# The New Keynesian Transmission Channel*

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**Abstract**

The success of the New Keynesian framework stems from its capability to match the aggregate responses to innovations in monetary policy and total factor productivity (TFP). Specifically, the model can account for a negative response of output to a positive innovation in the policy rate and a negative response of employment to a positive innovation in TFP. We reexamine the transmission channel of the textbook model and show that these successful results rely on the assumption that firm profits are redistributed to working households. We contrast the textbook model to a worker-capitalist model where profits are consumed by non-working capitalists. This modification renders employment and output unresponsive to monetary policy and employment unresponsive to TFP.

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# 1 Introduction

The textbook New Keynesian model, *e.g.* as presented by Galí (2009), has been widely used for business cycle analysis, ranging from the old literature on monetary policy rules, *e.g.* Rotemberg and Woodford (1999), to newer findings on policy options at the zero lower bound, *e.g.* Farhi and Werning (2012). Apart from its micro-founded notion of "aggregate demand", the success of the model stems largely from its ability to match the aggregate responses to innovations in monetary policy and total factor productivity (TFP). VAR evidence shows that output reacts negatively to positive innovations in the policy rate and that employment reacts negatively to positive innovations in TFP.[1] These findings are consistent with the predictions of the New Keynesian model, but not with the real business cycle (RBC) theory.

What explains these results? We reexamine the model by concentrating on the labor market equilibrium. We find that the transmission mechanism relies entirely on the distribution and cyclical behavior of firm profits. We make this argument by means of a thought-experiment that contrasts the textbook model to a simple alternative model, in which non-working capitalists consumes profits and workers only receive labor income. We feed in a monetary and a TFP shock to both models, and compare the equilibrium responses.

Consider the response to a positive monetary policy shock: In the textbook model, higher interest rates lead to a contraction in current consumption demand as households back-load consumption their in line with the "'Dynamic IS curve'" (DIS) . To bring down labor supply, real wages fall and profits increase. The decrease in wages depress labor supply and aggregate output because, with an additional source of income in the form of redistributed profits, the substitution effect of wage changes on labour supply dominates the income effect. Profits rise as markups are strongly countercyclical, increasing the labour supply response through a negative income effect. In contrast, our worker-capitalist model features none of these effects. Because the worker only receive wage income, the substitution and income effect cancel out, leaving labour supply and thus output constant. Worker consumption increases in line with the DIS curve, by an amount exactly equal to the increase in wages. This increase in consumption is offset on the demand side through an commensurate fall in profits, equal to capitalist consumption.

Next, consider the response to a positive TFP shock. In the textbook model, the shock temporarily increases output, wage income and lower marginal costs through higher productivity. Lower marginal cost and increased output both contribute to increasing profits, which in consequence increase more than wages. Because the labor-reducing income effect of higher profits dominates the labor-increasing effect of higher wages, equilibrium employment falls. In contrast, this effect cannot happen in the worker-capitalist model. The increase in profits only raises capitalist consumption, and the income and substitution effect from wage

[1] Concerning monetary policy shocks, see *e.g.* Christiano et al. (1999); Christiano and Eichenbaum (2005). Concerning TFP shocks, VAR evidence supporting the negative response of employment to TFP is found in Galí (1999); Galí and Rabanal (2004); Francis and Ramey (2005). These findings have been criticized by Christiano et al. (2003); Chari et al. (2008).

changes on labour supply cancel out. Thus, employment stays constant.

The countercyclical (procyclical) response in firm markups and profits to monetary policy (TFP) shocks is well-known in the literature, see *e.g.* Christiano and Evans (1997); Nekarda and Ramey (2013). To the best of our knowledge, however, it is not well-known that the distribution and cyclical behavior of firm profits is key to the transmission mechanism. We think that these results cast some doubt on the transmission mechanism of the textbook model. Given the observed distribution of financial assets, profits cannot significantly affect the elasticity of labor supply to wages for the majority of the workforce. Moreover, VAR evidence shows that profits are pro-cyclical with respect to monetary policy shocks. Our result points to that the usual 'aggregate demand' interpretation of the model should not be taken for granted, since it ignores the factors governing labor supply.

Our analysis is related to recent papers on the role of income distribution in the New Keynesian framework. Close in spirit to our work is Walsh (2014) who constructs a similar worker-capitalist model, but use it for positive analysis rather as a means of a thought-experiment. Bilbiie (2008) incorporates limited asset market participation, and show how the standard aggregate demand logic in the New Keynesian framework hinges on participation rates being above a certain threshold. If participation is low enough the sign of the response of output to monetary policy shock can be reversed. In reduced form, his model resembles our worker-capitalist model, since he assumes that non-participating households receive no profit income.

Section 2 lays out the standard new-Keynesian model and our worker-capitalist model. Section 3 analyses and contrasts the responses to monetary policy and TFP shocks of the two models. We discuss evidence and suggest ways forward for future research in Section 4.

## 2 Two models

Throughout the paper, we will compare two models: the model presented in Galí (2009) and a model which distinguishes households that can supply labor (workers) from households that hold claims to firm profits (capitalists).[2] The former will be referred to as the "standard model" and the latter to as the "worker-capitalist model". We will describe and derive the log-linearized equilibrium of the standard model, and then show how the worker-capitalist model differs.

### 2.1 The standard model

The standard model consists of a measure 1 of identical households, one final good producer, a continuum of intermediate goods producers and one government.

