A Nominal Demand-Augmented Phillips Curve: Theory and Evidence

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Abstract

I show that state-dependent menu cost pricing models give rise to a nominal demand-augmented Phillips curve (NDPC), which adds nominal demand as a second determinant to a standard New Keynesian Phillips curves (NKPC). According to the NDPC, inflation increases if either real marginal costs (gaps) increase [moving along the NKPC] or if nominal demand increases [shifting the NKPC]. A large increase in inflation can thus be consistent with negligible movements in the unemployment rate if the nominal demand impulse is sufficiently strong to induce a large shift of the Phillips curve. From an empirical NKPC perspective, nominal demand maps into endogenous cost-push shocks, but does not imply a non-linear Phillips curve.

I estimate the NDPC using cross-sectional data for U.S. states. Consistent with the theory, my estimates confirm that both nominal demand and marginal costs are significant determinants of inflation. In contrast to a large body of time series literature, the dependence of inflation on its past values is small and insignificant.

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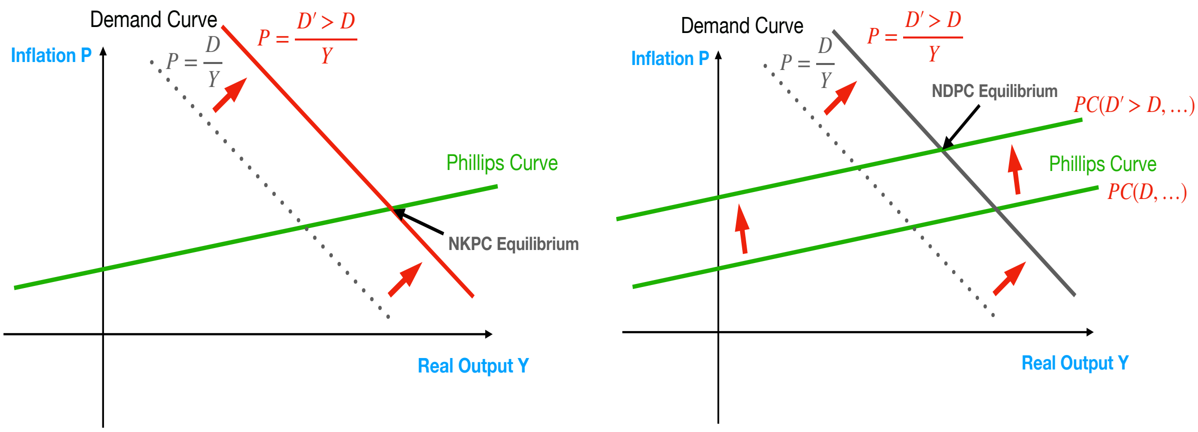
1 Introduction

The New Keynesian Phillips curve (NKPC) is a key building block for understanding inflation within New Keynesian models. The NKPC explains inflation through one determinant, real marginal costs (gaps), typically measured through output or unemployment (gaps). According to the NKPC, inflation increases if and only if the output gap increases. And vice versa, inflation falls if and only if the output gap decreases. The inflationary effects of a positive demand stimulus are described through a shift of the demand curve along the Phillips curve, shown in the left panel of Figure 1. If the Phillips curve is flat, the stimulus mainly leads to an increase in output and a decrease in unemployment, while the inflation rate moves only marginally. If, on the other hand, the Phillips curve is steep, we observe a larger increase in inflation and only a small change in output and in unemployment. Unsurprisingly, the slope of the Phillips curve is a key factor for understanding the comovement of inflation, output and unemployment.

Indeed, a flat Phillips curve can account very well for the co-movement of inflation, output and unemployment during the 1990s and 2000s. In particular there is no missing reinflation and missing disinflation during this period (Hazell et al., 2021) (henceforth HHNS). These authors find the Phillips curve to be quite flat, explaining why the large observed swings in unemployment are consistent with the small observed movements in the inflation rate.

This success however, masks a dilemma. Whereas a flat Phillips curve is needed to account for the missing reinflation in the late 2010s and the missing disinflation during and after the Great Recession, periods with high inflation, such as the late 1960s, the 1970s, the early 1980s and 2021/2 would require a steep Phillips curve. A unified explanation of the full US inflation history thus seems to be a challenge. Potential explanations, such as a nonlinear Phillips curve, which rely on large changes in the slope over time, have to confront the conflicting evidence in HHNS. These authors only find a small decrease in the slope of the Phillips curve at least since the 1980s. The challenge exists independently of supply or demand shocks driving the economy, simply because large and small movements in inflation require different slopes of the Phillips curve.

I show that state-dependent pricing models break this tight link between inflation and real marginal costs. These models give rise to a nominal demand-augmented Phillips curve (NDPC), which adds nominal demand growth as an additional explanatory variable to the standard New Keynesian Phillips curve (NKPC). An observed increase in inflation is



(a) NKPC: Only Demand curve shifts (b) NKPC: Both Demand and Phillips curves shift

Figure 1: Nominal Demand shift $D' > D$: NKPC and NDPC

Note - D: Nominal Demand; Y: Real Output; P: Price Level (=Inflation for $P_{-1} = 1$);
Panel (a): Nominal demand increase from D to D' shifts the demand curve $P = D/Y$ along the Phillips curve. The NKPC equilibrium is located on the (non-shifted) Phillips curve.
Panel (b): Nominal demand increase from D to D' shifts the demand curve $P = D/Y$ rightwards *and* the Phillips curve upwards. The NDPC equilibrium is located at the intersection of the shifted demand and the shifted Phillips curve.

then explained through higher real marginal costs and/or higher nominal demand growth. A fiscal stimulus shifts the demand curve along the Phillips curve as in the NKPC. In addition, the increase in demand shifts the Phillips curve such that the inflation response combines the shifts of the demand curve *and* of the Phillips curve, as the right panel of Figure 1 illustrates. The NDPC can therefore explain large increases in inflation in spite of a flat NKPC, simply through an expansion of nominal demand growth and the resulting shift of the NKPC.

