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Profit Taxation and Aggregate Price Stickiness*

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This paper studies the impact of profit taxation on aggregate price stickiness in New Keynesian economics by introducing profit taxation into An (2009). We show that the impact is theoretically ambiguous. Our result has three key implications. First, it disagrees with the recent conclusion drawn by Kleven and Kreiner (2003) that "taxation of profits increases the degree of price rigidity" (p.1128). Second, it is also at odds with the traditional Keynesian idea that taxes act as automatic stabilizers. Finally, it suggests that fiscal and monetary policies can coordinate their impact on aggregate price stickiness to stabilize the economy.

Key Words: Aggregate Price Stickiness; Economic Fluctuation; Profit Taxation.
JEL Classification Numbers: E3, E5, H2.

1. INTRODUCTION

Although price stickiness is central to Keynesian models, in most such models it has no solid microeconomic foundation. Thus, construction of microeconomic foundations for price stickiness is a top priority for New Keynesian economists. To meet this challenge, New Keynesian economists have put forward two parallel ideas, viz., small menu costs (Mankiw, 1985) and near-rationality (Akerlof and Yellen, 1985). The following studies (e.g., Blanchard and Kiyotaki, 1987; Ball and Romer, 1989, 1990, 1991), in general, expand on the near-rationality model, with the key difference being that those following studies derive their results from basic optimization assumptions so that explicit welfare calculations are allowed.[1]

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[1] See Rotemberg (1987) and Blanchard (1990) for comprehensive surveys of this literature.

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The papers in the New Keynesian economics literature share three common features. First, they assume that all the firms are homogeneous. Second, they show that a second-order "small" price-adjustment barrier for an individual firm to adjust its price can cause changes in money supply to have a first-order "large" effect on real economic variables.[2] Finally, the fraction of the firms that keep their price unchanged following a money supply shock is exogenous. In the initial equilibrium of their models, each firm is assumed to set its own price to maximize its own profit. Then, they introduce a money supply shock into their models. Following the money supply shock, they assume that β fraction of the firms keeps their price unchanged, whereas the remaining $(1-\beta)$ fraction of the firms changes their price to charge the new optimal price. They either assume a general parametric β (Akerlof and Yellen, 1985) or assume that β is equal to one (Mankiw, 1985; Blanchard and Kiyotaki, 1987; Ball and Romer, 1989, 1990, 1991). But no matter what, β is assumed to be exogenous in both cases.

Assuming an exogeneous β is fine for their research purposes, but β should be an endogenous variable. In addition, β can be considered as a measure of aggregate price stickiness by its definition. Therefore, if one can endogenize β, then he can go further to characterize the behavior of aggregate price stickiness by studying the properties of the endogenized β.

An (2009) characterizes the behavior of aggregate price stickiness. To do so, he accomplishes two tasks. First, he endogenizes β in the near-rationality model (Akerlof and Yellen, 1985).[3] He accomplishes this task by introducing a distribution of price-adjustment barriers among the firms into the near-rationality model. Specifically, he assumes that the firms are heterogeneous, rather than being homogeneous, in the sense that they have different price-adjustment barriers. The distribution of the price adjustment barriers is common knowledge among the firms. Second, he studies the properties of the endogenized β to characterize the behavior of aggregate price stickiness and obtains three key results detailed as below:

(a) $\lim_{\varepsilon\to 0}\beta(\varepsilon)=1$, where β denotes the money supply shock, i.e., the fractional change in the money supply m. This result says that when there is a money supply shock but turns out to be small, β approaches one.

(b) $\frac{d\beta}{d\varepsilon}|_{\varepsilon=0}=0$. As $\frac{d\beta}{d\varepsilon}|_{\varepsilon=0}=0$, then by applying Taylor's expansion, one has that when ε is small (close to zero), $\beta(\varepsilon)-\beta(0)=\beta(\varepsilon)-1\propto\varepsilon^2$. In other words, when the money supply shock is small (close to zero), almost all the firms will keep their price unchanged, whereas only a small fraction

[2]Small menu costs and near-rationality are, by definition, equivalent routes to the same place. For the convenience of exposition, we therefore follow An (2009) to give them a unified terminology, viz., price-adjustment barrier.

