Wage policy in an open–economy Kalecki–Kaldor model: A simulation study

Rudiger von Arnim*

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Abstract This paper discusses a Post–Keynesian model of income, production, and trade. The one–country, one–sector model features Kaleckian investment demand, Kaldorian productivity and a labor market module based on a wage–price spiral. The model is first presented for a closed economy with exogenous real wages; second, for a closed economy with endogenous real wages; third, for an economy open to trade with endogenous real wages. Simulations with different calibrations show key characteristics of the model. Monte Carlo simulations over reasonable parameter ranges shed some light on the effectiveness of wage policies in open economies.
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JEL classification E12, E20, C63, C68

1 Introduction

This paper attempts to further our understanding of a Post–Keynesian macroeconomic model of the real side by (1) endogenizing wage, price and productivity in an otherwise standard Neo–Kaleckian framework, and (2) investigating model sensitivity to different parameter regimes using Monte Carlo analysis. The latter is aimed at the debate in Post–Keynesian research regarding the nature of the demand regime as either profit–led or wage–led, and consequences therefrom for distributive policies in an open economy.

The discussion rests on two strands of literature. First, the Neo–Kaleckian literature on interactions between the rate of capacity utilization and the distribution of income, see Rowthorn (1982), Dutt (1984), Taylor (1985), Bhaduri and Marglin (1990) and Lavoie (1995). In a nutshell, growth must be wage–led in the "stagnationist" Kaleckian model, and can be profit–led in the "exhilirationist" version, if the positive response of investment demand to profitability outweighs the negative response of consumption demand via the the multiplier. The distribution of income is fully determined by the degree of monopoly, and a shock to the mark–up leads to a decrease in rates of profit and utilization—the paradox of cost—if demand is wage–led, and to an increase in rates of profit and utilization if demand is profit–led. Second, a cornerstone of Kaldorian growth models is the Kaldor–Verdoorn law, see Kaldor (1978), Thirlwall (1983) as well as contributions

*The University of Utah, Department of Economics, 260 Central Campus Drive, OSH Rm. 343, Salt Lake City, UT 84112; E–Mail: rudiger.vonarnim@economics.utah.edu. I am deeply grateful for Lance Taylor's guidance throughout this project. I would like to thank as well Duncan K. Foley for his many suggestions. Comments from Deepankar Basu, Alex Izurieta, Massimiliano LaMarca, Marc Lavoie, Tracy Mott, Codrina Rada, Servaas Storm and three anonymous referees greatly improved the paper. All remaining errors are of course mine.

in McCombie et al. (2003). In a nutshell, the Kaldor–Verdoorn law determines labor productivity growth as a function of demand growth. Naastepad (2006) and Rada and Taylor (2006) employ rules of the Kaldor–Verdoorn type to endogenize productivity in models with Kaleckian investment. In these models, nominal wage and price remain exogenous. The wage share then must fall over an expansion, unless it is assumed that real wage growth matches (or exceeds) productivity growth. Further, exports are introduced as a function of real unit labor cost, extending the direct link between domestic demand and distribution to the foreign sector. The resulting demand regime tends more strongly to be profit–led. Blecker (1989), in contrast, shows how the simple stagnationist Kaleckian model can tend to relax the paradox of cost if the economy is open to trade, and exports are a function of the real exchange rate. However, in that model wages and productivity are exogenous.

How does such a Kalecki–Kaldor model behave with endogenous nominal wage, price and productivity? How does trade affect such a model? These are the two questions posed, and in the following sections I present a Kalecki–Kaldor model of a closed economy (section 2), then include a wage curve and mark–up equation (section 3), and lastly open the economy to trade (section 4). Section 4 closes with an examination of parameter configurations that would support the effectiveness of wage policies in an open economy. Section 5 discusses simulations of such and other shocks based on a variety of different model calibrations; section 6 takes this approach a step further, examining Monte Carlo simulations of different model calibrations as well as model responses to shocks. Section 7 concludes.

Before taking off, though, a couple of comments on scope and approach are in order. First, both the Kaleckian and Kaldorian models are called *growth* models, but the view taken here is that the rate of capacity utilization is not the adjusting variable in the long run. Similarly, the Kaldor–Verdoorn law might be better suited to the short run. The model(s) presented here will be interpreted in the short run, and, correspondingly, the capital stock is taken as fixed. Second, the model combines goods and labor market, but leaves finance out of the picture. Third, the model is static, and therefore cannot be compared to cyclical models, which can describe dynamics and growth around an unstable equilibrium with stationary state variables. The seminal reference here is Goodwin (1967), and, i.e., Barbosa-Filho and Taylor (2007) present a recent example. This literature informs the discussion, but clearly has a different scope. Lastly, the model is presented in growth rates, which simplifies analysis, and enables detailed comparative static exercises.

2 A Kalecki–Kaldor model of a closed economy

The model of this section is a closed economy version of Naastepad (2006) and Rada and Taylor (2006), section 7. The focus of the former is to introduce a real wage effect on productivity, arguing that firms substitute away from labor with rising costs for the latter, thus inducing technical change. As a result, wage restraint can lead to stagnation as well as a slowdown in productivity growth. The focus of the latter (with regard to this model) is to discuss the implications of shocks and policies for employment generation. However, in both papers, real wage growth is exogenous. That implies a pro–cyclical profit share, unless it is assumed that real wage growth matches (or exceeds) that of labor productivity. The closed economy can be summarized in the following five relationships:

$$\hat{I} = \hat{I}_0 - \rho\hat{\psi} + \beta\hat{u} \text{ with } \rho = (\psi/\pi)\alpha \text{ and } u = V/K \quad (2.1)$$

$$\hat{s} = -\sigma\hat{\psi} = -(s_\pi - s_\psi)(\psi/s)\hat{\psi} \quad (2.2)$$

$$\hat{\xi} = \hat{\xi}_0 + \delta\hat{V} \quad (2.3)$$

$$\hat{V} = \hat{I} - \hat{s} \quad (2.4)$$

$$\hat{L} = \hat{V} - \hat{\xi}, \quad (2.5)$$

where *hats* denote growth rates. I is investment, I_0 represents autonomous investment or "animal spirits," ψ are real unit labor costs and V real GDP. $0 < \alpha < 1$ is the elasticity of investment demand with respect to the profit share, and $0 < \beta < 1$ the elasticity of investment demand with respect to the rate of capacity utilization $u = V/K$. The standard Kaleckian investment function implies that the paradox of cost always applies, whereas the version used here does not, see Bhaduri and Marglin (1990).

s is the aggregate saving propensity, and follows from the accounting identity that saving out of wage income plus saving out of profit income sum to total saving. $\sigma > 0$ is the elasticity of saving with respect to the wage share, so that the saving propensity always falls with a redistribution of income towards wage earners.

$\xi = V/L$ is average labor productivity, and is determined by a Kaldor–Verdoorn Law, named after Verdoorn (1949) and Kaldor (1978). Kaldor argued that average labor productivity increases with the expansion of manufacturing due to increased specialization and learning–by–doing. The literature on the topic is extensive, and generally finds strong support for a positive link between demand growth and productivity growth. $0 < \delta < 1$ is the Kaldor–Verdoorn elasticity; see McCombie et al. (2003) and references therein.

Value added V is determined from the demand side, and employment L follows given a *changing* labor input coefficient $1/\xi$. Strictly speaking, only I and ξ are determined by behavioral functions. Closure assumptions—output is demand–determined and labor supply does not constrain the economy—complete the model.

2.1 Short run equilibrium

In the short run, $K = K_0$ and $\hat{K} = 0$, so that the two equations of the model can be written in productivity growth $\hat{\xi}$ and demand growth $\hat{V}$,[1]

$$\hat{\xi}_{ED} = \frac{\hat{\omega}(\sigma - \rho) + \hat{I}_0}{\sigma - \rho} - \frac{1 - \beta}{\sigma - \rho}\hat{V}, \text{ and} \quad (2.6)$$

$$\hat{\xi}_P = \hat{\xi}_0 + \delta\hat{V}, \quad (2.7)$$

[1] In the short run, $\hat{K} = 0$ implies that a higher rate of demand growth is equivalent to a higher rate of capacity utilization. With only gross savings and investment flows considered, it implies as well that net investment is zero. The assumption is not required, but simplifies the discussion.

where $\hat{\xi}_{ED}$ is the *effective demand*–curve, and $\hat{\xi}_P$ represents a Kaldor–Verdoorn *productivity* schedule. Demand is profit–led if $\sigma - \rho < 0$, i.e. if the (leakage) elasticity of saving is smaller than the (injection) elasticity of investment, both with respect to real unit labor costs. The equilibria

$$\hat{\xi}^* = \frac{\delta \hat{I}_0 + (1-\beta)\hat{\xi}_0 + (\sigma-\rho)\delta\hat{\omega}}{1-\beta+(\sigma-\rho)\delta} \text{ and} \tag{2.8}$$

$$\hat{V}^* = \frac{\hat{I}_0 + (\sigma-\rho)(\hat{\omega}-\hat{\xi}_0)}{1-\beta+(\sigma-\rho)\delta} \tag{2.9}$$

show that growth, as typical for models with this structure, depends on trend growth rates, here of investment $\hat{I}_0$, productivity $\hat{\xi}_0$, and of real wages $\hat{\omega}_0$, as well as the relevant elasticities. The equilibrium is economically meaningful if $1-\beta+(\sigma-\rho)\delta > 0$, meaning either

$$\delta > -\frac{1-\beta}{\sigma-\rho} \text{ if demand is wage–led, } (\sigma-\rho>0, \textbf{WL}), \text{ or} \tag{2.10}$$

$$\delta < -\frac{1-\beta}{\sigma-\rho} \text{ if demand is profit–led, } (\sigma-\rho<0, \textbf{PL}). \tag{2.11}$$