Real marginal cost is the only determinant in the NKPC, which operates through the size of price changes (intensive margin; moving along the NKPC) without changing their frequency (extensive margin; shifting the NKPC). An increase in real marginal costs leads to larger price adjustments, but does not change the number or identity of price-adjusting firms. The NDPC adds an extensive margin to the NKPC, which describes how an increase in nominal demand triggers more frequent price adjustments and leads to higher inflation. Alvarez et al. (2019) provide supporting evidence for the importance of the extensive margin, using Argentinian data for both low and high inflation rate episodes. They find that “aggregate inflation changes are mostly driven by changes in the frequency of price increases and decreases, as opposed to the size of price changes.”

The literature since Golosov and Lucas (2007), has focused on how state-dependent and time-dependent pricing affects the slope of the New Keynesian Phillips curve, but has neglected the implications for specifying the Phillips curve. An exception is Caballero and Engel (2007), who show that switching from time-dependent to state-dependent pricing adds nominal demand as a shifter to the Phillips curve. Neglecting the nominal demand term thus leads to a misspecification of the Phillips curve through omitting a variable. Caballero and Engel (1993, 2007) also illustrate that the severity of the omitted variable problem depends on several important modeling assumptions. Is the economy in a steady state? How fat are the tails of the price (gap) distribution? Is this distribution continuous or does it feature mass points? How persistent are demand growth shocks? Whereas these assumptions are critical for the properties of the Phillips curve, they are hard to verify in the data, rendering theoretical results hard to interpret. I therefore move to an empirical analysis of the NDPC, which does not invoke these strong assumptions.

The empirical results corroborate the specification of the NDPC with two determinants of inflation, using U.S. cross-sectional data and building on recent work of HHNS. My empirical implementation uses the U.S. state-level consumer price indices constructed by HHNS, and the Bartik-type instrument developed in HHNS.[1] I conduct panel data regressions with time fixed effects to absorb aggregate effects including long-run inflation expectations and U.S. monetary policies, such as setting nominal interest rates or targeting U.S. nominal GDP.[2]

But instead of estimating the NKPC as in HHNS, I estimate the NDPC. The NDPC features nominal demand as a determinant of inflation, but for a clean identification, I use nominal fiscal transfers instead of nominal demand. The theoretical model establishes in two steps, the required causal link between fiscal transfer payments, nominal demand and inflation. First, incomplete markets break Ricardian equivalence, such that nominal fiscal transfers affect nominal and real aggregate equilibrium demand even if prices are flexible (Hagedorn, 2016). Second, state-dependent pricing models imply a nominal demand-augmented Phillips curve, where both real marginal cost and nominal demand are determinants of the inflation rate. The incomplete markets model with state-dependent pricing thus implies that estimating the NDPC requires adding state-level transfer payments to an otherwise standard NKPC. The theory also shows that the inflationary effect of transfer payments depends on the magnitude of the induced demand increase. This effect

[1] Other work using regional pricing data include Fitzgerald et al. (2014), McLeay and Tenreyro (2020) and Hooper et al. (2019). Beraja et al. (2019) use regional wage instead of inflation data.

[2] See Fitzgerald et al. (2014) and McLeay and Tenreyro (2020) among others, for the benefits of using regional data in order to understand inflation.

is higher the more transfers are targeted to households with high marginal propensities to consume. Sending checks to low-income households has larger effects on demand and thus on inflation, than for example a capital income tax cut. The transfers used in the empirical analysis thus include unemployment insurance benefits and other income maintenance program payments targeted to groups of known high marginal propensities to consume. Other transfers with low marginal propensities to consume are theoretically unable to statistically distinguish the NDPC from the NKPC. The empirical analysis combines this causal link between inflation and nominal demand with an identification strategy to estimate the NDPC.

The theoretical analysis shows that the NKPC and NDPC are not equivalent, since nominal demand is a non-redundant determinant of inflation. The empirical analysis adds the quantitative importance of nominal demand as a determinant of regional inflation rates. The empirical analysis also confirms further theoretical predictions: Nominal demand cannot be replaced with real demand in the NDPC; nominal demand is not a proxy for real marginal costs or lagged inflation rates; and the estimated coefficient on marginal costs is biased if nominal demand is not included in the regression.[3] From an empirical NKPC perspective, nominal demand is an omitted variable, and movements in nominal demand would be interpreted as cost-push shocks. Viewed through this lens, the large transfers sent out by the U.S. government in response to the Covid-19 disruptions would map into the cost-push shocks identified as the main driver of the 2021/22 inflation in Del Negro et al. (2022).[4]

I also find that adding a lagged inflation term to the NDPC yields a small and insignificant coefficient for past inflation rates. In contrast, results based on aggregate U.S. time series data typically reveal a sizeable and significant role for lagged inflation rates in the NKPC (e.g. Gali et al., 2005, and further references therein). Within New Keynesian models, this result is interpreted as evidence of explicit price indexation to past inflation rates. My findings support an alternative interpretation in which inflation is indirectly linked to past inflation rates through nominal demand. On the hand, nominal demand is linked to past inflation rates, e.g. because Social Security payments are inflation indexed. On the other hand, nominal demand determines the current inflation rate according to the NDPC.

[3]It is important to note that the empirical analysis confirms predictions of the state-dependent pricing model, but is not a complete test of the model or its underlying assumptions.

[4]Theories of cost-push shocks are offered by Rubbo (2020), who shows that a multi-sector model generates endogenous cost-push shocks, and Stroebel and Vavra (2019) who find that markups, which rise with house prices, are a potential micro-foundation of cost-push shocks.

