Conference Paper - The effects of distributional shocks on output and unemployment

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Abstract: What are the effects of shocks to the labor share on aggregate demand, output and unemployment? I incorporate a labor market and wage-setting a la Nash in the canonical Bhaduri-Marglin model, which makes the labor share a negative function of unemployment and allows demand growth to influence distribution. The model implies a set of sign restrictions on the responses of unemployment, output and the labor share to distributional, demand and supply shocks. I then use these sign restrictions in a structural vector autoregression to identify whether aggregate demand is wage led or profit led using quarterly data for the U.S economy. I find that demand is profit-led in the short-run, but wage-led in the long-run: distributional shocks contract output and employment in the short-run, but increase output in the long-run with no effects on unemployment. These distributional shocks account for roughly a third of the long-run variance of output.

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[WORK IN PROGRESS. PLEASE DO NOT CITE OR DISTRIBUTE]

1 Introduction

The labor share in national income - which measures how much of total output is paid as the wage bill - has been falling continuously in most advanced economies since the 1980's. The labor share is closely interrelated with the distribution of income: since capital is more unequally distributed than labor, a decline in the labor share typically means that income inequality rises, with the associated social an political problems that this entails, such as rising polarization or increased political instability. An important strand of though in macroeconomics also posits that changes in the labor share can have important macroeconomic consequences.

Suppose workers in the economy experiment a sudden, unanticipated decrease in their bargaining position, perhaps as a result of gradual changes in the institutional framework that governs bargaining relations. What would be the effects on output and unemployment? In many standard New-Keynesian models with monopoly unions or search and matching frictions, an increase in the bargaining power of workers lead to a decrease in output and an increase in unemployment, in the short and the long-run. Since these prediction seem to be robust across a wide set of models (e.g, Gali, Smets and Wouters, 2012) , previous researchers have exploited them to quantify the role of bargaining power shocks have in explaining business cycle fluctuations (Foroni, Furlanetto and Lepetit, 2018) and the recent decline in the labor share (Bergholt, Furlanetto and Maffei-Faccioli, 2022). In what follows, I will refer to such shocks to the bargaining power of workers as 'distributional' shocks for brevity.

Because recent empirical exercises *impose* negative effects of these distributional shocks on output and employment, we have little, independent empirical evidence on their effects in the macroeconomy that relies on credible identification assumptions. The purpose of this project is to help fill that gap by developing a simple, demand-led growth model that builds on Fazzari, Ferri and Variato (2020); the key innovation is to create a channel through which distributional shocks can have either positive or negative effects in the short-run and the long-run. In our model economy, an increase in the bargaining power of workers raises the labor share, which then increases aggregate consumption - because the marginal propensity to consume out of labor income is higher than capital income - but reduces investment - since a rising labor share squeezes corporate profits, cash-flows and hence, for financially constrained firms, investment. Hence, the total effect of aggregate demand and output is ambiguous.

We then augment this economy with demand and supply shocks, and show that the solution of the model takes the form of a structural vector autoregression which includes output growth, unemployment and the labor share, and is driven by three structural shocks: demand, supply and distributional shocks. The model implies a set of robust sign restrictions on the contemporary impact of these shocks on key variables, many of which are shared by standard New Keynesian model. In particular, a demand shock raises output and decreases unemployment, while also increasing the labor share. A supply shock increases unemployment and decreases the labor share. The distributional shock, however, raises the labor share, but has ambiguous impact on unemployment and output.

This identification strategy is both sufficiently agnostic - it only imposes sign restrictions on the impact of certain macroeconomic shocks - and sufficiently grounded in theory - the sign restrictions are derived from an explicit macroeconomic model - to produce credible empirical results.

My main results are as follows. First, I find that distributional shocks are contractionary upon impact, decreasing output and increasing unemployment. This finding provides support for the assumption of previous DSGE literature where distributional shocks are assumed to be contractionary on the short-run, as is also coherent with much of the Post-Keynesian literature that finds that the U.S economy is profit-led. Second, I find that distributional shocks are weakly expansionary in the long-run, with a small positive effect on output and no effects on unemployment. To the best of my knowledge, this is the first paper to uncover this empirical finding. This provides support against the current practice of assuming distributional shocks are either contractionary or have no effect in the long-run, common in the DSGE literature. It also provides support to a large Neo-Kaleckian literature where distributional shocks are expansionary in the long-run. Third, I find that these distributional shocks account for a third of the variance of output in the long-run, which implies that they are an important part of business cycle fluctuations. This provides support for a large marxist literature that has emphasized how conflict over the distribution of income between capital and labor shapes economic performance.

Related Literature. The current project contributes to the three strands of literature in the following ways. First, as discussed in the introduction, the project provides a novel identification strategy to determine the impact of distributional shocks on output and unemployment, both at business-cycle fluctuations and on the long-run. Current econometric practice typically imposes that output falls and unemployment rises at impact (Foroni et. al, 2018), in the long-run (Bergholt et. al, 2022), or assumes distributional shocks do not impact output (Smets and Wouter, 2003; Justiniano, Primiceri and Tambalotti, 2013). In contrast, our identification strategy allows distributional shocks to have positive and long-run effects on output, instead of ruling out such effects by assumption.

Second, our paper contributes to the large literature on the recent decline on the labor share by allowing demand growth to affect the labor share. While several explanations have been put forward to explain the decline in the labor share, such as the decline in the price of investment (Karabarbounis and Neiman, 2014), rising automation (Acemoglu and Restrepo, 2019), an increase in market power and mark-ups (Azar and Vives, 2021), and a decline in the bargaining power of workers (Stansbury and Summers, 2020), the hypothesis that weaker demand growth could explain the decline in the labor share has not been explored empirically.[1] Furthermore, since our simple model allows the bargaining power of workers and improvements in technology to affect the labor share, we can conduct an empirical analysis of the strength of each channel, something which has been missing in the literature[2].

Finally, the projects contributes to the large literature on wage-led vs profit-led growth (for an introduction, see Stockhammer and Lavoie, 2013). This literature seeks to test empirically whether distributional shocks have positive or negative effects on output in the long-run. This research is typically grounded in a simple Keynesian goods-market, partial equilibrium model and uses single-equation regressions of the labor share on output or its components and other controls. Naturally, the main objection to this literature is that both output and the labor share are endogenous variables, and hence regressing the labor share against output does not allow one to identify the dynamic causal effects of distributional shocks on output. I contribute to this long-standing debate by using a simple general equilibrium model where output and income distribution are endogenous, and propose an identification strategy that disentangles different sources of the correlation between the labor share and output - namely, demand, technology and distributional shocks.

[1] The literature on the decline of the labor share is vast, and this is only a representative sample of the explanations given. Space constraints prevent a more extensive discussion of the literature.

[2] An important exception is Bergholt et. al (2022), where the authors quantify the contributions of worker power, mark-ups, automation and the relative price of investment on the recent decline of the labor share. Their empirical exercise, however, does not contemplate weaker demand growth.

