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JEL Classification: D42, E52, E58, L16

Keywords: monetary policy, neutrality, sticky prices, Entry, product variety, monopolistic competition, Dixit-Stiglitz, sunk costs

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Monetary Neutrality with Sticky Prices and Free Entry[I]

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PSE and CEPR

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Monetary policy is neutral even with fixed prices, if there is free entry and variety is determined optimally as in Dixit and Stiglitz (1977). When individual prices are sticky, entry substitutes for price flexibility in the welfare-based price index. In response to aggregate demand expansions, the intensive (quantity produced of each good) and extensive (number of goods being produced) margins move in offsetting ways, leaving aggregate production unchanged. Deviations from neutrality thus occur only when variety is not optimally determined (preferences are not Dixit-Stiglitz) or when entry is subject to frictions.

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1 Introduction

For decades now, the standard framework to study monetary policy over the business cycle has been the New Keynesian (NK) model.[1] The framework relies on *price stickiness*, most often coupled with monopolistic competition: firms price at a markup over marginal cost, which also makes it optimal for them to keep producing even at sticky prices when marginal cost goes up.[2] This departure from perfectly competitive markets where prices adjust without frictions then allows aggregate demand fluctuations and monetary policy to have real effects on output and employment.

This paper presents a *neutrality proposition* that is to the best of my knowledge novel. I show that even with sticky prices, the frictionless equilibrium is restored by introducing competition along another margin: free entry that determines endogenous variety optimally, as in the original workhorse model of monopolistic competition used in this literature: Dixit and Stiglitz (1977). In a version of the model with such *free entry*, monetary policy is in fact *neutral* even when prices are *fixed*.[3] This free entry mechanism has been widely used in several other areas: in every period, firms enter until profits are driven to zero and have to pay a fixed cost in order to produce.[4]

To understand the basic intuition, it is useful to start from essentially a static version of the model: fixed prices, and quantity theory $M = PC$. Recall the *fixed-variety* (no entry) NK model, in response to an increase in money supply M. With flexible prices, the price level P (and prices of all individual goods) increase proportionally, and consumption is unchanged, $C = \bar{C}$, as is any other real variable: monetary neutrality, or classical dichotomy, holds. Whereas with fixed prices, $P = \bar{P}$, consumption increases.

Free entry replaces price flexibility, and acts as a novel margin that gives adjustment in the aggregate price level even in this most extreme case: when individual prices are fixed. How is neutrality restored? When money supply increases, demand for each firm does go up; increasing their labor demand, firms bid up the real wage (marginal cost), which

[1] Clarida, Gali, and Gertler (1999), Woodford (2003), Gali (2008), and Walsh (2010) are the reference textbook expositions. Classic references on quantitative versions of the models include Christiano, Eichenbaum, and Evans (2005), and Smets and Wouters (2007). Blanchard and Kiyotaki (1987) is a key reference on monopolistic competition, nominal rigidities and non-neutrality, and Barro and Grossman (1971) and Benassy (1976) two pioneering contributions in the field.

[2] Price stickiness is justified by invoking price adjustment costs or menu costs. Another form of nominal rigidities giving a role for monetary policy and aggregate demand is wage stickiness, with efficiency wages the rationale to keep wages constant when employment expands.

[3] Strictly speaking, this result holds *locally*, to first-order, in a way made precise below.

[4] An incomplete list of flexible-price models with this entry mechanism used for diverse issues—endogenous growth, endogenous TFP, trade, effects of government spending, technology diffusion, entry and business cycles—includes i.a. Romer (1986), Romer (1987), Chaterjee and Cooper (1993) Devereux, Head, and Lapham (1996); Comin and Gertler (2006); Jaimovich (2007); Jaimovich and Floetotto (2008).

erodes markups and profit margins, and—with free entry—triggers exit. The economy ends up producing and consuming the same aggregate quantities with the same factor prices, although the distribution is different: there is a smaller number of firms, producing more and hiring more labor per firm.[5] In other words, the extensive and intensive margins perfectly offset each other in this benchmark Dixit-Stiglitz (DS), free-entry case.

The neutrality proposition outlined here relies on market entry generating the optimal number of varieties, which points to two ways in which neutrality breaks down.[6] First, if preferences are not the knife-edge DS case, but for example the general CES aggregate (used in the 1975 working paper version of DS, but also by Benassy, 1996 and others), then the market does not create the optimal number of varieties.[7] Depending on whether consumers value an extra variety more or less than the market, an increase in demand can then lead to an expansion or recession. Second, if entry itself is subject to frictions, for example if costs are sunk, or if it takes a while for firms to start producing, real effects of monetary policy do occur.[8] The implications of these two extensions for the effects of monetary policy on real activity are sketched in the final section.

