labor Share: Summary Statistics

	Naive-GDP	PI-GDP	PI$_2$-GDP	SE-GDP	Naive-GVA	Naive-GVA-NF	SE-GVA-NF	SE-GVA
mean	0.557	0.614	0.674	0.639	0.570	0.588	0.646	0.671
stdev	0.023	0.016	0.017	0.023	0.032	0.022	0.018	0.026
min	0.555	0.571	0.581	0.591	0.501	0.531	0.597	0.637
occurrence	*1929*	*1929*	*1929*	*2011*	*1936*	*1941*	*1941*	*2011*
max	0.594	0.644	0.711	0.725	0.620	0.623	0.698	0.795
occurrence	*1970*	*1943*	*1970*	*1932*	*2001*	*2001*	*1932*	*1932*
1970–1929[a]	0.062	0.098	0.115	0.033	0.101	0.017	0.086	0.089
2011–1970[a]	−0.030	−0.063	−0.066	−0.040	−0.044	−0.068	−0.063	−0.063
Skewness	−0.621	−0.423	−0.362	1.034	−0.664	−0.804	−0.514	2.498
Kurtosis	−0.488	−0.242	0.854	2.378	−0.845	0.046	1.241	7.772
Normality	[0.044]	[0.259]	[0.080]	[0.000]	[0.014]	[0.009]	[0.007]	[0.000]
$\sigma_{\widetilde{ls}}/\sigma_{\widetilde{y}}$	0.229	0.226	0.227	0.258	0.257	0.268	0.316	0.355
corr($\widetilde{ls}_t, \widetilde{y}_t$)	0.174**	0.444***	−0.065	−0.465***	−0.262***	−0.196***	−0.533***	−0.652***

Notes: [a]Changes have been calculated for annual means. Normality test is Jarque-Bera. Superscripts ***, **, and * reflect the 1%, 5%, and 10% significance level, respectively.

Table 2. Quarterly Labor Share: Summary Statistics

	Naive-GDP	PI-GDP	PI$_2$-GDP	SE-GDP	BLS
mean	0.566	0.618	0.674	0.632	104.7
stdev	0.016	0.012	0.015	0.019	3.2
min	0.522	0.587	0.633	0.581	94.4
occurrence	*1948q2*	*2012q3*	*2011q4*	*2012q3*	*2012q3*
max	0.598	0.648	0.714	0.664	111.0
occurrence	*1970q1*	*1970q1*	*1970q1*	*1960q4*	*1960q4*
1970–1947[a]	0.062	0.022	0.026	−0.001	−0.487
2011–1970[a]	−0.047	−0.050	−0.074	−0.066	−12.841
Skewness	−0.454	0.171	−0.105	−0.496	−0.912
Kurtosis	−0.143	−0.094	0.333	−0.432	0.881
Normality	[0.009]	[0.505]	[0.385]	[0.002]	[0.000]
$\sigma_{\widetilde{ls}}/\sigma_{\widetilde{y}}$	0.370	0.374	0.357	0.359	0.482
corr($\widetilde{ls}_t, \widetilde{y}_t$)	−0.200***	−0.092	−0.232***	−0.385***	−0.275***

Notes: [a]Changes have been calculated for annual means. Normality test is Jarque-Bera. Superscripts ***, **, and * reflect the 1%, 5%, and 10% significance level, respectively.

SE-GDP, SE-GVA, SE-GVA-NF relative to other ones, and (ii) the labor share tends to be relatively more volatile relative to GVA in the private sector than GDP in the entire economy, a more comprehensive measure of economic activity.

The raw labor share is generally countercyclical at business cycle frequencies (especially in quarterly data and since 1947). The cyclical comovement of the labor share with output differs significantly among the constructed variants, though. In particular, as opposed to other labor share measures, the short-run components of annual **Naive-GDP** and **PI-GDP** measures are significantly *positively* correlated with output. This is driven primarily by the strongly procyclical behavior of these series in the beginning of the sample, before World War II. We confirm that these series are again countercyclical when considered for the postwar subperiod only, consistent with their quarterly postwar counterparts.[6]

However, this countercyclicality is not especially strong (around -0.2, -0.4 for the quarterly series) and there is in some cases acyclicality (**PI-GDP**). It is further interesting to note that **PI-GDP** and **PI$_2$-GDP**, though intended to capture the same aspect (namely, labor share corrected for proprietors' income), have such distinct properties: in annual data (1929–2012), the former is apparently procyclical and the latter a-cyclical; whereas in quarterly data (1947q1–2013q1), the former is acyclical and the latter countercyclical. This discrepancy is due to the cyclical variation in the wedge between labor share measures: taxes on production and business current transfer payments.

The series are also mostly characterized by negative skewness (i.e., by a long tail to the left indicating a few very low values) but with no particular common features in kurtosis ("peakedness"). Likewise the null of normality is mostly rejected for annual and quarterly series.

Moreover, we computed the cumulative changes over two subperiods with a breakpoint in 1970, and for most annual series (6 out of 8), the decrease in the labor share after 1970 was smaller than the strong rise from 1929 to 1970. This applies in particular to **PI$_2$-GDP**.

4.3 *Persistence*

A key property of any time series is its persistence. If subject to a shock, the level of persistence tells us if, and how soon, the series will revert to its mean: the higher the persistence, the slower that reversion. In the context of the labor share, and the controversy surrounding its perceived decline across many series and countries (and thus how long that will last), this is a key metric.

4.3.1 *Method*

Assume the following general AR(1) process:[7]

$$X_t = \mu + \rho X_{t-1} + \beta_1 t + \beta_2 t^2 \tag{6}$$

This nests three models: (m$_1$) only with a constant ($\beta_1 = \beta_2 = 0$); (m$_2$) with a linear trend ($\beta_2 = 0$); and (m$_3$) with a quadratic trend (in models m$_1$ − m$_3$, X is the level of the labor share); and model (m$_{1+}$) where (m$_1$) is reestimated using the logged and HP-filtered labor share series, $\widetilde{x}$, instead of its level.

Models (m$_1$) and (m$_{1+}$) are consistent with the usual interpretation of the labor share as being stable around a long-run mean, $\frac{\mu}{1-\rho}$. In the subsequent models, the "mean" is allowed to shift, reflecting secular trends, long-lasting cycles, structural changes in the economy, etc. Clearly, the ρ value that emerges from m$_2$ and m$_3$ captures persistence at the high-frequency end since some of the long-run variation is removed by the included trends.