A higher past inflation rate then leads to higher nominal demand, which in turn induces higher current inflation. Inflation is thus persistent because its determinants are persistent and not because of explicit price indexation.

Section 2 presents a selective review of the literature on state-dependent pricing focusing on the implications for the Phillips curve and derives the nominal demand-augmented Phillips curve. The literature survey complements the insights of Caballero and Engel (1993, 2007) on the importance of several modeling assumptions. As an extreme case, the strong assumptions in Gertler and Leahy (2008) ensure that their state-dependent pricing model can be mapped into a standard New Keynesian Phillips curve. As another extreme case, inflation and real marginal costs are fully disconnected in the Caplin and Spulber (1987) state-dependent pricing model, due to their assumptions ensuring monetary neutrality. The assumptions in most other contributions are located between the two extremes, but are typically closer to the NKPC than to the Caplin and Spulber (1987) world (e.g. Golosov and Lucas, 2007; Midrigan, 2011; Auclert et al., 2022). Hagedorn et al. (2022) use a menu costs model with idiosyncratic productivity shocks and stochastic menu costs and follow the calibration strategy in Midrigan (2011). Their model simulations confirm my empirical findings. First, nominal demand growth shifts the Phillips curve. Second, the model generates inflation persistence, i.e. inflation depends on its own lagged value. Third, the estimated coefficient on the lagged value of inflation is small when nominal demand growth is added to the regression.[5] Further corroborating model evidence is provided by Blanco et al. (2022), who show that inflation is strongly non-linear in nominal demand growth in their menu cost model, questioning the use of linear methods to study inflation dynamics.

The regional incomplete markets model with state-dependent pricing laid out in Section 3 yields the regional Phillips curve with nominal demand. Section 4 uses the regional Phillips curve to derive the empirical specification, describes the data, depicts the relationship between nominal demand and inflation and explains the identifying approach. Section 5 presents the empirical results and Section 6 concludes.

[5] In Hagedorn et al. (2022), in contrast to Auclert et al. (2022), firms optimize the full non-linear price setting problem and nominal demand growth is autocorrelated as observed in the data.

2 Inflation, Nominal Demand, and the Phillips Curve

The aim of this Section is to clarify the role of nominal demand as an additional determinant of the inflation rate in line with the empirical findings in Section 5. To this end, I derive a nominal demand-augmented Phillips curve (NDPC) which shows that marginal costs and nominal demand jointly determine the inflation rate.

The New Keynesian Phillips curve (NKPC) explains inflation through marginal cost and inflation expectations. Section 2.2 presents examples motivated by findings from the literature on state-dependent pricing, to show why the NKPC needs to be augmented with a nominal demand component. These examples show that real marginal costs and inflation can be negatively related in state-dependent pricing models, whereas they are positively related in Calvo models. The examples also illustrate the role of nominal demand as a determinant of inflation, and that nominal demand cannot be replaced with real demand. From an empirical perspective, state-dependent pricing models could induce an omitted variable bias for standard Phillips curves which do not include a nominal demand term, implying a bias or the wrong sign for the coefficient on marginal costs. These arguments also suggest that nominal demand resembles a cost-push shock, and I explain in Section 5 under which conditions this is the case. Before turning to the examples in Section 2.2 and the derivation of the nominal demand augmented Phillips curve (NDPC) in Section 2.3, I first present the state-dependent pricing model in Section 2.1.

2.1 Price Setting Model

2.1.1 Demand

Period t aggregate household nominal demand is D_t, which in this Section is taken as given. The full model in Section 3 integrates (Hazell et al., 2021) (henceforth HHNS), Bilbiie (2008, 2017, 2019), nominal fiscal policy and state-dependent pricing so that nominal demand is a meaningful and endogenous function. Households consume differentiated goods $c_t(i)$ at a price $p_t(i)$ indexed by $i \in [0, 1]$. I assume that the composite consumption C_t is a Dixit-Stiglitz aggregator of these differentiated goods with $\epsilon > 1$,

$$C_t = \left[\int_0^1 c_t(i)^{\frac{\epsilon-1}{\epsilon}} \right]^{\frac{\epsilon}{\epsilon-1}}.$$

Each period, the household chooses $c_t(i)$ to maximize C_t, taking aggregate spending

$$D_t = \int_0^1 p_t(i)c_t(i)di$$

as given. This requires that household demand for each good i be

$$c_t(i) = \Big(\frac{p_t(i)}{P_t}\Big)^{-\epsilon}\frac{D_t}{P_t},$$

where

$$P_t = \Big[\int_0^1 p_t(i)^{1-\epsilon}\Big]^{\frac{1}{1-\epsilon}} \tag{1}$$

is the price index and total nominal expenditures satisfies

$$D_t = P_tC_t = \int_0^1 p_t(i)c_t(i)di,$$

2.1.2 Firms

There is a measure-one continuum of firms, indexed by $i \in [0,1]$, producing differentiated goods. A firm i $[0,1]$ with price $p_t(i)$ faces demand

$$y(p_t(i), P_t, D_t) := \Big(\frac{p_t(i)}{P_t}\Big)^{-\epsilon}\frac{D_t}{P_t}$$

The nominal cost of producing $y_t(i)$ units of real output is

$$P_tmc(\frac{D_t}{P_t})y_t(i),$$

where $mc_t = mc(\frac{D_t}{P_t})$ is real marginal costs, which depend only on real aggregate demand D_t/P_t and are thus common to all firms.[6] To focus on aggregate demand, idiosyncratic and aggregate productivity shocks are absent, and changes in aggregate demand is the only driver of price-adjustment decisions.