The equilibrium exists, if $\delta \neq (1-\beta)/(\sigma-\rho)$, and is stable if the response of investment to an increase in demand is smaller than the response of savings.[2] The model allows thought experiments on how to sustain demand, productivity and employment growth, but takes the real wage as given. As previously mentioned, Naastepad (2006) focuses on the effect real wage growth can have on productivity growth, but since it does not alter the qualitative features of the model, this line of inquiry is not pursued here.[3]

3 A Kalecki–Kaldor model of a closed economy with wage and price setting

The model of this section is the same as above plus wage curve and mark–up price:

$$\hat{w} = \hat{w}_0 + w_1(\hat{L} - n) \tag{3.1}$$

$$\hat{Q} = \hat{q}_0 + q_1(\hat{w} - \hat{\xi}), \tag{3.2}$$

where w is the nominal wage, and Q the price, marked–up on nominal unit labor cost $w/\xi = wL/V$. $\hat{w}_0$ and $\hat{q}_0$ are trend inflation rates of wages and prices, respectively. The wage curve (Blanchflower and Oswald (1990)) implies that the wage level w rises with the rate of employment, L/N, given bargaining strength of workers summarized in the elasticity $w_1 > 0$. n represents the growth rate

[2] In levels, $g^I = I/K = (1-\psi)^\alpha u^\beta$, and $g^S = su = (s_\pi - (s_\pi - s_\psi)\psi)u$, and for stability in the goods market $g_u^I - g_u^S = s - \beta\pi^\alpha u^{\beta-1} < 0$, which is generally satisfied. In section 4 and simulations, imports increase the leakage elasticity and further stabilize the goods market.

[3] If productivity growth speeds up with higher real wage growth, the productivity rule is $\hat{\xi} = \hat{\xi}_0 + \gamma\hat{\omega} + \delta\hat{V}$, and the equilibrium demand growth rate becomes $\hat{V}^* = (\hat{I}_0 + (\sigma-\rho)((1-\gamma)\hat{\omega} - \hat{\xi}_0))/(1-\beta+(\sigma-\rho)\delta)^{-1}$ meaning $\gamma > 1$ reverses the sign of real wage growth on equilibrium output growth, given the demand regime $\sigma - \rho$, see Naastepad (2006), page 418. Since γ appears to be smaller than unity, it does not dramatically alter the qualitative features of the model. It does save some complexity, too.

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of the labor force N.

3.1 Price, real wage and distribution

Let us start with a couple of comments on the price Q. First, it is labelled such because the letter P is reserved for the price of total supply, which differs from the price Q of value added in an open economy, see equation (4.1). Second, Q rises with nominal unit labor costs, given the mark–up elasticity $0 < q_1 < 1$. The standard formulation, i.e. $Q = (1+\tau)w/\xi$, with a fixed mark–up, fixes the profit share at $\pi = \tau/(1+\tau)$, which would defeat the purpose of determining the distribution of income endogenously.[4] Hence, the equation for Q implies an endogenous mark–up. First, though, let us have a closer look at nominal unit labor costs, inflation and the real wage. Nominal unit labor cost growth is

$$\begin{aligned} \hat{w} - \hat{\xi} &= \hat{w}_0 - (1+w_1)\hat{\xi}_0 - w_1 n + \psi_1 \hat{V}, \text{ with} \\ \psi_1 &= w_1 - (1+w_1)\delta. \end{aligned} \tag{3.3}$$

The parameter ψ_1 deserves close attention, since, as will be seen throughout this section, the characteristics of price and distributive regime change with ψ_1. (ψ_1 will play as well a key role in the simulation exercises in section 5.) $\psi_1 > 0$ if $w_1/(1+w_1) > \delta$, and vice versa, meaning strong bargaining and weak productivity effects imply rising nominal unit labor costs with demand growth.

Inflation, derived from nominal unit labor costs, is

$$\begin{aligned} \hat{Q} &= \overline{\eta} + q_1 \psi_1 \hat{V}, \text{ with} \\ \overline{\eta} &= \hat{q}_0 + q_1 \overline{q}, \text{ and} \\ \overline{q} &= \hat{w}_0 - (1+w_1)\hat{\xi}_0 - w_1 n, \end{aligned} \tag{3.4}$$

and partials $\frac{\partial \hat{Q}}{\partial \hat{q}_0} > 0$, $\frac{\partial \hat{Q}}{\partial \hat{w}_0} > 0$, $\frac{\partial \hat{Q}}{\partial \hat{\xi}_0} < 0$, $\frac{\partial \hat{Q}}{\partial n} < 0$. Since $0 < q_1 < 1$, the sign of $\partial \hat{Q}/\partial \hat{V} = q_1 \psi_1$ varies with ψ_1. The price rises with activity ($\psi_1 > 0$) if nominal unit labor costs rise with activity. Price setting depends on bargaining power of workers (w_1) and the strength of productivity gains (δ); the implicit assumption is that firms do not necessarily have sufficient pricing power in product markets to realize profits generated due to unit cost savings.

The real wage is $\hat{\omega} = \hat{w} - \hat{Q}$, which becomes

$$\begin{aligned} \hat{\omega} &= \overline{w} + (w_1(1-\delta) - q_1\psi_1)\hat{V}, \text{ with} \\ \overline{w} &= \hat{w}_0 - w_1(\hat{\xi}_0 + n) - \overline{\eta}. \end{aligned} \tag{3.5}$$

If $\psi_1 < 0$, $\partial \hat{\omega}/\partial \hat{V} \gg 0$, but the total effect will not be much larger than $w_1(1-\delta)\hat{V}$, since both q_1 and ψ_1 are likely to be small. On the other hand, if $\psi_1 > 0$, $\partial \hat{\omega}/\partial \hat{V} > 0$ as well, since

[4] In the standard model, the constant mark–up τ represents the only link between distribution and demand, and exogenous changes to the mark–up are the only channel through which distribution can have an effect on demand. Blecker (1989), page 399, emphasizes this point.

$w_1 > -\frac{\delta q_1}{(1-q_1)(1-\delta)}$. Pro–cyclical real wages are build into the model, but prices can be (weakly) counter–cyclical.[5]

Next, the distributive curve $\hat{\psi} = \hat{w} - \hat{Q} - \hat{\xi}$ is

$$\begin{aligned} \hat{\psi} &= \overline{\psi} + (1-q_1)\psi_1\hat{V}, \text{ with} \\ \overline{\psi} &= -\hat{q}_0 + (1-q_1)\overline{q}. \end{aligned} \tag{3.6}$$

$\partial\hat{\psi}/\partial\hat{V} > 0$ if $\psi_1 > 0$, and distributive adjustment exhibits a profit squeeze (**PS**), since real unit labor costs rise with activity; whereas $\partial\hat{\psi}/\partial\hat{V} < 0$ if $\psi_1 < 0$, and distributive adjustment exhibits "forced saving" (**FS**), since productivity growth outruns real wage growth, and the profit share rises.[6]

Now, let us consider the mark–up τ mentioned above. With the price equation Q, τ is endogenous. Since $Q = (1+\tau)w/\xi$ at any point in time must hold, $\tau = q_0(w/\xi)^{q_1-1} - 1$, and log–differentiation gives

$$\hat{\tau} = \frac{1}{\pi}\left[\hat{q}_0 - (1-q_1)\overline{q} - (1-q_1)\psi_1\hat{V}\right], \tag{3.7}$$

which implies that $\partial\hat{\tau}/\partial\hat{V} > 0$ if $\psi < 0$, and vice versa.[7] To summarize, a profit squeeze, i.e. $\psi_1 > 0$ and a higher wage share over the course of an expansion, coincides with a counter–cyclical mark–up, and a (weakly) pro–cyclical price. Forced saving, i.e. $\psi_1 < 0$ and a higher profit share over the course of an expansion, coincides with a pro–cyclical mark–up, and a (weakly) counter–cyclical price. To emphasize: If $\psi_1 < 0$, Q falls with an increase of demand despite a rising mark–up τ, because per unit nominal costs decrease due to strong productivity effects.

3.2 Short run equilibrium

The two equations in $\hat{\psi}$ and $\hat{V}$ are

$$\hat{\psi}_{ED} = \frac{\hat{I}_0}{\rho-\sigma} - \frac{1-\beta}{\rho-\sigma}\hat{V} \tag{3.8}$$

$$\hat{\psi}_D = \overline{\psi} + (1-q_1)\psi_1\hat{V}, \tag{3.9}$$

where subscripts stand for ED = *effective demand*, D = *Distribution* and, as above, $\rho-\sigma$ determines the demand regime. If $\rho - \sigma > 0$, demand will be profit–led, **PL**, and wage–led, **WL**, otherwise.

[5]See Messina et al. (2009) for an analysis of real wage cycles in OECD countries. Less unionized countries—i.e., the US—show consistently and more strongly pro–cyclical real wages, since unions stabilize earnings.

[6]Such forced saving in combination with the Kaleckian demand specification is not equivalent to macroeconomic adjustment with forced saving under full employment. The latter implies that at or near full employment price increases diminish real wealth and in turn consumption as asset holders desire to replenish their savings. In this case the economy still operates below full capacity, and forced saving refers to a rising profit share due to productivity growth in excess of real wage growth.

[7]$\psi = 1/(1+\tau)$, so that $\hat{\psi} = -\pi\hat{\tau}$, and the two approaches are identical.