As far as I am aware of, only two other frameworks restore neutrality with sticky prices, based on different mechanisms; this paper adds a third. The first is Caplin and Spulber's 1987 (s, S) model with *menu costs*, that under certain conditions delivers aggregate neutrality, because of a different "extensive margin" mechanism: the fraction of firms changing prices adjusts in a compensating way.[9] The second is the model with flexible *durable goods* prices and sticky non-durable prices of Barsky, House, and Kimball (2007) that also features neutrality in a limit case whereby the durable and non-durable sectors co-move in opposite and offsetting ways leaving aggregate GDP unchanged. The intuition there stems from the near invariance of the shadow value of (long-lived) durables to (short-lived) monetary shocks. At the oposite end of the spectrum, even a small *sticky* durables sector makes the model behave as if most prices were sticky, even though most other goods have flexible prices; it follows that durables dominate the behavior of the model even when they account for a small

[5] The result holds in an intertemporal version with sticky prices and Taylor rules sketched in the appendix.

[6] To relate to another, more famous neutrality proposition, Miller (1988) stated, 30 years after the Modigliani Miller theorem: " (...) showing what doesn't matter can also show, by implication, what does." This is also the spirit of my neutrality result.

[7] See Bilbiie, Ghironi, and Melitz (2016) for a discussion of the distortions and welfare costs in a flexible-price model under general-homothetic preferences for variety.

[8] Models in this class include i.a. Bilbiie, Ghironi and Melitz (2007), Bergin and Corsetti (2008), and Bilbiie, Ghironi and Fujiwara (2014); see also Appendix B. A third related possibility is firm heterogeneity: monetary policy may have a selection effect if it changes the distribution of active firms, thus changing (endogenous) aggregate productivity. We leave this last topic for future research.

[9] Caplin and Leahy (1991) and Dotsey, King, and Wolman (1999) are examples of steate-dependent pricing models with menu costs in which neutrality breaks down.

share of expenditure. The mechanisms of these two frameworks are thus very different from the neutrality proposition emphasized here.

2 Fixed Variety

Let us recall how neutrality breaks down with sticky prices in fixed-variety, textbook NK models. On the household side, maximization of utility subject to a budget and a cash-in-advance constraint yields the labor supply and money demand equations:[10]

$$\chi L_t^{\varphi} = \frac{1}{C_t^{\gamma}} \frac{W_t}{P_t} \tag{1}$$

$$P_t C_t = M_t, \tag{2}$$

where L are hours worked, C total consumption, W nominal wage, P the price level, and M the quantity of money. Consumption is a CES aggregate and each individual good is produced by a monopolistic competitive firm, indexed by z, using a technology given by: $Y_t(z) = L_t(z)$. Cost minimization taking the wage as given, implies that real marginal cost is $w_t = \frac{W_t}{P_t}$.Profits of the firm are $D_t = P_t Y_t - W_t L_t$, and P_t is the profit-maximizing price equal to a markup over marginal cost. The aggregate production function is $Y_t = L_t$, and the economy resource constraint $Y_t = C_t$. Under *flexible prices*, optimal pricing implies a constant markup rule, and denoting by a star the equilibrium the solution is $w_t^* = \frac{\theta-1}{\theta}$ and $C_t^* = Y_t^* = L_t^* = \left(\frac{\theta-1}{\theta\chi}\right)^{\frac{1}{\varphi+\gamma}}$.

With *fixed prices*, cost minimization taking the wage as given, implies that real marginal cost is $W_t/\bar{P}$. Profits of the firm are $D_t = \bar{P} Y_t - W_t L_t$, where $\bar{P}$ is *not* the profit-maximizing price. The aggregate production function is still $Y_t = L_t$, and the economy resource constraint is $Y_t = C_t$; this implicitly assumes that all markets clear, although one price is fixed. Something needs to adjust for this to happen, and that something is the nominal (and hence real) wage. The two equilibrium conditions evaluated at $P_t = \bar{P}$ deliver:

$$C_t = \frac{M_t}{\bar{P}}$$

$$\frac{W_t}{\bar{P}} = \chi \left(\frac{M_t}{\bar{P}}\right)^{\varphi+\gamma}$$

where the time-varying markup is the inverse of the wage, and is decreasing with M_t: in

[10] The full solution also implies and Euler equation and a transversality condition; these are standard and orthogonal to our argument.

other words, it is countercyclical.[11]

The essence of the NK model is here: if price adjustment is imperfect, output is demand-determined: an increase in money supply leads to an increase in output, consumption, and hours. A demand shock leads to an increase in demand by firms who cannot pass this through to prices, generating real effects and a breakup of neutrality. We will show that with free entry under the Dixit-Stiglitz aggregate, neutrality is restored.