### 2.2 Households

Households derive utility from consuming the final good and disutility for working. They collect wage and profit income and can trade a in a riskless nominal bond. A household's problem is

$$\begin{aligned} \max_{C_t, B_{t+1}, N_t} \quad & E_0 \sum_{t=0}^{\infty} \beta^t \left( \frac{C_t^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\varphi}}{1+\varphi} \right) && (1) \\ \text{s.t.} \quad & P_t C_t + Q_t B_t \leq B_{t-1} + W_t N_t + P_t D_t && (2) \end{aligned}$$

where $D_t$ is real per capita profits. The solution is characterized by an Euler equation and an intratemporal optimality condition:

$$\begin{aligned} Q_t &= \beta E_t \left\{ \frac{C_{t+1}^{-\sigma}}{C_t^{-\sigma}} \frac{P_t}{P_{t+1}} \right\} && (3) \\ \frac{W_t}{P_t} C_t^{-\sigma} &= N_t^{\varphi} && (4) \end{aligned}$$

### 2.3 Final good production

A representative final goods producer operates under perfect competition and combines intermediate goods $Y_{it}$ with the technology:

$$Y_t = \left( \int_{i=0}^{1} Y_{it}^{\frac{\epsilon-1}{\epsilon}} di \right)^{\frac{\epsilon}{\epsilon-1}} \qquad (5)$$

[2]Strictly speaking, we deviate slightly from Galí (2009). (Galí, 2009) assumes that households' demand a variety of goods produced by a final goods sector under monopolistic competition. More convenient for our purposes, we assume that the households demand only one good produced by a competitive final goods sector which in turn demand a variety of inputs produced by an intermediate goods sector, the latter being under monopolistic competition. The models are isomorphic.

The firm takes prices $P_t, \{P_{it}\}$ as given and solves a standard profit-maximization problem

$$\max_{Y_{it}} P_t Y_t - \int_{i=0}^{1} P_{it} Y_{it} di \tag{6}$$

subject to (5). The solution is characterized by a demand curve for intermediate goods:

$$Y_{it} = \left(\frac{P_{it}}{P_t}\right)^{-\epsilon} Y_t \tag{7}$$

## 2.4 Intermediate goods producers

Intermediate goods producers have monopoly power and set prices according to the scheme proposed by Calvo (1983). Specifically, they use a concave production technology with labor as the sole input:

$$Y_{it} = A_t N_{it}^{1-\alpha} \tag{8}$$

In each period, a firm can change its price with probability $1 - \theta$. In its decision problem, it maximizes the present discounted value of profits using the market discount factor $Q_t$ taking the wage $W_t$, the aggregate price level $P_t$ and the demand function (7) as given. The optimal resetting price $P_t^*$ is found as the solution to

$$\begin{aligned} \max_{P_t^*} \quad & \sum_{k=0}^{\infty} \theta^k E_t Q_{t,t+k} \left\{ P_t^* Y_{t+k|t} - \Psi_{t+k}(Y_{t+k|t}) \right\} && (9) \\ & \text{s.t.} \Psi_{t+k}(Y_{t+k|t}) = \frac{W_{t+k}}{P_{t+k}} \left(\frac{N_{t+k|t}}{A_{t+k}}\right)^{\frac{1}{1-\alpha}} \\ & Y_{it} = \left(\frac{P_{it}}{P_t}\right)^{-\epsilon} Y_t \end{aligned}$$

here $Q_{t,t+k} \equiv \beta^k \left(C_{t+k}/C_t\right)^{-\sigma} P_t/P_{t+k}$ is the stochastic discount factor, $\Psi_{t+k}(\cdot)$ is the cost function and $Y_{t+k|t}$ is the output in period $t + k$ given that prices were last reset in period $t$.

The solution is characterized by

$$\sum_{k=0}^{\infty} \theta^k E_t \left\{ Q_{t,t+k} Y_{t+k|t} (P_t^* - \mathcal{M} \psi_{t+k|t}) \right\} = 0 \tag{10}$$

where $\psi_{t+k|t} = \frac{\partial \Psi_{t+k}(Y_{t+k|t})}{\partial Y_{t+k|t}}$ and $\mathcal{M} = \frac{\epsilon}{\epsilon - 1}$ is the markup over marginal cost that would have prevailed under flexible price setting ($\theta = 0$).

Given the resetting price $P_t^*$ and the price level in the previous period $P_{t-1}$, it can be shown that the Calvo pricing scheme implies an aggregate law of motion of the form:

$$\left(\frac{P_t}{P_{t-1}}\right)^{1-\epsilon} = \theta + (1-\theta)\left(\frac{P_t^*}{P_{t-1}}\right)^{1-\epsilon} \tag{11}$$

## 2.5 Central bank

The central bank sets monetary policy according to standard Taylor rule with persistent shocks.

$$\frac{1}{Q_t} = \frac{1}{\beta}\Pi_t^{\phi_\pi}\left(\frac{Y_t}{Y_t^{flex}}\right)^{\phi_y} e^{\nu_t} \tag{12}$$

where $Y_t^{flex}$ is the (efficient) output that would have prevailed at time $t$ under flexible price setting.

## 2.6 Resource constraints

The economy is closed by the following set of resource constraints

$$C_t \leq Y_t \tag{13}$$

$$B_{t+1} \leq 0 \tag{14}$$

$$N_t \leq \int_{i=0}^{1} N_{it} di \tag{15}$$

## 2.7 The log-linearized equilibrium

Of any variable $X_t$, $\bar{X}$ denotes the steady state value, $x_t$ denotes the log and $\tilde{x}_t$ the log deviation from the flexible prices equilibrium.