[3]Dotsey et al. (1999) endogenize a similar parameter in a dynamic general equilibrium setting, but without focusing on characterizing the behavior of aggregate price stickiness.

of the firms that is merely in second-order of the money supply shock will change their price to charge the new optimal price. Therefore, prices are not only sticky, but price stickiness is very significant for small money supply shocks in a well-defined sense. Intuitively, only a small fraction of the firms will have price-adjustment barriers so small that it pays them to change their price in response to small money supply shocks.

(c) There exists the possibility of multiple equilibrium values of β. This result is due to that following a money supply shock, the profit loss for an individual firm to keep its price unchanged decreases as β increases. In other words, the higher the fraction of the firms that keep their price unchanged following a money supply shock, the less incentive for an individual firm to change its own price. This is exactly the concept of strategic complementarity (Cooper and John, 1988).[4] In a word, due to strategic complementarity, the possibility of multiple equilibrium values of β cannot be excluded, further suggesting the possibility of coordination failures among the firms. Therefore, models with price stickiness (Mankiw, 1985; Akerlof and Yellen, 1985) and models with coordination failures (Diamond, 1982) are not completely competing paradigms to explain economic fluctuations but can be compatible with each other.

Given the central and foundational role played by aggregate price stickiness in the Keynesian theory of economic fluctuations, the following questions naturally arise: Can fiscal policy affect aggregate price stickiness? To what degree? This paper aims to answer these questions by studying the impact of profit taxation on aggregate price stickiness in New Keynesian economics. To do so, we introduce profit taxation into An (2009).[5] We show that the impact of profit taxation on aggregate price stickiness is theoretically ambiguous.

Our result has three key implications. First, it disagrees with the recent conclusion drawn by Kleven and Kreiner (2003) that "taxation of profits increases the degree of price rigidity" (p.1128). Second, it is also at odds with the traditional Keynesian idea that taxes act as automatic stabilizers. Finally, it suggests that fiscal and monetary policies can coordinate their impact on aggregate price stickiness to stabilize the economy.

In the immediate wake of the Great Recession, an emerging literature has advanced from the traditional Representative Agent New Keynesian (RANK) framework to the so-called Heterogeneous Agents New Keynesian

[4]By strategic complementarity, they mean that the optimal strategy of a decision-maker depends positively on the strategies of the other decision-makers.

[5]Introducing profit taxation into the dynamic general equilibrium model by Dotsey et al. (1999) can make the same points as ours. We choose to introduce profit taxation into An (2009) for two key reasons. First, to facilitate comparison because Kleven and Kreiner (2003) and An (2009) share the same setting. Second, if one can use a simpler model to make the same points, why bother to employ a more complicated model?

(HANK) framework that combines key features of heterogeneous agents and New Keynesian economies (Oh and Reis, 2016; McKay and Reis, 2016; Guerrieri and Lorenzoni, 2017; Kaplan et al., 2018). The bulk of this recent literature has, in general, focused on the role of household heterogeneity.[6] An (2009) and this paper show that firm heterogeneity should also deserve appropriate attention.

2. MODEL

An (2009) endogenizes β by assuming that firms are heterogeneous and introducing a distribution of price-adjustment barriers among the firms into Akerlof and Yellen (1985)'s near-rationality model. We further extend An (2009)'s model by introducing profit taxation into it. Therefore, in this section we first recapitulate Akerlof and Yellen (1985) and An (2009), and then present our extended model.

2.1. A Recapitulation of Akerlof and Yellen (1985)

The near-rationality model (Akerlof and Yellen, 1985) assumes a monopolistically competitive economy with a fixed number of homogeneous firms. The sales of each firm depend on the level of real aggregate demand and the firm's own price relative to the aggregate price level.

In the initial equilibrium, each firm sets its own price to maximize its own profit, under the assumption that a change in its own price has no effect on the prices charged by rivals or on the aggregate price level. That is, each firm is assumed to be a Bertrand maximizer.

Then, Akerlof and Yellen introduce a money supply shock ε, where ε is defined as the fractional change in the money supply m, viz., the money supply changes from m to $m(1+\varepsilon)$ with a money supply shock ε. Following the money supply shock, they assume that β fraction of the firms keeps their price unchanged, whereas the remaining $(1-\beta)$ fraction of the firms changes their price to charge the new optimal price.

