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Intangible Capital, Returns to Scale and Aggregate Price Stickiness*

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Intangible capital has become a large and increasingly important part of firms' capital stocks, especially over the last three decades. A common premise in the literature on intangible capital is that it can contribute to higher returns to scale. In this article, we study the impact of rising intangible capital on aggregate price stickiness via the channel of returns to scale in New Keynesian economics. Our basic methodology is to base on An (2009, 2022) to do a comparative static analysis regarding returns to scale. We show that the impact is theoretically ambiguous thanks to strategic complementarity (Cooper and John, 1988). Our analysis suggests that fiscal and monetary policies can respond to the rising intangible capital by varying and coordinating their impact on aggregate price stickiness to stabilize the economy.

Key Words: Aggregate Price Stickiness; Intangible Capital; Returns to Scale.
JEL Classification Numbers: E3, E5.

1. INTRODUCTION

From the nineteenth century until about three decades ago, businesses largely invested in physical capital, such as plants and equipment. But in the last three decades, intangible capital, including data, software, patents & copyrights, brands and organizational capital, has become a large and increasingly important part of firms' capital stocks (Corrado et al., 2013). According to recent research by the McKinsey Global Institute (MGI), intangible capital accounted for about 40 percent of all investment in the

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US and ten European economies by 2019, up 29 percent from 1995.[1] Plus, investment in intangible capital appears to have surged again in 2020 as digitalization accelerated in response to the COVID-19 pandemic.

Intangible capital is, in addition to its increasing prevalence, also fundamentally different from physical capital. A common premise in the literature on intangible capital is that it can contribute to higher returns to scale. The reason is that intangible capital is more "scalable" than physical capital thanks to its fundamental property of "nonrivalry in use" (Haskel and Westlake, 2018; Crouzet et al., 2022). For example, a machine tool cannot be used simultaneously in different factory locations, but a design blueprint, data, or a software can. Newman (2014), Begenau et al. (2018) and Jones and Tonetti (2020) all emphasize the potential role of data for the rise of returns to scale. Chiavari (2021) finds that the average firm-level returns to scale increased within all US sectors by about 5 percent between 1980 and 2014. Lashkari et al. (2021) utilize French data to document that firms' adoption of information and communication technologies (ICT) gave rise to higher returns to scale.

Previous studies have highlighted the importance of rising intangible capital as a source of economic growth (e.g., Corrado et al., 2009). Their basic methodology is to add intangible capital to the standard growth accounting framework (Solow, 1957). They find that intangible capital has been an important driver of modern economic growth.

In this article, we study the implications of rising intangible capital for economic fluctuations. More specifically, we study the impact of rising intangible capital on aggregate price stickiness via the channel of returns to scale in New Keynesian economics. Our basic methodology is to base on An (2009, 2022) to do a comparative static analysis regarding returns to scale. We show that the impact is theoretically ambiguous thanks to strategic complementarity (Cooper and John, 1988).[2] Our analysis suggests that fiscal and monetary policies can respond to the rising intangible capital by varying and coordinating their impact on aggregate price stickiness to stabilize the economy.

The remainder of this article is organized as follows. First, we review the relevant literature on aggregate price stickiness. Then, we present our theoretical analysis. Finally, we briefly conclude.

[1]The MGI research is available online at https://www.mckinsey.com/capabilities/growth-marketing-and-sales/our-insights/getting-tangible-about-intangibles-the-future-of-growth-and-productivity (Accessed on May 28, 2023).

[2]By strategic complementarity, they mean that the optimal strategy of a decision-maker depends positively on the strategies of the other decision-makers. In the context of our settings, strategic complementarity means that the higher the fraction of the firms that keep their price unchanged in response to an exogenous shock, the less incentive for an individual firm to change its own price.

2. LITERATURE REVIEW ON AGGREGATE PRICE STICKINESS

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.[3]

The articles in the forecited 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.[4] 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.

Although assuming an exogeneous β is fine for their research purposes, 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).[5] He accomplishes this task

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

[4]Small menu costs and near-rationality are, by definition, equivalent routes to the same place. For the convenience of exposition, we hence follow An (2009, 2022) to give them a unified terminology, viz., price-adjustment barrier.

[5]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.

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 ε 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 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) The possibility of multiple equilibrium values of β cannot be excluded. 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). 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, An (2022) further studies the impact of fiscal policy (more specifically, profit taxation) on aggregate price stickiness in New Keynesian economics. To do so, he introduces profit taxation into An (2009). He shows that the impact of profit taxation on aggregate price stickiness is theoretically ambiguous, viz., the sign of $\frac{\partial \beta(\varepsilon,t)}{\partial t}$ is theoretically ambiguous, where t denotes the profit tax rate. His result has three key implications that are detailed as below:

(a) It disagrees with the key conclusion drawn by Kleven and Kreiner (2003) that "taxation of profits increases the degree of price rigidity" (p.