Log-linearizing the intermediate goods firms' first order condition (10), using the aggregate law of motion for prices (11) and substituting in the household intratemporal condition (4) and market clearing conditions (15), (13), we get the "forward-looking Phillips curve" (NKPC):

$$\pi_t = \beta E_t \pi_{t+1} + \kappa \tilde{y}_t \tag{16}$$

where $\kappa = \frac{\alpha+\varphi+\sigma(1-\alpha)}{1-\alpha+\alpha\epsilon}\frac{(1-\theta)(1-\beta\theta)}{\theta}$. Log-linearizing the Euler equation (3) and substituting goods market clearing (13) we get the "Dynamic IS" (DIS) curve:

$$\tilde{y}_t = -\upsilon\left(i_t - E_t\pi_{t+1} - r_t^n\right) + E_t\tilde{y}_{t+1} \tag{17}$$

where $i_t = -\log Q_t$ and $\upsilon = \frac{1}{\sigma}$ and $r_t^n$ denotes the natural real interest rate, that is the real interest rate that would have prevailed in the equilibrium with flexible prices. We solve for $r_t^n$ by finding the output path when $\theta = 0$, using that prices are set as a constant markup $\mathcal{M}$ over marginal cost in (10):

$$r_t^n = \rho + \xi E_t \Delta a_{t+1} \tag{18}$$

where $\rho = -\log\beta$ and $\xi = \frac{\sigma(1+\varphi)}{\alpha+\varphi+\sigma(1-\alpha)}$. Summarizing, the equilibrium is described by (16), (17), (18), and the log of the Taylor rule:

$$i_t = \rho + \phi_\pi \pi_t + \phi_y \tilde{y}_t + \nu_t \tag{19}$$

## 2.8 The worker-capitalist model

The worker-capitalist model differs from the standard textbook model only in one aspect. Instead of a measure 1 of identical households the worker-capitalist model has a measure 1 of workers, who receive only labor income, and a measure 1 of capitalists, who receive only profit income. Workers solve the problem:

$$\max_{C_{wt},B_{wt+1},N_t} \quad E_0 \sum_{t=0}^{\infty} \beta^t \left( \frac{C_{wt}^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\varphi}}{1+\varphi} \right) \tag{20}$$

$$\text{s.t.} \quad P_t C_{wt} + Q_t B_{wt} \leq B_{wt-1} + W_t N_t \tag{21}$$

Accordingly, their solution is characterized by an Euler equation and an intratemporal condition analogous to (3) and (4).

The capitalists in the model are assumed to be hand-to-month as thus simply receive and consume firm profits each period ($C_{ct} = D_t$). The purpose of this assumption is to do away with all labor supply effects stemming from profits. It is thus a way to high-light, by way of contrast, the role that profits play in the textbook model.[3] We assume that capitalists control the intermediate goods firms and, when allowed to reset prices, maximise the profit stream with discount factor $\beta$. Since $Q_t = \beta$ in the steady state of the standard model, the linearized first order condition of the firms' maximization problems around the steady state will be identical in the two models.

Everything else is identical to the standard model. Deriving the equilibrium is analogous. The equations that describe the log-linearized equilibrium are

$$\pi_t = \beta E_t \pi_{t+1} + \kappa_{wc} \tilde{y}_t \tag{22}$$

$$\tilde{y}_t = -\upsilon_{wc} \left( i_t - E_t \pi_{t+1} - r_t^n \right) + E_t \tilde{y}_{t+1} \tag{23}$$

$$r_t^n = \rho + \xi_{wc} E_t \Delta a_{t+1} \tag{24}$$

$$i_t = \beta + \phi_\pi \pi_t + \phi_\pi \tilde{y}_t + \nu_t \tag{25}$$

where $\kappa_{wc} = \frac{1+\varphi-(1-\sigma)(1-\alpha)}{(1-\sigma)(1-\alpha+\alpha\epsilon)} \frac{(1-\theta)(1-\beta\theta)}{\theta}, \upsilon_{wc} = \frac{(1-\sigma)(1-\alpha)}{\sigma(1+\varphi)}$ and $\xi_{wc} = \frac{\sigma(1+\varphi)}{1+\varphi-(1-\sigma)(1-\alpha)}$.

## 2.9 Parameterization

All parameters are the same in the two models. We choose the same calibration as that in Chapter 3 in Galí (2009), in which a time period should be interpreted as a quarter of a year. Thus, we set an elasticity of intertemporal substitution $1/\sigma = 1$ (balanced growth path preferences)[4], Frisch elasticity $\varphi = 1$, $\alpha = 1/3$, $\epsilon = 6$, $\theta = 2/3$, $\beta = 0.99$. For the Taylor rule, we set $\phi_\pi = 1.5, \phi_y = 0.125$.

[3] An alternative assumption that would produce the exact same equilibrium outcome is having all income going to representative agent, but where there is 100 % taxation on profits which is spent on wasteful government consumption

[4] The model is not defined for exactly $\sigma = 1$, why we will let $\sigma$ be infinitely smaller than 1

For this parameterization, with $\sigma$ approaching 1 from below, it is easily confirmed that both models have two eigenvalues outside the unit circle, implying a unique stable equilibrium for any shock.

# 3 Results

## 3.1 Innovations in monetary policy

We start by considering innovations to monetary policy. The success of the New Keynesian framework for policy analysis partly stems from its capability to match the VAR evidence on how output respond to innovations in the policy rate. We will compare the impulse-responses of the two models to explore how the distribution of profit income affect theses results.

We assume that innovations in the policy rate follows the process

$$\nu_t \quad = \quad \rho_\nu \nu_{t-1} + \epsilon_{\nu t} \tag{26}$$

with $\rho_\nu = 0.9$. We feed a positive 25 basis point shock to the models. The responses are plotted in Figure 1.