If a firm keeps its price unchanged following the money supply shock, it will incur a profit loss $L(\varepsilon,\beta)$ that is a function of both ε and β. Akerlof and Yellen have shown that $L(\varepsilon,\beta)$ has two properties. First, $\lim_{\varepsilon\to 0} L(\varepsilon,\beta) = 0$. This property says that when there is a money supply shock but turns out to be small, the profit loss approaches zero. Second, $\frac{\partial L(\varepsilon,\beta)}{\partial \varepsilon}|_{\varepsilon=0} = 0$. As $\frac{\partial L(\varepsilon,\beta)}{\partial \varepsilon}|_{\varepsilon=0} = 0$ then by applying Taylor's expansion, one has that when ε is small (close to zero), $L(\varepsilon,\beta) - L(0,\beta) = L(\varepsilon,\beta) - 0 \propto \varepsilon^2$. In other words, when the money supply shock is small (close to zero), the profit

[6]See Galí (2018) for an assessment of this recent literature. An exception is Ottonello and Winberry (2020) who explore the implication of firms' financial heterogeneity for the transmission of monetary policy.

loss is merely in second-order of the money supply shock. Therefore, if an individual firm keeps its price unchanged following a small money supply shock, its behavior is suboptimal but still near-rational because its profit loss is merely in second-order of the money supply shock.

Plus, Ball and Romer (1991) have shown that the loss function $L(\varepsilon, \beta)$ has two additional properties, viz., $\frac{\partial L(\varepsilon,\beta)}{\partial \beta}|_{\varepsilon=0} = 0$ and $\frac{\partial L(\varepsilon,\beta)}{\partial \beta}|_{\varepsilon>0} < 0$. These two properties suggest that following a money supply shock, the profit loss for an individual firm to keep its price unchanged decreases in the fraction of the firms that keep their price unchanged. In other words, the higher the fraction of the firms that keep their price unchanged following a money supply shock, the less incentive for an individual firm to change its own price.

2.2. A Recapitulation of An (2009)

To endogenize β in the near-rationality model (Akerlof and Yellen, 1985), An (2009) introduces only a single change, viz., he assumes that the firms are heterogeneous, rather than being homogeneous, in the sense that they have different price-adjustment barriers, with the distribution of the price-adjustment barriers being common knowledge among the firms. Specifically, he assumes that each firm has a positive price-adjustment barrier $c_i > 0$, where i is the firm index. The price-adjustment barriers for all the firms (i.e., $\{c_i\}$) follow a certain distribution that is common knowledge among the firms. As for notation, he uses F to denote the cumulative distribution function (CDF) of the price-adjustment barriers. F is assumed to be first-order differentiable and strictly increasing. As $c_i > 0$ for each firm i, one has $F(0) = 0$. As F is first-order differentiable and strictly increasing, one has $F' > 0$, where F' is the first-order derivative of F.

Following the money supply shock, each firm will decide whether to change its own price or not. Consider a specific firm, saying, firm i. When the manager of firm i sets the price following the money supply shock, he would form a rational expectation of the distribution of other firms' price-setting behavior: β fraction of the firms will keep their original optimal price unchanged, whereas the remaining $(1 - \beta)$ fraction of the firms will change their price to charge the new optimal price.

Why would the manager form such a rational expectation? A reasonable explanation is: If $L(\varepsilon, \beta) > c_i$, then firm i would change its price to charge the new optimal price; otherwise, firm i would keep its price unchanged. The key point is that $\{c_i\}$ follows a certain distribution that is common knowledge among the firms. With all the firms following the above price-setting behavior, the equilibrium outcome consistent with the rational expectation is that β fraction of the firms will keep their original optimal price unchanged, whereas the remaining $(1 - \beta)$ fraction of the firms will change their price to charge the new optimal price. Thus, An

(2009) obtains the equilibrium equation as follows:

$$1-\beta = F(L(\varepsilon,\beta)). \tag{1}$$

Equation (1) intuitively makes sense. First, by the definition of β, its left-hand side (i.e., $(1-\beta)$) is the fraction of the firms that change their price to charge the new optimal price. Second, by the definition of F, its right-hand side (i.e., $F(L(\varepsilon,\beta))$) is the fraction of the firms whose price-adjustment barrier is less than $L(\varepsilon,\beta)$. Because firm i would changes its price to charge the new optimal price if its price adjustment barrier c_i is less than $L(\varepsilon,\beta)$ (i.e., $c_i < L(\varepsilon,\beta)$), $F(L(\varepsilon,\beta))$ is also the fraction of the firms that change their price to charge the new optimal price. Taken together, the two sides of Equation (1) are equal and hence, it holds.

