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## What is the impact of an exogenous shock to the wage share? VAR results for the US economy, 1973-2018

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# DEPARTMENT OF ECONOMICS

## Working Paper

**What is the impact of an exogenous shock to the wage share? VAR results for the US economy, 1973-2018**

Deepankar Basu  
Leila Gautham

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# What is the Impact of an Exogenous Shock to the Wage Share? VAR Results for the US Economy, 1973–2018

Deepankar Basu and Leila Gautham<sup>1</sup>

## Abstract

This paper uses a novel empirical strategy to present empirical estimates of the effect of an exogenous shock to distribution on demand and accumulation for the US economy from 1973 to 2018. We use recursive vector autoregressions to identify the impact of shocks to the wage share. We impose restrictions motivated by a simple neo-Kaleckian open-economy model, and build on the recursive identification scheme in Christiano, Eichenbaum and Evans (1999) to show that this small set of plausible and transparent assumptions are sufficient to identify the impact of shocks to distribution. We find that positive shocks to the wage share have long-lasting negative impacts on demand and growth. Our results are robust to the inclusion of additional variables and to differences in specification.

**Key words:** Demand-distribution dynamics, neo-Kaleckian models, functional income distribution, VAR estimation

**JEL classifications:** D3, C32, E25

## 1. Introduction

The relationship between distribution, demand and growth has occupied a central place in contemporary debates within heterodox macroeconomics. Early models that built on the work of Michal Kalecki (collectively referred to as "neo-Kaleckian" models) emphasized the result that distributional changes tilting national income in favor of profits would depress both capacity utilization and the accumulation rate or growth rate. This decidedly underconsumptionist conclusion was put into question by the seminal contribution of Bhaduri and Marglin (1990), who showed that increases in the profit share, through positive effects on investment or the trade balance, might result in an increase in capacity utilization or the rate of growth. A large and growing literature has followed Bhaduri and Marglin's (1990) lead by attempting to empirically ascertain whether individual economies are profit-led or wage-led, the former referring to an economy where a shift in income towards profits boosts demand and growth, and the latter referring to the opposite scenario. We contribute to this literature by using a novel empirical strategy to credibly identify the effect of shocks to the functional distribution of income on aggregate demand and growth.

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Existing empirical studies can be divided into broad groups: structural models that attempt to separately estimate the effect of distribution on different components of aggregate demand, and systems models that investigate the overall relationship between distribution and demand, while accounting for the endogeneity of distributional variables (Blecker 2011). We take the second approach and use vector autoregressions (VARs) to construct impulse response functions as a way to identify the effect of distributional shocks on demand and growth. VARs are powerful tools to explore interrelationships between macroeconomic aggregates while imposing minimal restrictions. But by themselves, i.e. without additional restrictions, they cannot tell us about how the economy might respond to distributional shocks. Existing studies that estimate the effect of distribution on demand have not paid much attention to the identification of shocks to distribution. We use a recursive strategy to identify the impact of shocks to the wage share on demand and growth for the US economy from 1973 to 2018. We impose a minimal set of assumptions, and show that our results are robust to differences in specification. Our substantive contribution is therefore in providing convincing empirical estimates of the effect of shocks of distribution on demand and growth.

The rest of this chapter is structured as follows: the next section lays out a simple theoretical model outlining the relationship between distribution and demand in the context of an open economy that we use to guide our empirical strategy. In this section, we also review existing empirical studies with a focus on papers that estimate the effect of the wage share or profit share on capacity utilization using a VAR methodology. Section 3 discusses the VAR framework and the problem of identifying structural shocks. We then outline two identification strategies that we use to identify shocks to distribution: a pure recursive VAR and a modified recursive VAR that builds on the seminal contribution of Christiano, Eichenbaum and Evans (1999). We discuss the application of both strategies to our research question, and present an econometric model and a discussion of the restrictions that we impose to identify shocks to distribution. Sections 4 and 5 describe our data and present and discuss our main results.

## **2. Neo-Kaleckian models and empirical work**

This section presents a basic neo-Kaleckian open economy model of the short run, extends it to account for medium run dynamics, and reviews some empirical literature relevant for our work. In section 2.1, we present a basic short-run model of the goods market that outlines the standard post-Keynesian/neo-Kaleckian insight of how the functional distribution of income determines aggregate demand. This model assumes a given real exchange rate and functional distribution. In section 2.2, following Blecker (2011), we then present a dynamic model of conflicting-claims inflation and a managed exchange rate,

which solves for medium-run equilibrium levels of the wage share and real exchange rate. Our modelling framework serves to synthesize existing insights from the theoretical post-Keynesian literature and forms a backdrop for the discussion of the empirical literature in section 3.3. The theoretical results also guide our own empirical strategy.

## 2.1 The baseline model

We model a one-sector open economy, where prices are set as a mark-up over average variable costs and labor is assumed to be the only variable input. Our pricing equation is therefore given as

$$P_t = (1 + \tau)W_t a_t$$

where  $P$  denotes prices,  $\tau$  is the mark-up,  $W$  is the nominal wage, and  $a$  denotes the inverse of labor productivity (subscripts for all variables denote the time period). Expressions for the wage share  $\psi$  and the real exchange rate  $q$  are therefore given by

$$\psi_t = \frac{W_t a_t}{P_t}$$

$$q_t = \frac{E_t P_t^F}{P_t}$$

where  $P^F$  denotes foreign prices and  $E$  denotes the nominal exchange rate (price of the foreign currency in terms of the domestic currency, for instance, \$/€). For the short-run goods market equilibrium, we assume that nominal wages, prices, labor productivity (and hence the wage share) and exchange rates and foreign prices are given. The open economy national income accounting identity (omitting fiscal variables for simplicity) would therefore require that

$$\frac{S_t}{K_t} = \frac{I_t}{K_t} + \frac{TB_t}{K_t}$$

where  $S$ ,  $I$ ,  $TB$ , and  $K$  refer, respectively, to aggregate savings, gross investment, the trade balance and capital stock. As is standard in post-Keynesian models, our behavioral equations represent the savings rate and the investment rate as depending negatively on the wage share and positively on the rate of capacity utilization  $z$ , so we have

$$s \equiv \frac{S_t}{K_t} = s(\psi_t, z_t), s_\psi < 0, s_z > 0$$

$$g \equiv \frac{I_t}{K_t} = g(\psi_t, z_t), g_\psi < 0, g_z > 0$$

We assume the ratio of the trade balance to capital stock to be a positive function of the real exchange rate and a negative function of the capacity utilization rate,

$$b \equiv \frac{TB_t}{K_t} = b(q_t, z_t), b_q > 0, b_z < 0$$

Substituting for these relations in the national income identity we get

$$s(\psi_t, z_t) = g(\psi_t, z_t) + b(q_t, z_t)$$

which allows us to solve for the equilibrium rate of capacity utilization as a function of the wage share and real exchange rate

$$z_t = z(\psi_t, q_t),$$

a linear version of which can be written as

$$z_t = a_0 + a_1\psi_t + a_2q_t \quad (1)$$

Demand can be characterized as profit-led if the partial derivative of equilibrium capacity utilization with respect to the wage share is negative, and growth is profit-led if the partial derivative of the accumulation rate (as a function of the equilibrium rate of capacity utilization) with respect to the wage share is negative.

While prices, nominal wages and the exchange rate are given in the short-run, we would expect them to adjust over the medium run. Following Blecker's (2011) adaptation of the conflict-driven inflationary process, we model the adjustment of prices by assuming that firms have a target mark-up rate (corresponding to a target wage share) that they attempt to achieve when setting prices, and that this target mark-up rate depends positively on the real exchange rate; we also assume that firms base their pricing decisions on past realizations of the wage share and the real exchange rate (which is a plausible assumption, as current realizations of the wage share and the real exchange rate depend on current prices and wages, and hence would not be known to firms). We can therefore model the dynamics of prices as

$$P_t = P_{t-1}[1 + p(\psi_{t-1}, q_{t-1})]$$

with  $p_\psi > 0$  (a higher wage share means that firms are further away from their target mark up and adjust prices upwards) and  $p_q > 0$  (a depreciation would improve competitiveness and induce firms to raise their prices).

Similarly, we assume that workers have a target real wage and that lower realized real wages in the previous period induces them to bargain for higher nominal wages in the present period. We can therefore think of nominal wage growth as depending positively on the difference between some target  $\omega$  and the previous period realization of  $\frac{W_{t-1}}{P_{t-1}^\alpha P_{t-1}^{F1-\alpha}}$  where  $\alpha$  denotes the relative importance of domestic goods in the workers' consumption bundles. So, we have

$$W_t = W_{t-1}[1 + w(\psi_{t-1}, q_{t-1})]$$

with  $w_\psi > 0$  and  $w_q > 0$ .