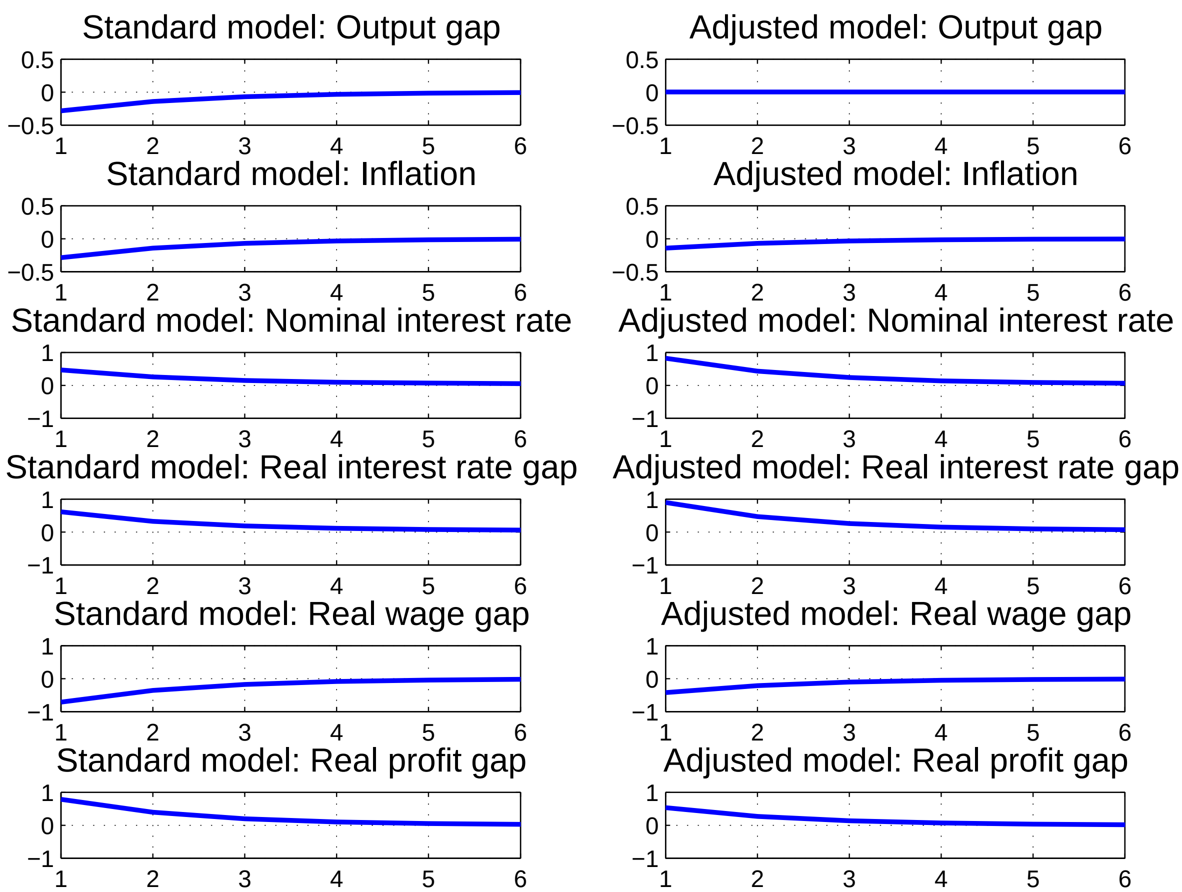


Figure 1: Equilibrium responses to 25 basis shock in the policy rate. The left panel shows the standard model, the right panel the worker/capitalist model. Inflation and interest rates are expressed in yearly terms, while the other variables are expressed in quarterly terms.

A positive shock to the policy rate in the standard model, as seen in the left column of Figure 1, produces a negative response in the output gap and inflation. How can we explain these results? Due to the policy innovation, the nominal interest rate jumps. To jump ahead the explanation, we assume that this produces a jump in the real interest rate. From the Euler equation we then know that the consumption gap ("aggregate demand") must initially fall and follow an upward-sloping path. Since $C_t = Y_t$ in this model, the output gap follows the same path. The fall in output lowers marginal costs, which incentivize those firms that can to lower prices. Deflation follows, which confirms the assumption about the fall in the real interest rate.

This is not the full story, however, since we have left out the behavior of labor supply, wages and profits. Since the production in this economy only uses labor as input, the transmission channel from the monetary shock to output necessarily goes through the response of labor supply. We proceed in two steps; first analyzing how wages and profits determines the response of labor supply, and then how wages and profits are determined in equilibrium.

To understand how profits and wages affect labor supply, we compare with the response of the worker-capitalist model, seen in the right column of Figure 1. In this model, all variables behave qualitatively similar to the standard model except for the output gap, which is constant.

What explains this difference? The reason is twofold. Firstly, without any profit income, the income and substitution effect of changes in the wage level cancel. Secondly, profits respond countercyclically, which means that households that recieve profit income experience a positive income effect. To see this formally, combine the optimality condition for labor supply (4) with bond market clearing, under the assumption that $\sigma = 1$, to find

$$F(N_t) = \frac{Z_t}{W_t/P_t} \tag{27}$$

where $F(N_t) = N_t^{-\varphi} - N_t$ is a decreasing function in $N_t \in [0, 1]$ and $Z_t$ denote any non-labor income earned by the labor-supplying household in both models. With $Z_t = 0$, as in the worker-capitalist model, labor supply is an exogenous constant. Without any non-labor income, the preferences we use dictate that the income and substituion effect of changes in the wage level exactly cancel. This is true for any preferences consistent with a balanced growth path, of which our preferences are preferences are a subset when $\sigma = 1$. With $Z_t = D_t$, as in the standard model, the variation in labor supply is determined by the fraction of labor to non-labor income. Non-labor income affects labor supply through an income effect, and wages affect labor supply since now the substitution effect dominates the income effect. In consequence, in the standard model the increase in profits as well as the fall in the wage level both contribute to depress labor supply.

To close the analysis we need to explain how wages and profits are determined in equilibrium. We first consider the response of wages, and then the response of profits.

Wages respond procyclically and with greater magnitude compared to output. The reason is that an increase in ouput implies that both consumption and labor supply must increase, which raises the marginal rate of substitution above output. To see this formally, combine the log-linearized production function (8) and market clearing condition (13) with the optimality condition for labor supply (4) to find:

$$\tilde{\omega}_t \quad = \quad \sigma\tilde{c}_t + \varphi\tilde{n}_t = (\sigma + \frac{\varphi}{1-\alpha})\tilde{y}_t \tag{28}$$

Equation (28) shows that as long as $\sigma + \frac{\varphi}{1-\alpha} > 1$, which must be true for any reasonable parameterization, the reponse in the wage level is stronger than that of output.