Moreover, a growing literature, starting in finance (Shephard and Andersen, 2008) but evolving into macroeconomics, analyzes time-varying stochastic volatility in time series. As Fernández-Villaverde and Rubio-Ramirez (2013) discuss, this often characterizes aggregate data: periods of high volatility are followed by low-volatility periods (e.g., contrast the early turbulent 1970s with the "great moderation," Stock and Watson, 2003). Accounting for the presence of stochastic volatility is then important for understanding aggregate fluctuations, for policy analysis, and for improved statistical inference (Hamilton, 2010). For robustness, therefore, we additionally estimate an SV-AR(1) process (model m$_4$):[8]

$$\widetilde{x}_t = \rho \widetilde{x}_{t-1} + e^\sigma \upsilon_{1t}, \upsilon_{1t} \sim \mathcal{N}(0, 1) \tag{6a}$$

$$\sigma_t = (1 - \rho_\sigma)\overline{\sigma} + \rho_\sigma \sigma_{t-1} + \eta_\sigma \upsilon_{2t}, \upsilon_{2t} \sim \mathcal{N}(0, 1) \tag{6b}$$

where, as before, $\widetilde{x}$ is the HP-filtered series of the logged labor share series.[9] Parameters ρ and ρ_σ represent the persistence of the level and volatility equation, respectively; $\overline{\sigma}$ is the unconditional mean of the volatility of the process, σ; and η captures the standard deviation of the volatility shocks.
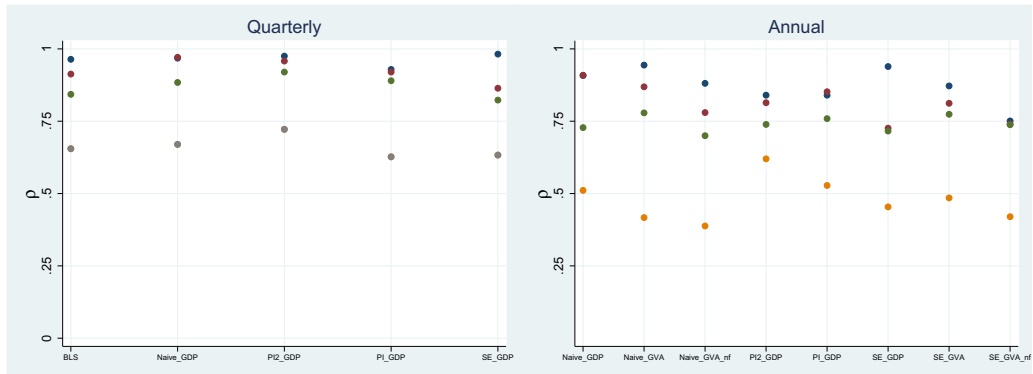
Figure 4. Persistence Measures by Series and Model.
Notes: Color code: m_1, m_2, m_3, m_{1+}, m_4. In some cases, circles fully overlap given sufficiently close values.
Note that full results are in Online Appendix C.
[Colour figure can be viewed at wileyonlinelibrary.com]

4.3.2 *Results*

Point estimates of ρ, although generally high, exhibit substantial heterogeneity (Figure 4). For example, for annual and quarterly series in m_1 $\rho \in [0.75, 0.94]$ and $\rho \in [0.93, 0.98]$, respectively, which imply half-lives of 2.5–12 and 2.5–9.5 years. For the annual series, the GVA series are far less persistent. Interestingly, the addition of a linear trend reduces ρ estimates significantly *only* for the series with GVA as output or adjusted by the self-employed. Models m_2, m_3 – as well as the filtered case m_{1+} – necessarily contract the persistence and half-lives. Extending the autoregressive model by a linear trend limits substantially the persistence only for the **SE-GDP** and **BLS** series, for which the linear trend is statistically significant. The quadratic model m_3 naturally fits the Naive series well given the strong hump shape in its profile. The full set of results is given in Online Appendix Section C.

We find that the data support moderate time-varying volatility, with persistence similar to that of the labor share series itself (and again the BLS series implies most volatility). It is estimated that a one standard deviation volatility shock increases the standard deviation of the labor share by around $100 \cdot (e^{\eta_\sigma} - 1) \approx 30\%$ for $\eta_\sigma \approx 0.28$. Figure 5 retrieves the implied stochastic volatility process. Setting the differences in the average magnitude of stochastic volatility aside, a similar story emerges: we see a gradual buildup of volatility from the mid-1960s through the 1970s (with the two oil shocks), then a remarkable sustained reduction in volatility from the mid-1980s to the mid-1990s (the "great moderation"), followed by sharp rise in the 2001 recession, and thereafter from the financial crisis onward.

Interestingly, while broad features of the data are mirrored in each series, there are also interesting differences between them. In particular, the **PI$_2$-GDP** series projects a far longer moderation period in terms of stochastic volatility and only spikes (and even then only temporarily) around the global financial crisis of 2007–2008. Accordingly, if the researcher were to examine that series in isolation, she would derive a view of the stability properties of the labor share quite distinct from the alternatives. The exact source of this discrepancy is uncertain but comparing **PI$_2$-GDP** to the **PI-GDP** series, one may hypothesize that the nature of the 2001 recession (the dotcom bubble) might have disproportionately affected the wedge between both measures: taxes on production and business current transfer payments.
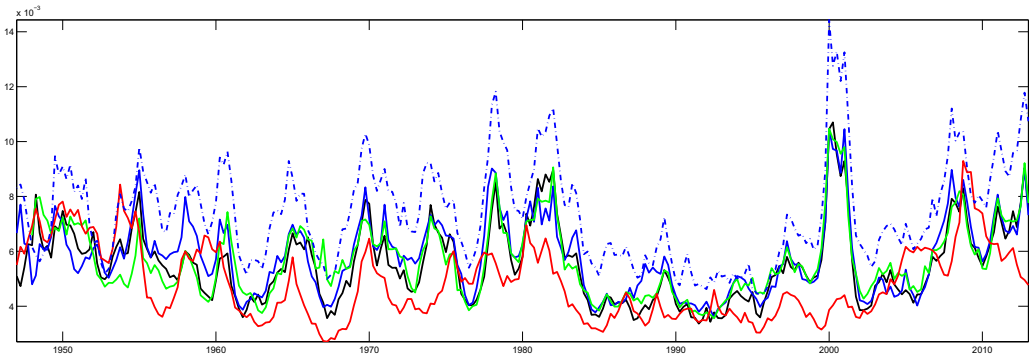
Figure 5. Stochastic Volatility of Quarterly Labor Share Series.
Notes: The plots show e^{σ_t}. Sample 1946q1 to 2013q1.
Naive-GDP, PI-GDP, PI$_2$-GDP, SE-GDP, BLS (dot-dashed).
[Colour figure can be viewed at wileyonlinelibrary.com]
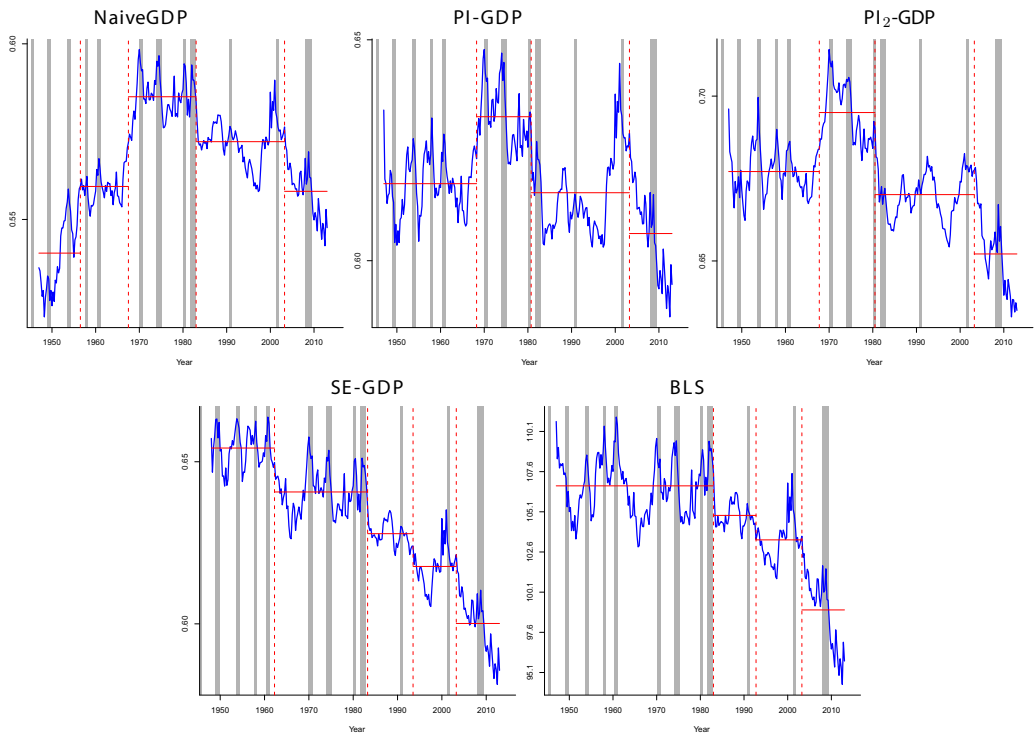
5. Structural Breaks