Firms have to hire y units of labor in the labor market (or other inputs). The aggregate supply curve for this input good leads to a cost function $C(Y)$ where Y is aggregate real

[6] This holds in the full model, since real marginal cost equals the real wage $w(Y_t)$ derived from household preferences, and all firms use the identical linear (in labor N) production function $y_t = N_t$. If the production function was $y_t = ZN_t$ for a constant-technology parameter Z, then marginal costs would be $mc(Y_t) = w(Y_t/Z)/Z$.

output. The Period t nominal profit of firm i with price p_t equals

$$\Gamma(p_t, P_t, D_t) := p_t y(p_t, P_t, D_t) - P_t mc(\frac{D_t}{P_t}) y(p_t, P_t, D_t).$$

2.1.3 Price Setting

Each firm inherits a price $p_{t-1}(i)$ from the previous period, but can pay an adjustment cost ξ to set a new price. The idiosyncratic adjustment cost ξ is i.i.d. and drawn from the distribution Υ, where $\Upsilon(x) = Prob(\xi \leq x)$ is the probability that ξ is less or equal to x.[7] The firm's pricing problem can be written recursively. Let $\bar{V}^f(p_t, P_t, D_t)$ be the Period t value function after price adjustment, and $V^f(p_{t-1}, P_t, D_t)$ be the Period t value function before price adjustment. Then $\bar{V}^f$ is equal to current profits plus the expected discounted future profit stream captured through V^f:

$$\bar{V}^f(p_t, P_t, D_t) = \Gamma(p_t, P_t, D_t) + \beta E_t V^f(p_t, P_{t+1}, D_{t+1}). \tag{2}$$

A firm's optimal Period t price p_t^* maximizes $\bar{V}^f$,

$$p_t^* = \operatorname*{argmax}_p \bar{V}^f(p, P_t, D_t). \tag{3}$$

The price adjustment decision then amounts to comparing the value at the optimal price minus adjustment costs with the value at the inherited price without adjustment costs:

$$V^f(p_{t-1}, P_t, D_t) = \max\{\bar{V}^f(p_t^*, P_t, D_t) - P_t\xi, \bar{V}^f(p_{t-1}, P_t, D_t)\}. \tag{4}$$

If $\bar{V}^f(p_t^*, P_t, D_t) - P_t\xi \geq \bar{V}^f(p_{t-1}, P_t, D_t)$ then the firm pays the adjustment cost ξ and $p_t = p_t^*$. If not, the price is unchanged, $p_t = p_{t-1}$.

If prices were flexible, firms would follow the standard pricing rule

$$p_t^* = \mathcal{M} \ P_t \ mc_t(\frac{D_t}{P_t})$$

with a mark-up $\mathcal{M} = \frac{\epsilon}{\epsilon - 1}$. I normalize $mc_t(1) = \frac{1}{\mathcal{M}}$ so that $p_t^* = P_t$ in a steady state with $P_t = D_t$.

[7] The distribution Υ is not necessarily continuous and is allowed to have mass points.

2.1.4 Price Dynamics

The gross inflation rate is defined as $\Pi_t = \frac{P_t}{P_{t-1}}$ so that using the definition of the price index in equation (1) yields

$$\Pi_t^{1-\epsilon} = \frac{P_t^{1-\epsilon}}{P_{t-1}^{1-\epsilon}} = \frac{\left[\int_0^1 p_t(i)^{1-\epsilon} di\right]}{\left[\int_0^1 p_{t-1}(i)^{1-\epsilon} di\right]}.$$

Following Caballero and Engel (2007), define $\Lambda_t(p_{t-1}(i), P_t, D_t)$ as firm $i's$ Period t probability of adjusting its price $p_{t-1}(i)$ prior to knowing its fixed adjustment cost ξ. The aggregate price dynamics is then described by

$$\Pi_t^{1-\epsilon} - 1 = \frac{P_t^{1-\epsilon} - P_{t-1}^{1-\epsilon}}{P_{t-1}^{1-\epsilon}} \tag{5}$$

$$= \frac{\left[\int_0^1 p_t^*(i)^{1-\epsilon}\Lambda(p_{t-1}(i), P_t, D_t) + p_{t-1}(i)^{1-\epsilon}(1 - \Lambda(p_{t-1}(i), P_t, D_t))di\right] - \int_0^1 p_{t-1}(i)^{1-\epsilon} di}{P_{t-1}^{1-\epsilon}}$$

$$= \frac{\left[\int_0^1 [p_t^*(i)^{1-\epsilon} - p_{t-1}(i)^{1-\epsilon}]\Lambda(p_{t-1}(i), P_t, D_t)di\right.}{P_{t-1}^{1-\epsilon}}$$

$$= \int_0^1 [\left(\frac{p_t^*(i)}{P_{t-1}}\right)^{1-\epsilon} - \left(\frac{p_{t-1}(i)}{P_{t-1}}\right)^{1-\epsilon}]\Lambda(p_{t-1}(i), P_t, D_t)di.$$

In contrast to Caballero and Engel (2007), I integrate over firms as in Galí (2015) and not over price gaps, allowing me to write the integral without using a density for price gaps.

2.2 Selective Literature Review

This section provides a selective literature review with a focus on the implications of state-dependent pricing for the Phillips curve and the role of nominal demand. In particular, I argue that, whereas real marginal costs are sufficient to determine the inflation rate in the NKPC with Calvo pricing, they are typically not sufficient in state-dependent pricing models. I also provide examples to illustrate this finding. I show that nominal demand cannot be replaced with real demand and that, in contrast to the NKPC, real marginal costs and inflation can move in opposing directions. More generally, this section shows the strong dependence of the properties of the Phillips curve on assumptions which are difficult to verify in the data. This firstly motivates conducting an empirical analysis in Sections 4 and 5, and secondly not imposing these strong assumptions in the empirical analysis.