3 Free Entry and Neutrality

At time t, the household consumes the basket of goods C_t, defined over a continuum of goods of measure—to be determined in equilibrium—N_t: $C_t = \left(\int_0^{N_t} c_t(z)^{\theta-1/\theta} dz\right)^{\theta/(\theta-1)}$, where $\theta > 1$ is the symmetric elasticity of substitution across goods. Let $p_t(z)$ denote the nominal price of good z, the consumption-based price index is then $P_t = \left(\int_0^{N_t} p_t(z)^{1-\theta} dz\right)^{1/(1-\theta)}$, and the household's demand for each individual good z is $c_t(z) = (p_t(z)/P_t)^{-\theta} C_t$.

There is a continuum of monopolistically competitive firms, each producing a different variety $z \in [0, N_t]$. Production requires only one factor, labor. Aggregate labor productivity is normalized to 1. Output supplied by firm z is (where $l_t(z)$ is the firm's labor demand for productive purposes):

$$c_t(z) = \begin{cases} l_t(z) - F, \text{ if } l_t(z) > F \\ 0, \text{ otherwise,} \end{cases}$$

where F is a fixed cost in units of the intermediate good: each producer has to produce this quantity before making sales (with constant TFP, this is also interpreted as overhead labor). This fixed cost determines the number of firms in equilibrium. Cost minimization taking the wage as given implies that the real marginal cost (which is the shadow value of relaxing the demand constraint $y_t(z) = c_t(z)$) is equal to the real wage $w_t \equiv W_t/P_t$.

Does the firms' price adjustment ability matter? We solve the model for given individual prices, and study two extreme examples, as in the fixed-variety NK model. In one extreme, price adjustment is perfect: firms can freely set prices for the good they produce in every period. In the second, prices are fixed. Let $p_t(z) = \bar{p}_t$ be arbitrary for now, and $\rho_t \equiv \bar{p}_t/P_t$ denote the real (relative) price of firm z's output. Then, firm z's profit in period t can be written as:

$$d_t(z) = \frac{\bar{p}_t}{P_t} c_t(z) - w_t l_t(z),$$

where the production and demand functions given above are the firm's constraints. In

[11]To have same SS markup as under flex price we need $\bar{P} = \left(\chi \frac{\theta}{\theta-1}\right)^{\frac{1}{\varphi+\gamma}}$.

an equilibrium with free entry and exit, the number of goods produced every period (and hence the number of producers) is determined by a free entry condition equating aggregate profits $\int_0^{N_t} d_t(z)dz$ to zero at all times. Therefore, in a Chamberlinian symmetric equilibrium (firms are identical and make identical choices), individual profits are also zero; replacing the individual production function in the expression for profits, equating to zero, and solving, we obtain:

$$c_t = \frac{1}{\mu_t - 1}F \tag{3}$$

where we defined a measure of the—potentially time-varying—markup:

$$\mu_t \equiv \frac{\bar{p}_t}{w_t P_t}.$$

Individual labor demand is hence:

$$l_t = \frac{\mu_t}{\mu_t - 1}F,$$

and aggregating across firms:

$$L_t = \frac{\mu_t}{\mu_t - 1}FN_t.$$

A symmetric equilibrium with N_t producing firms implies, from the CES-DS aggregate, the benefit of variety through relative prices:

$$\rho_t = N_t^{\frac{1}{\theta-1}}.$$

Aggregate accounting is, because the profit share is zero by free entry:

$$C_t = w_t L_t.$$

Rewriting the markup rule by replacing the above equilibrium conditions, the real wage is:

$$w_t = \rho_t \frac{1}{\mu_t} = N_t^{\frac{1}{\theta-1}} \frac{1}{\mu_t} = \left(\frac{\mu_t - 1}{\mu_t} \frac{1}{F} L_t \right)^{\frac{1}{\theta-1}} \frac{1}{\mu_t},$$

which captures aggregate labor demand; endogenous changes in markups shift the labor demand schedule. Using this we can write aggregate consumption (output) as:

$$C_t = \frac{N_t^{\frac{1}{\theta-1}}}{\mu_t} L_t = \left(\frac{\mu_t - 1}{\mu_t} \frac{1}{F} L_t \right)^{\frac{1}{\theta-1}} \frac{L_t}{\mu_t}, \tag{4}$$

which illustrates that shows that firm entry acts like an endogenous increase in total factor productivity, and that aggregate output variations come from the extensive margin (entry and exit), and the intensive margin (output per firm, through the markup).