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The equilibria are

$$\hat{\psi}^* = \frac{(1-\beta)\overline{\psi} + \psi_1 \hat{I}_0}{1-\beta+(\rho-\sigma)\psi_1} \tag{3.10}$$

$$\hat{V}^* = \frac{\hat{I}_0 - (\rho-\sigma)\overline{\psi}}{1-\beta+(\rho-\sigma)\psi_1} \tag{3.11}$$

and for the model to make sense

$$\psi_1 > -\frac{1-\beta}{\rho-\sigma}, \text{ if } \rho-\sigma>0, \textbf{PL}, \text{ and} \tag{3.12}$$

$$\psi_1 < -\frac{1-\beta}{\rho-\sigma}, \text{ if } \rho-\sigma<0, \textbf{WL}. \tag{3.13}$$

This condition is violated if (1) $\psi_1 > 0$, (PS), and $\rho - \sigma < 0$, (WL), *and* $\psi_1 > \frac{1-\beta}{\sigma-\rho}$, meaning the demand curve cuts the distributive curve from above, or (2) if $\psi_1 < 0$, (FS), and $\rho - \sigma > 0$, (PL), *and* $\psi_1 < -\frac{1-\beta}{\rho-\sigma}$, meaning the demand curve cuts the distributive curve from below. When would this occur? In both cases the slope of the demand growth schedule is *small.* The slope of the demand growth schedule decreases as β approaches 1 from below. The Keynesian stability condition, however, requires that the response of savings to an increase in income must exceed the response of investment, which means that β cannot become very large.[8]

4 A Kalecki–Kaldor model of an *open* economy with wage and price setting

Opening the economy to trade requires several changes: Price P of total supply X and price Q of value added $V = (1-f)X$ differ, since the former includes imports, valued at eP_f. Real consumption is nominal after–saving income $(1-s)QV$ deflated by P, which means that the price ratio Q/P enters the multiplier. Assuming that all trade passes through domestic firms, the multiplier includes as well the import propensity. The demand curve has to reflect these changes.

First, let us consider prices. As mentioned, Q, eP_f, and P now differ. e is the domestic currency price of one unit of foreign currency; in all of the following, $P_f = 1$ for brevity. The wage curve and Q are as above, but the profit rate becomes $r = (1-\psi)(Q/P)u$. P averages Q and e, weighted by the import propensity f, and its growth rate is $\hat{P} = (1-f)\hat{Q} + f\hat{e}$. The crucial assumption here is that firms mark–up on domestic costs, but, given the import propensity f, pass on external costs without a further pricing decision. After substituting, $\hat{P}$ is

$$\hat{P} = (1-f)\overline{\eta} + f\hat{e} + (1-f)q_1\psi_1\hat{V} \tag{4.1}$$

with $\overline{\eta} = \hat{q}_0 + q_1\overline{q}$ as above, and partials $\frac{\partial\hat{P}}{\partial\hat{q}_0} > 0$, $\frac{\partial\hat{P}}{\partial\hat{w}_0} > 0$, $\frac{\partial\hat{P}}{\partial\hat{\xi}_0} < 0$, $\frac{\partial\hat{P}}{\partial n} < 0$, $\frac{\partial\hat{P}}{\partial\hat{e}} > 0$. The sign of $\partial\hat{P}/\partial\hat{V} = (1-f)q_1\psi_1$ depends on ψ_1. Like in the previous section, price and mark–up behavior

[8]The Keynes–Kalecki approach has been critized for the rigidity of this condition, see, for example, Skott (2008).

and distributive adjustment hinge on the relative magnitude of the bargaining elasticity w_1 and the Kaldor–Verdoorn elasticity δ. P reflects that, depending on the share of domestic content in total supply, $(1-f)$.

4.1 Exports, imports and the multiplier

Export and import functions can be written as

$$\hat{M} = \hat{f} + \hat{X} = \hat{\phi}_0 - \phi_1(\hat{e} - \hat{P}) + \hat{X} \tag{4.2}$$

$$\hat{E} = \hat{\epsilon} + \hat{X}_f = \hat{\epsilon}_0 + \epsilon_1(\hat{e} - \hat{P}) + \hat{X}_f, \tag{4.3}$$

where income elasticities of import and export demand are assumed unitary, but price elasticitities of import and export demand are $-\phi_1$ and ϵ_1. Simulations and shocks below do not focus on exports and imports directly, so that the trend demand growth rates $\hat{\phi}_0 = 0, \hat{\epsilon}_0 = 0$ are set to zero.

With total supply $X = C + I + E$, value added $V = (1-f)X$ and real consumption $C = (1-s)QV/P$, the multiplier becomes $m = \frac{(1-f)}{1-(1-f)(1-s)Q/P}$ and its growth rate is $\hat{m} = m_Q(\hat{Q} - \hat{P}) + m_\psi\hat{\psi} - m_f\hat{f}$, where the elasticities (at unitary base year prices) are

$$m_f = f(1-f)^{-2}m > 0,$$

$$m_Q = -m_P = (1-s)m > 0, \text{ and}$$

$$m_\psi = sm\sigma = m(s_\pi - s_\psi)\psi > 0.$$

After substituting the growth rate of the import propensity f, $\hat{f} = -\phi_1(\hat{e} - \hat{P})$, the growth rate of the multiplier becomes

$$\hat{m} = m_Q\hat{Q} + m_\psi\hat{\psi} + m_f\phi_1\hat{e} - (m_Q + m_f\phi_1)\hat{P}. \tag{4.4}$$

The multiplier increases with value added prices Q, since it implies a rise in real income QV/P, and increases with ψ, since wage earners have a higher propensity to consume. The multiplier *decreases* with supply price P, since it implies a fall in real income,[9] and decreases in the import propensity f. f is a decreasing function of e/P, meaning a nominal devaluation decreases imports, and increases the multiplier, whereas domestic price increases increase imports, hence decrease the multiplier. The introduction of import costs brings prices to the fore. Next to the wage share ψ, prices Q and P as well as the nominal exchange rate e impact the multiplier. The open economy results can differ starkly from the closed economy results. To see how, we have to take up effective demand.

4.2 Effective demand and short run equilibrium

The effective demand curve now includes external demand, $\hat{V} = \hat{m} + \chi\hat{I} + (1-\chi)\hat{E}$ with $\chi = mI/V$ the multiplier adjusted share of investment in GDP. After some algebra the effective demand

[9] $m_Q = -m_P$, but since $\hat{Q} \neq \hat{P}$, the effects do not cancel.

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schedule can be written as

$$\hat{V} = \frac{\lambda(\overline{\eta} - \hat{e}) + \chi\hat{I}_0 + (1-\chi)\hat{X}_f}{1 - \lambda q_1\psi_1 - \chi\beta} + \frac{m_\psi - \chi\rho}{1 - \lambda q_1\psi_1 - \chi\beta}\hat{\psi}. \tag{4.5}$$

The slope coefficient's denominator $1 - \lambda q_1\psi_1 - \chi\beta$ is positive for reasonable parameter values. This will be true even if $\lambda q_1\psi_1$ is positive, since this product will be small; see the discussion further below. Hence, the sign of the slope coefficient hinges on the numerator. Demand is profit–led if $m_\psi - \chi\rho < 0$, and vice versa. The difference $m_\psi - \chi\rho$ plays a central role in the simulation exercises of section 5. Another crucial parameter is λ:

$$\lambda = fm_Q - (1-f)\left[m_f\phi_1 + (1-\chi)\epsilon_1\right], \tag{4.6}$$

with partials $\frac{\partial\lambda}{\partial(1-\chi)} < 0$, $\frac{\partial\lambda}{\partial f} < 0$, $\frac{\partial\lambda}{\partial\phi_1} < 0$ as well as $\frac{\partial\lambda}{\partial\epsilon_1} < 0$, but $\frac{\partial\lambda}{\partial m} > 0$. In words, the more *open* the economy, meaning the higher f and $1-\chi$, the smaller (and more likely negative) is λ. And, the more *flexible* the economy, meaning the higher ϵ_1 and ϕ_1, the smaller (and more likely negative) is λ. How can this parameter be interpreted? First, λ is akin to a Marshall–Lerner condition. A nominal devaluation $\hat{e} > 0$ is expansionary if $\lambda < 0$, meaning the sum of the (weighted) import and export price elasticities ϕ_1 and ϵ_1 has to be larger than the elasticity of the multiplier with respect to value added price Q, $(1-f)(m_f\phi_1 + (1-\chi)\epsilon_1) > fm_Q$.

However, trade effects shift the ED–curve as well through inflation and productivity trends. If $\lambda < 0$, $\frac{\partial\hat{V}}{\partial\hat{q}_0} < 0$, $\frac{\partial\hat{V}}{\partial\hat{w}_0} < 0$, $\frac{\partial\hat{V}}{\partial\hat{\xi}_0} > 0$, $\frac{\partial\hat{V}}{\partial\hat{n}} > 0$, and vice versa. Essentially, if the economy responds strongly to changes in external competitiveness and $\lambda < 0$, wage policies have contractionary effects that emphasize—if profit–led—or limit and possibly reverse—if wage–led—the endogenous effects of distributional changes on demand.[10] Since λ has these important effects, it joins $m_\psi - \chi\rho$ and ψ_1 in the set of parameters most important for simulation exercises below.