From Equation (1), one can solve for the equilibrium value of β. Thus, An (2009) has endogenized β, an exogeneous parameter in the near-rationality model.

Then, An (2009) goes further to characterize the behavior of aggregate price stickiness by studying the properties of the endogenized β. Building on the four properties of the loss function $L(\varepsilon,\beta)$ shown by Akerlof and Yellen (1985) and Ball and Romer (1991), he obtains three key results: (1) $\lim_{\varepsilon\to 0}\beta(\varepsilon) = 1$; (2) $\frac{d\beta}{d\varepsilon}|_{\varepsilon=0} = 0$; and (3) There exists the possibility of multiple equilibrium values of β.

2.3. The Extended Model

Now, let us introduce profit taxation into An (2009). We use t to denote the profit tax rate. We assume that t is constant and the same for all the firms.[7] As the profit loss for an individual firm to keep its price unchanged following a money supply shock also depends on the profit tax rate t, we hence augment the loss function from $L(\varepsilon,\beta)$ in the benchmark model to $L(\varepsilon,\beta,t)$ in our extended model. Corresponding to Equation (1), we can then write the equilibrium equation for our extended model as below:

$$1-\beta = F(L(\varepsilon,\beta,t)). \tag{2}$$

From Equation (2), one can solve for the equilibrium value of β in our extended model.

From Equation (2), one can follow the proof of An (2009) to show that his three key results still hold in our extended model: (1) $\lim_{\varepsilon\to 0}\beta(\varepsilon,t) = 1$; (2) $\frac{\partial\beta(\varepsilon,t)}{\partial\varepsilon}|_{\varepsilon=0} = 0$; and (3) There exists the possibility of multiple equilibrium

[7]In reality, profit taxation is asymmetric, not allowing immediate deductibility for losses. Our assumption abstracts from this. Note that Kleven and Kreiner (2003) also treat t as a constant (p.1127).

values of β.[8] The reason is that the four properties of the loss function shown by Akerlof and Yellen (1985) and Ball and Romer (1991) carry over to our extended model.

Because profit taxation suggests that the government shares the profit loss with firms, the loss function $L(\varepsilon, \beta, t)$ has an additional property, viz., $\frac{\partial L(\varepsilon,\beta,t)}{\partial t} < 0$. This property says that the profit loss $L(\varepsilon, \beta, t)$ decreases as the profit tax rate t increases.

Now, we are ready to propose and prove the following proposition:

PROPOSITION 1. *The sign of* $\frac{\partial \beta(\varepsilon,t)}{\partial t}$ *is theoretically ambiguous.*

Proof. If we take derivative with respect to t on both sides of Equation (2), we have $-\frac{\partial \beta(\varepsilon,t)}{\partial t} = F' \left(\frac{\partial L(\varepsilon,\beta,t)}{\partial \beta} \times \frac{\partial \beta(\varepsilon,t)}{\partial t} + \frac{\partial L(\varepsilon,\beta,t)}{\partial t} \right)$. By simple algebra, we have $\frac{\partial \beta(\varepsilon,t)}{\partial t} = -\frac{F'}{1+F' \frac{\partial L(\varepsilon,\beta,t)}{\partial \beta}} \frac{\partial L(\varepsilon,\beta,t)}{\partial t}$. As $F' > 0$, $\frac{\partial \beta(\varepsilon,t)}{\partial \beta} < 0$ and $\frac{\partial L(\varepsilon,\beta,t)}{\partial t} < 0$, the sign of $\frac{\partial \beta(\varepsilon,t)}{\partial t}$ therefore hinges on the sign of $\left(1 + F' \frac{\partial L(\varepsilon,\beta,t)}{\partial \beta}\right)$: (1) If $\left(1 + F' \frac{\partial L(\varepsilon,beta,t)}{\partial \beta}\right) > 0$, then $\frac{\partial \beta(\varepsilon,t)}{\partial t} > 0$; and (2) If $\left(1 + F' \frac{\partial L(\varepsilon,\beta,t)}{\partial \beta}\right) < 0$, then $\frac{\partial \beta(\varepsilon,t)}{\partial t} < 0$. Because the sign of $\left(1 + F' \frac{\partial L(\varepsilon,\beta,t)}{\partial \beta}\right)$ is theoretically ambiguous, the sign of $\frac{\partial \beta(\varepsilon,t)}{\partial t}$ is hence theoretically ambiguous. ▮