The demand side is the same as before, $P_tC_t = M_t$, where P_t is price level (CPI index). For simplicity and without loss of generality, take the case of inelastic labor and denote labor by $L_t = L$;[12] Consider arbitrary individual prices $\bar{p}_t$, a particular case of which is that of fixed prices $\bar{p}_t = \bar{p}$ (but for now we leave it free, the point being precisely that we can do this). An equilibrium (for given $\bar{p}_t$ and exogenous M_t) consists of sequences for the endogenous variables C, N, w, μ, P so that all agents optimize and markets clear, and is fully described by the five equations in Table 1.

Table 1. Model Summary

Variety effect	$\frac{\bar{p}_t}{P_t} = N_t^{\frac{1}{\theta-1}}$
Pricing (labor demand)	$w_t = \frac{1}{\mu_t} N_t^{\frac{1}{\theta-1}}$
Free entry, zero profits	$N_t = \frac{L}{F}\frac{\mu_t - 1}{\mu_t}$
Aggregate accounting	$C_t = w_t L$
Money demand	$M_t = P_t C_t$

Eliminating the price index and the real wage, we obtain:

$$\begin{aligned} C_t &= \frac{L}{\mu_t} N_t^{\frac{1}{\theta-1}} \\ N_t &= \frac{L}{F}\frac{\mu_t - 1}{\mu_t} \\ C_t &= \frac{M_t}{\bar{p}_t} N_t^{\frac{1}{\theta-1}} \end{aligned}$$

To close the model, we need one more equation to determine the individual price.

First, assume *flexible prices*; this delivers the constant-markup rule $\rho_t^* = \frac{\theta}{\theta-1} w_t^*$, i.e. with our notation:

$$\mu_t^* = \frac{\theta}{\theta - 1},$$

giving the flexible-price equilibrium denoted with a star:

$$\begin{aligned} C_t^* &= (\theta - 1)\frac{L}{\theta}\left(\frac{L}{\theta F}\right)^{\frac{1}{\theta-1}}; \; N_t^* = \frac{L}{\theta F}; \\ p_t^* &= M_t \frac{\theta}{\theta - 1}\frac{1}{L}; \; P_t^* = M_t \frac{\theta}{\theta - 1}\frac{1}{L}\left(\frac{L}{\theta F}\right)^{-\frac{1}{\theta-1}}. \end{aligned}$$

[12] This is equivalent to log utility in consumption since $C = wL$: there is no extra income effect. With log-CRRA we would have $L = \chi^{-\frac{1}{1+\varphi}}$ where χ leisure weight and φ inverse elasticity.

As with fixed variety, prices are proportional to money supply and monetary policy is neutral. Notice that in this equilibrium individual labor demand and per-firm output are constant:

$$c_t^* = (\theta - 1) F; \; l_t^* = \theta F.$$

Assume now arbitrary (sticky) prices, we obtain the aggregate equilibrium in closed form as a function of the ratio of money supply to individual price $\frac{M_t}{\bar{p}_t}$:

$$\begin{aligned}
\mu_t &= \bar{p}_t \frac{L}{M_t}; \; N_t = \frac{L - \frac{M_t}{\bar{p}_t}}{F} \\
C_t &= \frac{M_t}{\bar{p}_t} \left(\frac{L - \frac{M_t}{\bar{p}_t}}{F} \right)^{\frac{1}{\theta - 1}}; \; P_t = \bar{p}_t \left(\frac{F}{L - \frac{M_t}{\bar{p}_t}} \right)^{\frac{1}{\theta - 1}}
\end{aligned}$$

while individual variables are:

$$l_t = \frac{L}{L - \frac{M_t}{\bar{p}_t}} F; c_t = \frac{\frac{M_t}{\bar{p}_t}}{L - \frac{M_t}{\bar{p}_t}} F.$$

What are the properties of this equilibrium, in particular what is the effect of a monetary injection? The following proposition is the main result.

Proposition 1 ***Neutrality with sticky prices and free entry****: An increase in money supply has no first-order effect on the aggregate real allocation regardless of firms' ability to reset their prices.*

To prove this, take a first-order Taylor expansion of total consumption around the point where $\mu_t = \mu_t^* = \frac{\theta}{\theta - 1}$, implying $\bar{p} \frac{L}{M} = \frac{\theta}{\theta - 1}$ and $\frac{1}{F} \left(L - \frac{M}{\bar{p}} \right) = \frac{L}{\theta F}$ (in a dynamic version of the model, this will be the steady state):

$$\begin{aligned}
C_t &\simeq C^* + \frac{1}{\bar{p}} \left(\frac{L - \frac{M}{\bar{p}}}{F} \right)^{\frac{1}{\theta - 1}} (M_t - M - \bar{p}_t + \bar{p}) - \frac{1}{\theta - 1} \frac{M}{\bar{p}} \frac{1}{\bar{p} F} \left(\frac{L - \frac{M}{\bar{p}}}{F} \right)^{\frac{1}{\theta - 1} - 1} (M_t - M - \bar{p}_t + \bar{p}) \\
&\rightarrow C \simeq C^*
\end{aligned}$$

To first order, aggregate consumption and the real wage are invariant to changes in the money supply, and to changes in individual prices. Monetary policy is neutral, and the ability of individual firms to reset prices irrelevant.