Finally, we model nominal exchange rates as being managed by the central bank which has a target real exchange rate, and adjusts nominal exchange rates to achieve that target

$$E_t = E_{t-1}[1 + e(q_{t-1})]$$

with  $e_q > 0$ .

These three equations give us dynamic equations for the adjustment of the wage share and the real exchange rate

$$\widehat{\psi}_t = \widehat{W}_t + x - \widehat{P}_t = w(\psi_{t-1}, q_{t-1}) - x - p(\psi_{t-1}, q_{t-1})$$

$$\widehat{q}_t = \widehat{E}_t + \widehat{P}_t^F - \widehat{P}_t = e(q_{t-1}) - p^F - p(\psi_{t-1}, q_{t-1})$$

where  $x$  and  $p^F$  denote the growth rate of labor productivity and the foreign price level, and are taken as given.

The steady-state values of  $q$  and  $\psi$  therefore satisfy

$$w(\psi, q) - x - p(\psi, q) = 0 \quad (2)$$

$$e(q) - p^F - p(\psi, q) = 0 \quad (3)$$

Equations (1), (2) and (3) define the baseline neo-Kaleckian model that we estimate and use for the VAR analysis. While we use the baseline model is useful for initiating the analysis, it has three important limitations.

First, it takes the accumulation rate to be affected contemporaneously by the wage share and capacity utilization rate, and does not allow for exogenous shocks to the accumulation rate. Rather, we would expect the accumulation rate to be exogenously given in the short-run with firms basing their investment decisions on past values of the wage share and capacity utilization rates; we also need to allow for exogenous shocks to have impacts on investment, primarily to capture the role of animal spirits in determining the accumulation rate. Second, the baseline model takes labor productivity growth to be exogenously given. Labor productivity would depend on the accumulation rate and also on the wage share: a higher wage share may induce firms to substitute away from labor through capital deepening. It would therefore be essential to allow for the endogeneity of labor productivity growth when attempting to estimate the interaction between the wage share and capacity utilization and accumulation. Finally, we would expect the setting of nominal wages and wage bargaining to depend on the unemployment rate. A more complete specification would therefore include three additional variables: the accumulation rate, the growth rate of labor productivity and the unemployment rate.

## 2.2 An extended Neo-Kaleckian model

Given the problems of the baseline model, we need to incorporate additional variables into our analysis and develop an extended neo-Kaleckian model. The first modification we bring in is to note that the rate of capital accumulation,  $g_t$ , is completely determined by variables in the previous period. This follows our understanding, alluded to above, that capital accumulation decisions are largely inherited from the past, they are not impacted by contemporaneous variables,

$$g_t = g(u_{t-1}, x_{t-1}, \psi_{t-1}, q_{t-1}, z_{t-1}) \quad (4)$$

The second modification is to endogenize labor productivity growth. We posit that the growth rate of labour productivity depends on the accumulation rate (thus allowing for Kaldor-Verdoorn learning-by-doing effects of investment on productivity growth) and also on the unemployment rate and the wage share, the latter two factors capturing the effects of labor-saving technological change:

$$x_t = x(g_t, u_t, \psi_t) \quad (5)$$

Next we turn to the determination of real exchange rate. Our analysis in the baseline model had shown that, in a medium run equilibrium, the real exchange rate is impacted by the wage share – capturing the effect of wage pressures on the relative price of domestic goods in the international market. To that mechanism, we now add to more determinants: the unemployment rate and the rate of capital accumulation. The first is meant to capture the effect of labour market tightness and the latter the impact of possible embodied technological change on relative prices. Bringing these together, we have

$$q_t = q(\psi_t, u_t, g_t) \quad (6)$$

The adjustment of prices is unchanged; however, we modify the nominal wage-setting process to depend on current unemployment rates (which affects the bargaining power of workers) and previous period labor productivity growth (which affects real wages for a given wage share) in addition to the previous period values of the wage share and the real exchange rate,

$$W_t = W_{t-1}[1 + w(u_t, x_{t-1}, \psi_{t-1}, q_{t-1})]$$

The equation for the adjustment of the wage share is altered as follows

$$\widehat{\psi}_t = w(u_t, x_{t-1}, \psi_{t-1}, q_{t-1}) - x(g_t, u_t, \psi_t) - p(\psi_{t-1}, q_{t-1}),$$

So that, in medium run equilibrium, the wage share becomes a function of the unemployment rate and the rate of capital accumulation,

$$\psi_t = \psi(u_t, g_t) \quad (7)$$

We allow the unemployment rate to depend on the rate of capacity utilization and labor productivity growth in the previous period, as well as on the current rate of accumulation,



$$u_t = x(g_t, z_{t-1}, x_{t-1}) \quad (8)$$

Finally, the rate of capacity utilization, being an indicator of demand, is impacted by all variables contemporaneously

$$z_t = z(g_t, u_t, \psi_t, q_t, x_t) \quad (9)$$

Equations (4) through (9) comprise the extended neo-Kaleckian model in this paper.

We estimate both the baseline model – given by equations (1) through (3) – and the extended model –given by linear versions of equations (4) through (9). The advantage of estimating the baseline model is that it requires fewer assumptions and is easier to interpret; however, the inclusion of additional variables is necessary for a more complete specification, and we therefore also estimate the extended model.

### **2.3 Existing empirical literature**

Empirical studies that examine the relationship between, on the one hand, distributional variables and, on the other, aggregate demand and growth, can be usefully divided into two categories: structural models (that attempt to separately estimate the different components of aggregate demand) and aggregative or systems models (that look at the overall relationship between distribution and demand). Examples of studies that attempt an econometric estimation of structural models include Hein and Vogel (2007), Stockhammer, Onaran and Ederer (2008), and Onaran, Stockhammer and Grafl (2011), among many others. As structural approaches typically regress the various components of aggregate demand (consumption, investment, exports, imports) on some measure of the functional distribution and other controls variables, their estimates are biased to the extent that the wage/profit share is endogenous. Moreover, estimating separate econometric equations for each component of aggregate demand misses out on dynamic interactions between these components, making it hard to interpret their coefficients or even computing standard errors for important effects that involve parameters from different equations (an example of the latter is the total effect of the profit share on the growth rate of GDP reported in Table 10 in Hein and Vogel (2008)).

Aggregative or systems approaches address the endogeneity of distribution and demand either through the use of instrumental variables or methods such as vector autoregressions (VARs). As our own method in this paper falls under this category, we provide a brief overview of studies that attempt to estimate the relationship between demand and distribution using systems approaches, highlighting, in each case, what we see to be limitations or problems in their methodology. Stockhammer and Onaran (2004) look at accumulation, demand, distribution and unemployment for the UK (1970-1997),

the US (1966-1997) and France (1972-1997) using a VAR analysis. They formulate a structural Kaleckian model for the interactions between these variables which provides the motivation for restrictions on contemporaneous effects in their VAR analysis. While their analysis confirms key Keynesian insights such as the importance of the goods market in determining unemployment, they do not find any significant effect of the distributional variable on effective demand for any of the countries. They do not read this as supporting the absence of interaction between distribution and demand, but rather that the positive and negative effects of the profit share on effective demand roughly offset each other.

However, some of their key identifying restrictions appear to be arbitrary rather than motivated by theoretical priors. For example, they allow capacity utilization to have a contemporaneous effect on the profit share, but do not allow the profit share to have a contemporaneous effect on capacity utilization. This contradicts their own theoretical model: capacity utilization is assumed to be determined by the *current* value of the profit share (equation 5, p. 424). It is possible that this restriction contributes to their finding that distribution does not play a role in determining goods market outcomes - by assumption, they do not allow distribution to have contemporaneous effects on utilization. A second problem is their failure to include real exchange rate dynamics in their analysis: as Blecker (2011) points out, an open economy with flexible mark-ups would respond differently depending on the source of the increase in the profit share.