2 The identification result in a simple environment

I first present my identification result in the simplest possible envioremement, which is partial equilibrium in nature: I assume that labor supply is infinitely elastic, and hence the unemployment rate is not a useful indicator of the state of the labor market. I ignore the effects that demand has on the supply side, and state simple conditions under which the distribution of income can be treated as exogenous. Hence, the model is a simple partial equilibrium model of the goods-markets, and stays as close as possible to the original Bhaduri-Marglin model. In the next section, I relax all of these assumptions and show that my identification result still holds.

2.1 An extension of Bhaduri-Marglin

Here I use a discrete-time version of the Bhaduri and Marglin (1990) model to incorporate shocks to demand and distribution. I introduce an exogenous demand component that evolves as a random walk, and hence, my setting borrows heavily from Pariboni (2016).

I start by stating my assumptions on production and distribution. I assume that the production function is Leontief:

$$Y_t = \min AL_t, \frac{K_t}{v} \tag{1}$$

Cost-minimization implies that conditional factor demands take the familiar forms:

$$L_t = \frac{Y_t}{A} \tag{2}$$

$$K_t = vY_t \tag{3}$$

Where Y_t is output, A_t is average labor productivity, L_t is employment, v is the capital output ratio and K_t is the capital stock. Next, I assume that the distribution of income is determine by Nash Bargaining between an organized pool of workers and a single capitalist. Although commonly in Neo-Kaleckian interpretations of the Bhaduri-Marglin model it is assumed that the mark-up determines the profit share and the distribution of income (see Lavoie (2022) and Hein (2014), for example), the use of Nash Bargaining will provide a simple and elegant way to incorporate feedbacks from demand to distribution in the next section. This is not to say that the mark-up is unimportant in determining the distribution of income - it certainly is - but my modeling assumptions are chosen for tractability. To the best of my knowledge, Tavani (2012) was the first heterodox author to incorporate wage bargaining *a la* Nash in standard heterodox models of growth and distribution; naturally, this assumption has been used in mainstream macroeconomics at least since McDonald and Solow (1992).[3]

I assume that the pool of worker's has linear preferences over the total wage bill, while capitalists have preferences over profits. Negotiation takes place after capital decisions are made and there is no second-hand market for capital. This implies that the outside option of capitalists is $-r_t K_t$, while I normalize the outside option of workers to 0. In the following section, I will relax this assumption and let the state of the labor market influence the outside option of workers; here, I am interested in deriving the result of an exogenous wage-share. The wage equation solves the following problem:

$$\max_{w} V = [w_t L_t]^{\eta_t} [A_t L_t - w_t L_t]^{1-\eta_t} \tag{4}$$

As it's well known, the interpretation of η_t is the exogenous bargaining power of workers. The first order condition gives:

$$\frac{\partial V}{\partial w_t} = \frac{\eta L_t}{L_t w_t} - \frac{(1-\eta) L_t}{L_t (A_t - w_t)} = 0 \tag{5}$$

After some algebraic manipulation, the wage equation that solves the bargaining problem is:

$$w_t = \eta_t A \tag{6}$$

Using this wage equation we can derive an expression for the wage share as:

$$\frac{w_t}{A} = \omega_t = \eta_t \tag{7}$$

Finally, I will assume that the bargaining power of workers evolves as follows:

$$\eta_t = \bar{\eta} + \varepsilon_t^{\eta} \tag{8}$$

Where ε_t^{η} is a white noise error term that satisfies $E[\eta_t] = 0$ and $V[\eta_t] = \sigma_\eta^2$. This completes our theory of production and distribution: as it's evident from the equation above, under our assumptions about production and Nash Bargaining, the wage share can be take to be

[3] See Blanchard and Giavazzi (2003) for a similar framework in a static application. Models of search and matching in the Diamond-Mortensen-Pissarides (DMP) tradition usually also derive their wage equations from Nash Bargaining.

exogenous to demand; shifts to the wage share can be given the structural interpretation of shifts to the bargaining power of workers, and perhaps more importantly, it becomes fully transparent to the reader that what is needed to maintain this hypothesis are specific assumptions about the outside option that the workers faces.

In what follows, I describe the demand side of this economy. I ignore for the sake of simplicity the government sector and assumed a close economy. Our equations for consumption and investment will be given by:

$$C_t = f_1(Y_t, \omega_t) \tag{9}$$

$$I_t = f_2(Y_t, \omega_t) \tag{10}$$

I now state the assumptions that I will make regarding these two functions. The first assumption is a balanced-growth assumption: along the balanced growth path, I will assume that the shares of consumption and investment are constant.

Assumption 1: (Balanced Growth) The functions $f_i : \mathbb{R}^2 \to \mathbb{R}$ are homogeneous of degree 1 in their first argument. Formally, $\forall \lambda > 0$ they satisfy:

$$\alpha C_t = f_1(\lambda Y_t, \omega_t) \tag{11}$$

$$\alpha I_t = f_2(\lambda Y_t, \omega_t) \tag{12}$$

This implies we can re-write the above expression as:

$$C_t = Y_t f_1(1, \omega_t) = Y_t g_1(\omega_t) \tag{13}$$

$$I_t = Y_t f_2(1, \omega_t) = Y_t g_2(\omega_t) \tag{14}$$

The reason why this assumption can be given a balanced-growth intepretation should be obvious: Using the equations above, they imply that along the balanced growth path, the shares of consumption and investment are trendless; or that they are uniquely functions of the labor share, which we have assumed to be constant. I contend that this assumption is fairly weak: it can be derived from more primitive assumptions about technical change and the production function in virtually all neoclassical growth models (see Uzawa, xx; and the discussion in Aghion et. al, xx) as well as being satisfied in many endogenous growth models

(Eaton, xx). It's also routinely satisfied in a wide family of models of both Neo-Kaleckian and Supermultiplier tradition: see, for example, the relevant textbook chapters in Lavoie (2022) and Hein (2014), and the models developed by Serrano (1995), Serrano and Feitas (2016), Fazzari, Ferri and Greenberg (2013) and Fazzari, Ferri and Variato (2020) all satisfy this condition. It's also worth noting that the functional form used for the consumption equation in Bhaduri and Marglin also satisfies this restriction, however, they do not impose it in their investment function. If there is a single result upon which disciples of Solow, Cass and Koopmans, Kalecki, Kaldor and Hicks can all agree on is that a growth path where the shares of consumption and investment are trendless is a reasonably feature of any growth theory.

I now state two more assumptions that are common in the literature, and which I will need for my identification result. The first is that, at least around the steady-growth path, the share of consumption is increasing in the labor share and the share of investment is decreasing in the labor share. The second one is technical in nature and it's needed to guarantee a positive but bounded Keynesian multiplier. I now state them in turn.

Assumption 2: I assume that the functions $g_i : \mathbb{R}^2 \to \mathbb{R}$ are class $\mathbb{C}^1$ and satisfy:

$$\frac{\partial(C_t/Y_t)}{\partial \eta_t} = \left.\frac{\partial g_1(\omega_t)}{\partial \eta_t}\right|_{\omega_t=\bar{\omega}} > 0 \tag{15}$$

$$\frac{\partial(I_t/Y_t)}{\partial \eta_t} = \left.\frac{\partial g_2(\omega_t)}{\partial \omega_t}\right|_{\omega_t=\bar{\omega}} < 0 \tag{16}$$

Assumption 3: (No Harrodian Instability) I assume that the functions $g_i : \mathbb{R}^2 \to \mathbb{R}$ satisfy:

$$g_1(\omega_t) + g_2(\omega_t)) < 1 : \omega_t \in N(\bar{\omega}) \tag{17}$$

Note that assumption (2) and (3) are *local* conditions, not global. The consumptions and investment functions could be highly non-linear, and it could be that shifts to the labor share violate our assumptions away from the steady state. I now present two examples, one where these assumptions are satisfied, and one where they are violated, in order to gain more economic intuition behind our identification result.