Ultimately, the importance of persistence is to gauge whether a series is or is not stationary (around a constant or a linear trend). When persistence takes the form of a unit root, the effect of an innovation is permanent. Since income shares are defined within the unit interval and have not exhibited corner solutions in history, one's prior might be that labor share does *not* contain a unit root.

Testing more formally for a unit root, however, is largely inconclusive. We implemented several tests (ADF, PP, ADF-GLS, symmetric and asymmetric ADF-ESTAR, and fractional). Results (see Online Appendix Figure F.1) vary substantially across the series, reflecting the existence of a clear downward trend in some of them (e.g., **SE-GDP**), hump-shaped trends in some others (e.g., **PI$_2$-GDP**), and their varying degrees of persistence. Note that some of the aforementioned facts could be a consequence of changes in the sectoral structure of the US economy (see, e.g., Elsby *et al.*, 2013). Since this goes beyond our remit, an indicative discussion of the role of the sectoral makeup of the aggregate labor share has been relegated to Online Appendix Section E.

Importantly, there is also no systematic evidence for stationarity when a structural break is allowed for.[10] This outcome may have been caused either by complicated dynamics of the considered time series – driven by their large persistence and presence of nonlinear trends – or by the existence of *more than one breakpoint* in the labor share. Accordingly, we complement our analysis by applying a multiple breaks detection procedure proposed by Bai and Perron (2003). As in previous exercises, we consider three assumptions about the deterministic component of the time series: only constant, linear trend, and quadratic trend. For each case, we report the *optimal* number of breaks in the data-generating process with corresponding breakpoints. The optimal number of structural changes is chosen with the BIC criterion, restricted to be at most 5.

Results are presented in Online Appendix Tables F.2 and F.3.[11] This testing procedure allows for changes in the mean and/or slope. Which case one relies upon is largely a matter of judgment. For simplicity and in line with usual interpretations, Figure 6 plots the quarterly mean breaks detected (to economize on space, the equivalent annual graphs are in Online Appendix Section D).

These results indicate strong evidence in favor of multiple structural breaks. However, the timing of breakpoints varies among different labor share variants. Typically, two to five structural changes might be identified: early 1940s, late 1950s, late 1960s–early 1970s, first half of 1980s, and late 1990s–early 2000s. The first (in annual data only, given the sample), third, and fourth of these breaks appear most

Figure 6. Structural Breaks Detected with the Bai and Perron (2003) Procedure – Quarterly Series. [Colour figure can be viewed at wileyonlinelibrary.com]

robust across specifications, and can be identified with World War II, the oil crisis, and the early 1980s recession. Alternatively, the latter two dates might be perceived as a mark of the beginning of the spread of ICT technologies across the United States.

To sum up, for each labor share series, we find evidence of *multiple* structural breaks, which explains why Zivot and Andrews (1992) tests of stationarity subject to a single structural break (Online Appendix Tables F.4– F.5) might have low power and thus should be treated with caution. A further caveat is due to heterogeneity in the dating. For instance, in the case of the **PI$_2$-GDP** series, tests suggest either no structural break at all, or three of them: during World War II, in late 1960s, and in early 1980s.

6. What Can Spectral Analysis Tell Us about Different Labor Share Measures?

Ambiguity over stationarity, the (likely) presence of structural breaks, and the apparent lack of convergence[12] between the labor share series suggest that it is low-frequency aspects that are most important to understand when comparing these alternate labor share series. We shall investigate this issue using spectral techniques. Our motivation in performing spectral analysis is to assess the importance of fluctuations with given periodicity for the total observed variance of the respective series and to justify whether oscillations of specific frequencies systematically comove between various definitions of the labor share.

Table 3. Shares of Specific Frequencies in Total Variance (%) – Annual Series

Periodicity (in years)	Demeaned			Excluded Linear			Excluded Quadratic		
	≥ 50	8–50	≤ 8	≥ 50	8–50	≤ 8	≥ 50	8–50	≤ 8
Naive-GDP	**73.6**	20.3	6.1	**72.8**	17.4	9.9	2.8	**65.7**	31.5
PI-GDP	25.8	**58.3**	15.9	28.0	**56.5**	15.5	3.5	**73.8**	22.7
PI$_2$-GDP	31.5	**48.3**	20.2	28.3	**48.9**	22.7	0.2	**68.1**	31.7
SE-GDP	18.0	**56.1**	25.9	15.5	**46.1**	38.4	15.9	**45.7**	38.4
Naive-GVA	**62.4**	33.5	4.0	**61.0**	21.0	17.9	0.9	**57.6**	41.5
Naive-GVA-NF	**54.3**	36.8	8.9	**46.1**	29.5	24.4	0.3	**56.1**	43.6
SE-GVA-NF	30.1	**42.3**	27.6	15.4	**44.0**	40.5	1.6	**51.9**	46.5
SE-GVA	4.1	**53.1**	42.8	9.4	**49.8**	40.8	7.3	**49.4**	43.3

Notes: The shares have been calculated based on periodogram estimates. Numbers in bold indicate the maximum of frequency share over each respective "stationarizing" processes.