Profits responds countercyclically to output. The reason stems from the large procyclical response of wages. To see this combine the log-linearized ressource constraint and the production function to find:

$$\tilde{d}_t \quad = \quad \frac{1}{\epsilon - (1-\alpha)(\epsilon-1)}\left[\tilde{y}_t - [\epsilon - (1+\alpha(\epsilon-1))]\tilde{\omega}_t\right] \tag{29}$$

From this equation we can see that there are two forces governing the response in profits. First, profits increase with the volume of production. Second, profits decrease with the wage level. The relative strength of these two effects is governed by the shape of the production function $\alpha$ and the degree of monpoloy power $\epsilon$. A higher $\alpha$ means that higher production volumes comes with higher marginal costs, dampening the positive volume effect on profits. A higher $\epsilon$ (lower monopoloy power) means that the impact of changes in the wage level on profits become greater, as firm have less scope to adjust their sale prices. Since $\left(\sigma + \frac{\varphi}{1-\alpha}\right) \times \left(\epsilon - (1+\alpha(\epsilon-1))\right) > 1$ for all plausible parameter values, (28) and (29) shows that profits will always respond countercyclically to output.

In the worker-capitalist model the determination of profits and wages is simple. Since labor supply is constant, wages must track consumption, and since output is constant, profits must be the negative of consumption:

$$\tilde{w}_{wc,t} \quad = \quad \tilde{c}_{wc,t} \tag{30}$$

$$\tilde{d}_{wc,t} \quad = \quad -\tilde{c}_{wc,t} \tag{31}$$

## 3.2 Innovations in TFP

Next, we consider innovations in TFP. Another strength of the New-Keynesian model lies in its capability to match negative response in employment to positive TFP shocks (Galí, 1999; Galí and Rabanal, 2004). We will compare the impulse-responses of the two models to explore how the distribution of profits affect these results.

We assume that the log of TFP $a_t$ follows the process

$$a_t = \rho_a a_{t-1} + \epsilon_{at} \tag{32}$$

with $\rho_a = 0.9$. We feed a positive 1 % shock to the models. The responses are plotted in Figure 2. Here, we do not plot deviations from the flex price equilibrium, as in Section 3.1, but the log deviations from steady state.

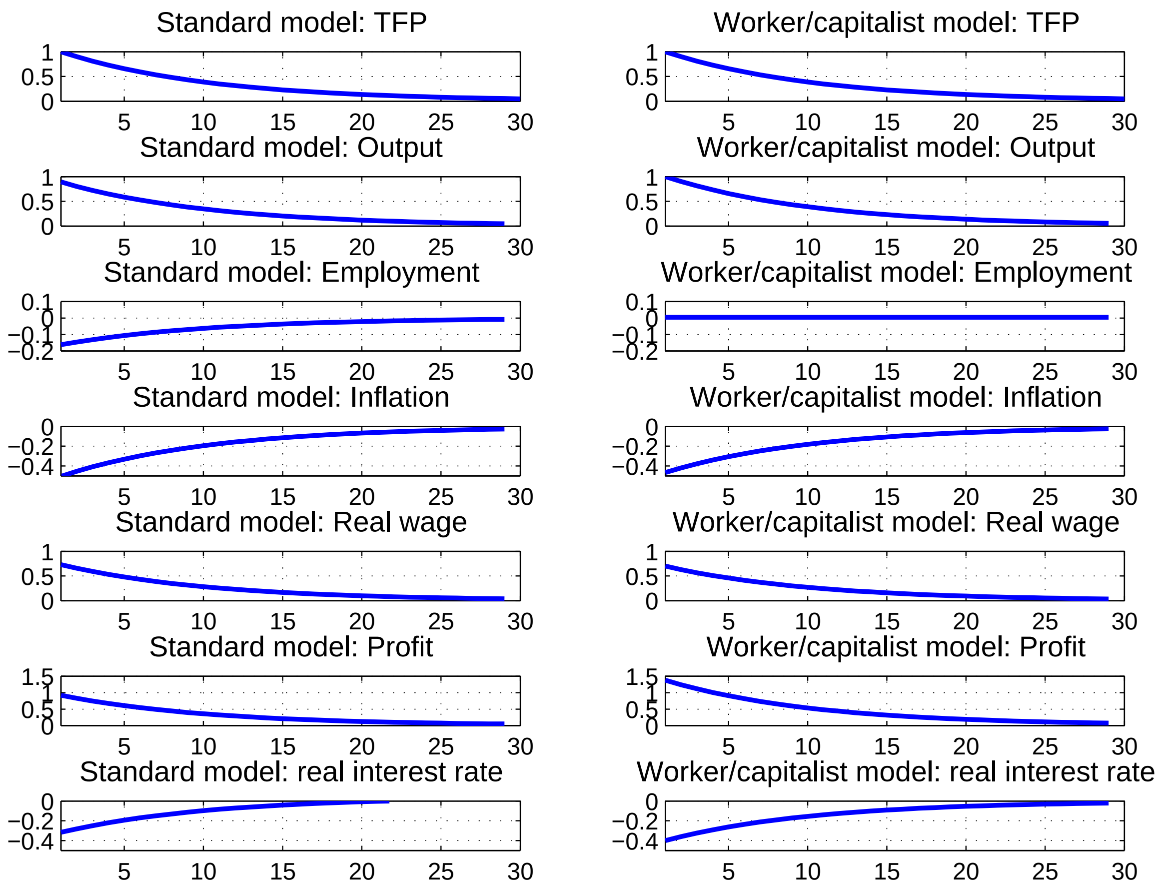


Figure 2: Equilibrium responses to 1 % shock to TFP. The left panel shows the standard model, the right panel the worker/capitalist model. Inflation and interest rates are expressed in yearly terms, while the other variables are expressed in quarterly terms.