Now, to gauge the total effect, let us consider the short run equilibrium:

$$\hat{V}^* = \frac{\chi\hat{I}_0 + (1-\chi)\hat{X}_f + \lambda(\overline{\eta} - \hat{e}) - (\chi\rho - m_\psi)\overline{\psi}}{1 - \chi\beta + (\chi\rho - m_\psi - \lambda q_1)\psi_1} \tag{4.7}$$

$$\hat{\psi}^* = \frac{(1 - \lambda q_1\psi_1 - \chi\beta)\overline{\psi} + \lambda(\overline{\eta} - \hat{e})\psi_1}{1 - \chi\beta + (\chi\rho - m_\psi - \lambda q_1)\psi_1}. \tag{4.8}$$

For the model to be economically meaningful,

$$\psi_1 > -\frac{1 - \lambda q_1\psi_1 - \chi\beta}{\chi\rho - m_\psi}, \text{ if } \chi\rho > m_\psi, \textbf{PL}, \text{ and} \tag{4.9}$$

$$\psi_1 < -\frac{1 - \lambda q_1\psi_1 - \chi\beta}{\chi\rho - m_\psi}, \text{ if } \chi\rho < m_\psi, \textbf{WL}. \tag{4.10}$$

[10] In Blecker (1989), the rate of accumulation of an open economy can increase in response to a lower mark–up if the economy is relatively closed, and trade elasticities are relatively small; the rate of accumulation decreases in response to a lower mark–up if the economy is relatively open. While the models differ, the key result is the same: The more open the economy, and the larger the trade elasticities, the more does growth of demand tend to respond negatively to a rise in the wage share, even if domestic demand is wage–led.

What is the equilibrium demand growth rate response to a shock? Note that the expression for $\hat{V}^*$ includes $\overline{\eta}$ and $\overline{\psi}$, both of which are parameters that include trend growth rates. Recall from above $\overline{\eta} = \hat{q}_0 + q_1\overline{q}$, and $\overline{\psi} = -\hat{q}_0 + (1-q_1)\overline{q}$ where $\overline{q} = \hat{w}_0 - (1+w_1)\hat{\xi}_0 - w_1 n$, so that writing $\theta = m_\psi - \chi\rho$ and simplifying gives $\lambda(\overline{\eta} - \hat{e}) + (m_\psi - \chi\rho)\overline{\psi} = (\lambda - \theta)\,\hat{q}_0 + (q_1\lambda + (1-q_1)\theta)\,\overline{q} - \lambda\hat{e}$. The equilibrium demand growth rate can then be written as

$$\hat{V}^* = \frac{\chi\hat{I}_0 + (1-\chi)\hat{X}_f + (\lambda-\theta)\,\hat{q}_0 + (q_1\lambda + (1-q_1)\theta)\,\overline{q} - \lambda\hat{e}}{1 - \chi\beta + (\chi\rho - m_\psi - q_1\lambda)\psi_1}. \tag{4.11}$$

With a positive denominator, the sign of the response of $\hat{V}^*$ to shocks to $\hat{q}_0$ depends on $\lambda - \theta$, and to $\hat{w}_0, \hat{\xi}_0, n$ on the q_1–weighted average of λ and θ. The following section takes a closer look at this condition, based on the arguably most interesting question what effect a policy induced increase of $\hat{w}_0$ would have.

4.3 Wage policy

With $\lambda < 0$, the demand curve $\hat{\psi}_{ED}$ (equation (4.5)) shifts left with $\hat{q}_0 > 0, \hat{w}_0 > 0$ and shifts right with $\hat{e} > 0, \hat{\xi}_0 > 0, \hat{n} > 0$. But how does the *equlibrium* demand growth rate (equation (4.11)) respond to an increase in the nominal wage rate? From equation (4.11), $\partial\hat{V}^*/\partial\hat{w}_0 > 0$ if $q_1\lambda + (1-q_1)(m_\psi - \chi\rho) > 0$. Since $\lambda < 0$, this implies that the equilibrium demand growth rate increases with a nominal wage increase if $(\chi\rho - m_\psi)/\lambda > q_1/(1-q_1)$. Now, profit– and wage–led demand regimes have to be considered separately.

1. $\lambda < 0$ and $\theta = (m_\psi - \chi\rho) < 0$ (**PL**): $\partial\hat{V}^*/\partial\hat{w}_0 > 0$ if $(\chi\rho - m_\psi)/\lambda > q_1/(1-q_1)$.
   The right hand side of the inequality above is positive, $q_1/(1-q_1) > 0$. The left hand side is negative; the condition is *always* violated, and equilibrium demand growth *always* responds negatively to a nominal wage increase.

2. $\lambda < 0$ and $\theta = (m_\psi - \chi\rho) > 0$ (**WL**): $\partial\hat{V}^*/\partial\hat{w}_0 > 0$ if $(\chi\rho - m_\psi)/\lambda > q_1/(1-q_1)$.
   As in the previous case, the right hand side is positive. In contrast to the previous case, the left hand side is positive as well. Hence, the condition can be satisfied, if $m_\psi \gg \chi\rho$, and/or λ is *small*, and/or q_1 is *small*, which implies that $\hat{\psi}_{ED}$ has to be fairly responsive (flat) to distributive changes. The equilibrium demand growth rate increases in response to a nominal wage increase if λ is small or the distributive response is large; see Figure 1 and the following discussion.

With $\lambda > 0$, $\hat{\psi}_{ED}$ shifts right with $\hat{q}_0 > 0, \hat{w}_0 > 0$ and shifts left with $\hat{e} > 0, \hat{\xi}_0 > 0, \hat{n} > 0$. How does equilibrium demand growth respond to an increase in the nominal wage rate? From equation (4.11), $\partial\hat{V}^*/\partial\hat{w}_0 > 0$ if $q_1\lambda + (1-q_1)(m_\psi - \chi\rho) > 0$. Since $\lambda > 0$, this implies that the equilibrium demand growth rate increases with a nominal wage increase if $(\chi\rho - m_\psi)/\lambda < q_1/(1-q_1)$. Again, profit– and wage–led demand regimes have to be considered separately:

1. $\lambda > 0$ and $\theta = (m_\psi - \chi\rho) < 0$ (**PL**): $\partial\hat{V}^*/\partial\hat{w}_0 > 0$ if $q_1/(1-q_1) > (\chi\rho - m_\psi)/\lambda$.
   The left hand side of this inequality is positive, the right hand side is as well. The condition is

satisfied, if $q_1 \gg 0$, and/or $\lambda \gg 0$, and/or $\chi\rho - m_\psi$ is *small*. In other words, the demand curve has to be fairly *un*responsive (steep) to distributive changes. Equilibrium demand growth increases in response to a wage increase if λ is large and the distributive response is weak; see as well Figure 2 and the following discussion.

2. $\lambda > 0$ and $\theta = (m_\psi - \chi\rho) > 0$ (**WL**): $\partial \hat{V}^*/\partial \hat{w}_0 > 0$ if $q_1/(1-q_1) > (\chi\rho - m_\psi)/\lambda$.
The left hand side is positive, but the right hand side is negative: The condition is always satisfied, since $q_1/(1-q_1) > 0$, and $(\chi\rho - m_\psi)/\lambda < 0$. If demand is wage–led and the economy is relatively closed to trade, wage policies are effective in spurring demand.

Wage policy can be successful, in the sense that it improves economic performance, if demand is strongly wage–led and $\lambda < 0$ is small, or if demand is only weakly profit–led, and $\lambda \gg 0$ is large. Wage policy cannot be successful, if $\lambda < 0$ and demand is profit–led, and is always successful, if $\lambda > 0$ and demand is wage–led.

Figure 1 and 2 highlight the issue. In Figure 1, $\hat{\psi}^1_D$ represents a distributive curve with forced saving, and $\hat{\psi}^1_{ED}$ a wage–led demand curve. All trend growth rates are assumed to be zero, so that the two curves cross at the origin, point A. A shock to $\hat{w}_0 > 0$ shifts the distributive curve upwards, and, if $\lambda < 0$, shifts (contracts) the demand curve leftward. Whether the new equilibrium demand growth rate is smaller (point B) or larger (point C) than zero, depends on the relative size of λ and the slope of the demand curve. In Figure 2, $\hat{\psi}^1_D$ represents a distributive curve with a profit squeeze, and $\hat{\psi}^1_{ED}$ a profit-led demand curve. With trend growth rates assumed to be zero the two curves cross at the origin, point A. The wage policy shifts the distributive curve upwards, and, if $\lambda > 0$, shifts the demand curve outward. Again, whether the new equilibrium demand growth rate is smaller (point B) or larger (point C), depends on the relative size of λ and the slope of the demand curve.

5 Calibration(s) and simulation(s)

How do these many and possibly small shifts in parameter regimes impact overall model results? This question is taken up in this section, which presents randomized calibrations and a variety of simulations.[11]

5.1 Calibration(s)

It is common practice to use a base year data set and elasticity values to calibrate a variety of parameters.[12] For an illustrative example, let's have a look at the investment function. Suppose

[11] The model of the previous section has been presented in growth rates, because it enabled a straightforward analysis of equilibria, composite elasticities and the impact of shocks. Calibration and simulation procedure are run in *levels*. Near the equilibrium, the linearized version describes the model's behavior reasonably well; calibrating and simulating the model in *levels* does show approximately the same behavior as the model above as long as the shocks considered are not large.

[12] The base year is derived from NIPA-tables, Bureau of Economic Analysis (BEA) data for the US economy, in Billion current US dollars, 2007:Q2.

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one can deduce a reasonable prior from available econometric evidence for the two elasticities, α and β. Investment I and the rate of capacity utilization $u = V/K$ are given from the base year data, allowing to solve for I_0. Thus, the key to calibration is to recognize that for each equation the base year value of the endogenous variable is known, hence the relationship can be used to determine one parameter.

It might be necessary to calibrate two parameters in a single relationship. For example, the gross macroeconomic propensity to save is a function of a distributive variable. Both the aggregate propensity s and the wage share ψ are known from the base year data, leaving two parameters, s_π and s_ψ, to be determined. Setting $s_\pi - s_\psi = s'$, with $0 < s' < 1$ gives the second degree of freedom, in effect defining how much larger the propensity to save out of profit income is than the propensity to save out of wage income.