In our exercise, we distinguish between the low-, medium-, and high- frequency range. High-frequency fluctuations are defined as all oscillations with periodicity below 8 years, interpreted as business-cycle fluctuations. The second range, the medium-term business cycles, as formulated by Comin and Gertler (2006), includes all fluctuations with periodicity between 8 and 50 years.[13] The longest swings with periodicity higher than 50 years are mapped into the low-frequency component, interpreted essentially as a stochastic trend.

For spectral techniques, the data should not have a unit root.[14] Given the ambiguity in formal unit root testing, we apply three approaches to excluding the deterministic component: removing the mean, linear, and quadratic trend from log-levels. Of course, a demeaned nonstationary series remains nonstationary, but in the familiar context where the labor share is seen as fluctuating around a constant mean, it provides a natural benchmark.

The estimated shares of specific frequencies in the overall variance are reported in Tables 3 and 4. Apart from the **SE-GDP** and **SE-GVA** variants,[15] the role of the low-frequency component is substantial. For the demeaned series, long cycles beyond 50 years (variations in the stochastic trend) are responsible for from 1/4 to almost 2/3 of the overall variance. The contribution of the low-frequency component is significant even if a linear trend is included in data-generating process. For both transformations, the medium-run component is more important than the short-run one in the case of all annual series and four out of five quarterly series.

Particularly interesting findings arise when analyzing the series excluding a quadratic trend. Naturally, extraction of a quadratic trend from the labor share data series limits the importance of the low-frequency component whose contribution to the overall variance falls below 4%. Second, we see that for the "Naive" series and for the series adjusted by proprietors' income, the share of the medium-term component is almost two times higher than of the high-frequency component.

On the other hand, the quarterly **SE-GDP** series (since 1947) seems to be characterized by quite distinct spectral characteristics. Most of its variance is concentrated in short-run frequencies, irrespectively of the data transformation.[16] **PI$_2$-GDP**, in contrast, provides a consistent message for both the annual and quarterly frequency: around 80% of its total variability is generated by medium-run cycles and a long-run hump-shaped swing, which can be very well fitted by a quadratic trend.

We have also performed cross-spectral analysis by computing coherence (Online Appendix Section B). This addresses the question whether the pairs of the different labor share variants systematically comove within specific frequency ranges. We find that coherence is always high in the high-frequency domain, thus corroborating the previously formulated conclusion that labor share series tend to be rather consistent in the short run. Coherence estimates are more ambiguous in the lower frequencies, though.

Table 4. Shares of Specific Frequencies in Total Variance (%) – Quarterly Series

Periodicity (in years)	Demeaned			Excluded Linear			Excluded Quadratic		
	≥ 50	8–50	≤ 8	≥ 50	8–50	≤ 8	≥ 50	8–50	≤ 8
Naive-GDP	**64.8**	27.9	7.4	**70.4**	21.3	8.3	3.8	**64.7**	31.6
PI-GDP	24.2	**51.0**	24.8	16.1	**60.1**	23.8	0.8	**69.5**	29.7
PI$_2$-GDP	**42.8**	37.9	19.3	29.8	**52.4**	17.8	0.4	**72.6**	27.0
SE-GDP	7.0	23.5	**69.5**	6.9	23.4	**69.7**	3.1	20.3	**76.6**
BLS	36.5	**36.8**	26.7	31.7	**35.0**	33.3	3.3	44.6	**52.2**

Notes: The shares have been calculated based on periodogram estimates. Numbers in bold indicate the maximum of frequency share over each respective "stationarizing" processes.

Our results obtained so far point to the general conclusion that while short-run properties of the labor shares are relatively consistent across the considered alternative definitions, their medium-run swings and long-run trends diverge substantially. At the same time, ambiguity in unit root test results is likely due to the high persistence and complicated dynamics of the considered series. We can also argue that the **PI$_2$-GDP** measure is probably not only the most sound theoretically, but also has intuitive empirical properties: (1) it is mean-reverting but highly persistent, with about 80% of its total variance observed in the medium- to long-run frequency range, (2) it is countercyclical over the short run, (3) it has recorded a secular decline since 1970, and (4) it can be understood as featuring three economically interpretable structural breaks: during World War II, in late 1960s, and in early 1980s.

7. A Historical Perspective on the Labor Share: More Wave than Cliff?

Before considering the effect of different labor-share variants in common economic applications, we now take a broader, historical view of the labor share. In the United States, as in many other countries, a great deal of debate has focused on the (sometimes precipitous) fall of the labor share in recent decades.

This has prompted discussion as to the sources of those falls. Common "culprits" include technological changes (Autor *et al.*, 2003; Acemoglu, 2003; Jones, 2005; Klump *et al.*, 2007), structural transformation within the economy (Kongsamut *et al.*, 2001; de Serres *et al.*, 2002; Ngai and Pissarides, 2007; McAdam and Willman, 2013a), shifting rents and shocks (Blanchard, 1997; Blanchard and Giavazzi, 2003), the rise of offshoring of labor-intensive tasks (Elsby *et al.*, 2013), increasing female labor force participation (Buera and Kaboski, 2012), changing patterns of firm size and age (Kyyrä and Maliranta, 2008), declines in relative prices for investment goods (Karabarbounis and Neiman, 2014), the tendency for capital returns to exceed economic growth rates (Piketty, 2014), and so on.