Proposition 1 says that the impact of profit taxation on aggregate price stickiness is theoretically ambiguous.

Proposition 1 has three key implications that are detailed as below:

(a) Proposition 1 first disagrees with the recent conclusion drawn by Kleven and Kreiner (2003) that "taxation of profits increases the degree of price rigidity" (p.1128). In a recent contribution, Kleven and Kreiner (2003) introduce a tax system into the theoretical framework of Blanchard and Kiyotaki (1987) and Ball and Romer (1989, 1990, 1991). Based on their observation that $\frac{\partial L(\varepsilon,\beta,t)}{\partial t} < 0$, they then conclude that "taxation of profits increases the degree of price rigidity" (p.1128). While we agree with them that $\frac{\partial L(\varepsilon,\beta,t)}{\partial t} < 0$, we disagree with their key conclusion that profit taxation contributes to price stickiness because Proposition 1 says that the impact of profit taxation on aggregate price stickiness is theoretically ambiguous. The proof of Proposition 1 shows that the root problem with their analysis is that they have ignored the impact of $\left(1 + F' \frac{\partial L(\varepsilon,\beta,t)}{\partial \beta}\right)$ as the result of their following Blanchard and Kiyotaki (1987) and Ball and Romer (1989, 1990, 1991) to assume an exogeneous β that is equal to one. In a word,

[8] We choose not to repeat this essentially repetitive exercise, but the proof is available upon request.

their analysis is incomplete and as a result, has reached wrong conclusions. Therefore, to study the impact of taxation on price stickiness, it is essential to endogenize aggregate price stickiness. Otherwise, the analysis would be incomplete and as a result, can lead to wrong conclusions.

(b) Proposition 1 is also at odds with the old Keynesian idea that taxes act as automatic stabilizers. An old insight of the traditional Keynesian theory is that taxes serve as automatic stabilizers by reducing effective demand in upturns and increasing effective demand in downturns. Proposition 1 suggests that whether profit taxation acts as automatic stabilizers (i.e., $\frac{\partial\beta(\varepsilon,t)}{\partial t} < 0$) or destabilizers (i.e., $\frac{\partial\beta(\varepsilon,t)}{\partial t} > 0$) is theoretical ambiguous. The contrast is due to that we focus only on the supply side effect of taxation, whereas the traditional Keynesian theory concentrates entirely on the demand side effect.

(c) Fiscal and monetary policies can coordinate their impact on aggregate price stickiness to stabilize the economy. As the endogenized β depends on both t and ε (i.e., $\beta = \beta(\varepsilon, t)$), viz., the endogenized aggregate price stickiness depends on both profit taxation and money supply shock, we reach the conclusion that fiscal and monetary policies can coordinate their impact on aggregate price stickiness to stabilize the economy. This coordination channel has largely been ignored by previous studies, however. For instance, in a recent important contribution, McKay and Reis (2016) first propose a business cycle model that merges the standard incomplete-market model with the standard New Keynesian business cycle model. They then calibrate it to the U.S. data to measure the effect of the U.S. tax-and-transfer systems on the dynamics of the business cycle. As they follow Calvo (1983) to assume that firms revise their prices with an exogenously given probability, they have essentially excluded or ignored the coordination channel identified and highlighted in this paper.