Obviously, such a calibration exercise leaves considerable leeway to the modeler to determine the particular manifestation of functions. Point estimates for elasticity values simply do not converge, however often data sets, methods and procedures are updated and extended. Using elasticities from other studies is prone with difficulties, since they depend on the underlying model, its assumptions as well as the data set used. For that reason, one can go a step further and randomize the calibration procedure. Principally, for each equation elasticities are drawn from a uniform probability distribution with suitable boundaries and fitted to the base year data by calculating the appropriate intercepts. Specifically, mean and variance for the uniform probability distributions of a randomized parameter p can be written as

$$E[p] = \frac{[(1-x)m + (1+x)m]}{2} = m, \text{ and} \tag{5.1}$$

$$Var[p] = \frac{[(1+x)m - (1-x)m]^2}{12} = \frac{1}{3}(xm)^2, \tag{5.2}$$

where $x > 0$ indicates the range of the distribution. The means m are chosen given prior evidence discussed below.

How to chose x? It would be desirable to limit dispersion, for a number of reasons. First, in the best of all worlds, point estimates serve as an acceptable prior, around which "true" parameters might fall with a limited degree of uncertainty. Second, increasing dispersion washes out discernible results by flattening the resulting distributions. Third, in Monte Carlo exercises I shift the means m, while maintaining x, in order to assess model sensitivity to possible changes to the prior. However, as will be seen in the next paragraphs, substantial uncertainty might require larger dispersion for at least some elasticities. I set $x = 0.3$ for most. Let us briefly look at a particular parameter. Suppose that for α, the cost elasticity of investment, $m = 0.40$, so that the lower bound of $E[\alpha]$ is equal to $\alpha^L = 0.70(0.40) = 0.28$, and the upper bound is $\alpha^H = 1.30(0.40) = 0.52$. Further, variance $Var[\alpha] = 0.0048$, and standard deviation $\sqrt{Var[\alpha]} = 0.069$.

How to chose the means m for all relevant parameters? Clearly, this is an area fraught with difficulties, so the preliminary disclaimer includes that I will try to outline weaknesses where possible. Importantly, this paper emphasizes the theoretical analysis of the model above rather than

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the specific empirical results.

That said, a number of studies have investigated the links between demand and distribution. One challenge in comparing and applying any of these results is that some rest on cyclical full–economy models, while others are single equation regressions. Barbosa-Filho and Taylor (2007) estimate a structural Goodwin model, finding a steep and profit–led demand curve. Similarly, Proano (2008) finds negative feedback from unit labor costs to economic activity for the US, EU–area, and selected large EU economies. Naastepad (2006) finds a significant impact of distributive changes on investment. Rada and Taylor (2006) suggest similar numbers. Gordon (1996) finds a significant relation between distribution and demand, and the US to be profit–led. Hein and Vogel (2008) discuss literature of single–equation estimations that often commend demand in developed economies to be wage–led. More open economies on the one hand and the United States on the other hand appear more often to be profit–led. Their own estimations confirm that empirical evidence on the nature of the demand regime is often conflicting and depends on model and estimation priors. There are other reasons that feed uncertainty about the size of this elasticity. I.e., the increasing use of profits for financial investments and share buybacks might render profits itself an inadequate proxy of internal finance available for investment. Here, I will assume that the distributive elasticity of investment (α) is positive and significant, meaning that higher unit labor costs lead to lower investment. Naastepad (2006) estimates $\alpha = 0.39$ for the Netherlands, which could arguably be higher for the US. Proano (2008) (and related literature) do not estimate separate investment functions, but instead an IS–curve for capacity utilization that depends on a distributive variable. Their estimates can be read as confirmation of that general range, leading me to adopt $\alpha = 0.40$.

The slope of the distributive curve is not less controversial. Here, too, the devil is in the detail. For example, Storm and Naastepad (2007) find that the profit share is pro–cyclical. Indeed, a glance at a plot of the (US) business cycle together with corporate profits relative to GDP strongly suggests a pro–cyclical profit share. However, in a *cyclical* model the profit share can rise over the early part of an expansion. With strong bargaining and the appropriate institutions, the wage share (profit share) will catch up (fall behind) and rise (fall) in the later stage of the cycle. Barbosa-Filho and Taylor (2007) find such a relationship. It would be consistent with profit squeeze distributive adjustment. Other dynamic models, such as Proano (2008), Flaschel et al. (2007), and Flaschel and Krolzig (2006), estimate wage–price spirals and find (1) the responsiveness of wages to pressure in the labor market to be quite strong, but (2) the mark–up elasticity to be much weaker—which would imply a high w_1 here, and possibly a profit squeeze. According to Proano (2008), the employment elasticity of wages $w_1 = 0.94$, and the mark–up elasticity $q_1 = 0.05$ in the US. Since w_1 near unity steers the calibration towards a profit–squeeze, and q_1 near 0 can exclude the possibility of a positive impact of wage policies if $\lambda > 0$ and demand is profit–led, I adopt $w_1 = 0.75$ and $q_1 = 0.20$ for the prior, with $x = .5$ for q_1.

The aggregate savings propensity is determined in the base year data, as is the wage share ψ, leaving the two class behavioral parameters s_π and s_ψ to be calibrated. s_π and s_ψ should be disaggregated as wage–receiving households versus capitalist profit–receiving households. Conceptually, this fits in a standard framework, because all valued added, including profits, is distributed to households who own shares, even though that would occur outside the scope of the model. It is less straightforward, however, when it comes to real world data. A substantial part of macroeconomic savings remains within corporations, purportedly to finance investment (Eichner and Kregel (1975)). Moreover, a substantial part of wage income might be more appropriately categorized with profit income, as recent research has shown, see Gordon and Dew-Becker (2008) and Piketty and Saez (2006). Here, I will be content with estimates discussed elsewhere. Naastepad (2006) estimates $s_w = 0.14$, and $s_\pi = 0.49$ for Netherlands, so that the difference turns out to be about 0.35. In the US, the difference *could* be higher. The average (net) saving propensity has been near 0 for a while (and has only recently started to rise), but high(er) income households are unlikely to save as little. I am assuming $s_\pi - s_\psi = 0.30$ for the prior.

Next, the demand elasticity β is less controversial, and its mean is set at 0.5. The Kaldor–Verdoorn coefficient δ is usually found to be in the range between 0.30 and 0.60, and I set $E[\delta] = 0.45$. See the contributions and references in McCombie et al. (2003) for discussion and estimates. The price elasticities ϵ_1 and ϕ_1 of exports and imports have frequently been subject to empirical testing. For the US, it has been argued that $\phi_1 > 1 > \epsilon_1$, leading to balance of payments problems, see Blecker (1998). Either way, at this level of aggregation price elasticities of trade are likely not too far from unity. However, since λ would not turn positive with trade elasticities near unity, I allow arbitrarily low bounds, drawing ϵ_1 and ϕ_1 from $[0.20, 1.00]$. I will use these bounds only in the following section, where the focus is to highlight how the model works.

How do these estimates figure in the theoretical model laid out above? Let's first examine the slope of the effective demand curve. Recall the relevant coefficient on $\hat{\psi}$. Using means of the prior for all behavioral parameters except α and $s_\pi - s_\psi$, and evaluating at the base year data gives

$$\frac{\partial \hat{V}}{\partial \hat{\psi}} = \frac{m_\psi - \chi\rho}{1 - \lambda q_1 \psi_1 - \chi\beta} \Rightarrow \frac{\partial \hat{V}}{\partial \hat{\psi}} > 0 \text{ if } 1.48(s_\pi - s_\psi) > \alpha. \tag{5.3}$$

It is important to see that this back–of–the–envelope calculation depends on the base year data. Different initial conditions can lead to different demand regimes. Based on elasticities previously discussed, the base year data with $\alpha = 0.40$ and $(s_\pi - s_\psi) = 0.30$ would render demand wage–led, which could, with only slight changes, swing the other way. The distributive regime is a little easier to eye–ball. With $w_1 = 0.90$ and $\xi_1 = 0.40$, $\psi_1 > 0$. However, if $w_1 < 1$ and $\xi_1 > 0.50$, distributive adjustment works against wage income recipients.

What does it take for λ to change sign? Given the base year data, $\lambda > 0$ if $0.36 > 0.37\epsilon_1 + 0.58\phi_1$. It is easy to see that both trade elasticities have to be significantly smaller than unity for λ to be positive, and for the effective demand curve to shift right (expand) in response to, i.e., wage policy or a nominal appreciation.

5.2 Simulations

This section reports illustrative simulation results. As will become clear, it does not take large changes in underlying elasticities to generate sign changes of crucial partial derivatives. Table 1 summarizes six different calibrations, which were chosen based on their characteristics in order to show how different parameter regimes influence simulation results. The top part of the table reports the elasticities drawn from uniform probability distributions with bounds indicated in square brackets. The bottom part reports the most important composite parameters. Row 11 shows θ, which determines the demand regime. The difference shown in row 13 determines whether $\partial\hat{V}/\partial\hat{q}_0 > 0$, row 14 whether $\partial\hat{V}/\partial\hat{w}_0 > 0$. Row 18 is the slope of the effective demand curve, and its inverse is the slope of $\hat{\psi}_{ED}$. Row 19 reports the slope of the distributive curve, $\hat{\psi}_D$.

Before we dive into the simulations, recall from the previous section that the trade elasticities ϵ_1 and ϕ_1 have been set with an unrealistically low bound of 0.20. In the three calibrations (2, 3 and 4) with a positive λ, the sum of the trade elasticities is less than 0.63. The US economy, with an import share in production of roughly 20 per cent, appears open enough to require these *very low* trade elasticities for λ to turn positive. Since this section is supposed to illustrate the model's working, rather than carry particular empirical weight, I stick with these low trade elasticities.