However, labor shares have enjoyed a rich evolution in history, exhibiting periods of sustained rises and stabilizations as well as falls; concentrating on the latter (and accordingly on quite limited samples) risks overlooking that richness. In that vein, in figures 7–10, we plot for the United States (as well as for the United Kingdom, Finland, and France, for which we have long data) the raw, medium-, and long-run component of the labor share (as in Tables 3 and 4). Table C.4 in the Online Appendix also verifies that these other countries, like the United States, have most of their observed frequency decomposition skewed to ranges outside the normal business cycle frequencies. Hence, historical data allow us to view the recent episode of labor share decline since the 1970s–1980s potentially as part of a long *wave* rather than an abrupt downfall or *cliff*. They also suggest that beside factors contributing to the recent labor share decline and factors that affect its business-cycle variability, attention should also be paid to factors that drove its earlier long waves, including the periods of secular increase.
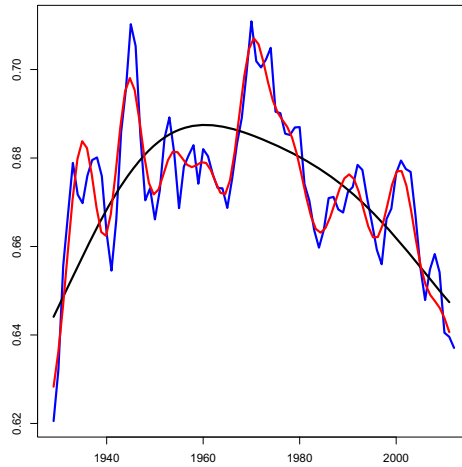
Figure 7. Labor Share in the USA (PI$_2$–GDP).
Notes: The blue, red, and black lines represent the raw series, the medium- to long-term component, and the long-run trend, respectively.
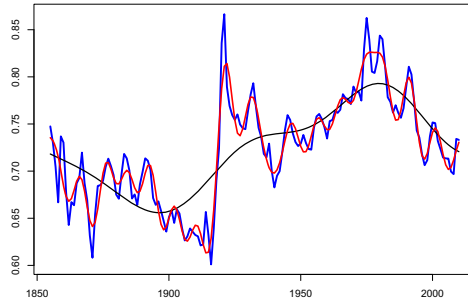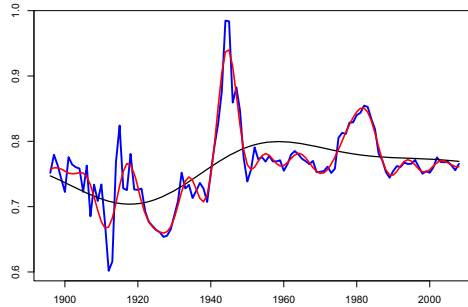[Colour figure can be viewed at wileyonlinelibrary.com]
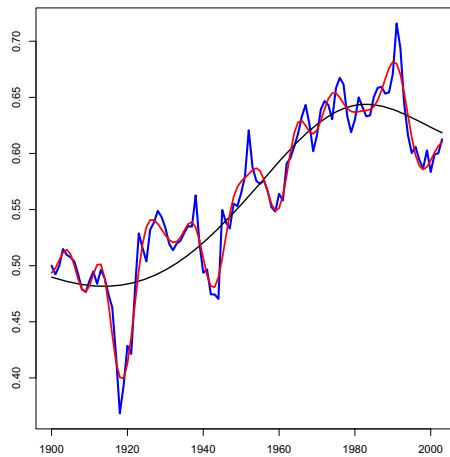
Figure 8. Labor Share in Finland.
Notes: The blue, red, and black lines represent the raw series, the medium- to long-term component, and the long-run trend, respectively. The data on the Finnish labor share are taken from Jalava *et al.* (2006).
[Colour figure can be viewed at wileyonlinelibrary.com]

This postulate is further motivated by the diverse cyclical properties of short-run fluctuations and long waves in the labor share. Namely, as shown in Tables 5 and 6 that are based on US data, the short-run labor share component is countercyclical, whereas the medium-run component is procyclical. This holds true, in particular, for the **PI$_2$–GDP** measure as well as other measures that are either unadjusted or adjusted by proprietors' incomes. For series adjusted by the number of the self-employed, however, the positive correlation over the medium run is less pronounced and sometimes statistically insignificant. We expect

Figure 9. Labor Share in the United Kingdom.

Notes: The blue, red, and black lines represent the raw series, the medium- to long-term component, and the long-run trend, respectively. The data on the British labor share are taken from Piketty (2014).

[Colour figure can be viewed at wileyonlinelibrary.com]

Figure 10. Labor Share in France.

Notes: The blue, red, and black lines represent the raw series, the medium- to long-term component, and the long-run trend, respectively. The data on the French labor share are taken from Piketty (2014).

[Colour figure can be viewed at wileyonlinelibrary.com]

Table 5. Cyclicality of the Short-Run and the Medium-Run Labor Share Component – Annual Series

	Naive-GDP	PI-GDP	PI$_2$-GDP	SE-GDP	Naive-GVA	Naive-GVA-NF	SE-GVA-NF	SE-GVA
Medium run	0.526***	0.668***	0.588***	0.127	0.419***	0.398***	0.044	0.131
Short run	0.174**	0.444***	−0.065	−0.465***	−0.262***	−0.196***	−0.533***	−0.652***

Note: Superscripts ***, ** and * reflect the 1%, 5% and 10% significance level, respectively.

Table 6. Cyclicality of the Short-Run and the Medium-Run Labor Share Component – Quarterly Series

	Naive-GDP	PI-GDP	PI$_2$-GDP	SE-GDP	BLS
Medium run	0.549***	0.618***	0.555***	0.135*	0.182**
Short run	−0.200***	−0.092	−0.232***	−0.385***	−0.275***

Notes: Superscripts ***, ** and * reflect the 1%, 5% and 10% significance level, respectively.

that this is due to the relatively small overall variability of the medium-frequency component of these series, especially the quarterly one (Tables 3–4).

As argued by Growiec *et al.* (2018), one reason for a positive correlation of the labor share with output over the longer run could be the interplay between and capital- and labor-augmenting technical change under gross complementarity of capital and labor. As this particular property of the labor share has not been emphasized thus far, alternative theories are yet to be provided.

8. An Application: New Keynesian Phillips Curves

As our next step, we highlight some concrete examples of the empirical consequences from using different labor share measures. Here we highlight one particular example where using labor share measures is an integral part of the application, namely, modeling inflation using New Keynesian Phillips curves (NKPCs). Online Appendix Section A considers two further applications: growth accounting and the analysis of technology shocks under different assumptions about the underlying labor share measure.

As in Galí and Gertler (1999) and subsequent studies the NKPC literature assumes staggered price setting under imperfect competition, where a fraction θ of firms do not change their prices in any given period. The remaining firms set prices optimally as a fixed markup, μ, over discounted expected marginal costs. When resetting, firms also take into account that the price may be fixed for many future periods, yielding the optimal reset price p_t^* (see Tsoukis *et al.*, 2011, for a comprehensive survey)

$$p_t^* = (1 - \theta\beta)\mathbb{E}_t \sum_{k=0}^{\infty} (\theta\beta)^k \left[mc_{t+k}^n + \mu \right] \tag{7}$$

where mc^n is (the log of) nominal marginal costs, β is a discount factor, and $\mathbb{E}_t$ is the expectation operator. The overall price level is then a weighted average of lagged and reset prices, $p_t = \theta p_{t-1} + (1 - \theta)p_t^*$. Given $mc_t^r \equiv mc_t^n - p_t$, and constant marginal costs across firms, the familiar "NKPC" emerges

$$\pi_t = \beta\mathbb{E}_t\pi_{t+1} + \lambda \left(mc_t^r + \mu \right) \tag{8}$$

where $\pi_t = p_t - p_{t-1}$ is inflation and $\lambda = \frac{(1-\theta)(1-\theta\beta)}{\theta}$ represents the reduced-form "slope."