Example 1: Consider an economy populated by a unit mass of workers and a single capitalist, which we have already assumed when discussing how distribution is determined. Suppose the working class and the capitalist class save a fixed fraction of their income. Denoting the marginal and average propensity to save by s_w and s_π for the two classes, the consumption function of this economy is:

$$C_t = (1 - s_w)w_t L_t + (1 - s_\pi)\Pi_t \tag{18}$$

Now use our wage equation which implies $w_t = \eta_t A_t$, and the the value function for the firm's profits, to get:

$$C_t = (1 - s_w)\omega_t Y_t + (1 - s_\pi)(1 - \omega_t)Y_t \tag{19}$$

After some algebraic manipulation, we can write the consumption share as:

$$\frac{C_t}{Y_t} = (1 - s_\pi) + (s_\pi - s_w)\omega_t \tag{20}$$

This satisfies our assumption 1. To satisfy assumption 2, what is need is that $(s_\pi - s_w) > 0$, that is, the capitalist class saves a higher fraction of their income than the working class. This is assumption is routinely made in virtually all of Post-Keynesian economic. Consider now an investment function of the form advocated by Fazzari, Ferri and Greenberg (2008), which ignores debt payments for simplicity:

$$I_t = \gamma\Pi_t = \gamma(1 - \omega_t)Y_t \tag{21}$$

The original investment function used by these authors is $\Pi_t - rD_t$, where D_t is the amount of debt the firm holds. The idea is that a fraction of firms in the economy are constrained by their cash-flows; the rationale is that there exists friction in the financial market that makes the cost of external finance higher than the cost of internal funds. If this is true, then increasing profits, and hence cash flows, will lead to an increase in investment. The sensitivity of investment to cash flows is here parametrized by γ. If $\gamma = 0$, then the cost of external funds and internal funds are equivalent.[4]. The investment share is:

$$\frac{I_t}{Y_t} = \gamma(1 - \omega_t) \tag{22}$$

A sufficient condition for assumption 2 to hold is $\gamma > 0$; there is overwhelming evidence in the micro literature on cash-flow and investment that this is the case. For assumption 3 to hold, we need:

[4]There is a large literature on the mapping between cash flows and the cost of external finance. For an important criticism of the cash-flow investment literature, see Kaplan and Zingales (1997); for a response, see Fazzari, Hubbard and Petersen (2000)

$$1 - s_\pi + \gamma + (s_\pi - s_w - \gamma)\omega_t < 1 \tag{23}$$

Consider some reasonable parameter values: suppose that $s_w = 0.15$, $s_\pi = 0.6$ and $\gamma = 0.35$. Since η is the labor share, consider $\eta = 2/3$. This yields a value for the left hand side roughly equal to 0.8.[5].

Hopefully, the linear example considered above convinces the reader that the assumptions we have imposed embody reasonable economic assumptions, are satisfied by a wide class of macroeconomics models, and do not impose to much restrictions on the data. Nevertheless, one must now the limits of our identification assumptions, and in the next example I present an economy that violates my assumptions on demand and distribtion.

Having understood when our assumptions are violated, I now close the model by assuming that there is a component of autonomous demand, Z_t, whose logarithm evolves as a random walk:

$$z_t = g_z + z_{t-1} + \varepsilon_t^z \tag{24}$$

Where $z_t = \log Z_t$. Goods market equilibrium will then imply that:

$$Y_t = C_t + I_t + Z_t \tag{25}$$

Now combine our equations for consumption, investment, and goods market equilibrium to get:

$$Y_t = \frac{1}{1 - g_1(\omega_t) - g_2(\omega_t)} Z_t \tag{26}$$

Hence, the solution of our model takes the simple form of the textbook Keynesian multiplier; however, now the multiplier varies along with the distribution of income. Thanks to assumption 3, we ensure that the multiplier is positive and bounded, which implies that output is positive and bounded as well. Now take logs and use the approximation $\log(1-x) \approx x$ when x is small to get:

$$\Delta y_t = g_z + g_1(\omega_t) + g_2(\omega_t) - (g_1(\omega_{t-1}) + g_2(\omega_{t-1})) + \varepsilon_t^z \tag{27}$$

[5]Mention that the values of propensity to save come from Schroeder; use the cash-flow literature to justify γ, there are cites in the JEBO paper. Also if one estimate this model by GMM this is what one obtains.

$$C_t/Y_t = g_1(\omega_t) \tag{28}$$

$$I_t/Y_t = g_2(\omega_t) \tag{29}$$

$$\omega_t = \bar{\eta} + \epsilon_t^{\eta} \tag{30}$$

These four equations summarize the behavior of the economy around the balanced growth path. We are now ready to state our identification result.

Proposition 1: Consider an economy where the wage share evolves according to (xx) and the consumption and investment functions satisfy assumptions 1 through 3. Then, around the balanced growth path ($\omega_t = \bar{\eta}$), a positive distributional shock increases the wage share, the consumption share, and decreases the investment share, while having ambiguous effects on the level of output.

Poof: The proof is straightforward. Take the partial derivatives of the economy described above to get:

$$\frac{\partial \omega_t}{\partial \epsilon_t^{\eta}} = 1 > 0 \tag{31}$$

$$\frac{\partial C_t/Y_t}{\partial \epsilon_t^{\eta}} = \frac{\partial g_1(\omega_t)}{\partial omega_t} > 0 \tag{32}$$

$$\frac{\partial I_t/Y_t}{\partial \epsilon_t^{\eta}} = \frac{\partial g_2(\omega_t)}{\partial \omega_t} < 0 \tag{33}$$

$$\frac{\partial \Delta y_t}{\partial \epsilon_t^{\eta}} = \frac{\partial g_1(\omega_t)}{\partial \omega_t} + \frac{\partial g_2(\omega_t)}{\partial \omega_t} \lesseqgtr 0 \tag{34}$$

This completes the proof.

I wish to remark that because I have assumed that autonomous demand grows at an exogenous rate, as it's common in super multiplier models, permanent changes to distribution - a change in $\bar{\eta}$ - have permanent effects on the level of output, but not the growth rate. This stands in contrast to a wide family of Neo-Kaleckian models, where such shifts have permanent effects on the growth rate. However, my identification procedure is designed to exploit the effects of *transitory* shocks - a one-time increase in ϵ_t^{η}. Although I won't provide a proof here, I conjecture that in a Neo-Kaleckian model a transitory shock to the labor share will also have only transitory effects to the growth rate. Moreover, I adopt the super-multiplier approach to growth because it will provide an extremely simple and elegant way to write down the solution of the model as a vector autoregression where the capital stock will not appear in the endogenous or exogenous variables. This is important because data on the capital stock contain a large amount of measurement error, and are not available on a quarterly frequency. In the Neo-Kaleckian model, the solution of the model usually takes the form of a vector of variables divided by the capital stock, and this makes formulating a stochastic version of the model cumbersome, and complicates estimation and inference. To summarize, I employ this version of the model because it eases identification and exposition, not because I have a strong prior on whether permanent shifts to the distribution of income have permanent effects on the growth rate.