3. CONCLUSION

Four general lessons can be learned from this paper. First, firm heterogeneity should deserve appropriate attention in New Keynesian economics. Second, to study the impact of taxation on price stickiness, it is essential to endogenize aggregate price stickiness. Otherwise, the analysis would be incomplete and as a result, can lead to wrong conclusions. Third, to examine the impact of taxation on economic fluctuations, it is essential to consider both the demand and supply side effects of taxation, particularly, incorporating the channel identified and highlighted in this paper. Finally, the impact of taxation on aggregate price stickiness and economic fluctuations is essentially an empirical question, calling on more empirical analysis like Poterba et al. (1986).

REFERENCES

Akerlof, George A. and Janet L. Yellen, 1985. A Near-Rational Model of the Business Cycle, With Wage and Price Inertia. *Quarterly Journal of Economics* **100(Supplement)**, 823-838.

An, Zhiyong, 2009. Aggregate Price Stickiness. *Annals of Economics and Finance* **10(1)**, 15-28.

Ball, Laurence and David Romer, 1989. Are Prices Too Sticky? *Quarterly Journal of Economics* **104(3)**, 507-524.

Ball, Laurence and David Romer, 1990. Real Rigidities and the Non-Neutrality of Money. *Review of Economic Studies* **57(2)**, 183-203.

Ball, Laurence and David Romer, 1991. Sticky Prices as Coordination Failure. *American Economic Review* **81(3)**, 539-552.

Blanchard, Olivier J., 1990. Why Does Money Affect Output? A Survey. In Handbook of Monetary Economics, Vol. 2, 779-835. Edited by B. M. Friedman and F. H. Hahn. Amsterdam: North-Holland.

Blanchard, Olivier J. and Nobuhiro Kiyotaki, 1987. Monopolistic Competition and the Effects of Aggregate Demand. *American Economic Review* **77(4)**, 647-666.

Calvo, Guillermo A., 1983. Staggered Prices in a Utility Maximizing Framework. *Journal of Monetary Economics* **12(3)**, 383-398.

Cooper, Russell and Andrew John, 1988. Coordinating Coordination Failures in Keynesian Models. *Quarterly Journal of Economics* **103(3)**, 441-463.

Diamond, Peter A., 1982. Aggregate Demand Management in Search Equilibrium. *Journal of Political Economy* **90(5)**, 881-894.

Dotsey, Michael, Robert G. King, and Alexander L. Wolman, 1999. State-Dependent Pricing and the General Equilibrium Dynamics of Money and Output. *Quarterly Journal of Economics* **114(2)**, 655-690.

Galí, Jordi, 2018. The State of New Keynesian Economics: A Partial Assessment. *Journal of Economic Perspectives* **32(3)**, 87-112.

Guerrieri, Veronica and Guido Lorenzoni, 2017. Credit Crises, Precautionary Savings, and the Liquidity Trap. *Quarterly Journal of Economics* **132(3)**, 1427-1467.

Kaplan, Greg, Benjamin Moll, and Giovanni L. Violante, 2018. Monetary Policy According to HANK. *American Economic Review* **108(3)**, 697-743.

Kleven, Henrik J. and Claus T. Kreiner, 2003. The Role of Taxes as Automatic Destabilizers in New Keynesian Economics. *Journal of Public Economics* **87(5-6)**, 1123-1136.

Mankiw, N. Gregory, 1985. Small Menu Costs and Large Business Cycles: A Macroeconomic Model of Monopoly. *Quarterly Journal of Economics* **100(2)**, 529-538.

McKay, Alisdair and Ricardo Reis, 2016. The Role of Automatic Stabilizers in the U.S. Business Cycle. *Econometrica* **84(1)**, 141-194.

Oh, Hyunseung, and Ricardo Reis, 2012. Targeted Transfers and the Fiscal Response to the Great Recession. *Journal of Monetary Economics* **59(Supplement)**, 50-64.

Ottonello, Pablo and Thomas Winberry, 2020. Financial Heterogeneity and the Investment Channel of Monetary Policy. *Econometrica* **88(6)**, 2473-2502.

Poterba, James M., Julio J. Rotemberg, and Lawrence H. Summers, 1986. A Tax-Based Test for Nominal Rigidities. *American Economic Review* **76(4)**, 659-675.

Rotemberg, Julio J. 1987. The New Keynesian Microfoundations. *NBER Macroeconomics Annual* **2**, 69-104.