The intuition is that free entry provides another margin for adjustment, thus inducing flexibility in the aggregate price level, even when individual prices are fixed. Furthermore, with Dixit-Stiglitz this entry is efficient: the flexible-price level is the utility-maximizing level of consumption. When money supply or individual prices change, markups and the number of firms change endogenously in order to keep consumption at the maximum level. Denoting with a hat percentage deviations:

$$\begin{aligned}\hat{\mu}_t &= \hat{p}_t - \hat{M}_t \\ \hat{N}_t &= (\theta - 1)\left(\hat{p}_t - \hat{M}_t\right).\end{aligned}$$

The general point is seen more clearly by log-linearizing the pricing (labor demand) and free entry conditions in Table 2 (around the flex-price steady-state as above):

$$\begin{aligned}\hat{w}_t &= \frac{1}{\theta - 1}\hat{N}_t - \hat{\mu}_t, \\ \hat{N}_t &= \hat{L}_t + (\theta - 1)\,\hat{\mu}_t.\end{aligned}$$

To obtain labor demand, we combine the two by eliminating $\hat{N}_t$; but when doing so, $\hat{\mu}_t$ *also disappears (*!), delivering:

$$\hat{w}_t = \frac{1}{\theta - 1}\hat{L}_t.$$

Thus, labor demand *does not shift* with the markup; this point is general and holds in any free-entry model of sticky prices with DS preferences that implies a relationship between markups and inflation (such as the one in Appendix A). The intuition is as follows. An increase in demand does bring about an increase in labor demand, just as in the fixed-variety model, because prices are sticky. Aggregate labor demand and production need to expand, and there are generally three margins for this: price adjustment, individual production (intensive), and entry (extensive). We turned off the first by assuming that prices are fixed, or exogenous. The relative adjustment borne by second and third depends on love for variety vs. markup, and a knife-edge case occurs when the two effects are precisely balanced, i.e. for CES Dixit-Stiglitz preferences: there is no effect on labor demand, for the market provides exactly the entry incentives needed, given by the benefit of an extra variety which is measured by $d \ln \rho / d \ln N$ (the elasticity of the relative price to the number of varieties).

Monetary policy becomes irrelevant for determining the real allocation: a version of classical dichotomy, or monetary neutrality holds. What *does* change? The markup will adjust, as will the number of firms and the quantity produced and labor employed by each. In particular, we evidently have:

$$\hat{\mu}_t = \frac{1}{\theta - 1}\hat{N}_t.$$

In response to an increase in aggregate demand markups fall and each firm faces higher demand; there is exit, and each surviving firm employs more labor to supply the higher per-firm demand.[13]

$$\begin{aligned}\hat{l}_t &= (\theta - 1)\left(\hat{M}_t - \hat{p}_t\right);\\ \hat{c}_t &= \theta\left(\hat{M}_t - \hat{p}_t\right).\end{aligned}$$

One caveat to the neutrality result is that while aggregate output and employment do not change, endogenous variety implies that the *composition* of the aggregate changes as the number of varieties adjusts: the intensive and extensive margins both change, but they do so in offsetting ways.

4 When Neutrality Fails: Sub-Optimal Variety and Entry Frictions

Two assumptions are key to achieve our neutrality proposition. The first pertains to variety: preferences are CES Dixit-Stiglitz; the second is about entry, which is frictionless up to the point where profits are zero.[14] We now briefly discuss relaxing these assumptions for the mere purpose of understanding how neutrality breaks down.