2.2 A justification for short-run restrictions.

In this section, I provide an example where the above stochastic version of the Bhaduri-Marglin model provides a justification for identifying the effects of distributional shocks using short-run restriction on the impact multiplier of a standard vector autoregressions (see, for example, Barbosa-Filho and Taylor (2006), Carvalho and Rezai, (2015), Kiefer and Rada (2015)). I view this as important because, as discussed in the introduction, the current econometric practice in this literature relies on such restrictions. Hence, it's crucial to know when economic theory justifies and when it doesn't justify these restrictions. I continue with a linear version of the economy developed in the previous section.

Example 1: (cont'd) Assume that the consumption and investment functions take the form outlined in the previous section. Then, the equations for the wage-share, the consumption-share and the investment-share are:

$$\omega_t = \bar{\eta} + \epsilon_t^{\eta} \tag{35}$$

$$\frac{C_t}{Y_t} = (1 - s_\pi) + (s_\pi - s_w)\omega_t \tag{36}$$

$$\frac{I_t}{Y_t} = \gamma(1 - \omega_t) \tag{37}$$

The equation for the growth rate of output is equal to:

$$\Delta y_t = g_z + (s_\pi - s_w - \gamma)\Delta\varepsilon_t^\eta + \varepsilon_t^z \tag{38}$$

As it should be evident, our distributional shock affects the wage share and the growth rate of output; however, our autonomous demand shock only affects the growth rate of output. This occurs because we have assumed no feedback from demand to distribution; an assumption we will relax in the next section. I now write down these equations in matrix form, ignoring the intercepts. We have that:

$$\begin{bmatrix} \omega_t \\ \Delta y_t \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ (s_\pi - s_w - \gamma) & 1 \end{bmatrix} \cdot \begin{bmatrix} \epsilon_t^\eta \\ \epsilon_t^z \end{bmatrix} \tag{39}$$

As it should be evident, an econometrician that trusted the short-run restrictions arising from this model could estimate the impact that demand and distributional shocks have on the growth rate of output and the wage share by using a standard Cholesky decomposition: he would simply order first the wage share in the system, and secondly the growth rate. The key identifiying assumption, as mentioned before, is that demand shocks do not affect contemporaneously the wage share. Naturally, this assumption has been relaxed many times in the related literature, and even Bhaduri and Marglin (1990) discuss the feedback from demand to distribution, although many important papers in the subsequent empirical literature treat the wage share as exogenous. Note that in applications, not always the growth rate of output is used; sometimes other stationary transformations of output - such as using the HP filter, as in Barbosa-Filho and Taylor (2006), are used. Nevertheless, the spirit of the identification scheme is the same.

In the next section, I will relax the assumption that demand shocks do not have effects on distribution by introducing a supply side, a determination of the unemployment rate, and allowing the outside option of workers to be influenced by the unemployment rate. I will then show that it's impossible to find a cholesky factorization that allows us to disentagle demand from distribution shocks - in other words, no short-run restrictions on a SVAR estimated with data on the wage share and the growth rate of output can identify these shocks separately. However, my proposed sign restriction approach will be robust to this extension, and hence provides a flexible way to identify distributional shocks while not having to believe that demand shocks do not affect distribution.

3 The supply side and feedback from demand to distribution

In this section, I develop a simple supply side of the model outlined above, which yields a simple theory of productivity growth, the unemployment rate, and a ceiling on output growth. I also allow the outside option of worker's to be influenced by the state of the labor market, which generates feedback from demand to distribution.

The supply side

The supply side is largely inspired on Fazzari, Ferri and Variato (2020), but for simplicity I abstract from endogenous labor supply. As outline in the section above, with a Leontief production function the conditional labor demand function can be written as:

$$Y_t = A_t L_t \tag{40}$$

In addition, I assume that there is learning-by-doing: as output accumulates over time, the level of technology increases, as first outline by Arrow (1962). Formally, there is a constant returns to scale technology that produces knowledge tomorrow from knowledge today and output:

$$A_t = e^{\phi_0 \varepsilon_t^a} A_{t-1}^{1-\phi_1} Y_{t-1}^{\phi_1} \tag{41}$$

The intuition behind the specification is straightforward: if we interpret average labor productivity as the stock of knowledge that society posses, which is what is emphasized by Romer (1982) and eloquently discussed in Jones (2019), then the stock of knowledge depreciates at a rate $(1 - \phi_1)$, and current output increases knowledge tomorrow by ϕ_1. The parameter ϕ_0 captures exogenous technical progress, and ε_t^a is a technology shock.

To close the supply side, we simply assume that the population of worker's is normalized to 1; so $N_t = 1$ and labor supply is perfectly inelastic. This means that all agents in the economy must either be employed or unemployed; formally:

$$u_t + L_t = 1 \tag{42}$$

Hence, our measure of the labor input L_t is the employment rate, and all movements in the labor market occur through the extensive margin; which is a reasonable first approximation, as Shimer (2005) documents, much of the cyclical variation in output occurs through adjustment employment, not man-hours or the average working week. In addition, over much of the post-war period, as xx show[6], the average work week was roughly constant, so abstracting from movements in the average work week seem a reasonable approximation when studying fluctuations and growth. It should be clear from this equation that this yields the approximation $\ln L_t \approx -u_t$.

We can use these three equations to derive a simple equation that synthesis the behavior of the supply side. First, plug our conditional labor demand in lagged output, and take logs to get:

$$a_t = \phi_0 + (1 - \phi_1)a_{t-1} + \phi_1 a_{t-1} + \phi_1 \ln L_{t-1} + \varepsilon_t^a \tag{43}$$

Where we have called $a_t = \ln A_t$. Using our previous approximation and some more algebra, the growth rate of productivity becomes:

$$\Delta a_t = \phi_0 - \phi_1 u_{t-1} + \varepsilon_t^a \tag{44}$$

(Say something here about linking this to micro data) We can now log-difference the conditional demand for labor and plug in our equation for the growth rate of labor productivity to get the following:

$$u_t = \phi_0 - \Delta y_t + (1 - \phi_1)u_{t-1} + \varepsilon_t^a \tag{45}$$

This equation summarizes the evolution of the unemployment rate. (Inntuition to follow)

Unemployment and Distribution

Consider now our Bargaining problem between workers and capitalists, but now suppose that there is an interesting outside option for workers. If the wage bargaining breaks down; in the sense that no agreement is reached, then the worker can walk away and get earn an alternative wage w_a with a probability that is equal to the employment rate, $(1 - u_t)$. The pool of worker's that bargains over the real wage take the alternative wage as given when bargaining. The economics behind this mechanism is simple: when the unemployment rate is low, it's easier to find a job elsewhere, and this endogenously increases the bargaining position of workers. Because the job-finding rate is a macroeconomic variable, it is given