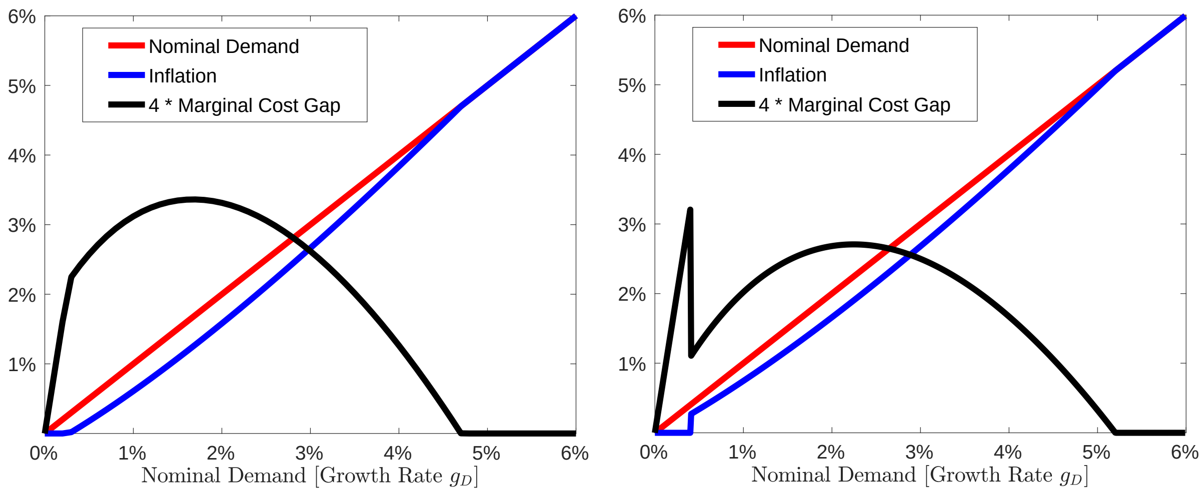
Several of my arguments can be illustrated in a one-period version of the model where the current Period t is the last period of this economy. Each firm decides whether to pay the fixed cost and set a new price for the current last period, or whether it does not pay the fixed cost and retains the last period's price. All firms face the same fixed cost of price adjustment. Before Period t, the economy is in a zero inflation steady state with zero nominal demand growth, $g_D = 0$. In Period t, nominal demand growth g_D increases unexpectedly (M.I.T. shock). The distribution of Period $t-1$ prices is uniform, but the second example adds a mass point to the lower bound of the price distribution.

In the first example shown in panel (a) of Figure 2, inflation is an increasing function of nominal demand growth. If the demand impulse is larger than $\bar{g}_D = 4.8\%$, all firms adjust their prices and we obtain the flexible price outcome in which inflation adjusts one-for-one with nominal demand, and real demand remains unchanged.[8] Comparing the two experiments $g_D^H > \bar{g}_D$ and $g_D^L = 0$ shows that real output Y is not sufficient to determine the inflation rate. Inflation equals g_D^H in the first experiment and $g_D^L = 0$ in the second. But real output Y is identical in the two experiments, whereas nominal demand is different and drives the inflation rate. This result also holds if the price adjustment cost was proportional to output Y. Nominal demand still matters, simply because D and P do not enter the firm problem symmetrically, and thus the firm problem cannot be rewritten in terms of real output Y.

For demand increases less than $\bar{g}_D$, inflation increases less than nominal demand and real demand is elevated. However, real output and marginal costs are a hump-shaped function of nominal demand. Increasing in the left half but decreasing in the right, implying that inflation cannot be written as a function of real demand but only of nominal demand. In particular, inflation cannot be explained only through real marginal cost. For example, comparing a $g_D = 3\%$ and a $g_D = 4\%$ scenario shows that inflation and marginal costs can be negatively related. Inflation is higher in the latter than the first scenario (3.8% vs. 2.6%), but the marginal cost gap is lower in the latter scenario (0.32% vs. 0.65%). On the other hand both inflation and marginal costs are higher for $g_D = 2\%$ than for $g_D = 1\%$, showing a positive relationship for low inflation rates.

The examples do not use a first-order approach, but are based on computing the full non-linear model. In particular, a firm objective function takes movements in the "shifter"

[8] In the calibrated menu cost model of Blanco et al. (2022), the threshold arises at an inflation rate of about $\bar{g}_D \approx 10\%$.



(a) Uniform Price Distribution (b) Mass Point

Figure 2: One-Period Example: Inflation and Marginal Costs

Note - The figures show the one-period response of inflation and the marginal cost gap to unexpected nominal demand growth rate M.I.T. shocks g_D between 0% and 6%. Both figures use $\epsilon = 5$, the aggregate real output elasticity of real marginal costs equals 2, and all firms face the same adjustment costs, which implies no price adjustment in the zero inflation, $g_D = 0$, steady state without g_D shocks. Panel (a) assumes a uniform distribution for initial prices and panel (b) adds a mass point to the left tail.

$y(p_t, P_t, D_t)$ into account and is not restricted to minimizing the price gap between the current and the optimal price as in first-order approaches (Alvarez and Lippi, 2014; Auclert et al., 2022).[9]

As already noted for example by Dotsey et al. (1999) and Caballero and Engel (2007), the response to nominal demand innovations depends on the price distribution. The second example in panel (b) of Figure 2 demonstrates that this dependency on the price distribution also prevents a clear and simple relationship between inflation and real marginal costs. The mass point of prices close to the left of the adjustment band implies that for small shocks no firm adjusts as in Alvarez et al. (2017), but for larger shocks all firms at the mass point adjust such that the price level increases more than nominal demand and real output and real marginal cost fall. Again inflation and real marginal costs move in opposite directions. Even nominal marginal costs and thus the optimal price decline at the mass point. Although each firm increases its price by less due to a lower optimal price, the aggregate price level increases since a mass of prices is adjusted upwards. All variables, the price level, real and nominal marginal costs and real output, jump at the mass point in response to a small

[9] The modifications of the standard menu cost model in Blanco et al. (2022) - strategic complementarities at the firm, not at the product level and products sold by firms are imperfect substitutes - imply non-linear inflation responses, challenging the standard usage of linear methods to solve menu cost models.

increase in nominal demand. This discontinuity does not allow for a first-order approach which requires differentiability (Auclert et al., 2022). Simple modifications of the example imply that the real marginal cost gap can even fall to negative values, while inflation remains positive and increasing at the same time.