In the standard model, plotted on the left hand side of Figure 2, the positive innovation to TFP renders a positive response in output, wages and profits directly. It also lowers marginal cost through the rise in the marginal productivty of labor. Lower marginal costs incentivize firms that can reset their prices to cut them. Deflation follows and will via the central bank's policy function bring about a drop in the nominal interest rate. In accordance, the real interest falls to follow an upward-sloping path, which is consistent with the downward-sloping path of output.

The more surprising element is that employment falls. As done in the previous section, we can understand this by comparing to the outcomes of the worker-capitalist model, seen in the right column of Figure 2. Here, the responses are qualititively similar to those of the standard model with the exception that employment stays constant.

The reason for this discrepancy is the same as with the monetary shock. Without any profit income,

income and substitution effects from any given change in the wage level always cancel under balanced growth path preferences, as seen in equation (27). The standard model thus relies on the redistribution of profits to the household in order to produce the fall in employment.

With profit income redistributed to the household, as in the standard model, the rise in the wage level contributes positively to employment beacuse the substitution effect dominates the income effect. The reason that employment falls, however, is that the labor-depressing income effect from the increase in profits dominates the labor-enhancing effect of the increase in wages. This contrasts with the response to a monetary policy shock seen in the previous section, where the response in wages and profits both contributed to depressing labor supply.

We now turn to the question how the response of wages and profits are determined in equilibrium. As in Subsection 3.1, we first consider the response of wages, and then the response of profits.

The wage response is procyclical. This stems from the fact that the increase in consumption is stronger than the fall in labor supply. To see this formally, combine the log-linearized production function (8) with goods market clearing (13) and the optimality condition for labor (4) to find:

$$\hat{\omega}_t \quad = \quad \sigma \hat{c}_t + \varphi \hat{n}_t = \sigma \hat{y}_t + \frac{\varphi}{1-\alpha} \left( \hat{y}_t - a_t \right)$$

where "hats" instead of "tildes" stands for deviations from steady state, rather than the flex price equilibrium. The wage level is determined by two opposing forces. For a given $a_t$, an increase in $y_t$ implies that both consumption and labor supply increase, which raises the marginal rate of substitution. For a given $y_t$, an increase in $a_t$ means that the same amount of consumption can obtained with less labor input, which lowers the marginal rate of substitution. Under our parametrization, the first effect dominates.

Profits respond procyclically to a productivity shock. To see this combine the log-linearized resource constraint and production function:

$$\hat{d}_t = \frac{1}{\epsilon - (1-\alpha)(\epsilon - 1)} \left[ \hat{y}_t + (\epsilon - 1) a_t - [\epsilon - (1 + \alpha(\epsilon - 1))] \hat{\omega}_t \right] \tag{33}$$

From this expression, we can see that profits is determined by relative strength of three forces. First, higher output raises profits directly by expanding volume of sales. Second, higher productivity lowers marginal costs and so raises profits. Third, higher wages raises marginal costs, and lower profits. In the analysis of the monetary policy shock in Subsection 3.1, where $a_t = 0$, we saw that the wage effect dominated the volume effect to make the profits response countercyclical with respect to output. Here, however, profits become procyclical. Apart from the direct effect from higher productivity seen in (33), this also stems from a weaker procycical relationship between wages and output, as seen in by comparing (33) to (28).

In the worker-capitalist model, wages and profits are determined in the same way as with respect to the monetary policy shock. Employment is constant, so wages must track the worker's consumption which in turn is determined by the evolution of the real interest rate. Profits are then the residual between the movement in output and wages:

$$\hat{w}_{wc,t} = \hat{c}_{wc,t} \tag{34}$$

$$\hat{d}_{wc,t} = \frac{1}{1-s_{wc}}\hat{y}_{wc,t} - \frac{s_{wc}}{1-s_{wc}}\hat{c}_{wc,t} \tag{35}$$

where $s_{wc}$ is the labor share of output in steady state of the worker-capitalist model.

# 4 Discussion

To summarize, the distribution and cyclical behavior of firm profits are of first-order importance for the responses to monetary and technological innovations in the New Keynesian textbook model. More specifically, profits play two roles in the textbook model. (1) A positive income stream from firm profits in the household budget reduces the relative income effect of wage changes, creating a positive effect from wages on labor supply and (2) fluctuations in profits in reaction to shocks directly affect the response of labour supply. A positive shock to the nominal interest rate contracts output both because wages fall and because profits increase. A positive innovation in TFP contracts employment because the labour-reducing income effect from increasing profits dominates the labour-expanding effect of increasing wages. Taken together ,our results suggest that the usual 'aggregate demand' interpretation of the model should not be taken for granted, since it ignores the factors governing labor supply.

We illustrated the importance of redistributed profits by means of a thought-experiment that contrasted the impulse-responses of the textbook model to that of a highly stylised alternative setting with hand-to-mouth capitalists that own firms and consume profits every period. We do not see this alternative model as a superior description of real economies. Rather, we use it as a heuristic instrument to highlight, by way of contrast, the transmission mechanism in the textbook model. We do, however, think that there are reasons to believe that the textbook model overstates the roles of redistributed profits. Specifically, that profits are a substantial part of household income or that profits are counter-cyclical with respect to a monetary policy shock appears to be at odds with US data. Saez and Zucman (2014) show that 91.5 % of non-pension equity wealth and 55.37 % of pension wealth is owned by by 10 % of the wealthiest households. Moreover, VAR evidence shows a large and pro-cyclical response of profits wheras wages are near flat in response to a monetary policy shocks (Christiano and Eichenbaum, 2005). [5] With the textbook model transmission channel, we would have that labor supply and output respond negatively to an unexpected drop in the nominal interest rate.