First, to illustrate the role of the Dixit-Stiglitz knife-edge case in delivering our neutrality result, consider a different CES utility function used for the first time in a working paper version of Dixit and Stiglitz (1975) (reprinted in Brakman and Heijdra, 2001).[15] Aggregate consumption is $C_t = (N_t)^{\epsilon - \frac{1}{\theta-1}}\left(\int_0^{N_t} c_t(z)^{\theta-1/\theta}\, dz\right)^{\theta/(\theta-1)}$, and the welfare-based price index $P_t = N_t^{\frac{1}{\theta-1}-\epsilon}\left(\int_0^{N_t} p_t(z)^{1-\theta}\, dz\right)^{1/(1-\theta)}$, where ϵ parameterizes love for variety. In particular, we now have $\rho_t = N_t^{\epsilon}$ with $\epsilon \lesseqgtr (\theta-1)^{-1}$: the benefit of an extra variety to the consumer is not necessarily aligned with the entrants' incentive to provide that variety, captured by the net markup.

The equilibrium conditions are the same as above, with the exponent $\frac{1}{\theta-1}$ replaced by ϵ throughout. To gauge the effect of this on equilibrium, consider the loglinear approximation of labor demand (pricing) in this case:

$$\hat{w}_t = \epsilon\hat{N}_t - \hat{\mu}_t,$$

[13] The last approximation uses $\frac{l}{c} = \mu = 1 + \frac{F}{c}$.

[14] A related assumption is that firms are identical; neutrality can break down if firms are heterogeneous as in e.g. Melitz (2003). Monetary policy could affect the real allocation by inducing selection, and thus changing average productivity—we leave this to future research.

[15] This utility function has been used widely in order to parameterize the love for variety separately: i.a. Benassy (1996), Blanchard and Giavazzi (2007), Bilbiie, Ghironi, and Melitz (2016).

which combined with the same free entry condition as above (the benefit of variety does not matter for that equation) delivers

$$\hat{w}_t = \epsilon \hat{L}_t - (1 - \epsilon (\theta - 1)) \hat{\mu}_t.$$

When love for variety exceeds the steady-state markup, $1 - \epsilon (\theta - 1) < 0$, and an increase in markup (a *fall* in inflation) leads to an *increase* in labor demand! That is because more markup means more incentives for entry, on the one hand, and more variety, on the other. But since the market does not provide enough incentives for entry, compared to what the consumer demands, the suboptimal number of producers have to expand their labor demand.

Consider a temporary demand increase through a monetary expansion: aggregate labor demand/production needs to expand, and this can be achieved, as before, through three margins: entry, price adjustment, and individual production—the relative adjustment of which now depends on how the love for variety compares to the markup.

When love for variety is high ($\epsilon > 1/ (\theta - 1)$) the extensive margin adjustment dominates: there is entry, and an increase in markup (fall in individual labor demand), which with sticky rather than fixed prices also implies deflation. Entry makes it relatively easier to satisfy consumer demand, so individual demand for these products has fallen: firms cut prices, generating deflation and an increase in markup. A Phillips curve written in terms of output swivels (its slope changes sign). In equilibrium, total consumption is:

$$\hat{C}_t = (1 - \epsilon (\theta - 1)) \left(\hat{M}_t - \hat{p}_t \right),$$

so by the same token monetary expansions are in fact contractionary—even though they lead to entry.

When love for variety is low, $\epsilon < 1/ (\theta - 1)$, it is the intensive margin that dominates: there is exit, and a decrease in markup (an expansion in individual labor demand). If prices can adjust, this leads to inflation—a more standard case with upward-sloping Phillips curve.

We see once again the knife-edge case occurring when the two effects are precisely balanced, i.e. for CES Dixit-Stiglitz preferences: there is no effect on labor demand, since the market provides exactly enough entry incentives, and monetary policy becomes irrelevant for determining the real allocation.

Another intuitive way to break neutrality in this model is to introduce an entry friction: for instance, if entry is subject to a sunk cost instead of a fixed cost. Equilibrium entry then takes place until the value of the firm, which is equal to discounted future profits, covers this sunk cost at the given suboptimal price.[16] Thus, firms internalize price stickiness in

[16] This is the setup used by i.a. Bilbiie, Ghironi and Melitz (2007) and Bilbiie, Ghironi and Fujiwara

their "sticky" entry decision. I outline this model in detail in Appendix B and show that neutrality indeed breaks down because varieties do not expand until profits are zero: sunk costs limit entry, thus generating positive profits in equilibrium. A monetary expansion triggers an increase in demand today, and thus an increase in consumption and output; but as before, it also leads to exit (by the same mechanism as before: the increase in demand leads to an increase in marginal cost, a decrease in profits, and firms exit) which reduces *future* consumption. Whether this is an empirically plausible breakup of neutrality remains an empirical question.[17]

5 Conclusions

In a standard NK framework with sticky prices, the neutrality of monetary policy is restored if free entry of new varieties is allowed so that firms make zero profits. The result depends on free entry providing the optimal number of varieties (in contrast to the case where the number of varieties are exogenously fixed). It is worth recalling that the optimally-determined entry margin considered here is in fact one of the defining features of the classic, workhorse framework used in the vast majority of studies on monetary policy cited above: the classic Dixit-Stiglitz framework.[18] Thus, this paper points to one stark implication of (*re*)considering endogenous entry and variety in the NK model: that entry moves the model towards neutrality, with the Dixit-Stiglitz free-entry limit in which neutrality holds, just as in the frictionless competitive model.