Additionally, it is often assumed that of the $1 - \theta$ price resetting firms a fraction, ω, set their price according to lagged inflation. This implies an NKPC with an intrinsic expectations component:

$$\pi_t = \gamma_f\mathbb{E}_t\pi_{t+1} + \gamma_b\pi_{t-1} + \lambda \left(mc_t^r + \mu \right) \tag{9}$$

where $\phi = \theta + \omega[1 - \theta(1 - \beta)]$, $\gamma_f = \frac{\theta\beta}{\phi}$, $\gamma_b = \frac{\omega}{\phi}$, and $\lambda = \frac{(1-\omega)(1-\theta)(1-\theta\beta)}{\phi}$.

Real marginal costs, mc^r, are difficult to measure, though. An early approach was to proxy them by using the (stationary) deviation of output from a linear/quadratic trend, or an HP-filtered series. Alternatively, Galí and Gertler (1999) and others argued in favor of proxying real marginal costs by average real unit labor costs. Under the special case of a (unitary substitution elasticity) Cobb–Douglas production function, real marginal costs reduce to the labor share; this has tended to be a common (if not the default) choice in the literature.[17] If the elasticity of substitution between capital and labor is not unitary, however, such a proxy can lead to biased estimates.

In the following application, we estimate both NKPC forms (specifications (8) and (9)) over 1960q1–2012q4; the start of the sample is chosen for comparisons with the Gali–Gertler study. Note that the driving variable, that is, the $\lambda(\cdot)$ term, whether it contains the output gap or the labor share, should, as befits a (price) gap term, be stationary. Stationarity in this context is simply another way of saying that there is cointegration between the optimal and actual price: $p_t^* - p_t$. In the case of a typical nonstructural output gap measure that stationarity is assured. As we know, this is less clear for the labor share measures. For instance, revisiting Figure 3, we see (from the 1960s onward) that **SE-GDP** and **PI$_2$-GDP** have

Table 7. New Keynesian Phillips Curve Estimates

	Naive-GDP	PI-GDP	PI$_2$-GDP	SE-GDP	BLS
Specification (8)					
θ	0.891***	0.907***	0.928***	0.915***	0.909***
β	0.980***	1.004***	1.009***	1.009***	1.008***
λ	0.015***	0.009**	0.005	0.007**	0.008***
$\mathcal{D}$	9.2	10.7	13.8	11.8	11.0
Specification (9)					
ω	0.104**	0.086**	0.089	0.065	0.035
θ	0.883***	0.901***	0.924***	0.912***	0.910***
β	0.961***	0.996***	1.002***	1.002***	1.004***
γ_b	0.106**	0.087**	0.088	0.066	0.037
γ_f	0.863***	0.909***	0.914***	0.936***	0.967***
λ	0.016***	0.009**	0.005	0.007**	0.008***
$\mathcal{D}$	8.5	10.1	13.1	11.4	11.1

Notes: The covariance matrix was estimated with a 12 lags Newey–West estimator. The list of instruments is the same as in Galí and Gertler (1999): four lags of inflation, the labor share, the output gap, the long–short interest rate spread, wage, and commodity price inflation. Galí (2015) additionally writes the NKPC instead using that $\lambda = \frac{(1-\theta)(1-\theta\beta)}{\theta} \cdot \Xi$ where $\Xi = \frac{1-\overline{LS}}{1-\overline{LS}+\overline{LS}\epsilon}$ and $\overline{LS}$ is the mean labor share and ϵ is the elasticity of substitution between product varieties. Using this formulation leads to a more reasonable price duration. Superscripts ***, ** and * reflect the 1%, 5% and 10% significance level, respectively.

exhibited a clear downward trend. The other three series are only borderline stationary in this period. This has a bearing on the success of the resulting estimates.

Outwardly, though, the NKPC estimations work relatively well across labor share types: parameters are correctly signed and tend to be significant (Table 7). For example, $\hat{\beta}$ tends to be around the benchmark region of unity.[18] However, estimates of the duration of price fixedness vary from 8.5–13.8 quarters. Although these durations are high (compared, say, to micro price-setting evidence), they are by no means untypical in the literature (see the excellent survey by Mavroeidis *et al.*, 2014).[19]

The slope parameters are of more interest here. To repeat, even though the driving variable should be stationary, at best our labor share series are borderline stationary. Accordingly, the minimization in the estimation algorithm places unusually low weights on the driving variable ($\lambda \in [0.005, 0.016]$). As predicted earlier, the **PI$_2$-GDP** and **SE-GDP** variants fare particularly poorly in that regard: the former never supports a statistically significant slope parameter, the latter supports a significant but quantitatively small one. Moreover, both of these specifications produce the most unreasonable price setting durations. The **NaiveGDP** and **PI-GDP** variants, by contrast, have the lowest durations, significant slopes, and significant parameters across both NKPC forms.

NKPCs are not, naturally, a foolproof way of gauging inflation movements; there are other modeling approaches. That is not the main issue, though: our main point was that the NKPC literature gave a central explanatory role to the labor share of income. However, arguably, this is not what most NKPC papers discuss. Much of the literature has instead become concerned with estimation and identification of dynamics (i.e., how much forward- and backward-looking price setting there is), which are the best instruments to use in the GMM estimation, etc. The question of whether results are sensitive to which labor share measure we use has received little attention. In our case, though, we have highlighted that we can tie the success of NKPC estimation to the relative properties of the available labor share variants.

9. Conclusions

We provided a systematic survey of the dynamic properties of a range of alternative US labor share measures. We documented that these measures are not only divergent in terms of the implied trends, which are visible to a naked eye, but also differ in terms of their other dynamic properties, such as the shares of short-, medium-, and long-run variation in total volatility of the series, degree of persistence, mean-reversion properties, and evidence for structural breaks.

Our results point to the general conclusion that while "short-run" properties of the labor shares are relatively consistent across all definitions, their "medium-run" swings and "long-run trends" substantially diverge. We also emphasize that while the labor share tends to be countercyclical in the short run, in the medium run, it becomes procyclical.

While we generally recommend caution when designing the empirical labor share measure suited to the given application at hand, we argue that the US series on the share of employees' compensation in GDP, adjusted for proprietors' income (which we call **PI$_2$-GDP**), has intuitive, economically interpretable properties, covers the entire economy, and thus might be perceived as the "headline" measure of the US labor share since 1929. This measure, compared to its alternatives, turns out to provide the relatively most consistent message across a range of diverse exercises and applications discussed in this article while providing implications that remain in accordance with known "stylized facts" formulated in the earlier literature.

This measure suggests that the US labor share has not only declined after 1970, but also *substantially increased* before that, exhibiting a hump-shaped pattern over the last 84 years. It corroborates the idea that instead of concentrating the decline in the labor share since 1970, one could also embrace the larger time span of available data and discuss the long cycle in this variable.