Let us also stress that our findings are specific to the textbook model. Thus, other changes to the environment may also affect the transmission of shocks, and the role of profits that we highlight. Particularly, any change that affects the comovement and relative magnitudes of wage income and consumption can be expected to change the response of labor supply to the shocks we consider. Thus, other non-wage sources of income, *e.g.* from asset investments or non-labor taxes and transfers, create an average difference of consumption and labor income that, if positive, could be expected to increase the labor supply response to wage changes, or, if negative, to dampen it. Similarly, additional consumption-smoothing opportunities, for example in the form of financial trade between workers and capitalists or agents outside the domestic

[5] We are not aware of any study who investigates the cyclicality of profits with respect to TFP shocks.Nekarda and Ramey (2013), however, find that markups over marginal costs are pro-cyclical conditional on TFP shocks.

economy, may act to dampen the income effect of wage changes on labor supply. Finally, any frictions in the labor supply response to income and wage changes may affect the nature of the New-Keynesian transmission mechanism more fundamentally. There are several examples of such frictional models in the literature, see e.g. Erceg et al. (2000); Walsh (2005); Blanchard and Galí (2010); Ravn and Sterk (2012). To analyze the role of these extensions for the New Keynesian transmission mechanism, we would ideally consider a general version of the New Keynesian model that captures the empirical joint distribution of incomes from various sources and asset holdings across households, and features a realistic description of frictions in labor markets. To explore the transmission channels in such a more general and realistic departure from the textbook model seems an interesting avenue for future research.

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# A Appendix

In this appendix, we derive the Phillip curve, the DIS curve and the equation for the natural real interest rate of the worker-capitalist model, (22), (23) and (24).

Of any variable $X_t$, $\bar{X}$ the steady state value, $x_t$ denotes the log, $\hat{x}_t$ the log deviation from the steady state and $\tilde{x}_t$ the log deviation from the flex price equilibrium.

## A.1 The Phillips curve

In the worker-capitalist model the intermediate firms are controlled by the capitalists. The later discount consumption across time by means of the discount factor $\beta$. Thus, compared to the standard model the market discount factor, $Q_{t,t+k}$, in the firms' problem is replaced by $\beta^k$.

$$\begin{aligned} \max_{P_t^*} \quad & \sum_{k=0}^{\infty} \theta^k E_t \beta^k \left\{ P_t^* Y_{t+k|t} - \Psi_{t+k}(Y_{t+k|t}) \right\} \\ & \text{s.t.} \Psi_{t+k}(Y_{t+k|t}) = \frac{W_{t+k}}{P_{t+k}} \left( \frac{N_{t+k|t}}{A_{t+k}} \right)^{\frac{1}{1-\alpha}} \\ & Y_{it} = \left( \frac{P_{it}}{P_t} \right)^{-\epsilon} Y_t \end{aligned} \tag{36}$$

The solution is characterized by

$$\sum_{k=0}^{\infty} \theta^k E_t \left\{ \beta^k Y_{t+k|t} (P_t^* - \mathcal{M} \psi_{t+k|t}) \right\} = 0 \tag{37}$$

where $\psi_{t+k|t} = \frac{\partial \Psi_{t+k}(Y_{t+k|t})}{\partial Y_{t+k|t}}$ and $\mathcal{M} = \frac{\epsilon}{\epsilon - 1}$ is the markup over marginal cost that would have prevailed under flexible price setting ($\theta = 0$).

Now define $\Pi_{t,t+k} = \frac{P_{t+k}}{P_t}$ and $MC_{t+k|t} = \frac{\psi_{t+k|t}}{P_{t+k}}$ to get

$$\sum_{k=0}^{\infty} \theta^k E_t \left\{ \beta^k Y_{t+k|t} \left( \frac{P_t^*}{P_{t-1}} - \mathcal{M} MC_{t+k|t} \Pi_{t-1,t+k} \right) \right\} = 0 \tag{38}$$

Log-linearizing this equation around the steady state gives us

$$p_t^* - p_{t-1} = (1 - \beta\theta) \sum_{k=0}^{\infty} (\beta\theta)^k E_t \left\{ \hat{mc}_{t+k|t} + (p_{t+k} - p_{t-1}) \right\} \tag{39}$$

Notice that this equation is identical to the similar equation in the standard model.[6]. This goes to show that letting capitalists own the firm does not changes the log-linearised optimality condition for pricing. The reason is that $Q_{t,t+k} = \beta^k$ holds in the steady state in the standard model.

We aim to derive an expression for the individual firm's marginal cost as a function of the average marginal cost in the economy. From the labor market clearing condition (15), production function (8) and

[6] *E.g.* page 45 in Galí (2009)

demand function (7) we get

$$
\begin{aligned}
N_t &= \int_{i=0}^{1} N_{it} di && (40)\\
&= \int_{i=0}^{1} \left(\frac{Y_{it}}{A_t}\right)^{\frac{1}{1-\alpha}} di && (41)\\
&= \left(\frac{Y_t}{A_t}\right)^{\frac{1}{1-\alpha}} \int_{i=0}^{1} \left(\frac{P_{it}}{P_t}\right)^{\frac{-\epsilon}{1-\alpha}} di && (42)
\end{aligned}
$$

The integral in (42) is measure of price dispersion which can be shown to be unity to a first order approximation. Taking logs, we get

$$y_t = a_t + (1-\alpha)n_t \tag{43}$$

The economy's average marginal cost is defined by

$$
\begin{aligned}
mc_t &= (w_t - p_t) - mpn_t && (44)\\
&= (w_t - p_t) - \frac{1}{1-\alpha}(a_t - \alpha y_t) - \log(1-\alpha) && (45)
\end{aligned}
$$

An individual firms expected marginal cost in period $t+k$ if resetting price in period $t$ is

$$
\begin{aligned}
mc_{t+k|t} &= (w_{t+k} - p_{t+k}) - mpn_{t+k|t} && (46)\\
&= (w_{t+k} - p_{t+k}) - \frac{1}{1-\alpha}(a_{t+k} - \alpha y_{t+k|t}) - \log(1-\alpha) && (47)
\end{aligned}
$$