The upper part of Table 1 makes it clear that it does not take large changes of elasticities to generate very different model behavior. As an example, compare the first and second calibration (column 2 and 3). Both are profit–led, but calibration 3 shows a profit squeeze and 2 forced saving. Importantly, λ has the same sign, but row 14 changes signs. Demand growth in the model calibrated with no.2 responds negatively to a wage shock, whereas demand growth in the model calibrated with no.3 responds positively to a wage shock. The difference between the trade elasticities (row 5 and 6) is *not* large. Similarly, read along rows 1 through 8, the variability of any given elasticity from calibration to calibration is not large, but in combination small changes switch the model from profit–led (no.1–no.3) to wage–led (no.4–no.6), and from profit squeeze (no.1 and no.3) to forced saving (no.2 and no.4–6).

Tables 2 and 3 summarize simulation results; Table 2 for model responses to a wage and to a productivity shock. Let us begin with the distributive shock in the upper part, here 5 per cent to the intercept term in the wage curve, w_0. The real wage rises across the board, and with it the wage share rises; investment falls with the increase in real unit labor costs. The profit rate r falls. How about the paradox of cost? The increase in the wage share, or the decrease in the mark–up, is too large to allow the paradox to pan out. Put differently, consumption does not respond sufficiently strong to the increase in real wages to have a larger effect on profits than the combined negative effect of reduced investment and a lower mark–up. Essentially, growth of GDP, where positive, is *too small*.

The point, though, is that the sign of GDP growth varies, depending on the sign of row 14 in Table 1. Simulations 2 and 6 can be drawn on to highlight subtle differences. Simulation 2 is profit–led/profit–squeeze with $\lambda > 0$ *and* $q_1\lambda + (1 - q_1)\theta > 0$. The upward shift of the distributive curve coincides with a *rightward* shift of the demand curve—and the shift is large enough to counter the *contractionary* move along $\hat{\psi}_{ED}$. Simulation 6, on the other hand, is wage–led/forced saving with $\lambda < 0$ *and* $q_1\lambda + (1 - q_1)\theta < 0$. The upward shift of the distributive curve coincides with a *leftward* shift of the demand curve—and the shift is large enough to counter the *expansionary* move along $\hat{\psi}_{ED}$. Simulation 5 is as well wage–led/forced saving, but shows very different results:

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With $\lambda < 0$ *but* $q_1\lambda + (1 - q_1)\theta > 0$, the *leftward* shift of the demand curve is not large enough to counter the *expansionary* move along $\hat{\psi}_{ED}$.

Note as well that inflation $\hat{Q}$ is fairly contained despite strong real unit labor cost increases. Q, however, ultimately varies with V, and the relatively weak demand effects limit price pressure in product markets. The same effect can be seen in the lower part of Table 2, where slightly stronger product market effects lead to some deflation. The productivity shock here essentially presents a mirror image of the nominal wage shock; it is the same parameter (row 14 in Table 1) that determines the outcome. The sign pattern of GDP, investment and distributive variables (ψ and r) is exactly reversed. Employment growth is negative across the board, but less so for the three profit–led calibrations (1–3). In the terminology of Rada and Taylor (2006), see page 497, the demand regime is *not strongly enough profit–led* to produce employment growth with a productivity shock.

The gain in competitiveness—the fall in the real wage and the concomitant real depreciation—leads only to moderate growth of net exports. If GDP growth is negative (2, 4 and 5), the trade balance improves largely due to a fall in imports. If GDP growth is positive, the rise in imports with $\hat{X} > 0$ balances the positive effects of international price changes.

Next, the upper part of Table 3 summarizes model responses to a demand shock, here 5 per cent increase of autonomous investment I_0. Column 1 in Table 3 reports simulation results with a profit–led/profit squeeze (PS/PL) calibration with $\lambda < 0$. Column 4 in Table 2 reports simulation results with a calibration more friendly to workers, since demand is wage–led and λ is positive, meaning wage policies are always successful. Still, productivity gains are so strong that not capitalists but workers are squeezed during the upturn—which turns out to be the main difference. The wage share falls by 0.41 per cent with forced saving, and rises by 0.06 per cent with profit squeeze; propensity to save (and multiplier) change with the distribution of income. Investment rises slightly stronger with forced saving, since real unit labor costs continue to fall. The headline numbers, however, do not show significant differences.

A nominal depreciation, finally, is again a more mixed bag. First, recall that a nominal depreciation is expansionary if $\lambda < 0$. Accordingly, simulation 1, 5 and 6 show positive growth of GDP. The international price effects are large relative to income effects, and net exports increase across all six simulations. Imported inflation ($\hat{P}$) is contained; it does not exceed 1 per cent in the six simulations. (In order to save space, $\hat{P}$ has not been reported.)

These simulations show how the model hangs together, and, crucially, illustrate how small parameter changes lead to very different outcomes. To further emphasize this point, trade elasticities were drawn from distributions with unrealistic lower bounds. The next section fixes this, in Monte Carlo simulations.

6 Monte Carlo

How do a large number of calibrations look on average? How successful can wage policy be on average? These questions can be approached with Monte Carlo simulations. A Monte Carlo exercise is, simply put, a repeated evaluation of a function with at least one random variable or parameter. The resulting data can be analyzed graphically either by plotting a histogram, or smoothing the corners of a histogram through a Kernel Density Estimation (KDE) procedure. KDE generates a continuous probability function, which can be integrated to evaluate probability mass below and above zero. With a normal Kernel the density function is

$$f[X] = \frac{1}{hn}\sum_{i}^{n}\sqrt{2\pi}\exp^{-\frac{1}{2}\left(\frac{X-p_i}{h}\right)^2}, \tag{6.1}$$

where p_i are the i elements of the distribution generated by n draws of the expression under consideration, i.e. the slope coefficient of effective demand growth. h represents the bandwidth—the bin width for the histogram—which determines the smoothness of the resulting distribution.[13]

For the following exercises, the trade elasticities are reset to a more realistic range. Means are now set to 0.7, which is arguably still low—but large enough to render λ negative in *all* 500 iterations. The question will be whether λ is large enough relative to the slope of a wage–led demand curve to make wage policy *always* have a negative effect on growth.

First, let us look at the slope of effective demand and distributive curve. How sensitive are the links between demand and distribution (the partial derivatives of the log–differentiated demand and distributive functions, $\partial\hat{V}/\partial\hat{\psi}$ and $\partial\hat{\psi}/\partial\hat{V}$) to carefully defined changes in parameter regimes? Thus, using the previously discussed calibration input set as a benchmark, means m of relevant elasticities are shifted, parameters calculated n–times, and resulting distributions compared. From previous sections it is clear that changes of either α or the savings differential $s_\pi - s_\psi$ have the opposite effect.[14] Similarly, w_1 and δ have opposite effects on the slope coefficient of the distributive curve. To save space, I focus on one parameter for either function, namely the cost elasticity of investment α and the bargaining elasticity w_1.

Figures 3 shows the resulting distributions; the left panel for the distributive curve. w_1 is drawn from different uniform probability distributions: The black line shows the prior, as reported in Table 1. The dotted line shows a downward shift of w_1 to $[.34, .64]$, and the dashed line an upward shift of w_1 to $[.7, 1.3]$. Bounds of all other elasticities are unchanged from the prior, see Table 1. A decrease in the bargaining elasticity has a strongly negative effect, whereas a further increase in w_1 rather flattens than shifts the distribution. Crucially, though, the figure suggests that it is not surprising that research has found point estimates in the left and in the right half of these distributions.

The right panel of Figure 3 shows probability distributions from repeated calculations of the

[13] It is well known that (1) the choice of the particular Kernel has only marginal effect on shape and location of resulting distributions, and that (2) the smoothing parameter h tends to be best chosen subjectively, despite rules of thumb. The bandwidth applied here is "approximately Silverman." See Greene (2007), pages 414–416, for a standard discussion.

[14] Section 5.1 suggests that there is considerable uncertainty about the magnitude of α and $s_\pi - s_\psi$. If both "true" parameters were to be found in opposite tail ends of the respective distributions, distributive links could be stronger than suggested by the following analysis; i.e., if α were to lie in the far left and $s_\pi - s_\psi$ in the far right of the respective distributions, demand would be more strongly wage–led, and vice versa.

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slope of the (log-differentiated) effective demand curve, with α drawn from different uniform probability distributions: The black line shows the prior, as reported in Table 1. The dotted line shows a downward shift of α to $[.18, .33]$, and the dashed line an upward shift of α to $[.38, .7]$. Bounds of all other elasticities are unchanged from the prior, see Table 1. The picture confirms that a Kaleckian economy will tend to be wage–led.

It is straightforward to extend the procedure underlying Figure 3 to investigate full model responses to shocks. First, define bounds of key elasticities to calibrate the full model n times. Second, shock the model as in the examples discussed in detail above. Third, calculate n sets of results. Fourth, shift bounds of key elasticities exactly as in the previous paragraphs. Rinse and repeat for the rest. Such exercises obviously furnish large sets of data—the sample size n times the number of equations times the number of different calibration input sets. Which statistics should be considered? Given that the discussion is focused on $\hat{\psi}$ and $\hat{V}$, I will focus on (1) the distributive response to a demand shock, and (2) on demand growth in response to a distributive shock. In other words, the simulation considers cross effects, that is, from a demand shock (I_0) via different distributive calibrations to the wage share, and from a distributive shock (w_0) via different demand calibrations to GDP.