Barbosa-Filho and Taylor (2006) more narrowly analyze the interaction between capacity utilization and the labor share for the US economy (1948-2002) using a 2-variable VAR. They find demand to be profit-led and distribution to be characterized by a profit-squeeze, providing empirical support for the Goodwin model. Their conclusions are, however, based exclusively on estimates from reduced form VARs. For the reduced form errors to *not* exhibit contemporaneous correlation, the labor share must not have a contemporaneous effect on capacity utilization, and vice versa. If this does not hold their estimates are appropriate for forecasting purposes but cannot be given a causal interpretation (Sims 1986). Other studies using VAR approaches generally appear to confirm these qualitative findings (profit-led demand and profit squeeze) (Carvalho and Rezai 2015, Kiefer and Rada 2014). Carvalho and Rezai (2015) split their US sample into two periods based on the degree of income inequality (pre- and post-1981) and estimate a recursive VAR for the labor share and capacity utilization. They do not, however, specify or justify the causal ordering they employ in the Cholesky decomposition that they appear to use. As impulse response functions from a recursive VAR are generally sensitive to the causal ordering that is imposed, this strengthens our view that estimations of demand and distribution have not paid much attention to the problem of identification.

A second, more substantive, problem is that with the exception of Stockhammer and Onaran (2004) the studies mentioned above estimate only bivariate VARs in capacity utilization and the wage/profit share. While this is a direct result of their focused attention on Goodwin-type dynamics, the simplicity of the model - which is certainly desirable in the case of a theoretical framework that intends to explain a particular dynamic process in capitalist economies - poses an important problem in econometric estimation: in particular, the issue of omitted variables and misspecification. In low-dimensional VARs, the effects of omitted variables are subsumed under “innovations” to included variables. If important variables are omitted from the system, the estimated impulse responses may be highly distorted and not have a structural interpretation (Lutkepohl 2005, 62). In the context of reduced form VARs in distribution and demand, as Skott (2017) persuasively argues, exogenous shocks may affect *both* demand and distribution, which means that we cannot uniquely ascertain the relationship between demand and distribution. A good example of this could be shocks that reduce wages in the context of flexible price mark-ups: this would increase the profit share but would also affect aggregate demand through the channel of real exchange rates. If real exchange rates are not controlled for, the estimated effect of distribution on demand would be very different than if the source of the positive shock to the profit share was a rise in the mark-up rate. The estimated relationship therefore hinges on which source of the shock is more common. While there could be multiple such sources of shocks, it should not preclude any attempt at empirical estimation. Rather, a more careful consideration of the factors that affect both distribution and demand and a properly-specified model would allow us to get at more convincing estimates of the relationship between distribution and demand. Our methodology, which we describe in section 3 below, attempts to do precisely that. We therefore believe that our estimates improve significantly on both the estimations based on structural models and on existing aggregative studies.

### **3. VAR and the Two Identification Strategies**

A vector autoregression (VAR) is a linear model in which each variable is explained by its own lagged values and the past and/or current values of the other variables in the system. Since their introduction by Sims (1980) they have been widely used as a macro-econometric tool to capture dynamic interactions in multiple time series (Stock and Watson 2001). To briefly describe the problem: the starting point of a VAR analysis would be to select a set of variables suggested by the theoretical model and regress each variable on its own lagged values and the lagged values of other variables. The resulting estimates from the reduced form model can be used to trace out the effect of a shock to one variable on the system. These dynamic response functions (called impulse responses) however, cannot

be interpreted as causal because these variables are likely to be correlated with each other, and we therefore cannot expect the shocks to be contemporaneously uncorrelated. Hence a shock to one variable would also have a contemporaneous effect on some other variable in the system through its own error term. The only way to generate economically meaningful impulse response functions is to work with orthogonal shocks, i.e. where each shock is contemporaneously uncorrelated with every other shock. However, there is no unique way to orthogonalize the reduced form errors. Identifying the full set of contemporaneous relations between all variables is impossible without imposing a sufficient number of restrictions.

To describe it formally, suppose our dynamic macro-econometric model is given by

$$AX_t = A_0 + A_1X_{t-1} + \dots + A_pX_{t-p} + e_t$$

where  $X_t = [\psi_t, q_t, z_t]'$  is a  $3 \times 1$  vector of three variables - the wage share, the real exchange rate, and the capacity utilization rate - of our baseline model;  $A$  is the matrix of contemporaneous relations between the variables;  $A_i$  is the matrix of relations between current values and lagged values, and  $e_t$  are structural shocks. In addition to the linearity assumption and time-invariance of the coefficients, we assume that  $\Sigma_e = E(e_t e_t') = I$  and  $E(e_s, e_t') = 0, \forall s \neq t$ . Given the endogeneity of the regressors, we cannot directly estimate this structural model. We instead estimate the reduced form model which is given by

$$X_t = B_0 + B_1X_{t-1} + \dots + B_pX_{t-p} + u_t$$

The reduced form errors are not contemporaneously uncorrelated:  $\Sigma_u = E(u_t u_t') = A^{-1} A^{-1'}$  and so the covariance matrix for the reduced form errors is not diagonal unless the matrix  $A$  is an identity matrix (in which case, none of the variables have a contemporaneous effect on each other). The implication of this is that we cannot interpret impulse responses calculated from the reduced form VAR as the causal impact of a shock to one variable in the system. Recovering the structural VAR from the reduced form estimates would, however, require us to impose a sufficient number of restrictions. In our  $3 \times 3$  VAR, for example, we can estimate the  $3 \times 3$   $\Sigma_u$  matrix. As it is symmetric, it contains 6 distinct values. As the  $A$  matrix has 9 distinct values, the system of equations given by  $\Sigma_u = A^{-1} A^{-1'}$  is under-identified. In particular, we need three additional restrictions to recover the structural model (for an  $n$ -variable system we would need  $\frac{n(n-1)}{2}$  restrictions).

In general, strategies for identification can be classified into two broad groups: structural VARs and recursive VARs. A recursive VAR depends on a particular ordering of the variables and implies restrictions on which variables are allowed to have contemporaneous effects on other variables. In particular, the strategy for estimating a recursive VAR involves imposing a lower (or upper) triangular

structure on the matrix  $A$ , which implies a strict ordering of the contemporaneous effects of variables in the VAR. An early example of a recursive VAR is Sims (1980). A key drawback of a recursive VAR is that changing the ordering of variables alters the impulse response functions. A structural VAR uses economic theory to impose restrictions on contemporaneous links between variables that do not necessarily force  $A$  into a triangular structure (Bernanke 1986, Sims 1986, Blanchard and Quah 1989). While triangularization guarantees the existence of a unique solution, we do not necessarily have a solution in the case of a structural VAR even if we impose the required number of restrictions – because the system of equations that need to be solved,  $\Sigma_u = A^{-1}A^{-1'}$ , are nonlinear, and the restrictions just make the number of equations equal to the unknowns.

### 3.1 Baseline model: A pure recursive VAR

To estimate our baseline model we employ a recursive VAR approach and use the model given in equations (1) through (3) to guide our causal ordering. The model suggest that both the real exchange rate  $q$  and the wage share  $\psi$  have a contemporaneous impact on the capacity utilization rate: therefore, we do not restrict the equation for the capacity utilization rate and allow it to be affected by current and lagged values of all three variables. However, our model does suggest that capacity utilization does not have a contemporaneous effect on either the exchange rate or the wage share: this gives us two zero restrictions on the matrix  $A$ . In order to identify the system we need a third restriction: theory does not suggest a particular causal ordering between  $q$  and  $\psi$ . We are therefore left with two possible orderings:  $\psi \rightarrow q \rightarrow z$  and  $q \rightarrow \psi \rightarrow z$ , where  $\rightarrow$  denotes causal impact running from the left to the right, for a recursive VAR identification.

Using  $e_t$  and  $u_t$  to denote structural and reduced form shocks, respectively, the first ordering would suggest that the equation  $Au_t = e_t$  takes the form

$$\begin{bmatrix} a_{11} & 0 & 0 \\ a_{21} & a_{22} & 0 \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{bmatrix} u_t^\psi \\ u_t^q \\ u_t^z \end{bmatrix} = \begin{bmatrix} e_t^\psi \\ e_t^q \\ e_t^z \end{bmatrix}$$

which suggests that shocks to capacity utilization are not allowed to affect current values of the real exchange rate and the wage share, and shocks to the real exchange rate are allowed to affect current values of the wage share. The second ordering would suggest that the equation  $Au_t = e_t$  takes the form

$$\begin{bmatrix} a_{11} & 0 & 0 \\ a_{21} & a_{22} & 0 \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{bmatrix} u_t^q \\ u_t^\psi \\ u_t^z \end{bmatrix} = \begin{bmatrix} e_t^q \\ e_t^\psi \\ e_t^z \end{bmatrix}$$

which suggests, again, that shocks to capacity utilization are not allowed to affect current values of the

wage share and real exchange rate, and shocks to capacity utilization do not affect current values of the real exchange rate. We estimate both orderings and compare them to ascertain the robustness of our results.