Using the demand function (7), we can thus write

$$mc_{t+k|t} = mc_{t+k} - \frac{\alpha\epsilon}{1-\alpha}(p_t^* - p_{t+k}) \tag{48}$$

Substituting (48) into (39), we get

$$p_t^* - p_{t-1} = (1-\beta\theta)\sum_{k=0}^{\infty}(\beta\theta)^k E_t\left\{\Theta \hat{m}c_{t+k} + (p_{t+k} - p_{t-1})\right\} \tag{49}$$

where $\Theta = \frac{1-\alpha}{1-\alpha+\alpha\epsilon}$ which can be rewritten as

$$p_t^* - p_{t-1} = \beta\theta E_t\left\{p_{t+1}^* - p_t\right\} + (1-\beta\theta)\Theta\hat{m}c_t + \pi_t \tag{50}$$

Using the law of motion for inflation (11) we get that

$$\pi_t = \beta E_t pi_{t+1} + \lambda \hat{m}c_t \tag{51}$$

where $\lambda = \frac{(1-\theta)(1-\beta\theta)}{\theta}\Theta$.

We now derive an expression for $\hat{m}c_t$. The labor f.o.c. (4) implies that

$$w_t - p_t = \sigma c_{wt} + \varphi n_t \tag{52}$$

From the workers budget constraint (21) we get that

$$(w_t - p_t) + n_t \quad = \quad c_{wt} \tag{53}$$

Combining (52) and (53) we get that

$$w_t - p_t = \frac{\sigma + \varphi}{1 - \sigma} n_t \tag{54}$$

Turning to $mc_t$, (53) and production technology (8) implies that

$$\begin{aligned} mc_t &= (w_t - p_t) - mpn_t && (55) \\ &= \frac{1 + \varphi - (1 - \sigma)(1 - \alpha)}{(1 - \sigma)(1 - \alpha)} y_t - \frac{1 + \varphi}{(1 - \sigma)(1 - \alpha)} a_t - \log(1 - \alpha) && (56) \end{aligned}$$

Under flexible prices we know that $mc_t = -\mu \equiv \log \mathcal{M}$. Hence, we define the natural level of output $y_t^n$ from

$$-\mu \quad = \quad \frac{1 + \varphi - (1 - \sigma)(1 - \alpha)}{(1 - \sigma)(1 - \alpha)} y_t^n - \frac{1 + \varphi}{(1 - \sigma)(1 - \alpha)} a_t - \log(1 - \alpha) \tag{57}$$

Subtracting (57) from (56) we get

$$\hat{mc}_t = \frac{1 + \varphi - (1 - \sigma)(1 - \alpha)}{(1 - \sigma)(1 - \alpha)} \tilde{y}_t \tag{58}$$

Substituting (60) into (51) we get the final Phillips curve

$$\pi_t = \beta E_t pi_{t+1} + \kappa_{wc} \tilde{y}_t \tag{59}$$

where $\kappa_{wc} = \frac{1+\varphi-(1-\sigma)(1-\alpha)}{(1-\sigma)(1-\alpha+\alpha\epsilon)} \frac{(1-\theta)(1-\beta\theta)}{\theta}$

## A.2 The DIS curve

The DIS curve in the worker-capitalist model (23) is derived from the workers' Euler equation (3), which in logs reads:

$$c_{wt} = E_t c_{wt+1} - \frac{1}{\sigma}(i_t - E_t \pi_{t+1} - \rho) \tag{60}$$

We write this equation in deviations from the flex price equilibrium:

$$\tilde{c}_{wt} = \tilde{c}_{wt+1} - \frac{1}{\sigma}(i_t - E_t \pi_{t+1} - r_t^n) \tag{61}$$

with

$$r_t^n \equiv \rho + \sigma \Delta c_{wt+1}^n \tag{62}$$

where $c_{wt}^n$ is the equilibrium level of consumption under flexible prices.

Next we find an expression for $\tilde{c}_{wt}$. We use (48), (52) and the production technology (8) to get

$$c_{wt} = \frac{1+\varphi}{(1-\sigma)(1-\alpha)}(y_t - a_t) \tag{63}$$

and so

$$\tilde{c}_{wt} = \frac{1+\varphi}{(1-\sigma)(1-\alpha)}\tilde{y}_t \tag{64}$$

Finally, substituting (64) into (61), we get the DIS curve

$$\tilde{y}_t = \tilde{y}_{t+1} - \hat{\upsilon}(i_t - E_t\pi_{t+1} - r_t^n) \tag{65}$$

where $\upsilon_{wc} = \frac{(1-\sigma)(1-\alpha)}{\sigma(1+\varphi)}$.

### A.3 The natural real interest rate

Here we derive the expression for the natural real interest rate (24). It is defined by (62). Using (63) we get that

$$r_t^n = \rho + \frac{\sigma(1+\varphi)}{(1-\sigma)(1-\alpha)}\left(\Delta y_{t+1}^n - \Delta a_{t+1}\right) \tag{66}$$

From (57) we get an expression for the natural output gap

$$y_t^n = -\frac{(\mu - \log(1-\alpha))(1-\sigma)(1-\alpha)}{1+\varphi-(1-\sigma)(1-\alpha)} + \frac{1+\varphi}{1+\varphi-(1-\sigma)(1-\alpha)}a_t \tag{67}$$

and so

$$\Delta y_{t+1}^n = \frac{1+\varphi}{1+\varphi-(1-\sigma)(1-\alpha)}\Delta a_{t+1} \tag{68}$$

Substituting (68) into (66) we get the expression for the natural level of the real interest rate:

$$r_t^n = \rho + \xi_{wc}^a \Delta a_{t+1} \tag{69}$$

where $\xi_{wc}^a = \frac{\sigma(1+\varphi)}{1+\varphi-(1-\sigma)(1-\alpha)}$.