Thin tails and a continuous distribution are non-innocuous assumptions typically made in the literature on state-dependent pricing. For example, Alvarez et al. (2017) impose these assumptions and find that the inflation response in state-dependent models is non-linear, in contrast to time-dependent models. A small change in nominal demand has a zero effect on inflation, while the response to large shocks is (locally) convex, and shocks above a certain size display full price flexibility. The examples show that these properties do not necessarily carry over to my framework, since I allow for example for mass points in the distribution of prices and do not assume a steady-state distribution of prices. Both assumptions, thin tails and no mass points, move the model closer to Calvo pricing, as they diminish the magnitude of the extensive margin. A thin tail means that few firms are close to their extensive margin of adjustment. Even if these firms are adjusting prices by a large amount, the low number of these firms generates a small response of the aggregate price level. Mass points generate a large increase in the number of adjusting firms in response to small changes in demand. Such a large change in the frequency of price adjustment is not captured by the Calvo model and can even imply, in contrast to the NKPC, that inflation and real marginal costs move in opposing directions.

Unfortunately, trying to verify these distributional assumptions in the data entails a severe identification problem. If a firm adjusts its price, a researcher observes the Period t price difference $\Delta^o p$ between the new and the current price. Since the observed $\Delta^o p$ equals the desired price gap $\Delta^d = p^*_{t,i} - p_{t,i}$, the difference between the optimal and the current price, $\Delta^d = \Delta^o p$ is observed for adjusting firms. For all other non-adjusting firms, the desired price gap $\Delta^d p$ is not observed in Period t. The probability of observing a price increase of x percent is the probability that the desired price change is x multiplied by the adjustment probability,

$$Prob(\Delta^o p = x) = Prob(\Delta^d p = x) Prob(\text{adjust} \mid \Delta^d p = x),$$

equating the LHS observable variable to a product of two unobservable variables on the RHS. The two unobservable variables are thus not identified. For example, the probability $Prob(\Delta^o p = x)$ could be low, either because only a few firms have a desired price change of x but the adjustment probability is large for these firms, or there are many firms with a desired price change x but the adjustment probability is low. In particular, large mass points in the distribution of desired price changes cannot be identified, simply because this large mass of firms might feature a low adjustment probability and is thus indistinguishable from a low mass of firms with a high adjustment probability. The time dimension in a panel data set does not overcome this identification issue, since the desired price gap is time-varying due to idiosyncratic shocks.

In the infinite horizon model, Hagedorn et al. (2022) show that nominal demand growth shifts the Phillips curve and that the model generates inflation persistence, i.e. inflation depends on its own lagged value. They use a menu costs model with idiosyncratic productivity shocks and stochastic menu costs and follow the calibration strategy in Midrigan (2011). In particular, they use a steady-state distribution without mass points to generate their results.[10]

Echoing the findings in Dotsey et al. (1999), Hagedorn et al. (2022) also show that the inflation response depends on the persistency of the nominal demand innovation. In terms of the empirical approach the infinite horizon model adds another reason as to why there is no one deep number describing the effect of nominal demand on inflation. This number not only depends on the distribution of prices, but also on the persistency of nominal demand. Imposing other assumptions makes the difference between the Calvo model and state-dependent models become even more evident. For example, Caplin and Spulber (1987) consider a menu cost model in which, under specific assumptions, money growth rate innovations have no effect on real output or on real marginal costs, i.e. money is neutral.

The examples and the literature show that the (distributional) assumptions typically imposed in the literature are quite strong. They should therefore be imposed in empirical work with great care to avoid biasing the results in a particular direction.

2.3 Nominal Demand Augmented Phillips Curve

I now derive the nominal demand-augmented Phillips curve (NDPC), which explains inflation through real marginal costs and nominal demand. I proceed in two steps to more effectively convey the intuition as to why higher nominal demand growth implies higher

[10] In Hagedorn et al. (2022), in contrast to Auclert et al. (2022), firms optimize the full non-linear price setting problem and nominal demand growth is autocorrelated as observed in the data.

inflation. First, I consider a model in which Period t is the last period of this economy, so that firms face a static and not a dynamic problem and afterwards I move to the infinite horizon. Log-linearizing equation (5) yields:

$$\pi_t = (\hat{p}_t^* - \hat{P}_{t-1}) \underbrace{\int_0^1 \Lambda(p_{t-1}(i), P_{t-1}, D_{t-1}) di}_{=:\bar{\Lambda}} + \underbrace{\int_0^1 \frac{1 - \tilde{p}_{t-1}(i)^{1-\epsilon}}{1-\epsilon} \hat{\Lambda}(i) di}_{=:\phi}, \tag{6}$$