[6] Look at JPE paper cited by Steinsson

for the individual worker. A slight modification of this specification is used routinely in the standard Diamond-Mortenssen-Pissarides model of search and matching; and it's possible to give a more rigorous microfoundation to this specification. However, for our present purposes this simpler specification is enough. The maximization problem becomes:

$$\max_{w} V = [(w_t - \bar{w}_t)L_t]^{\beta_t}[A_t L_t - w_t L_t]^{1-\beta_t} \tag{46}$$

The wage equation that solves this problem is:

$$w_t = \beta_t A_t + (1 - \beta_t) w_a \tag{47}$$

As discussed above, the alternative wage, in equilibrium is:

$$w_a = (1 - u_t) w_t \tag{48}$$

Combine these two expressions to obtain the following wage equation:

$$w_t = \frac{\beta_t}{\beta_t + (1 - \beta_t) u_t} A_t \tag{49}$$

Which yields an expression for the wage share, $\omega_t = w_t / A_t$, equal to:

$$\frac{w_t}{A_t} = \omega_t = \frac{\beta_t}{\beta_t + (1 - \beta_t) u_t} \tag{50}$$

Call the right-hand side of this equation $h(u_t)$. This distributional function fulfills a number of appealing properties: it is decreasing and convex, it implies that at full employment, the labor share would go to unity, and as the economy approaches massive unemployment, it tends to β:

$$h'(u_t) = -\frac{\beta_t (1 - \beta_t)}{(\beta_t + (1 - \beta_t) u_t)^2} < 0 \tag{51}$$

$$h''(u_t) = \frac{2\beta_t (1 - \beta_t)^2}{(\beta_t + (1 - \beta_t) u_t)^3} > 0 \tag{52}$$

$$\lim_{u_t \to 1} h(u_t) = \beta_t \tag{53}$$

$$\lim_{u_t \to 0} h(u_t) = 1 \tag{54}$$

Now we call β_t the bargaining power of workers; and it follows the same stochastic process as before:

$$\beta_t = \bar{\beta} + \varepsilon_t^{\eta} \tag{55}$$

This completes our description of the supply side and the distribution of income. The demand side is identical to the previous section; in what follows, however, for ease of exposition, I consider the economy of example 1 to derive our identification result in a linear setting.[7]

3.1 The Balanced Growth Path

Before presenting our identification results in this setting, it will be useful to re-state the four main equations of the model and the behavior of the deterministic balanced growth path. To do so, recall that we have:

$$\Delta y_t = g_z + (s_\pi - s_w - \gamma)\Delta\omega_t + \varepsilon_t^z \tag{56}$$

$$u_t = \phi_0 - \Delta y_t + (1 - \phi_1)u_{t-1} + \varepsilon_t^a \tag{57}$$

$$\omega_t = \frac{\beta_t}{\beta_t + (1 - \beta_t)u_t} \tag{58}$$

$$\beta_t = \bar{\beta} + \varepsilon_t^{\eta} \tag{59}$$

These systems of equations have a straightforward economic interpretation. Equation (xx) is an IS curve, which synthesis equilibrium in the goods market as a function of the growth rate of autonomous demand and changes in the distribution of income. It is shifted by a structural autonomous demand shock. Equation (yy) synthesis the supply-side of the model; it combines the learning by doing equation, the production function, and the resource constraint in the labor market. It is shifted by a technology shock. Finally, equations (zz1) and (zz2) are the distributional or wage-setting curves combined with the stochastic process for the bargaining power of workers. I will use bars over variables to denote steady-state values; the steady state of the model is:

$$\Delta\bar{y} = g_z \tag{60}$$

[7]Pretty sure that one can show this in the non-linear economy, perhaps show it in an Appendix.

$$\bar{u} = \frac{\phi_0 - g_z}{\phi_1} \tag{61}$$

$$\bar{\eta} = h(\bar{u}) \tag{62}$$

The balanced growth path is essentially identical to that of the FFV (2020) model, but it endogeneizes the distribution of income, and provides a complete theory of relative prices. It has a nice recursive structure: as in most supermultiplier models, the growth rate of output equals the growth rate of autonomous demand. With the growth rate of output determined, unemployment is the gap between the exogenous rate of technical progress, and the rate of growth of autonomous demand. It thus has the intuitive interpretation of being the gap between aggregate demand growth and aggregate supply growth, loosely speaking. Unemployment is fully Keynesian, even in the long-run: there exists unemployment due to a fundamental lack of aggregate demand. Finally, the wage share is negative function of the unemployment rate.

We can perform three simple comparative statics exercises which we will emphasize in the empirical section: How does a rise in the growth rate of autonomous demand affect the economy? How does a rise in autonomous technical progress affect the economy? And what about the effects that a higher bargaining power of workers have on the economy?

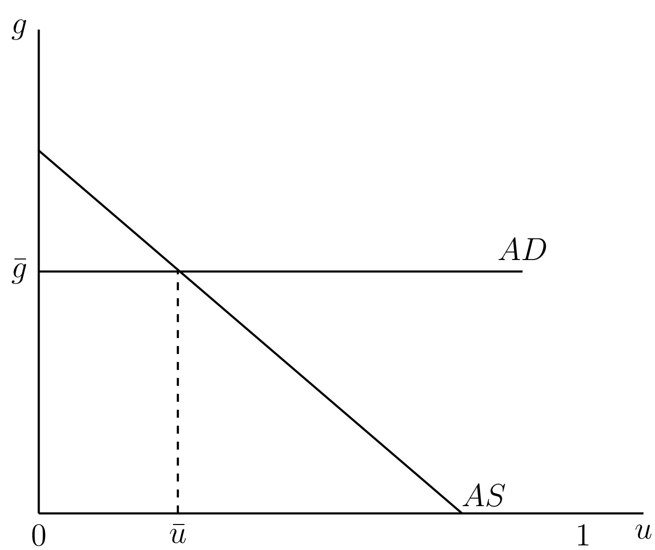


Figure 1: The Balanced Growth Path

Business Cycles and Distributional Shock

Despite having an extremely simple solution around the balanced growth path, the model yields interesting implications for studying business cycles. I first linearize the distributional equation around it's balanced growth path. A first order approximation of η around $(\bar{u}, \bar{\beta})$:

$$\omega_t \approx h(\bar{u}, \bar{\beta}) + h_u(\bar{u}, \bar{\beta})(u_t - \bar{u}) + h_\beta(\bar{u}, \bar{\beta})(\beta_t - \bar{\beta}) \tag{63}$$

$$\omega_t \approx \frac{\bar{\beta}}{\bar{\beta} + (1-\bar{\beta})\bar{u}} - \frac{\bar{\beta}(1-\bar{\beta})}{[\bar{\beta} + (1-\bar{\beta})\bar{u}]^2}(u_t - \bar{u}) + \frac{\bar{u}}{[\bar{\beta} + (1-\bar{\beta})\bar{u}]^2}(\beta_t - \bar{\beta}) \tag{64}$$

$$\omega_t \approx \bar{\eta} + \Psi_u(u_t - \bar{u}) + \Psi_\varepsilon \varepsilon_t^\eta \tag{65}$$