It should be obvious to the reader, but the author feels nevertheless compelled to state it: I do not take this limit to be a literal description of how the world works. But I do believe that NK models could do more in the realm of including entry and variety in order to study first-order issues such as the optimal design and the interdependence of monetary policy and structural reforms and markets deregulation, or in environments featuring innovation-driven growth, or its interaction with trade policies. All these topics are customarily analyzed using models with entry and expanding variety, and this paper points out that monetary policy faces new challenges and tradeoffs in that class of models.

(2014). Blanchard and Kiyotaki (1987) already considered in Section IV a version of their model with entry, but the number of firms is nevertheless fixed in short run; this leads to a breakup of neutrality for reasons similar to the ones emphasized here (entry is subject to a friction).

[17] See Lewis and Poilly (2012) for an empirical exploration of such issues.

[18] Entry and optimal variety are such an integral part of Dixit-Stiglitz that they constitute, in fact, the very title of the paper. It is worth mentioning that the paper has more than 10.000 citations (and likely many more references without), many of which come from models of monetary policy.

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Appendix: For Online Publication

A Sticky prices and Taylor rule: a dynamic NK model

We now sketch a more familiar-looking NK model with a Phillips curve and Taylor rule. Consider an equation linking PPI inflation (in firms' individual prices) and markup, resulting from price adjustment costs à la Rotemberg (1982); for simplicity, assume that firms optimize only for one period—this preserves the output-inflation trade-off while simplifying the algebra, namely we have:

$$\pi_t = -\psi \mu_t,$$

where ψ is an index of price stickiness; the equation could also come from a setup with a fraction of firms keeping prices fixed, and a fraction resetting every period without recognizing the impact on future demand—a limit case of Calvo (1983)-Yun (1996). The derivation of aggregate labor demand in text still holds, in particular there is still the same neutrality same neutrality and we have $\pi_t = -\psi \frac{1}{\theta-1} \hat{N}_t$

On the demand side we now introduce a portfolio decision, the result of which is a loglinearized Euler equation; recognizing that to first-order consumption is as under flexible prices (this can be shown easily) we have:

$$-\gamma \hat{C}_t^* = -\gamma E_t \hat{C}_{t+1}^* + i_t - E_t \pi_{t+1}^C$$

where π_t^C is CPI inflation, the growth rate of the welfare price index, which is related to PPI inflation through:

$$\pi_t = \pi_t^C + \frac{1}{\theta - 1} \left(\hat{N}_t - \hat{N}_{t-1} \right)$$

The model is closed with a Taylor rule, as usual

$$i_t = \phi \pi_t - \epsilon_t$$

Replacing, we have

$$-\phi\psi \frac{1}{\theta - 1} \hat{N}_t - \epsilon_t = -\psi \frac{1}{\theta - 1} E_t \hat{N}_{t+1} - \frac{1}{\theta - 1} \left(E_t \hat{N}_{t+1} - \hat{N}_t \right)$$

one equation

$$\hat{N}_t = \frac{\psi + 1}{\phi\psi + 1} E_t \hat{N}_{t+1} - \frac{\theta - 1}{\phi\psi + 1} \epsilon_t$$

As in the standard NK model, the Taylor principle $\phi > 1$ insures unique equilibrium. An interest rate cut still triggers exit, as with a money rule—the more so, the lower the response to inflation.

B Sunk entry cost

When entry itself is subject to a friction, neutrality breaks down. We illustrate this by analyzing briefly a model where entry is subject to a sunk cost and new entrants only start producing after one period (as in e.g. Bilbiie Ghironi and Melitz, 2007, 2012, 2016 and Bilbiie Fujiwara and Ghironi, 2014)—we refer the interested reader to those papers a detailed outline of the economic environment and equilibrium.

The number of produced goods/firms N_t now evolves according to $N_{t+1} = (1-\delta) N_t + N_{E,t}$ where $N_{E,t}$ are new entrants and δ an exit, "death" shock hitting only incumbents. The budget constraint of household, imposing that in equilibrium they hold all firm shares, is:

$$C_t + N_{E,t} v_t = w_t L_t + N_t d_t.$$

The Euler equation with log utility is

$$v_t = \beta E_t \left\{ \left(\frac{C_t}{C_{t+1}} \right) \left[(1-\delta) v_{t+1} + d_{t+1} \right] \right\},$$

which iterated forward gives the value of a firm as a function of discounted future profits. As before we omit the standard transversality condition.