### 3.2 Extended Model: CEE recursive VAR

The extended model introduces three variables in addition to the wage share, real exchange rate and capacity utilization rate and also suggests how contemporaneous links between these variables could be modelled, as we have discussed in section 2.2. Since there are a total of 720 possible orderings among the 6 variables in our system, a strategy based on recursive identification and comparisons among the impulse response functions from the different orderings is infeasible. Another possible approach would be to impose restrictions on the  $A$  matrix and estimate the full set of structural shocks, as used in, for instance, Bernanke (1986) or Sims (1986). The disadvantage of this approach is that it requires us to specify many more restrictions – in this case a total of 15 restrictions – than can be justified by theoretical considerations alone. Moreover, as we have indicated above, this approach does not guarantee the existence or uniqueness of the impulse response functions. Hence, we turn to an alternative identification strategy developed by Christiano, Eichenbaum and Evans (1999) (henceforth CEE).

The CEE methodology is a modified recursive VAR approach. Its power lies in the fact that it guarantees existence and uniqueness of the impulse response functions without requiring a full set of causal ordering among the variables in the VAR. The main disadvantage of the CEE method is that it can identify the structural shocks associated with only one variable in the VAR. For us, this is not a problem because our interest is in identifying only the shock to distribution (measured by the wage share) and its impulse response functions. More precisely, since our variable of interest is  $\psi$ , the only assumptions necessary to uniquely identify the effect of a structural shock to  $\psi$  are to partition all the other variables into two sets: a set of variables of  $X_{1t}$  that are causally prior to  $\psi_t$ , and a set of variables of  $X_{2t}$  that are not causally prior to  $\psi_t$  (that is, they do not have a contemporaneous effect on either  $X_{1t}$  or  $\psi_t$ ). If we have  $k_1$  variables that are causally prior to  $\psi_t$  and  $k_2$  that are not causally prior to  $\psi_t$ , this implies that the identification of the structural shocks through the equation  $\Sigma_u = A^{-1}A^{-1'}$  restricts the matrix  $A$  be of the form

$$\begin{bmatrix} A_{11} & 0 & 0 \\ A_{21} & a_{22} & 0 \\ A_{31} & A_{32} & A_{33} \end{bmatrix}$$

where  $A_{11}$  is a  $k_1 \times k_1$  matrix,  $A_{21}$  is  $1 \times k_1$  matrix,  $A_{31}$  is a  $k_2 \times k_1$  matrix,  $A_{32}$  is a  $k_2 \times 1$  vector

and  $A_{33}$  is a  $k_2 \times k_2$  matrix. The pioneering contribution of CEE (1999) was to show that all the matrices  $A$  that satisfy the above block triangular structure and solve the equation  $\Sigma_u = A^{-1}A^{-1'}$  imply the same value for  $a_{22}$ . In effect, therefore, CEE show that imposing a particular causal ordering among  $X_{1t}$  and  $X_{2t}$ , is not necessary in order to uniquely identify  $a_{22}$  (and the elements of the vector  $A_{32}$ ), and therefore the impulse response functions associated with a shock to  $\psi$ .

Hence, our identifying restrictions in the CEE approach are the following:

- a) the rate of accumulation and the unemployment rate are causally prior to the wage share (this means that the wage share does not have a contemporaneous impact on the rate of accumulation or the unemployment rate),
- b) the wage share is causally prior to the real exchange rate, the rate of labor productivity growth and the capacity utilization rate (this means that the real exchange rate, the rate of labor productivity growth and the capacity utilization rate do not have contemporaneous impacts on the wage share, and by the previous assumption, on the rate of accumulation and the unemployment rate).

Note that we do not impose *any restrictions* on the contemporaneous relationships between the rate of accumulation and the unemployment rate; and, neither do we impose *any restrictions* on the contemporaneous relationships between the real exchange rate, the growth rate of labor productivity, and the capacity utilization rate.

## 4. Data

Unless mentioned otherwise, the frequency of all data is quarterly, and the time period is from the first quarter of 1973 to the fourth quarter of 2018. Our starting period is constrained by the availability of data on the real exchange rate. For series that have been seasonally adjusted, we use the seasonally adjusted data. We summarize the construction and sources for the six key variables that we use in our VAR analysis and briefly discuss results from unit root tests on these variables.

### 4.1 Variable definitions

#### *Wage share*

The wage share variable  $\psi$  is the percentage share of compensation of employees in net value added, that is  $\frac{\psi}{100} = \frac{W_n}{Y_n}$ , where  $Y_n$  is the net value added of the corporate business sector in current dollars and is obtained from the National Income and Product Account (NIPA) and  $W_n$  is the compensation of employees in the corporate business sector (corresponding to rows 3 and 4 of NIPA Table 1.14 (Gross

Value Added of Domestic Corporate Business in Current Dollars), respectively).

#### *Real exchange rate*

The variable for the real exchange rate  $q$  is obtained from the Real Trade Weighted US Dollar Index series provided by the Board of Governors of the Federal Reserve System. This is a monthly series of a weighted average of bilateral real exchange rates of a broad group of major US trading partners, where weights are based on annual data on international trade. It is therefore a geometrically weighted average of  $\frac{e_{j,t}p_t}{p_{j,t}}$  where  $e_{j,t}$  is the price of the US dollar in terms of foreign currency  $j$ , and  $p_t$  and  $p_{j,t}$  are price indexes for the US and for economy  $j$ , respectively. Quarterly averages were obtained from the monthly series.

#### *Capacity utilization rate*

The capacity utilization rate  $z$  is constructed as 100 times the ratio of real GDP to potential GDP. Real GDP is a seasonally adjusted quarterly series in chained (2012) dollars and is obtained from the NIPA (corresponding to row 1 of NIPA Table 1.1.6 Real Gross Domestic Product, Chained Dollars). Potential GDP is obtained from Congressional Budget Office estimates of real potential GDP in chained (2012) dollars.

#### *Accumulation rate*

The accumulation rate  $g$  is constructed by dividing gross domestic private non-residential fixed investment (current dollars, seasonally adjusted) by the current cost net stock of private non-residential fixed assets (current dollars). The fixed asset series is annual - quarterly series are not obtainable. The conversion from annual to quarterly data is made by means of linear interpolation. Private non-residential fixed investment is obtained from the NIPA and private non-residential fixed assets are obtained from the BEA's Fixed Assets Accounts (corresponding to row 2 of NIPA Table 5.3.5 (Private Fixed Investment by Type), and row 4 of Fixed Assets Accounts, Table 1.1 (Current-Cost Net Stock of Fixed Assets and Consumer Durable Goods), respectively).

#### *Labor productivity growth rate*

Measures of labor productivity are taken from the BLS's series of real output per hour index for the non-farm business sector (corresponding to the BLS Series ID: PRS85006093). The BLS constructs this series by using BEA's estimates of real non-farm business sector output and dividing this by hours of labor input from BLS's Current Employment Statistics (CES) program, which provides monthly survey data on total employment, and employment and average weekly hours of production.

#### *Unemployment rate*

These data are from the BLS's seasonally-adjusted monthly civilian unemployment rate, which is the



number of unemployed persons as a percentage of the labor force, restricted to the non-institutional civilian population of age 16 and above (this corresponds to the BLS Series ID: LNS14000000). Monthly data was averaged to get the quarterly series. This series pertains to the whole economy rather than just the private sector.

#### 4.2 Descriptions and properties of the time-series variables

As a preliminary step to our econometric analysis and to ensure that our specification is correct, we check for the degree of integration for our 6 variables. From the time series plots for each of our six variables which is shown below, none of the variables display a time trend. We perform an augmented Dickey-Fuller (ADF) test and a Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test to check for the presence of a unit root. Both tests are specified to allow for a drift term but not a time trend (given the lack of a trend observed in the time-series plots). The results from the ADF test and the KPSS test are summarized below in Table 1. The null hypothesis for the ADF test is that the time series has a unit root: we are able to reject the null for  $x$ ,  $g$ , and  $z$  at the 5% level of significance. The ADF rejects the null of non-stationarity for  $q$  at the 10% level, but fails to reject the null for  $u$  and  $\psi$ , even at the 10% level. The null hypothesis for the KPSS test is that the series is stationary. It confirms the results from the ADF test in that we cannot reject the null that  $x$ ,  $g$ , and  $z$  are stationary at the 5% level. However, the KPSS test does not reject the null that  $u$ ,  $q$  and  $\psi$  are stationary at the 10% level. We therefore conclude that three time series ( $g$ ,  $x$ ,  $z$ ) are stationary while three series are marginally stationary ( $u$ ,  $\psi$ ,  $q$ ). In the following section, our VAR specification takes all 6 variables in levels; however, for the purpose of robustness, we also show some of our key results using three variables ( $u$ ,  $\psi$ ,  $q$ ) in differenced form.