Figure 4 shows results. The left panel shows probability distributions of wage share growth in response to demand "policy," the right panel probability distributions of GDP growth to "wage policy." The black line shows model responses under the calibration prior, as reported in Table 1. Dotted line and dashed line represent model responses to the same shock(s), with calibrations changed as described above (see Figure 3). Location and shape of the distributions of the left panel are consistent with location and shape of the distributions of the slope coefficient of the distributive curve, see the left panel of Figure 3. The distributions in the right panel, however, differ. All three distributions are shifted leftwards, and GDP growth is, on average, negative, despite demand, on average, being wage–led—λ can be quite important.

Figure 5 shows a combination of "policies," here an increase of productivity and nominal wages. Recall from Table 2 and the discussion above that a productivity shock can be expansionary, and certainly increases investment, but has strong adverse distributive effects. The combination ameliorates the negative external effects, which cause the leftward shift of distributions showing GDP growth in the right panel of Figure 4; but distributive effects are on balance still negative.

7 Conclusions

The focus of this paper is an investigation of a small but comprehensive Post–Keynesian model of the real side, with particular emphasis on calibration and the impact thereof on model behavior. Endogenous prices and wages turn out to be crucial for model outcomes in the open economy version of the model. Distinguishing between a mark–up on domestic variable cost and the supply price of output, which includes import costs, brings the price ratio of Q and P in the multiplier and therewith the demand curve. Specifically, shocks to a price or the wage rate shift not only the distributive curve, but as well the demand curve. The sign and size of the shift depends on

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the base year data, particularly multiplier and trade elasticities, but tends to be adverse from the perspective of wage income recipients.

Whether this adverse effect outweighs the positive impact of redistribution under a wage–led demand regime depends on elasticities and slopes, and can easily go either way. The key parameters are (1) $m_\psi - \chi\rho$, which determines the demand regime as either profit–led ($-$) or wage–led ($+$), (2) ψ_1, which determines the distributive regime as either profit squeeze ($+$) or forced saving ($-$) and (3) λ, which determines the sign and magnitude of a demand *shift* in response to, i.e., a wage increase. Relative size and interaction of (1) and (3) determine the total effect of a wage increase on demand, and the analysis supports the claim that external liberalization limits space for redistributive policy that is simultaneously geared towards demand expansion.

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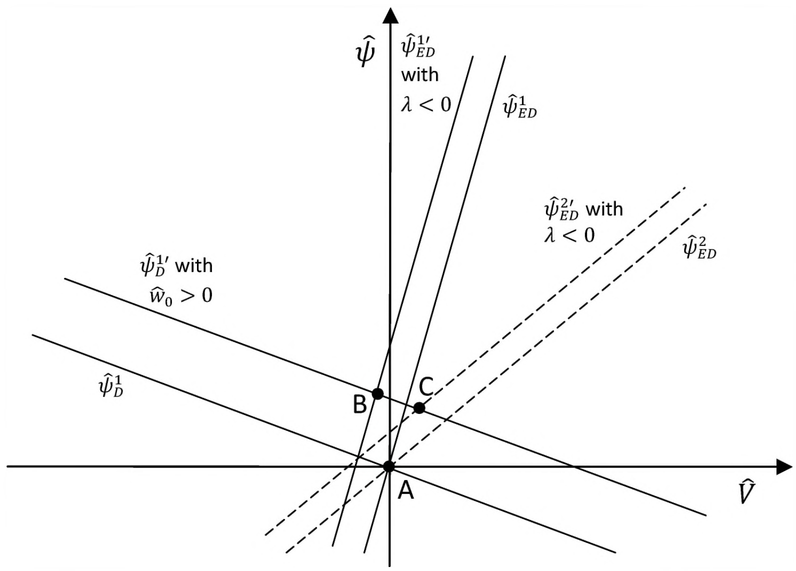

Figure 1: $\hat{\psi}_D^1$ represents a distributive curve with forced saving, and $\hat{\psi}_{ED}^1$ a wage-led demand curve. All trend growth rates are assumed to be zero, so that the two curves cross at the origin, point A. A shock to $\hat{w}_0 > 0$ shifts the distributive curve upwards, and, if $\lambda < 0$, shifts the demand curve leftward. Whether the new steady state demand growth rate is smaller (point B) or larger (point C), depends on the relative size of λ and the slope of the demand curve.

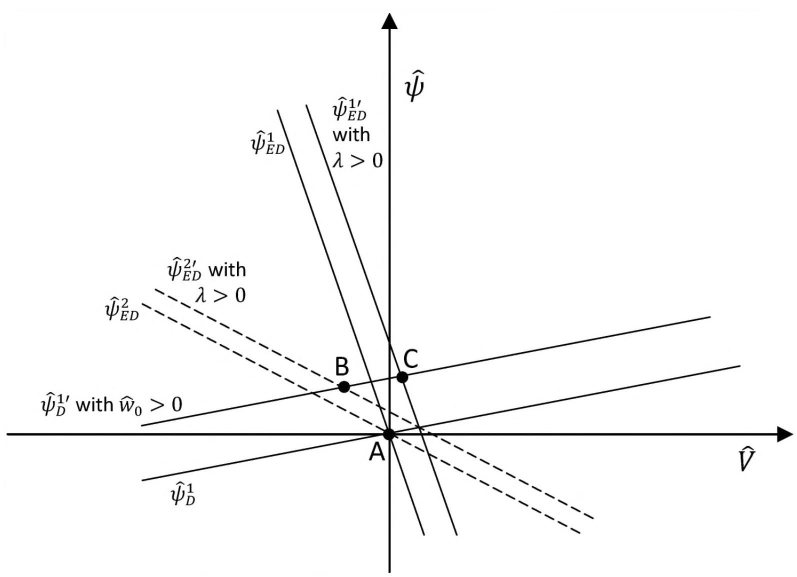

Figure 2: In this figure, $\hat{\psi}_D^1$ represents a distributive curve with a profit squeeze, and $\hat{\psi}_{ED}^1$ a profit-led demand curve. All trend growth rates are assumed to be zero, so that the two curves cross at the origin, point A. A shock to $\hat{w}_0 > 0$ shifts the distributive curve upwards, and, if $\lambda > 0$, shifts the demand curve outward. Whether the new steady state demand growth rate is smaller (point B) or larger (point C), depends on the relative size of λ and the slope of the demand curve.

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	Six calibrations		**1**	**2**	**3**	**4**	**5**	**6**
	Random seed #		13	452	437	34	42	32
			PL/PS	PL/FS	PL/PS	WL/FS	WL/FS	WL/FS
	Elasticities							
1	$s_\pi - s_\psi$	[.21,.39]	0.23	0.33	0.25	0.36	0.37	0.24
2	α	[.28,.52]	0.47	0.52	0.52	0.40	0.40	0.32
3	β	[.35,.65]	0.40	0.50	0.58	0.38	0.51	0.52
4	δ	[.32,.59]	0.37	0.54	0.32	0.50	0.51	0.54
5	ϕ_1	[.20,1.00]	0.56	0.25	0.23	0.22	0.74	0.67
6	ϵ_1	[.20,1.00]	0.55	0.21	0.40	0.30	0.84	0.74
7	w_1	[.53,.98]	0.61	0.67	0.77	0.68	0.56	0.73
8	q_1	[.10,.30]	0.18	0.22	0.19	0.28	0.28	0.19
	Parameters							
9	m_ψ		0.35	0.51	0.38	0.56	0.58	0.37
10	$\chi\rho$		0.49	0.54	0.54	0.42	0.42	0.33
11	$\theta = m_\psi - \chi\rho$		-0.14	-0.03	-0.16	0.14	0.16	0.04
12	λ		-0.15	0.15	0.09	0.13	-0.36	-0.28
13	$\lambda - \theta$		-0.01	0.18	0.24	-0.01	-0.52	-0.32
14	$\lambda q_1 + (1 - q_1)\theta$		-0.14	0.01	-0.11	0.13	0.02	-0.02
15	$\lambda q_1 \psi_1$		0.00	-0.01	0.00	-0.01	0.02	0.01
16	$\chi\beta$		0.22	0.27	0.32	0.21	0.28	0.28
17	$1 - \lambda q_1 \psi_1 - \chi\beta$		0.78	0.74	0.68	0.80	0.70	0.71
18	$\theta[1 - \lambda q_1 \psi_1 - \chi\beta]^{-1}$		-0.18	-0.04	-0.23	0.17	0.23	0.06
19	ψ_1		0.02	-0.23	0.20	-0.17	-0.23	-0.20

Table 1: These six different calibrations are used for illustrative simulations. The top part of the table reports elasticities drawn from uniform probability distributions with bounds indicated in square brackets. The bottom part reports the most important composite parameters. Row 11 shows θ, which determines the demand regime. The difference shown in row 14 determines whether demand growth responds positively to a wage shock. Row 18 is the slope of the effective demand curve, its inverse is the slope of $\hat{\psi}_{ED}$. Row 19 reports the slope of the distributive curve, $\hat{\psi}_D$.