Acknowledgments

Notes

1. Note that our study is not intended to be completely comprehensive. This is because we focus exclusively on measures that (at least) attempt to capture factor shares for the entire economy and not its selected parts. Therefore, all labor share measures considered here are *gross* measures, inclusive of depreciation. For a discussion on the difference between gross and net factor shares, see Rognlie (2015) and Bridgman (2017). We also exclude sector-specific factor shares, such as the factor shares in the corporate sector (Karabarbounis and Neiman, 2014). For an indicative sectoral analysis, though, please consult Online Appendix Section E.

2. Measuring the labor share is not limited to aggregate or sectoral data only. Highly disaggregated data are sometimes also used to estimate aggregate factor shares. For example, Young (1995) used census and survey data to match the self-employed and other unpaid workers with employees, cross-tabulated by gender, sector, age, and other relevant characteristics. He then imputed implicit labor compensation for the individuals belonging to the labor force groups that are listed as "unpaid" in

official statistics. So, imputed labor incomes constitute a microfounded way of adjusting the Naive labor share measure. Last but not least, there is seminal work of Dale Jorgenson and coauthors, aiming to document aggregate quality adjusted labor services as well as labor compensation (see Ho and Jorgenson, 1999, for example). However, viewed from the perspective of the current analysis, we exclude these data because available series are only annual and have shorter time span, that is, the postwar period.

3. Note that **SE-GVA** is also the "headline measure" of the US labor share in Elsby *et al.* (2013).

4. We have examined this issue more systematically by checking stationarity of *differences* between all possible pairs of alternative labor share measures. Our results (available on request) indicate that stationarity of differences is typically rejected.

5. We applied a smoothing parameter equal to 100 and 1600 to annual and quarterly data, respectively. We also examined one-sided HP filtered series as well as used the Ravn and Uhlig (2002) adjustment to the smoothing parameter applied to the annual series, with minimal qualitative differences.

6. Analyses based on annual data trimmed to the period 1947–2012 are available upon request.

7. We also tried an AR(2) specification. Despite the fact that, as opposed to the AR(1) model, such a specification is able to capture hump-shaped dynamics with a stationary stochastic process, our results are very similar. The sum of both autoregressive coefficients is generally close to but significantly less than unity. Adding a quadratic trend substantially reduces the estimated persistence. The differences across various labor share specifications are of comparable magnitude. Details are available from the authors upon request.

8. The Bayesian method used to retrieve these shocks is, for given priors, to evaluate the likelihood using the sequential importance resampling particle filter and Randomized Block Metropolis-Hastings algorithm to maximize the posterior. After filtering, the historical distribution of the volatilities is obtained by a backward-smoothing routine.

9. As before, we repeated the exercise with a one-sided HP filter with minimal qualitative differences.

10. Our analysis suggests that if there were structural breaks, there have been more than one. This pertains to all the considered series. First, we find that the $\mathcal{F}$ statistic of the Chow single breakpoint test, based on a simple data-generating process including only deterministic components, is below its critical value at any possible breakpoint. Therefore, this test does not allow us to reject the null of no structural break against the alternative of a single break.

11. Notice that the fall in the labor share from 2001 is not always picked up by the tests reflecting the influence of "trimming" at the end of the sample, as well as the fact that we limit the number of breaks to at most five.

12. Naturally, we mean "convergence" in terms of dynamic and frequency characteristics, rather than convergence of levels, the ruling out of which was discussed in Section 3.

13. To be more precise, our medium-frequency component is equivalent to the Comin and Gertler (2006) "low-frequency subcomponent" of medium-term business cycles.

14. The shares of given frequency domains in the total variance of a time series have been computed by cumulating raw periodogram values over each desired frequency (low, medium, and high), and then dividing by total variance. Such an estimator is only asymptotically consistent, though (for a general overview, see Hamilton, 1994, chapter 6), which provides the caveat that its efficiency can be low if the series is short.

15. The annual **SE-GDP** variant should be treated with caution. Robustness of the long cycle to subtracting a quadratic trend is in the case of this series likely driven by a structural break in the NIPA data on self-employment. To a smaller extent, this break also influences the properties of **SE-GVA**.

16. High-frequency fluctuations are also the most important part of the frequency domain for **BLS** series but only when the quadratic trend is extracted from data.

17. See McAdam and Willman (2013b) for a derivation of real marginal costs in the NKPC framework assuming a CES production function and parametric factor utilization margins.
18. Occasionally, as in other studies, its point estimate numerically exceeds one marginally (indeed, some authors set $\beta = 1$ in estimation for simplicity, Martins and Gabriel, 2009) but is still insignificantly different from standard values 0.95–0.99)
19. For example, Galí *et al.* (2001), Gagnon and Khan (2005), and Smets and Wouters (2003) for the euro area.

References

Acemoglu, D. (2003) Labor-and capital-augmenting technical change. *Journal of the European Economic Association* 1: 1–37.

Arpaia, A., Pérez, E. and Pichelmann, K. (2009) Understanding labour income share dynamics in Europe. Working paper, European Commission, European Economy Paper No. 379.

Autor, D.H., Levy, F. and Murnane, R.J. (2003) The skill content of recent technological change: An empirical exploration. *Quarterly Journal of Economics* 118(4): 1279–1333.

Bai, J. and Perron, P. (2003) Computation and analysis of multiple structural change models. *Journal of Applied Econometrics* 18(1): 1–22.

Bentolila, S. and Saint-Paul, G. (2003) Explaining movements in the labor share. *Contributions to Macroeconomics* 3(1): 1–33.

Blanchard, O. and Giavazzi, F. (2003) Macroeconomic effects of regulation and deregulation in goods and labor markets. *Quarterly Journal of Economics* 118: 879–908.

Blanchard, O.J. (1997) The medium run. *Brookings Papers on Economic Activity* 28(2): 89–158.

Bowley, A.L. (1937) *Wages and Income in the United Kingdom since 1860*. Cambridge: Cambridge University Press.

Bridgman, B. (2017) Is labor's loss capital's gain? Gross versus net labor share. *Macroeconomic Dynamics*, forthcoming.

Buera, F.J. and Kaboski, J.P. (2012) The rise of the service economy. *American Economic Review* 102(6): 2540–2569.

Cobb, C.W. and Douglas, P.H. (1928) A theory of production. *American Economic Review* 18: 139–165.

Comin, D. and Gertler, M. (2006) Medium-term business cycles. *American Economic Review* 96(3): 523–551.

Cooley, T.F. and Prescott, E.C. (1995) Economic growth and business cycles. In T.F. Cooley (ed.), *Frontiers of Business Cycle Research* (pp. 1–38). Princeton: Princeton University Press.

de Serres, A., Scarpetta, S. and de la Maisonneuve, C. (2002) Sectoral shifts in europe and the United States: How they affect aggregate labour shares and the properties of wage equations. Working paper WP 326, OECD Economics Department.