where $\hat{p}_t^* - \hat{P}_{t-1}$ denotes the percentage deviation of p_t^*/P_{t-1} from one, $\tilde{p}_{t-1}(i) = \frac{p_{t-1}(i)}{P_{t-1}}$ and $\bar{\Lambda}$ and ϕ depend on the distribution of period $t-1$ prices $p_{t-1}(i)$.[11] To focus on inflation changes caused by changes in the demand shock, I assume that $\pi_t = 1$ if $D_t = D_{t-1}$, $P_{t-1} = D_{t-1}$ and $p_{t-1}^* = P_{t-1}$. On the one hand, this assumption is sufficient to nest the New Keynesian Phillips curve within my state-dependent model and to derive equation (6). On the other hand this assumption does not impose any further restrictions on the distribution of Period $t-1$ prices, $\tilde{p}_{t-1}(i)$. In contrast to the literature (e.g. Alvarez and Lippi, 2014), I also do not assume that price gaps $p_t^* - p_{t-1}(i)$ are small. I also do not assume $D_t - D_{t-1}$ to be small. I define $\hat{\Lambda}(i) = \Lambda(p_{t-1}(i), P_t, D_t) - \Lambda(p_{t-1}(i), P_{t-1}, D_{t-1})$ as the change in the adjustment probability of firm i due to changes in nominal demand, $D_t - D_{t-1}$, and in the price level , $P_t - P_{t-1}$. Since I do not restrict $D_t - D_{t-1}$ to be small, $\hat{\Lambda}(i)$ allows for large changes in nominal demand and does not require infinitesimal changes as in first-order approaches. The optimal price

$$\hat{p}_t^* - \hat{P}_{t-1} = \hat{mc}_t + \hat{P}_t - \hat{P}_{t-1},$$

implying

$$\pi_t = (\hat{mc}_t + \hat{P}_t - \hat{P}_{t-1})\bar{\Lambda} + \phi \tag{7}$$

and thus solving for inflation π_t yields:

$$\pi_t = \frac{\bar{\Lambda}}{1-\bar{\Lambda}} \hat{mc}_t + \frac{1}{1-\bar{\Lambda}} \phi. \tag{8}$$

Using arguments similar to Caballero and Engel (2007) shows that ϕ is increasing in the growth rate of nominal demand, $\Delta D_t = \log(D_t) - \log(D_{t-1})$, and decreasing in the inflation

[11] Permanent shocks to prices prevent linearizing around a fixed steady-state price level both in my model and in New Keynesian models (Woodford, 2003) and instead requires considering the relative price p_t^*/P_{t-1}. Alternatively one can consider $\hat{p}_t^* - \hat{P}_{t-1}$ the percentage deviation of p_t^* from P_{t-1}.

rate, $\pi_t = \Delta P_t = \log(P_t) - \log(P_{t-1})$,

$$\phi = \tilde{\phi}^D \Delta D_t + \tilde{\phi}^P \Delta P_t \tag{9}$$

with $\tilde{\phi}^D \geq 0$ and $\tilde{\phi}^P \leq 0$ if the output elasticity of marginal costs

$$\epsilon_{mc(Y),Y} = \frac{\partial mc(Y)}{\partial Y} \frac{Y}{mc(Y)} \geq \max\{\mathcal{M} - 1, \bar{p}, 1 + (\epsilon - 1)(1 - \underline{p})\}$$

for a mark-up $\mathcal{M}$ and a Period $t-1$ price distribution within the interval $[\underline{p} \cdot p^*, \bar{p} \cdot p^*]$, where $\underline{p}$ and $\bar{p}$ are defined as the lowest and highest percentage deviations from the optimal price.[12]

The basic reason for $\phi^D \geq 0$ is similar to Caballero and Engel (2007) under the assumptions on $\epsilon_{mc(Y),Y}$ needed to rule out equilibrium multiplicity in my richer environment. If firm $i's$ previous period price is below the optimal price, $\tilde{p}_{t-1}(i) < 1$, then this firm wishes to adjust upwards and the adjustment probability increases in response to a nominal demand expansion, implying that

$$\underbrace{\frac{1 - \tilde{p}_{t-1}(i)^{1-\epsilon}}{1 - \epsilon}}_{>0} \underbrace{\hat{\Lambda}(i)}_{>0} > 0.$$

In other words, firms with prices that are too low relative to the optimal one are more likely to increase their price.

If firm $i's$ previous period's price is above the optimal level, $\tilde{p}_{t-1}(i) > 1$ then this firm would want to adjust its price downwards and the adjustment probability decreases in response to a nominal demand expansion, implying that

$$\underbrace{\frac{1 - \tilde{p}_{t-1}(i)^{1-\epsilon}}{1 - \epsilon}}_{<0} \underbrace{\hat{\Lambda}(i)}_{<0} > 0$$

is again positive. In other words, firms with excessively high prices relative to the optimal one are now less likely to decrease their price, since the nominal expansion pushes towards price increases. Note that $\phi > 0$ is due to changes in the probability of price adjustment, $\hat{\Lambda}(i) \neq 0$, and that these changes are not random, but depend on the previous period's price level. If all firms' price adjustment probabilities increased by the same amount, the

[12] A sufficiently steep marginal cost curve also rules out coordination equilibria where a firm's optimal price is increasing in the prices set by other firms (Ball and Romer, 1991).

price index would not change, since price increases and decreases would offset each other. Instead the changes are selective. Consistent with the empirical evidence in Alvarez et al. (2019), the probability of price increases rises and the probability of price decreases falls.

Using (9) in (7) yields

$$\pi_t = (\hat{mc}_t + \pi_t)\bar{\Lambda} + \tilde{\phi}^D \Delta D_t + \tilde{\phi}^P \pi_t,$$

and solving for the inflation rate π_t:

$$\pi_t = \underbrace{\frac{\bar{\Lambda}}{1 - \bar{\Lambda} - \tilde{\phi}_P}}_{\tilde{\zeta}} \hat{mc}_t + \underbrace{\frac{\tilde{\phi}_D}{1 - \bar{\Lambda} - \tilde{\phi}_P}}_{=:\tilde{\Phi}^D} \Delta D_t, \tag{10}$$

where $\tilde{\zeta} \geq 0$ and $\tilde{\Phi}^D \geq 0$.