1128). Kleven and Kreiner (2003) introduce a tax system into the theoretical framework of Blanchard and Kiyotaki (1987) and Ball and Romer (1989, 1990, 1991) and reach a key conclusion that "taxation of profits increases the degree of price rigidity" (p. 1128). An (2022) shows that their conclusion is wrong, resulting from their following Blanchard and Kiyotaki (1987) and Ball and Romer (1989, 1990, 1991) to assume an exogeneous β that is equal to one. In other words, 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) It 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. An (2022)'s result 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 theoretically ambiguous. This sharp contrast is due to that An (2022) focuses 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 in An (2022), he reaches 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 example, 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 An (2022).

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 (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, 2022) and this article show that firm heterogeneity should also deserve appropriate attention.

3. 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. An (2022) furthers extends An (2009)'s model by introducing profit taxation into it. Therefore, in this section we first recapitulate Akerlof and Yellen (1985) and An (2009, 2022), and then study the relationship between returns to scale and aggregate price stickiness.

3.1. 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 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

[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.

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., $\frac{\partial L(\varepsilon,\beta)}{\partial \varepsilon}|_{\varepsilon=0} = 0$ and $\frac{\partial L(\varepsilon,\beta)}{\partial \varepsilon}|_{\varepsilon>0} < 0$. 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.

3.2. 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 $\beta = \beta(\varepsilon)$. 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) The possibility of multiple equilibrium values of β cannot be excluded.

3.3. A Recapitulation of An (2022)

An (2022) furthers extends An (2009)'s model by introducing profit taxation into it. As for notation, he uses t to denote the profit tax rate. He assumes 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, the loss function $L(\varepsilon, \beta)$ in An (2009) can hence be augmented to $L(\varepsilon, \beta, t)$. Corresponding to Equation (1), the equilibrium equation can be written as below:

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

From Equation (2), one can solve for the equilibrium value of $\beta = \beta(\varepsilon, t)$.

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.

From Equation (2) and by utilizing the property $\frac{\partial L(\varepsilon,\beta,t)}{\partial t} < 0$, An (2022) proposes and proves a proposition saying that the sign of $\frac{\partial \beta(\varepsilon,t)}{\partial t}$ is theoret-

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

ically ambiguous. His proposition has three key implications: (1) It first disagrees with the key conclusion drawn by Kleven and Kreiner (2003) that "taxation of profits increases the degree of price rigidity" (p. 1128); (2) It is also at odds with the old Keynesian idea that taxes act as automatic stabilizers; and (3) Fiscal and monetary policies can coordinate their impact on aggregate price stickiness to stabilize the economy.

3.4. Returns to Scale and Aggregate Price Stickiness

Akerlof and Yellen (1985) assume a monopolistically competitive economy and hence, the loss function would depend on the returns to scale. The same reasoning applies to An (2009, 2022) because both are extensions of the former. Therefore, the loss function can be further augmented from $L(\varepsilon, \beta, t)$ in An (2022) to $L(\varepsilon, \beta, t, \gamma)$, where γ denotes the returns to scale. Corresponding to Equation (2), the equilibrium equation can be written as below:

$$1 - \beta = F(L(\varepsilon, \beta, t, \gamma)). \tag{3}$$

From Equation (3), one can solve for the equilibrium value of $\beta = \beta(\varepsilon, t, \gamma)$.

Blanchard and Kiyotaki (1987) have shown that the loss function $L(\varepsilon, \beta, t, \gamma)$ has an additional property, viz., $\frac{\partial L(\varepsilon,\beta,t,\gamma)}{\partial \gamma} < 0$.