Note that, $\Psi_u \leq 0$ and $\Psi_\epsilon \geq 0$ for all parameter values. Stacking below the stochastic process for growth and unemployment we get:

$$\Delta y_t = g_z + (s_\pi - s_w - \gamma)\Delta\omega_t + \varepsilon_t^z \tag{66}$$

$$u_t = \phi_0 - \Delta y_t + (1 - \phi_1)u_{t-1} + \varepsilon_t^a \tag{67}$$

To simplify notation in the calculations that follow, call $\alpha = (s_\pi - s_w - \gamma)$. If $\alpha > 0$, then the system is wage led; if $\alpha < 0$, then the system is profit led. To derive our reduced-form, start with the structural system of simultaneous equations as:

$$\begin{bmatrix} 1 & 0 & -\Psi_u \\ -\alpha & 1 & 0 \\ 0 & 1 & 1 \end{bmatrix} \cdot \begin{bmatrix} \omega_t \\ \Delta y_t \\ u_t \end{bmatrix} = \begin{bmatrix} \bar{\eta} - \Psi_u \bar{u} \\ g_z \\ \phi_0 \end{bmatrix} + \begin{bmatrix} 0 & 0 & 0 \\ -\alpha & 0 & 0 \\ 0 & 0 & (1-\phi_1) \end{bmatrix} \cdot \begin{bmatrix} \eta_{t-1} \\ \Delta y_{t-1} \\ u_{t-1} \end{bmatrix} + \begin{bmatrix} \Psi_\varepsilon & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} \epsilon_t^\eta \\ \epsilon_t^z \\ \epsilon_t^a \end{bmatrix} \tag{68}$$

Or, more compactly in matrix form:

$$BY_t = C + AY_{t-1} + D\epsilon_t \tag{69}$$

To identify the impact of the structural shocks on the endogenous variables, we need to put restrictions on the matrix B^{-1}. I first compute this matrix in the present model:

$$B^{-1} = \begin{bmatrix} 1 & -\Psi_u & \Psi_u \\ \alpha & 1 & \alpha\Psi_u \\ -\alpha & -1 & 1 \end{bmatrix} \tag{70}$$

We can now obtain the reduced-form VAR by pre-multiplying everything by B^{-1}. I omit the un-interesting constants; this yields:

$$\begin{bmatrix} \omega_t \\ \Delta y_t \\ u_t \end{bmatrix} = \begin{bmatrix} \alpha\Psi_u & 0 & \Psi_u(1-\phi_1) \\ -\alpha & 0 & \alpha\Psi_u(1-\phi_1) \\ \alpha & 0 & (1-\phi_1) \end{bmatrix} \cdot \begin{bmatrix} \eta_{t-1} \\ \Delta y_{t-1} \\ u_{t-1} \end{bmatrix} + \begin{bmatrix} \Psi_\varepsilon & -\Psi_u & \Psi_u \\ \alpha\Psi_\varepsilon & 1 & \alpha\Psi_u \\ -\alpha\Psi_\varepsilon & -1 & 1 \end{bmatrix} \cdot \begin{bmatrix} \epsilon_t^\eta \\ \epsilon_t^z \\ \epsilon_t^a \end{bmatrix} \tag{71}$$

As it should be evident, once we introduce feedback from demand to distribution then there exists no short-run restrictions that can help us identify the impact of distributional shocks, and disentangle their effects from autonomous demand shocks or supply shocks. Note that, despite the fact that the structural shocks don't have any added persistence, the model features some interesting dynamics: the cross-correlation functions between all the endogenous variables are not equal to 0. As it should also be clear, eliminating the impact of demand on distribution through the outside option of worker's allows a Cholesky factorization; however, this comes at the cost of eliminating a lot of the dynamic feedback between the endogenous model variables.

Proposition 2: (Short-Run Identification). Consider the economy studied in section 3. If $\Psi_u = 0$, then there exists a Cholesky factorization where distribution is ordered first, growth is ordered second and unemployment is ordered third that allows to identify the dynamic causal effects of shocks to the bargaining power of workers, autonomous demand, and the state of technology, on the economy.

Proof: Substitute this restriction inside of the structural VAR. We get the following:

$$\begin{bmatrix} \omega_t \\ \Delta y_t \\ u_t \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 \\ -\alpha & 0 & 0 \\ \alpha & 0 & (1-\phi_1) \end{bmatrix} \cdot \begin{bmatrix} \omega_{t-1} \\ \Delta y_{t-1} \\ u_{t-1} \end{bmatrix} + \begin{bmatrix} \Psi_\varepsilon & 0 & 0 \\ \alpha\Psi_\varepsilon & 1 & 0 \\ -\alpha\Psi_\varepsilon & -1 & 1 \end{bmatrix} \cdot \begin{bmatrix} \epsilon_t^\eta \\ \epsilon_t^z \\ \epsilon_t^a \end{bmatrix} \tag{72}$$

Note that, since Ψ_u is a highly non-linear function of $(\bar{\beta}, g_z, \phi_0, \phi_1)$, testing this restriction implies testing a highly non-linear restriction on the model parameters. Furthermore, it requires that either $\beta = 0$ or $\beta = 1$ to be true - that is, either workers have none or all of the bargaining power. With a steady-state unemployment rate of 6%, this a value of $\beta = 0.03$ will yield a value of $\Psi_u = 0.077$.

Having seen how a recursive identification scheme can be recovered if we assume that the outside option of worker's does not depend on the state of the labor market, I now prove that the general SVAR without sign restrictions is stable provided that the total effects of distributional shocks on demand are not too strong.

Proposition 3: Consider the linearized solution to our model embodied in the SVAR of equation (79). The SVAR is globally stable under a profit-led regime ($\alpha < 0$) if $\alpha\Psi_u < \phi_1$, and globally stable under a wage-led regime ($\alpha > 0$) if $\alpha\Psi_u > \phi_1 - 2$.

Proof: See Appendix A.1.

Are these stability conditions likely to be satisfied? Suppose the learning-by-doing parameter is equal to 0.25, which is the point estimate Fazzari and Gonzalez (2022) find, and which is withing the range of what is commonly found in the micro literature. Suppose also that the effects of distribution on demand are modest; $\alpha = -0.1$, which can be obtained by setting $s_w = 0.15, s_p = 0.5$ and $\gamma = 0.45$. Then, this results in a lower bound for Ψ_u equal too:

$$\Psi_u > -2 \tag{73}$$

In other words, the effects that an increase on unemployment has on the wage share is bounded from below - it cannot be too negative. In the wage-led case, a similar statement can be made. Consider the same example but now $s_w = 0.15, s_p = 0.6$ and $\gamma = 0.35$, which results in $\alpha = 0.1$. Then, we get:

$$\Psi_u > -10.75 \tag{74}$$

As it can be readily appreciated, the stability conditions are much more stringent under a profit-led regime than under a wage-led regime. From a statistical point of view, what is going on is that a profit-led regime increases the persistence of the unemployment rate - if this effect is too strong, the system explodes. Under a wage-led regime, the unemployment rate becomes less persistent. Because the baseline model features some reasonable amount of persistence - if $\Psi_u = 0$, the first-order correlation of the unemployment rate would be 0.75 in our example - much stronger effects of the unemployment rate on distribution are needed to stabilize the system.