Elsby, M., Hobijn, B. and Sahin, A. (2013) The decline of the U.S. labor share. *Brookings Papers on Economic Activity* 47(2): 1–63.

Fernández-Villaverde, J. and Rubio-Ramirez, J. (2013) Macroeconomics and volatility: Data, models, and estimation. In *Advances in Economics and Econometrics: Theory and Applications, 10th World Congress of the Econometric Society*, Cambridge University Press.

Gagnon, E. and Khan, H. (2005) New phillips curve under alternative production technologies for Canada, the United States, and the Euro area. *European Economic Review* 49(6): 1571–1602.

Galí, J. (2015) *Monetary Policy, Inflation, and the Business Cycle: An Introduction to the New Keynesian Framework and Its Applications*. Princeton: Princeton University Press.

Galí, J. and Gertler, M. (1999) Inflation dynamics: A structural econometric analysis. *Journal of Monetary Economics* 44: 195–222.

Galí, J., Gertler, M. and Lopez-Salido, J.D. (2001) European inflation dynamics. *European Economic Review* 45(7): 1237–1270.

Gollin, D. (2002) Getting income shares right. *Journal of Political Economy* 110: 458–474.

Gomme, P. and Rupert, P. (2007) Theory, measurement and calibration of macroeconomic models. *Journal of Monetary Economics* 54(2): 460–497.

Growiec, J., McAdam, P. and Mućk, J. (2018) Endogenous labor share cycles: Theory and evidence. *Journal of Economic Dynamics and Control* 87: 74–93.

Hamilton, J.D. (1994) *Time Series Analysis*. Princeton: Princeton University Press.

Hamilton, J.D. (2010) Macroeconomics and ARCH. In T. Bollerslev, J.R. Russell and M. Watson (eds.), *Festschrift in Honor of Robert F. Engle*, Chapter 12 (pp. 79–96). Oxford: Oxford University Press.

Ho, M.S. and Jorgenson, D.W. (1999) The quality of the US work force, 1948-95. Harvard University, mimeo with data update through 1999.

Jalava, J., Pohjola, M., Ripatti, A. and Vilmunen, J. (2006) Biased technical change and capital-labour substitution in Finland, 1902-2003. *The B.E. Journal of Macroeconomics* 6(1): 1–20.

Johnson, D. (1954) The functional distribution of income in the United States, 1850-1952. *Review of Economics and Statistics* 36: 175–182.

Jones, C.I. (2005). The shape of production functions and the direction of technical change. *Quarterly Journal of Economics* 120: 517–549.

Kaldor, N. (1961). Capital accumulation and economic growth. In L.A. Lutz and D.C. Hague (eds.), *The Theory of Capital*. London: Palgrave Macmillan.

Karabarbounis, L. and Neiman, B. (2014) The global decline of the labor share. *Quarterly Journal of Economics* 129(1): 61–103.

Klump, R., McAdam, P. and Willman, A. (2007) Factor substitution and factor augmenting technical progress in the US: A normalized supply-side system approach. *Review of Economics and Statistics* 89: 183–192.

Kongsamut, P., Rebelo, S. and Xie, D. (2001) Beyond balanced growth. *Review of Economic Studies* 68(4): 869–882.

Kyyrä, T. and Maliranta, M. (2008) The micro-level dynamics of declining labour share: Lessons from the Finnish great leap. *Industrial and Corporate Change* 17: 1146–1172.

Martins, L.F. and Gabriel, V.J. (2009, December) New Keynesian Phillips curves and potential identification failures: A generalized empirical likelihood analysis. *Journal of Macroeconomics* 31(4): 561–571.

Mavroeidis, S., Plagborg-Møller, M. and Stock, J.H. (2014) Empirical evidence on inflation expectations in the New Keynesian Phillips curve. *Journal of Economic Literature* 52(1): 124–188.

McAdam, P. and Willman, A. (2013a) Medium run redux. *Macroeconomic Dynamics* 17(4): 695–727.

McAdam, P. and Willman, A. (2013b) Technology, utilization, and inflation: What drives the New Keynesian Phillips curve? *Journal of Money, Credit and Banking* 45(8): 1547–1579.

Ngai, L.R. and Pissarides, C.A. (2007) Structural change in a multisector model of growth. *American Economic Review* 97(1): 429–443.

Piketty, T. (2014) *Capital in the Twenty-First Century*. Cambridge Massachusetts: Harvard University Press. Translated from French by Arthur Goldhammer.

Raurich, X., Sala, H. and Sorolla, V. (2012) Factor shares, the price markup, and the elasticity of substitution between capital and labor. *Journal of Macroeconomics* 34(1): 181–198.

Ravn, M.O. and Uhlig, H. (2002) On adjusting the Hodrick-Prescott filter for the frequency of observations. *Review of Economics and Statistics* 84: 371–375.

Rognlie, M. (2015) Deciphering the fall and rise in the net capital share: Accumulation or scarcity? *Brookings Papers on Economic Activity* 46(1): 1–54.

Shephard, N. and Andersen, T.G. (2008) Stochastic volatility: Origins and overview. Economics Series Working Papers 389, University of Oxford, Department of Economics.

Smets, F. and Wouters, R. (2003) An estimated dynamic stochastic general equilibrium model of the euro area. *Journal of the European Economic Association* 1(5): 1123–1175.

Stock, J.H. and Watson, M.W. (2003) Has the business cycle changed and why? In *NBER Macroeconomics Annual 2002*, Volume 17, NBER Chapters, pp. 159–230. National Bureau of Economic Research, Inc.

Tsoukis, C., Kapetanios, G. and Pearlman, J. (2011) Elusive persistence: Wage and price rigidities, the New Keynesian Phillips curve and inflation dynamics. *Journal of Economic Surveys* 25(4): 737–768.

Valentinyi, A. and Herrendorf, B. (2008) Measuring factor income shares at the sector level. *Review of Economic Dynamics* 11(4): 820–835.

Young, A. (1995) The tyranny of numbers: Confronting the statistical realities of the east asian growth experience. *Quarterly Journal of Economics* 110(3): 641–680.

Young, A.T. (2004) Labor's share fluctuations, biased technical change, and the business cycle. *Review of Economic Dynamics* 7(4): 916–931.

Young, A.T. (2010) One of the things we know that ain't so: Is US labor's share relatively stable? *Journal of Macroeconomics* 32(1): 90–102.

Young, A.T. (2013) US elasticities of substitution and factor augmentation at the industry level. *Macroeconomic Dynamics* 17(4): 861–897.

Zivot, E. and Andrews, D.W.K. (1992) Further evidence on the great crash, the oil-price shock, and the unit-root hypothesis. *Journal of Business & Economic Statistics* 10(3): 251–270.

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