Entrants have to pay a cost of f_E labor units to produce, which upon entering they start doing after one period. Entry now occurs up to the point where the value of the firm equals the sunk cost:

$$v_t = f_E w_t$$

The benefit of variety is, as before, $\rho_t \equiv \frac{\bar{p}_t}{P_t} = N_t^{\frac{1}{\theta-1}}$ with the individual price arbitrary as in the benchmark free-entry model. Any price-setting scheme can be summarized by the markup rule $\frac{\bar{p}_t}{P_t} = \mu_t w_t$, where $\bar{p}_t$ is determined by such price-setting scheme; we assume here that it is exogenous and arbitrary. Profits per firm are not zero any longer: indeed, they are:

$$d_t = \frac{\bar{p}_t}{P_t} c_t - w_t l_t = \left(1 - \frac{1}{\mu_t}\right) \frac{C_t}{N_t}.$$

Finally, as in the main text we focus on a simple model of aggregate demand: quantity theory $P_t C_t = M_t$.

An equilibrium consists of sequences for the endogenous variables C, N_E, v, N, d, w, p, P

such as all agents optimize and markets clear, and is fully described by the eight equations outlined above.

A more complicated version of this model is analyzed numerically in the papers cited at the outset. Here, we provide an analytical solution in a simple limit case: that where all firms are replaced every period, that is the full-depreciation limit $\delta \rightarrow 1$. We will see that even in this case, neutrality fails: money injections have effects on the real allocation. Replacing the firm dynamics equation, the free-entry and the pricing conditions into the aggregate resource constraint we obtain:

$$C_t = \rho_t \left(L - f_E N_{t+1}\right),$$

while the Euler equation simplifies to: $v_t C_{t+1} = \beta d_{t+1} C_t$.Replace to obtain $f_E \rho_t N_{t+1} = \beta \frac{\mu_t}{\mu_{t+1}} \left(\mu_{t+1} - 1\right) C_t$ and finally the equilibrium:

$$\begin{aligned} N_{t+1} &= \frac{\beta \left(\mu_{t+1} - 1\right)}{\frac{\mu_{t+1}}{\mu_t} + \beta \left(\mu_{t+1} - 1\right)} \frac{L}{f_E} \\ C_t &= \left(N_t\right)^{\frac{1}{\theta-1}} \frac{\frac{\mu_{t+1}}{\mu_t}}{\frac{\mu_{t+1}}{\mu_t} + \beta \left(\mu_{t+1} - 1\right)} L \end{aligned}$$

The quantity equation implies $\frac{P_t}{\bar{p}_t} C_t = \frac{M_t}{\bar{p}_t}$ which using the expression for consumption derived above gives:

$$\frac{L\bar{p}_t}{M_t} - 1 = \beta \mu_t \left(1 - \frac{1}{\mu_{t+1}}\right) \tag{5}$$

Loglinearize around $\mu = \theta / \left(\theta - 1\right)$ and$\frac{L\bar{p}}{M} = 1 + \frac{\beta}{\theta-1}$:

$$\hat{\mu}_t = \left(\beta^{-1} \left(\theta - 1\right) + 1\right) \hat{M}_t - \left(\theta - 1\right) \hat{\mu}_{t+1}$$

The number of firms, using (5) is: $N_{t+1} = \left(1 - \frac{M_t}{L\bar{p}_t}\right) \frac{L}{f_E}$ or, loglinearized:

$$\hat{N}_{t+1} = -\left(\theta - 1\right) \beta^{-1} \hat{M}_t.$$

Finally, consumption is:

$$\hat{C}_t = \frac{1}{\theta - 1} \hat{N}_t + \hat{M}_t = \hat{M}_t - \beta^{-1} \hat{M}_{t-1}.$$

A monetary expansion triggers an increase in demand today; but as before, it also leads to exit (by the same mechanism: increase in demand, increase in marginal cost, profits go down, firms exit) which –because of the time-to-build lag—reduces consumption tomorrow more than one-to-one. Notice two features: with no discounting, when $\beta \to 1$ the steady-state of the model converges to that of the free-entry model. Intuitively, since agents are indifferent to time (recall that in addition $\delta \to 1$ too) whether the cost is sunk of per-period becomes irrelevant. The second implication is that in the same no-discounting case a *permanent* increase in money supply is neutral. Finally, notice that if in addition there were no time-to-build lag ($N_t = N_{E,t}$) we recover the free-entry model.