4 The Estimation Procedure

Consider the standard reduced-form VAR model:

$$y_t = C_B + \sum_{i=1}^{P} B_i y_{t-i} + e_t \tag{75}$$

where y_t is $N \times 1$ vector containing our N endogenous variables, C_B is a $N \times 1$ vector of constant, B_i for $i = 1, ..., P$ are $N \times N$ parameter matrices, with P the number of lags (5 in our baseline scenario), and e_t the vector of residuals with $u_t \sim N(0, \Sigma)$ where Σ is the $N \times N$ variance-covariance matrix.

Wee estimate the model using Bayesian methods, which allows us to handle the large number of parameters. We specify unemployment and the wage share in levels, while we specify output in first-differences, as implies by our theoretical model. We back out our estimates for output in levels computing the cumulated responses of the impulse-response function for output over multiple horizons.

In order to map the reduced-form shocks e_t into a vector of structural shocks ϵ_t, we need to impose restrictions on the estimated variance-covariance matrix. Specifically, the reduced-form shocks can be written as a linear combination of the structural shocks ϵ_t:

$$u_t = A\varepsilon_t \tag{76}$$

with $\epsilon_t \sim N(0, I_N)$, where I_N is an $N \times N$ identity matrix and A is a non-singular parameter matrix. Our goal is to identify A from the symmetric matrix Σ, and to do that we impose the sign restrictions implied by our model. These take the form on restrictions on the sign of the variables' impact response to shocks, following the procedure described in Rubio-Ramirez, Waggoner and Zha (2010). These restrictions, which were derived in the previous section, are presented in Table 1 below. The distributional shock raises the labor share, but depending on the value of α, can increase or decrease growth and unemployment. The demand shock increases output and decreases unemployment, a prediction shared by many New-Keynesian models. Finally, a supply shock increases unemployment, a prediction shared by many New-Keynesian models[8], and decreases the labor share, while it's impact on output will depend on the demand regime. The innovation innovation of this paper is exploiting the fact that an increase in demand raises the labor share, since higher output growth leads to lower unemployment, as implied by the aggregate supply equation, and hence, a higher labor share, as implied by the wage curve. The mechanism is straightforward: higher demand and

[8] Like in New-Keynesian models, output is demand-determined in the environment we study. Given that output is fixed by demand, a sudden rise in labor productivity then has the perverse effect of decreasing labor demand, which then increases unemployment.

lower unemployment strengthen the bargaining position of workers, which increases the labor share.

Table 1: Sign Restrictions

	Distributional	Demand	Supply
Labor Share	+	+	−
GDP Growth	?	+	?
Unemployment	?	−	+

My research design estimates a simple structural vector auto-regression with the labor share, output and unemployment, and imposes the sign restrictions derived from the model to identify the impact of distributional shocks on output and unemployment. We use publicly available data which can be downloaded from the FRED between the period 1959Q1 - 2022Q2, to conduct our empirical exercise. Our measure of the labor share is the WASCUR series (compensation of employees) divided by nominal GDP. This series has a somewhat lower level than what is commonly reported - it starts at 49% in 1959, peaks at 52% in 19969, and then falls to 44% today.[9].

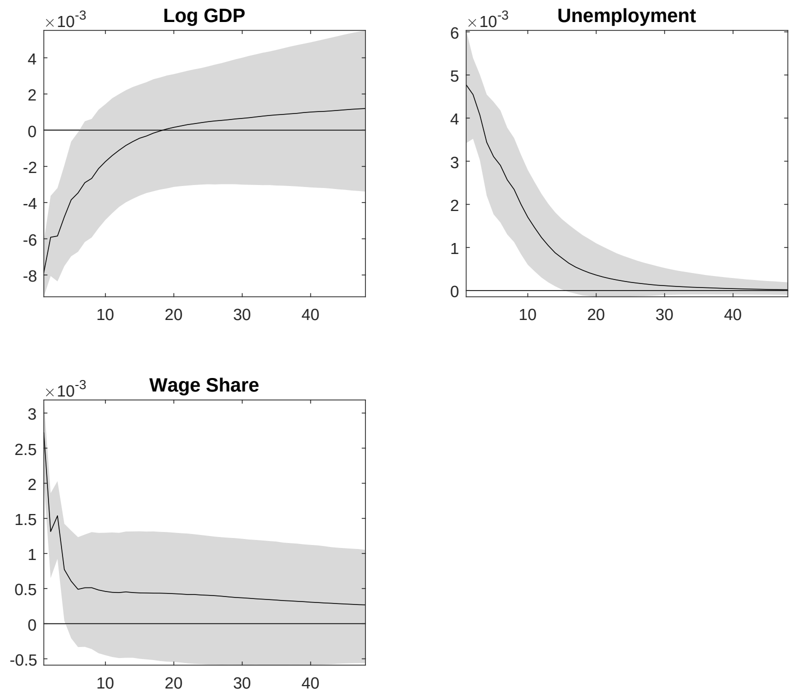
5 Results

The results of our estimated procedure are summarized in Figures 2, 3 and 4. Figure 2 shows the response of GDP, Unemployment and the Wage Share to a distributional shock. The Wage Share rises upon impact, as implied by our sign restriction, and then decreases monotonically for several periods. It's interesting to note that there is no sign reversal. The two top panels summarize one of the key results from the paper: GDP contracts substantially upon impact and takes 5 years to go back to it's initial level. After that, GDP starts expanding until quarter 48, but the confidence intervals contain 0. With regards to unemployment, it rises upon impact, and then declines monotonically to it's initial value.At business cycle frequencies, then, there is some strong evidence distributional shocks are contractionary, while there is some weak evidence that they are expansionary in the long-run.

Figure 5 and 6 show the IRF's for demand and technology shocks. In the short-run, demand shocks raise output and decrease unemployment. This result is consistent both Post-Keynesian and standard New Keynesian models, and has been replicated across other SVAR

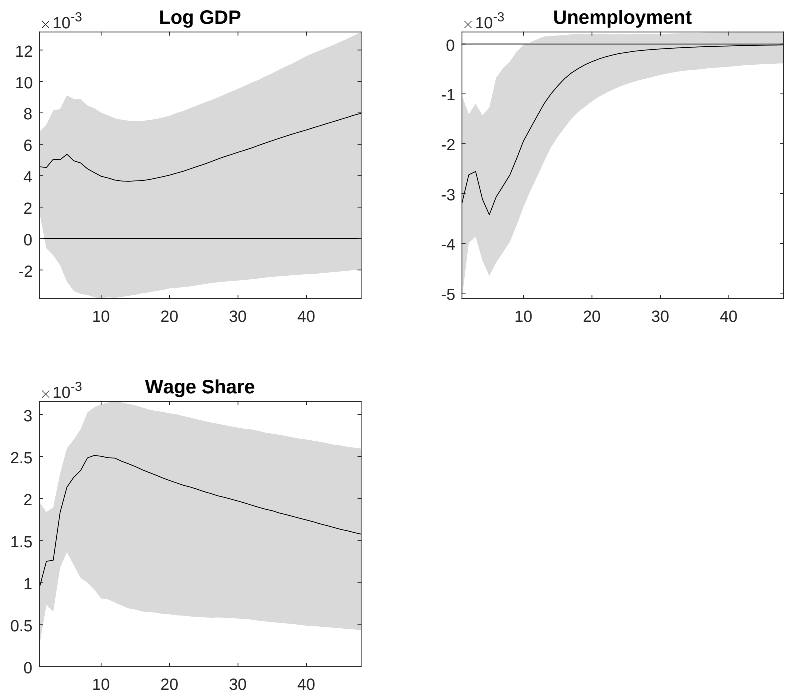
[9]I plan to conduct robustness checks on the sample period, number of lags and different measures of the labor share.