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	Simulations	**1**	**2**	**3**	**4**	**5**	**6**
	Random seed #	13	452	437	34	42	32
		PL/PS	PL/FS	PL/PS	WL/FS	WL/FS	WL/FS
	5% Wage increase						
1	GDP	-0.95	0.01	-0.84	0.80	0.09	-0.18
2	Wage Share	4.05	3.85	3.90	3.47	3.56	4.07
3	Investment	-4.08	-3.86	-4.35	-2.41	-2.72	-2.63
4	Net exports	0.05	-0.47	0.34	-1.42	-2.02	-1.00
5	Employment	-0.60	0.00	-0.57	0.40	0.04	-0.08
6	Productivity	-0.35	0.00	-0.27	0.40	0.04	-0.10
7	Propensity to save	-3.17	-4.33	-3.28	-4.26	-4.53	-3.37
8	Real (product) wage	3.72	3.90	3.65	3.94	3.66	4.00
9	Inflation (Q)	0.89	1.10	0.89	1.34	1.37	0.93
10	Profit rate	-8.42	-7.12	-8.02	-5.61	-6.45	-7.72
	5% Productivity increase						
1	GDP	1.25	-0.21	1.15	-1.35	-0.19	0.13
2	Wage Share	-6.21	-6.08	-6.58	-5.56	-5.30	-6.65
3	Investment	5.93	5.72	6.96	3.58	3.80	3.95
4	Net exports	0.20	0.97	-0.26	2.39	3.21	1.91
5	Employment	-4.01	-4.85	-4.02	-5.40	-4.85	-4.71
6	Productivity	5.48	4.88	5.39	4.28	4.90	5.07
7	Propensity to save	4.86	6.84	5.55	6.83	6.73	5.50
8	Real (product) wage	-1.06	-1.46	-1.52	-1.49	-0.64	-1.88
9	Inflation (Q)	-1.42	-1.80	-1.57	-2.21	-2.09	-1.59
10	Profit rate	12.88	10.93	13.44	8.60	9.41	12.43

Table 2: Summary of simulation results. The upper part shows model responses to a 5 per cent shock to the wage curve intercept w_0; the lower part shows model responses to a 5 per cent shock to ξ_0. Results are reported in growth rates, see Table 1 for the underlying calibrations.

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	Simulations	1	2	3	4	5	6
	Random seed #	13	452	437	34	42	32
		PL/PS	PL/FS	PL/PS	WL/FS	WL/FS	WL/FS
	5% Investment increase						
1	GDP	3.55	3.83	3.95	3.42	3.87	3.92
2	Wage Share	0.06	-0.65	0.63	-0.41	-0.63	-0.61
3	Investment	6.42	7.66	6.73	6.69	7.58	7.51
4	Net exports	-3.56	-3.75	-4.03	-3.34	-3.52	-3.74
5	Employment	2.23	1.76	2.67	1.68	1.89	1.80
6	Productivity	1.29	2.03	1.25	1.71	1.94	2.09
7	Propensity to save	-0.04	0.74	-0.53	0.50	0.80	0.51
8	Real (product) wage	1.35	1.36	1.89	1.29	1.29	1.46
9	Inflation (Q)	0.01	-0.19	0.15	-0.16	-0.25	-0.14
10	Profit rate	3.43	5.08	2.75	4.19	5.07	5.10
	5% Nominal depreciation						
1	GDP	0.92	-0.98	-0.60	-0.78	2.43	1.91
2	Wage Share	0.02	0.17	-0.10	0.10	-0.40	-0.30
3	Investment	0.35	-0.66	-0.26	-0.37	1.54	1.17
4	Net exports	3.99	3.00	3.33	3.02	4.79	4.39
5	Employment	0.58	-0.46	-0.41	-0.39	1.19	0.88
6	Productivity	0.34	-0.53	-0.19	-0.40	1.22	1.02
7	Propensity to save	-0.01	-0.19	0.08	-0.12	0.51	0.25
8	Real (product) wage	0.35	-0.36	-0.29	-0.30	0.82	0.72
9	Inflation (Q)	0.00	0.05	-0.02	0.04	-0.16	-0.07
10	Profit rate	-0.03	-2.21	-1.34	-1.87	2.24	1.55

Table 3: Summary of simulation results. The upper part shows model responses to a 5 per cent shock to autonomous investment I_0; the lower part shows model responses to a 5 per cent shock to e. Results are reported in growth rates, see Table 1 for the underlying calibrations.

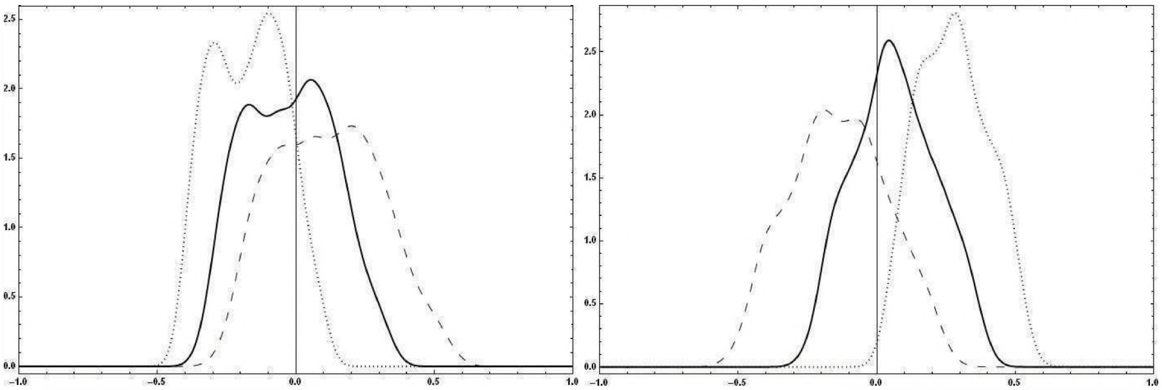

Figure 3: Slope of distributive and demand curve. The left panel shows distributions from repeated calculations of the slope of the distributive curve, with w_1 drawn from *different* uniform probability distributions: The black line shows the prior, as reported in Table 1. The dotted line shows a downward shift of w_1 to [.34,.64], and the dashed line an upward shift of w_1 to [.7, 1.3]. The right panel shows distributions from repeated calculations of the slope of the effective demand curve, with α drawn from *different* uniform probability distributions: The black line shows the prior, the dotted line a downward shift of α to [.18,.33], and the dashed line an upward shift of α to [.38, .7].

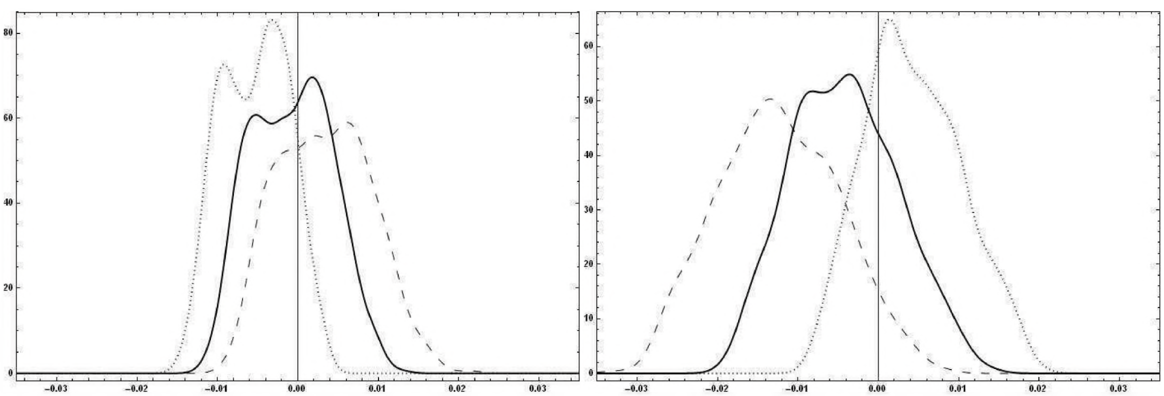

Figure 4: Cross-effects. The left panel shows distributions resulting from repeated simulations of the model, here the response of wage share growth ($\hat{\psi}$) to "demand policy," introduced with $\hat{I}_0$=5%. The right panel shows the response of GDP growth ($\hat{V}$) to "wage policy," introduced with $\hat{w}_0$=5%. The parameter shifts correspond to those of Figure 3 above: In the left panel, w_1 is varied; in the right panel, α.

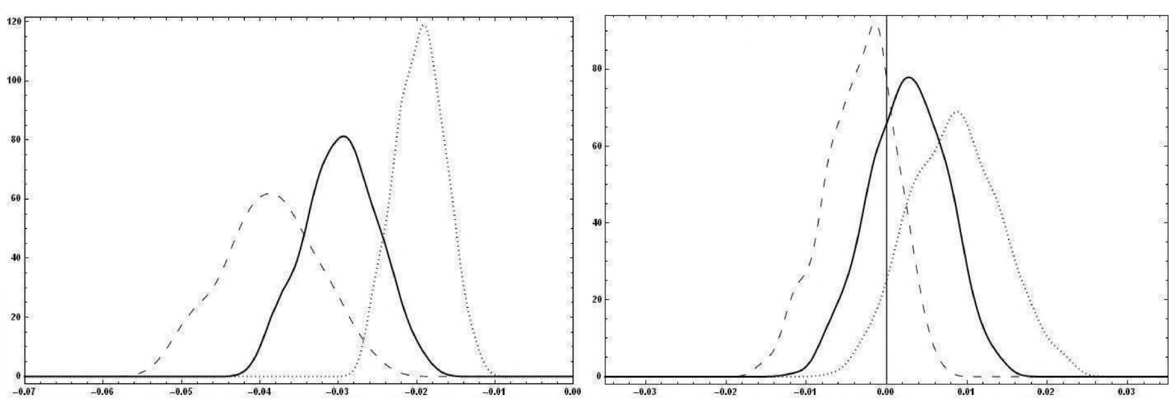

Figure 5: Combined wage and productivity policy. The left panel shows distributions resulting from repeated simulations, here the response of wage share growth ($\hat{\psi}$) to a combined wage and productivity "policy," introduced as $\hat{w}_0 = \hat{\xi}_0 = 5\%$. The right panel shows the response of GDP growth ($\hat{V}$) to the same combined policy. The parameter shifts correspond to those of Figure 3 above: In the left panel, w_1 is varied; in the right panel, α.