**Table 1: ADF and KPSS test results**

|     | ADF                         | KPSS                        |
|-----|-----------------------------|-----------------------------|
| $u$ | Not reject at the 10% level | Not reject at the 5% level  |
| $x$ | Reject at the 1% level      | Not reject at the 1% level  |
| $g$ | Reject at the 1% level      | Not reject at the 1% level  |
| $z$ | Reject at the 5% level      | Not reject at the 5% level  |
| $q$ | Reject at the 10% level     | Not reject at the 10% level |

| $\psi$  | Not reject at the 10% level | Not reject at the 5% level |
|---|-----------------------------|----------------------------|
| Note: All tests include a drift/constant term but no time trends. The null hypothesis for the ADF test is that the series has a unit root. The null for the KPSS test is that the series is stationary. The lags for the ADF test were chosen by AIC criterion. |                             |                            |

## 5. Results

### 5.1 Baseline model: A pure recursive VAR

As explained in section 3.1, we first estimate the reduced form VAR in the wage share, real exchange rate and the capacity utilization rate,

$$X_t = B_0 + B_1X_{t-1} + \dots + B_pX_{t-p} + u_t$$

where  $X_t = [\psi_t, q_t, z_t]'$ . We use a lag length of 2 quarters, which is the optimal lag length as given by the Akaike information criterion (AIC). We include a constant, but not a time trend, as the time series plots do not suggest that any of the variables trend over time. The correlation matrix for the reduced form residuals (the matrix  $\Sigma_u = E(u_t u_t')$ ) is shown in Table 2 below. There is substantial correlation among the residuals to justify treating them all as part of a system.

|        | $\psi$   | $q$      | $z$      |
|--------|----------|----------|----------|
| $\psi$ | 1.00000  | -0.01274 | -0.44751 |
| $q$    | -0.01274 | 1.00000  | -0.03987 |
| $z$    | -0.44751 | -0.03987 | 1.00000  |

In order to identify the structural shocks from the reduced-form errors, we proceed to estimate a recursive VAR using two alternative causal orderings: the causal ordering  $\psi \rightarrow q \rightarrow z$  and the causal ordering  $\psi \rightarrow z \rightarrow q$ , and the results from each are presented below in sections 5.1.1 and 5.1.2 respectively.

#### 5.1.1 Causal ordering $\psi \rightarrow q \rightarrow z$

The recursive VAR implied by this causal ordering does not allow the capacity utilization to have a contemporaneous effect on either the real exchange rate or the wage share and does not allow the real exchange rate to have a contemporaneous effect on the wage share. This imposes a lower triangular form on the matrix  $A$ , which allows us to uniquely identify  $A$  using the matrix of reduced-form residuals shown above in Table 2 in the equation  $\Sigma_u = A^{-1}A^{-1'}$ . Table 3 shows the forecast error

variance decomposition for all three variables based on this causal ordering. For instance, about 27% of the 10-quarter ahead forecast error variance of the capacity utilization rate is accounted for by shocks to the wage share, while 48% of the 10-period ahead forecast error variance for the wage share is accounted for by shocks to the capacity utilization rate. For both the capacity utilization rate and the wage share, variation in the real exchange rate accounts for less than 2% of error variance for any forecast horizon.

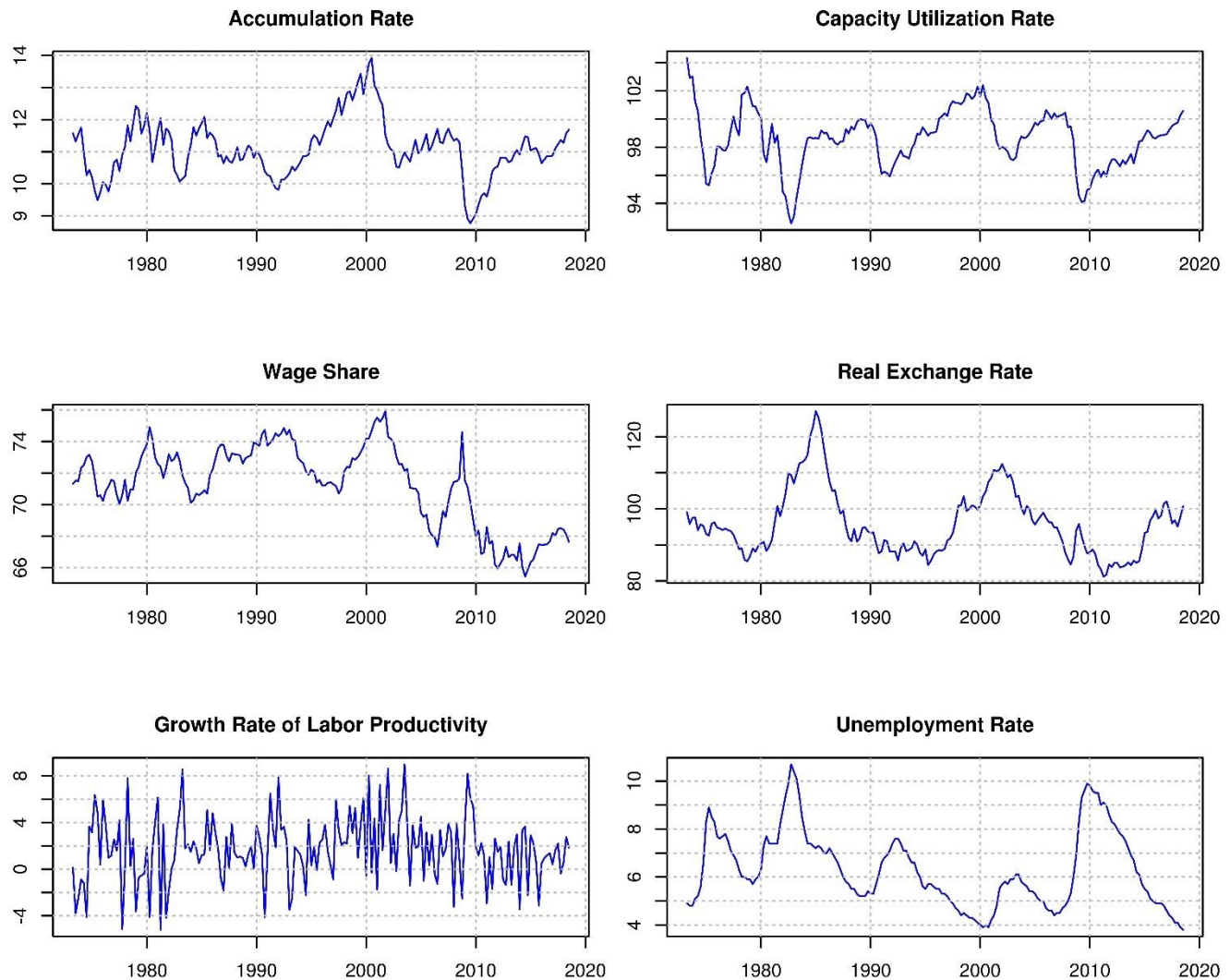


Figure 1: Time series plots of the variables in the VAR analysis for the period 1973Q1 to 2018Q4.

The impulse response functions that are generated using the structural shocks are shown in below in Figure 2, with 95% confidence intervals that are generated by bootstrapped standard errors (100 runs). Panel A shows impulse responses for all three variables due to a 1-standard deviation

increase to the structural error associated with the wage share. The effect of a rise in  $\psi$  on  $q$  is small and negative (a real depreciation), but is not statistically significant. However, an increase in  $\psi$  has a negative effect on the capacity utilization rate that is statistically significant and long-lasting (it persists for more than 15 quarters). This result indicates that aggregate demand can be characterized as being profit-led. Panel B shows impulse response functions due to a 1-standard deviation increase in the structural error associated with the real exchange rate. That the effect of a shock to the real exchange rate on the wage share and the capacity utilization rate is small and not significant is not surprising, as the US is a large, relatively closed, economy. We do however observe that an appreciation of the real exchange rate has a small but positive effect on the wage share, which confirms our theoretical expectations that real appreciations force reductions in the mark-up rate and hence an increase in the wage share. Panel C of Figure 2 shows that a positive 1-standard deviation increase in the structural error associated with the capacity utilization rate has a positive and long-lasting effect on the wage share, indicating the presence of a profit-squeeze.