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

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

Proof. If we take derivative with respect to γ on both sides of Equation (3), we have $-\frac{\partial \beta(\varepsilon,t,\gamma)}{\partial \gamma} = F' \times \left(\frac{\partial L(\varepsilon,\beta,t,\gamma)}{\partial \beta} \times \frac{\partial \beta(\varepsilon,t,\gamma)}{\partial \gamma} + \frac{\partial L(\varepsilon,\beta,t,\gamma)}{\partial \gamma}\right)$. By simple algebra, we have $\frac{\partial \beta(\varepsilon,t,\gamma)}{\partial \gamma} = -\frac{F'}{1+F' \times \frac{\partial L(\varepsilon,\beta,t,\gamma)}{\partial \beta}} \times \frac{\partial L(\varepsilon,\beta,t,\gamma)}{\partial \gamma}$. As $F' > 0$, $\frac{\partial L(\varepsilon,\beta,t,\gamma)}{\partial \beta} < 0$ and $\frac{\partial L(\varepsilon,\beta,t,\gamma)}{\partial \gamma} < 0$, the sign of $\frac{\partial \beta(\varepsilon,t,\gamma)}{\partial \gamma}$ therefore hinges on the sign of $\left(1 + F' \times \frac{\partial L(\varepsilon,\beta,t,\gamma)}{\partial \gamma}\right)$: (1) If $\left(1 + F' \times \frac{\partial L(\varepsilon,\beta,t,\gamma)}{\partial \gamma}\right) > 0$, then $\frac{\partial \beta(\varepsilon,t,\gamma)}{\partial \gamma} > 0$; and (2) If $\left(1 + F' \times \frac{\partial L(\varepsilon,\beta,t,\gamma)}{\partial \gamma}\right) < 0$, then $\frac{\partial \beta(\varepsilon,t,\gamma)}{\partial \gamma} < 0$. Because the sign of $\left(1 + F' \times \frac{\partial L(\varepsilon,\beta,t,\gamma)}{\partial \beta}\right)$ is theoretically ambiguous, the sign of $\frac{\partial \beta(\varepsilon,t,\gamma)}{\partial \gamma}$ is hence theoretically ambiguous. ▌

Proposition 1 says that the impact of higher returns to scale on aggregate price stickiness is theoretically ambiguous.

Proposition 1 bears some resemblance to the key result of An (2022) saying that the impact of profit taxation on aggregate price stickiness is theoretically ambiguous. By comparing their proofs, it is clear that the resemblance results from the sign ambiguity of $\left(1 + F' \times \frac{\partial L(\varepsilon,\beta,t,\gamma)}{\partial \beta}\right)$

(or $\left(1+F' \times \frac{\partial L(\varepsilon,\beta,t)}{\partial \beta}\right)$ in An (2022)). Because the sign ambiguity of $\left(1+F' \times \frac{\partial L(\varepsilon,\beta,t,\gamma)}{\partial \beta}\right)$ (or $\left(1+F' \times \frac{\partial L(\varepsilon,\beta,t)}{\partial \beta}\right)$ in An (2022)) is further due to $\frac{\partial L(\varepsilon,\beta,t,\gamma)}{\partial \beta} < 0$ (or $\frac{\partial L(\varepsilon,\beta,t)}{\partial \beta} < 0$ in An (2022)), both the ambiguity of returns to scale on aggregate price stickiness and the ambiguity of profit taxation on aggregate price stickiness are ultimately owing to strategic complementarity (Cooper and John, 1988), viz., the higher the fraction of the firms that keep their price unchanged, the less incentive for an individual firm to change its own price.

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

(a) The impact of rising intangible capital on aggregate price stickiness via the channel of returns to scale is theoretically ambiguous. As discussed in detail in the Introduction section, a common premise in the literature on intangible capital is that it can contribute to higher returns to scale. Because (1) rising intangible capital can contribute to higher γ and (2) the sign of $\frac{\partial \beta(\varepsilon,t,\gamma)}{\partial \gamma}$ is theoretically ambiguous by Proposition 1, we reach the conclusion that the impact of rising intangible capital on aggregate price stickiness via the channel of returns to scale is theoretically ambiguous. As (1) the theoretical ambiguity regarding the impact of rising intangible capital on aggregate price stickiness via the channel of returns to scale results from the sign ambiguity of $\frac{\partial \beta(\varepsilon,t,\gamma)}{\partial \gamma}$ and (2) the sign ambiguity of $\frac{\partial \beta(\varepsilon,t,\gamma)}{\partial \gamma}$ is, in turn, ultimately owing to strategic complementarity (Cooper and John, 1988) by the aforementioned proof and discussion of Proposition 1, the theoretical ambiguity regarding the impact of rising intangible capital on aggregate price stickiness via the channel of returns to scale is, hence, ultimately caused by strategic complementarity (Cooper and John, 1988), viz., the higher the fraction of the firms that keep their price unchanged, the less incentive for an individual firm to change its own price.

(b) Fiscal and monetary policies can respond to the rising intangible capital by varying and coordinating their impact on aggregate price stickiness to stabilize the economy. Because (1) the endogenized β depends on t, ε and γ (i.e., $\beta = \beta(\varepsilon, t, \gamma)$) and (2) rising intangible capital can contribute to higher returns to scale, we reach the conclusion that fiscal and monetary policies can respond to the rising intangible capital by varying and coordinating their impact on aggregate price stickiness to stabilize the economy.

4. CONCLUSION

Three general lessons can be learned from this article. First, firm heterogeneity should deserve appropriate attention in New Keynesian economics. Second, fiscal and monetary policies can respond to the rising intangible capital by varying and coordinating their impact on aggregate price stickiness to stabilize the economy. Finally, the impact of rising intangible capital on aggregate price stickiness and economic fluctuations is essentially an empirical question, calling on empirical analysis.

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