Figure 2: IRF - Distributional Shock



exercises with different identification schemes. Two new results, however, stand out: first, output expands permanently after a demand shock; that is, demand shocks have permanent expansionary effects. Note that this restriction is not imposed on our SVAR, but it's implied by our Post Keynesian model. This result coincides with the recent work by Girardi et. al (2018) and Furlanetto (2021) that find evidence that transitory demand shocks can have permanent effects on output. Second, the wage share expands in the short-run, and continues to increase until quarter 10, and then declines monotonically. This result is consistent with our model and our labor-market mechanism through which demand affects distribution: a demand expansions causes a rise in output, a decrease in unemployment, which leads to a stronger bargaining position of workers, and an expansion of the wage share. To the best of my knowledge, this is the first paper to highlight and document a strong positive response of the wage share to demand shocks. This lends support to the idea that a lot of the wage-led results that have been found using single equation methods can be explained by demand shocks that generate a positive correlation between output and the wage share. Finally, our results for the technology shock are similar to New-Keynesian models that include an automation channel to explain the wage share: a rise in productivity expands output, but holding demand fixed, this leads to less labor requirements and increases unemployment. This weakens the bargaining power of workers and depresses the wage share.

Figure 3: IRF - Demand Shock



Our estimation method also allows us to conduct a variance decomposition exercise, where we express the fluctuations in each variable at different horizons as the function of our three structural shocks. Table 2 shows the contribution of our distributional shock to the Wage Share, Output and Unemployment at different horizons. This distributional shock is the dominant force of short-run movements in the wage share, and it's importance declines substantially as the horizon rises. At the 10-year horizon, it only accounts for one fifth of the movements in the wage share. Meanwhile, its contribution to GDP is fairly stable across horizons, accounting for roughly one fourth of the fluctuations in output, and little more than one tenth of the fluctuations in unemployment. This shows that distributional shocks are an important source of business cycle fluctuations at all horizons, and account for most of the short-run movements in the wage-share.

Tables 3 and 4 show the same exercise for demand and technology shocks, respectively. Both of these shocks account for a negligible amount of the fluctuations in the wage-share in the short-run, but their importance increases as the horizon rises. Demand shocks account for

Figure 4: IRF - Technology Shock

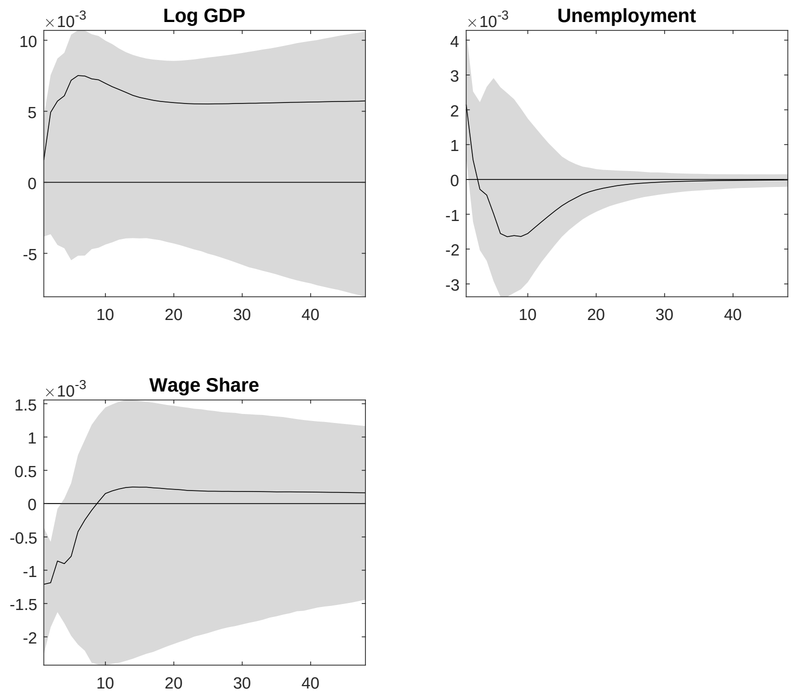


Table 2: Variance Decomposition - Distributional Shock

Horizon	Wage Share	Log GDP	Unemp
1	85	26	16
2	56	25	14
4	35	25	13
8	26	25	13
20	22	25	13
40	21	25	13

60% of the fluctuations of the wage share in the long-run. Again, to my knowledge, this is the first piece of empirical evidence showing that demand shocks shape long-run distributional outcomes. Technology shocks account for very little of the fluctuations in output and unemployment at all horizons, and demand shocks account for 70% of the fluctuations in unemployment in the long-run, and half of the fluctuations in output in the long-run. These results point to the dominance of demand shocks in accounting for macroeconomic performance in the long-run, a result fully consistent with Post-Keynesian economics, but at odds with DSGE models of both the Real Business Cycle and New Keynesian variety.

Table 3: Variance Decomposition - Demand Shock

Horizon	Wage Share	Log GDP	Unemp
1	13	57	69
2	38	56	72
4	51	55	70
8	56	55	70
20	59	55	70
40	59	55	70

Table 4: Variance Decomposition - Technology Shock

Horizon	Wage Share	Log GDP	Unemp
1	1	16	14
2	4	18	13
4	13	18	15
8	17	18	15
20	19	18	15
40	19	18	15

6 Conclusion

This paper is still a work in progress. It develops a simple extension of the canonical Bhaduri-Marglin model to incorporate a labor market, unemployment, and endogeneizes wage setting using a Nash Bargaining protocol. When one allows the state of the labor market to influence wage setting, one introduces a general equilibrium channel through which higher demand can increase the wage share. The model is then used to disentangle demand, supply and distributional shocks and to study the effects that distributional shocks have on output and unemployment. I find substantial evidence that these shocks are contractionary in the short-run, but some weak evidence that they are expansionary in the long-run. These shocks account for a fourth of the fluctuations of output at long-run horizons, and for most of the movement in the wage share in the short-run.

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Appendix

Collected Proofs

6.1 Proof of Proposition 3

To prove that the system is stable, all roots of the characteristic equation of the matrix:

$$\begin{bmatrix} \alpha\Psi_u - \lambda & 0 & \Psi_u(1-\phi_1) \\ -\alpha & -\lambda & \alpha\Psi_u(1-\phi_1) \\ \alpha & 0 & (1-\phi_1)-\lambda \end{bmatrix} \tag{77}$$

Must be inside the unit circle. Computing the characteristic equation, we get that two roots are equal to 0, and the third root is equal too:

$$\lambda = (1-\phi_1) - \alpha\Psi_u \tag{78}$$

There are two cases: the profit-led case and the wage-led case. Two inequalities must be satisfied for each case; show that one of each inequality is satisfied automatically thanks to signs, and then show the bounds in each case.