Table 3. Forecast error variance decomposition for the system  $\psi \rightarrow q \rightarrow z$

| Forecast error in | Quarters ahead | Proportion of forecast error variance accounted for by shocks to |      |      |
|-------------------|----------------|--|------|------|
|                   |                | $\psi$   | $q$  | $z$  |
| $z$               | 10             | 0.27   | 0.01 | 0.72 |
|                   | 15             | 0.28   | 0.01 | 0.71 |
|                   | 20             | 0.28   | 0.01 | 0.70 |
| $q$               | 10             | 0.00   | 0.99 | 0.00 |
|                   | 15             | 0.00   | 0.99 | 0.01 |
|                   | 20             | 0.00   | 0.99 | 0.01 |
| $\psi$            | 10             | 0.52   | 0.00 | 0.48 |
|                   | 15             | 0.36   | 0.01 | 0.63 |
|                   | 20             | 0.29   | 0.02 | 0.69 |

### 5.1.2 Causal ordering $q \rightarrow \psi \rightarrow z$

The recursive VAR implied by this causal ordering does not allow the capacity utilization to have a contemporaneous effect on either the real exchange rate or the wage share but - unlike the previous model - allows the real exchange rate to have a contemporaneous effect on the wage share but does not allow the wage share to have a contemporaneous effect on the real exchange rate. We find that our

main qualitative results are robust to the change in the specification: a positive shock to the wage share has a long-lasting and negative effect on the capacity utilization rate (profit-led demand), while a positive shock to the capacity utilization rate has a positive effect on the wage share (profit squeeze).

Table 4. Forecast error variance decomposition for the system  $q \rightarrow \psi \rightarrow z$

| Forecast error in | Quarters ahead | Proportion of forecast error variance accounted for by shocks to |        |      |
|-------------------|----------------|--|--------|------|
|                   |                | $q$  | $\psi$ | $z$  |
| $z$               | 10             | 0.01   | 0.27   | 0.72 |
|                   | 15             | 0.01   | 0.28   | 0.71 |
|                   | 20             | 0.01   | 0.28   | 0.70 |
| $q$               | 10             | 1.00   | 0.00   | 0.00 |
|                   | 15             | 0.99   | 0.00   | 0.01 |
|                   | 20             | 0.99   | 0.00   | 0.01 |
| $\psi$            | 10             | 0.00   | 0.52   | 0.48 |
|                   | 15             | 0.01   | 0.36   | 0.63 |
|                   | 20             | 0.02   | 0.29   | 0.69 |

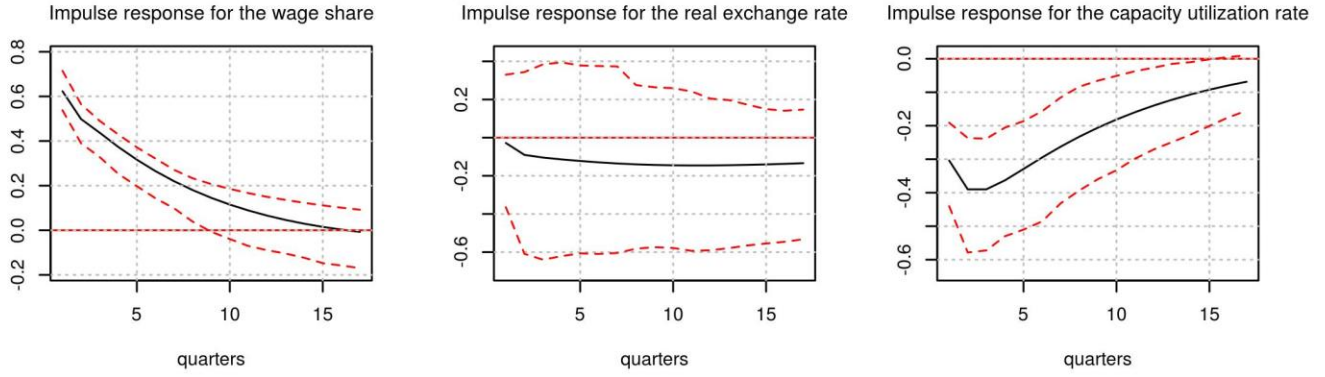
## 5.2 The extended model: CEE recursive VAR

To implement the CEE identification, we first estimate a reduced form VAR for all 6 variables of our extended: we estimate

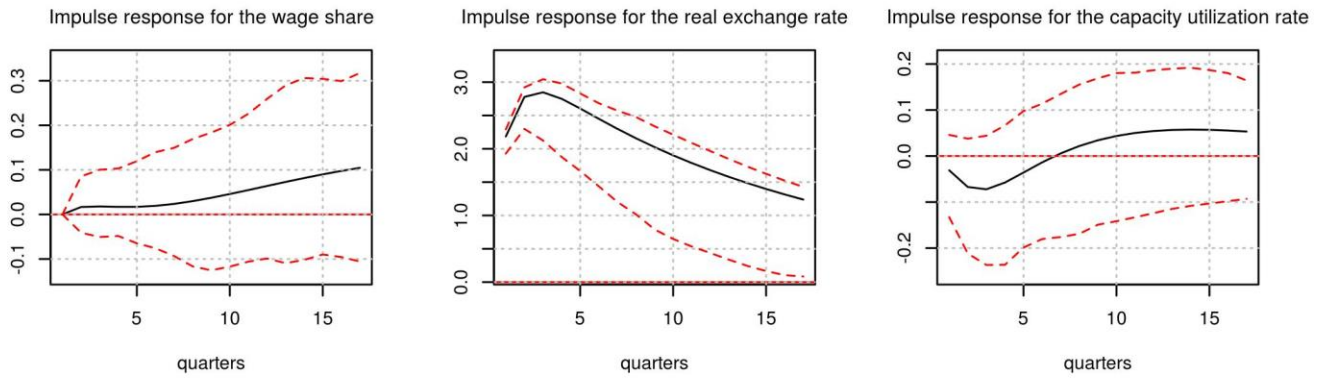
$$X_t = B_0 + B_1 X_{t-1} + \dots + B_p X_{t-p} + u_t$$

where  $X_t = [g_t, u_t, \psi_t, q_t, x_t, z_t]'$ . We then partition  $X_t$  into three sets of variables: the set  $X_{1t} = [g_t, u_t]'$  that are causally prior to  $\psi_t$ ,  $\psi_t$ , and the set  $X_{2t} = [q_t, x_t, z_t]'$  that are not causally prior to  $\psi_t$  (that is, they do not have a contemporaneous effect on either  $X_{1t}$  or  $\psi_t$ ). We utilize the causal ordering  $g_t \rightarrow u_t \rightarrow \psi_t \rightarrow q_t \rightarrow x_t \rightarrow z_t$  to construct impulse response functions for each of the variables due to a 1-standard deviation shock to the wage share using a Choleski decomposition. As the results from the CEE recursive VAR allow for the most general and complete specification, we show our results for the main specification which estimates all variables in levels, and also a second specification which estimates three variables (the unemployment rate, the wage share, and the real exchange rate) in first differences and the other variables in levels.

Panel A. Impact of a 1-standard deviation shock to the wage share



Panel B. Impact of a 1-standard deviation shock to the real exchange rate



Panel C. Impact of a 1-standard deviation shock to the capacity utilization rate

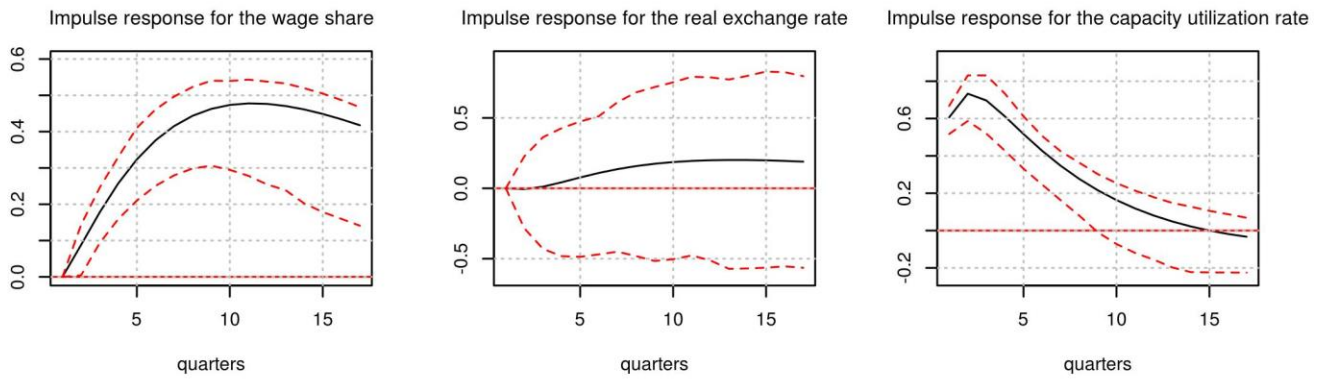
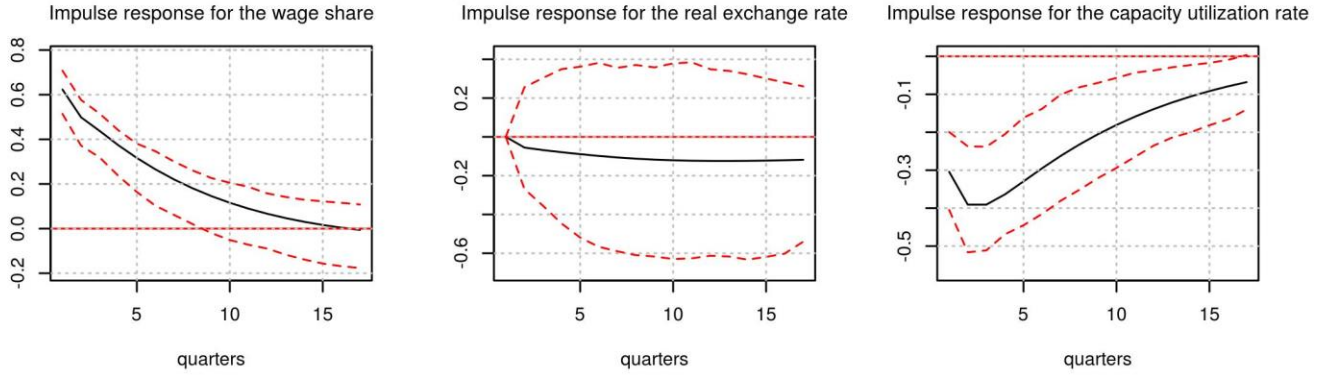
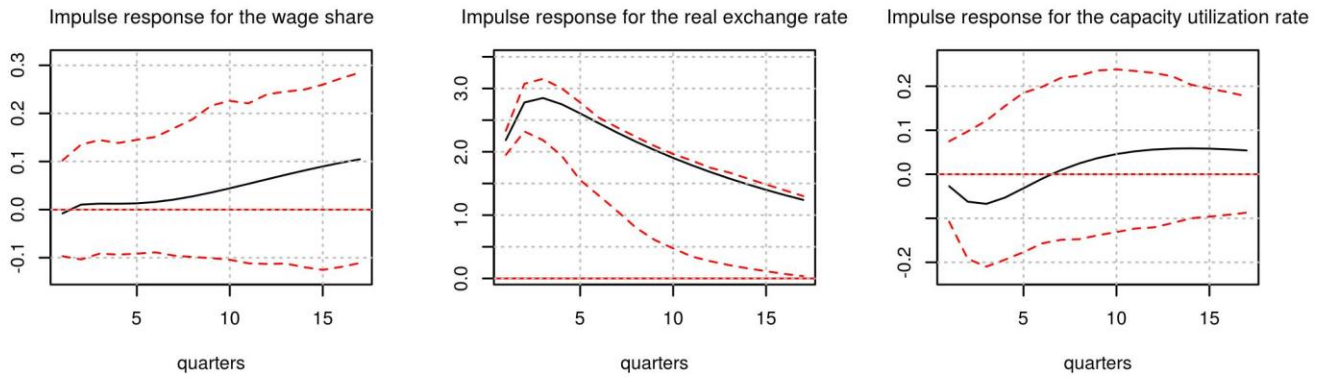


Figure 2: Impulse response functions based on the causal ordering ( $\psi \rightarrow q \rightarrow z$ ).

Panel A. Impact of a 1-standard deviation shock to the wage share



Panel B. Impact of a 1-standard deviation shock to the real exchange rate



Panel C. Impact of a 1-standard deviation shock to the capacity utilization rate

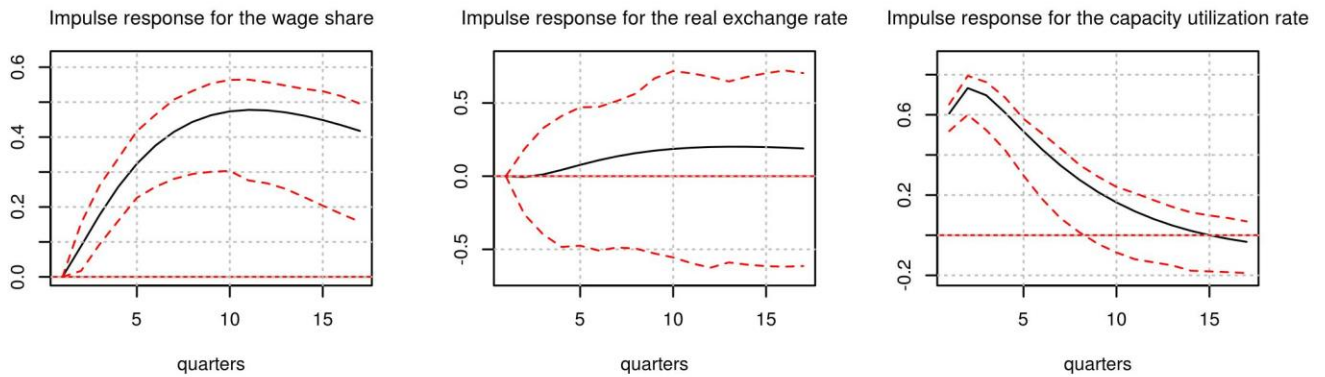


Figure 3: Impulse response functions based on the causal ordering ( $q \rightarrow \psi \rightarrow z$ ).

Figure 4 shows impulse response functions for all six variables due to a 1-standard deviation positive shock to the wage share (all variables estimated in levels). The confidence bands are somewhat

wider, compared to the baseline VAR, because the number of variables is greater - however, an increase in the wage share continues to have a negative and long-lasting effect on the capacity utilization rate, confirming the previous result that demand is profit-led. We find that growth is also profit-led: the accumulation rate also undergoes a long-lasting and negative effect in response to the increase in the wage share. In addition, the increase in the wage share increases the unemployment rate – as would be expected by the profit-led nature of demand. There is a negative effect on the growth rate of labor productivity - however, this operates for a very short period of time. As in the baseline model, there is no significant effect of the increase in the wage share on the real exchange rate. Figure 5 shows that estimating the unemployment rate, the wage share and the real exchange rate in first differences does not alter our results: we continue to find that a positive shock to the wage share has a long-lasting and negative effect on the capacity utilization rate and the accumulation rate.

Taken together, our results strongly suggest that the US economy, in the period 1973 to 2018, is characterized by both demand and growth being profit-led. Our simple recursive VAR in the wage share, real exchange rate and capacity utilization rate shows that a positive shock to the wage share has a negative, long-lasting effect on the utilization VAR. In an extended variable VAR that includes variables for the accumulation rate, unemployment rate and labor productivity growth rate, we continue to find that a positive shock to the wage share has a long-lasting negative impact on growth and demand. Our results are robust to both the inclusion of additional variables and to differences in specification (first differences instead of levels).

## **6. Conclusions**

The seminal contribution of Bhaduri and Marglin (1990) established the theoretical possibilities of profit-led and wage-led demand and growth in heterodox macroeconomic models. This suggested that the impact of distributional changes on demand and growth were ambiguous for any capitalist economy. Hence, identification of the nature of demand and growth became an empirical question. In this paper, we have contributed to the empirical literature on profit-led and wage-led demand and growth by presenting credible estimates of an exogenous shock to distribution (measured by the wage share) using a novel empirical strategy developed by Christiano, Eichenbaum and Evans (1999).

We begin our analysis in this paper by laying out a basic open economy neo-Kaleckian model to think about the relationship between distribution and demand (or growth). The basic model gives us relationships among three endogenous variables: the capacity utilization rate, the real exchange rate, and the wage share. We extended the basic model by incorporating three additional variables: the



accumulation rate, the unemployment rate, and the growth rate of labour productivity. The basic and the extended theoretical models motivate our empirical analyses.

We use a VAR framework for estimation since it allows for the most general way to model the co-movements among a group of variables over time. The basic theoretical model is used to estimate a 3-variable VAR using recursive identification. The extended theoretical model is used to estimate a 6-variable VAR using the Christiano, Eichenbaum and Evans (1999) identification strategy. Impulse response functions from the 3-variable VAR show that the US economy was profit-led in terms of demand and that it witnessed profit squeeze. Impulse response functions from the 6-variable VAR confirm and strengthen that result: a 1 standard deviation positive shock to the wage share had a long-lasting negative effect on both the capacity utilization rate and the accumulation rate.

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Onaran, Özlem, Engelbert Stockhammer, and Lucas Grafl. "Financialisation, income distribution and aggregate demand in the USA." *Cambridge Journal of Economics* 35, no. 4 (2011): 637-661.

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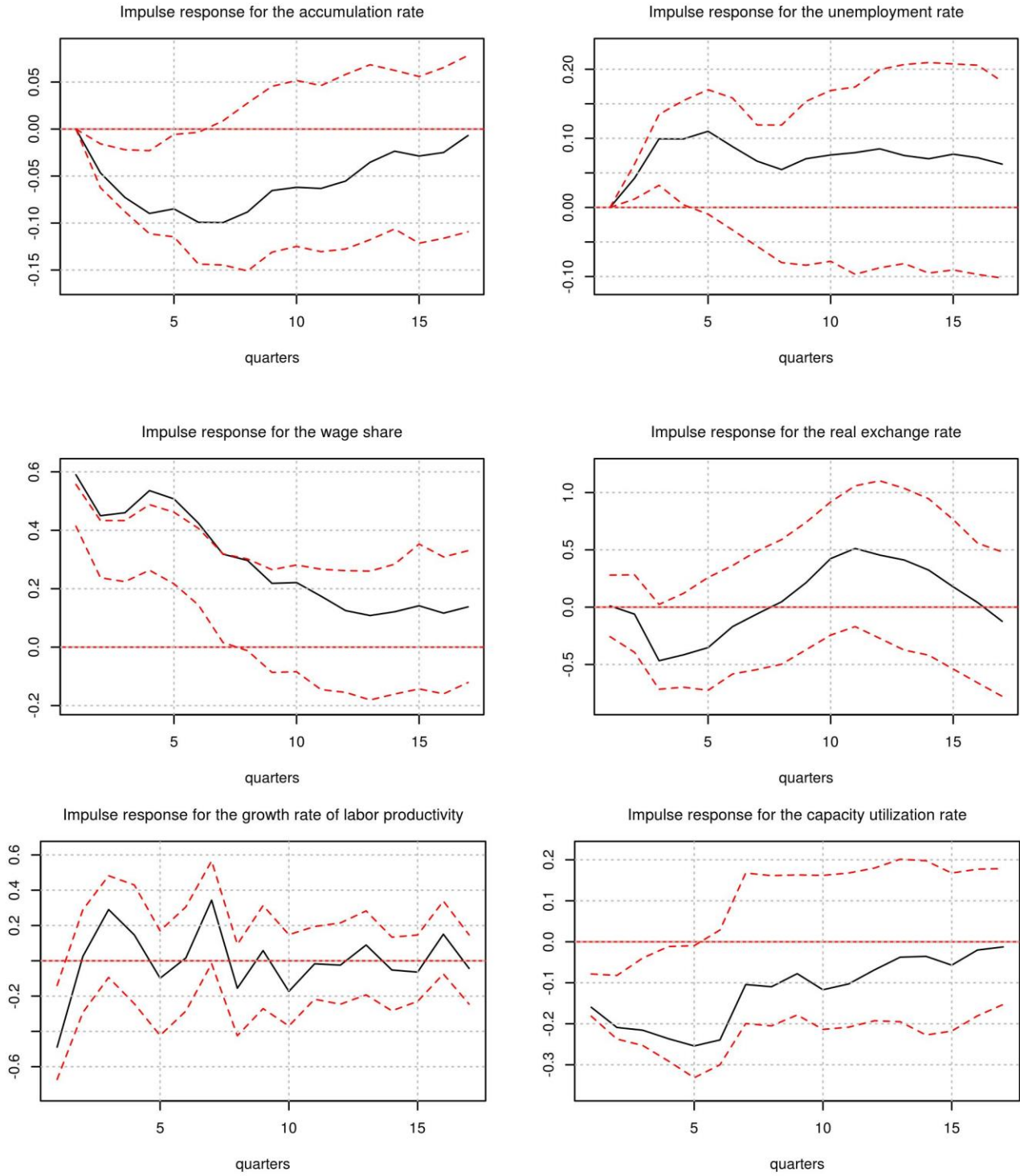


Figure 4: Impulse response functions for a 1-standard deviation shock to the wage share (all variables in levels).

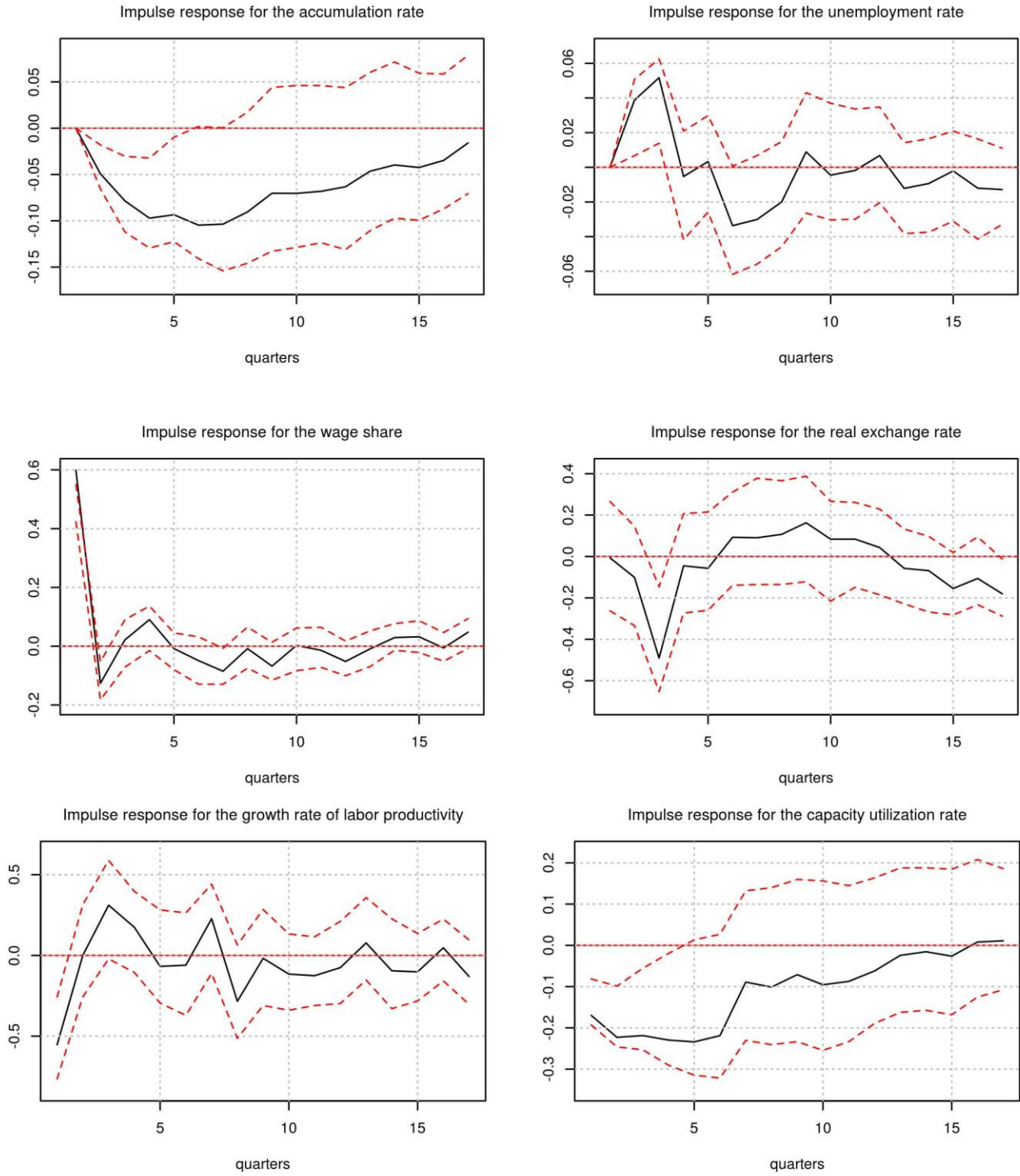


Figure 5: Impulse response functions for a 1-standard deviation shock to the wage share ( $u$ ,  $\psi$  and  $z$  in first differences).