Equations (8) and (10) show that inflation has two determinants, real marginal costs, as in New Keynesian models with Calvo pricing, and nominal demand. The coefficients on both determinants are non-negative, but can equal zero for small changes in nominal demand, as the examples in Section 2.2 illustrate. However, the average effects, for example obtained in a regression including larger changes in nominal demand, are positive:

$$\pi_t = \underbrace{\tilde{\zeta}}_{>0} \hat{mc}_t + \underbrace{\tilde{\Phi}^D}_{>0} \Delta D_t. \tag{11}$$

One implication is that one of the two variables is not sufficient to explain the inflation rate. Both marginal costs and nominal demand are needed. The magnitude of the coefficients depends, for example, on the magnitude of shocks and the distribution of prices. Without strong assumptions there is no theorem showing that $\hat{mc}_t$ and ΔD_t have the same sign. As the examples in Section 2.2 show, it may well be that both determinants and inflation move in the same direction - $\pi_t > 0$, $\hat{mc}_t > 0$ and $\Delta D_t > 0$ - but this is not a general result. Inspecting the proof shows that we also obtain the inflation equations (10) and (11) if the price adjustment cost was proportional to output Y, $Y\xi$. Inflation cannot simply be written only as a function of real marginal costs.

To extend the analysis to an infinite horizon, note that equation (6) for the inflation rate is still valid in an infinite horizon model. But the optimal price setting is different, since expected future marginal costs now have to be taken into account. Following Dotsey et al. (1999) to derive the optimal price,

$$(\hat{p}_t^* - \hat{P}_{t-1}) \quad = \quad \Xi E_t \sum_{k=0}^{\infty} \beta^k \lambda_{k,t} [\hat{mc}_{t+k} + (\hat{P}_{t+k} - \hat{P}_{t-1})], \tag{12}$$

where $\lambda_{k,t}$ is the probability of not changing the price until period $t+k$ and $\Xi = \frac{1}{\sum_{k=0}^{\infty} \beta^k \lambda_{k,t}}$.[13]

Using this in equation (6) and further rearranging the terms yields

$$\pi_t(1 - \bar{\Lambda}) = (\bar{\Lambda}\ \Xi) E_t \sum_{k=0}^{\infty} \beta^k \hat{mc}_{t+k} + \underbrace{\phi_t + \beta \bar{\Lambda} E_t \sum_{k=1}^{\infty} \beta^k \phi_{t+k}}_{=:\Phi_t},$$

where a time index is added to ϕ_{t+k} to make the dependence on the $t+k-1$ price distribution explicit. Dividing by $1 - \bar{\Lambda}$ yields the inflation rate

$$\pi_t = \frac{(\bar{\Lambda}\ \Xi)}{1 - \bar{\Lambda}} E_t \sum_{k=0}^{\infty} \beta^k \hat{mc}_{t+k} + \frac{\Phi_t}{1 - \bar{\Lambda}}.$$

The previous analysis carries over to the infinite horizon model and shows that Φ_t is increasing in ΔD_t and decreasing in π_t. The extensive adjustment margin Φ_t depends on the full history of demand innovations, $\Delta D_t, \Delta D_{t-1}, \Delta D_{t-2}, \ldots$ since these shocks determine both the current price adjustment and past price adjustments, and thus the current distribution of prices which, as we have seen above, affect the current inflation response. Current and future expected price adjustments also depend on the expectations of future demand innovations, which have to be based on Period t information, which can be summarized through the full history of demand innovations. We therefore obtain:

$$\pi_t \quad = \quad \zeta E_t \sum_{k=0}^{\infty} \beta^k \hat{mc}_{t+k} + \Phi_D^0 \Delta D_t + \sum_{k=1}^{\infty} \Phi_D^k \Delta D_{t-k} \tag{13}$$

with $\Phi_D^0 > 0$. An increase in nominal demand by x percent eventually results in an x percent incresae in the price level, implying that

$$\sum_{k=0}^{\infty} \Phi_D^k = 1. \tag{14}$$

Motivated by the approach in Hazell et al. (2021), we can decompose the nominal demand

[13] Calvo pricing would simplify $\lambda_{k,t} = \theta^k$ and $\Xi = 1 - \beta\theta$ where $1 - \theta$ is the Calvo probability of adjusting the price.

variation into a transitory and a long-run component. Let $g_\infty = E_t \lim_{s\to\infty} \Delta D_s$ be the expected long run growth rate of nominal demand, which in the absence of real growth, equals the expected long-run inflation rate:

$$\pi_\infty = E_t \lim_{s\to\infty} \pi_s = g_\infty = E_t \lim_{s\to\infty} \Delta D_s.$$

The transitory component then equals $\Delta D_t - g_\infty$. Using these definitions and equation (14), equation (13) can be rewritten as:

$$\pi_t \;=\; \zeta E_t \sum_{k=0}^{\infty} \beta^k \hat{mc}_{t+k} + \Phi_D^0(\Delta D_t - g_\infty) + \sum_{k=1}^{\infty} \Phi_D^k(\Delta D_{t-k} - g_\infty) + \pi_\infty. \qquad (15)$$

3 Regional Inflation and Nominal Demand

This section combines the open economy model of HHNS with the two agent incomplete markets model of Bilbiie (2019), the state-dependent pricing model in Section 2 and adds nominal government transfers. Building on the price level determinacy results in Hagedorn (2016), I show that incomplete markets and nominal transfers ensure that real and nominal aggregate demand are functions (not correspondences) of the price level. I then derive a regional version of the augmented Phillips curve developed in Section 2.3, which will be used in the empirical analysis using US state-level data. As emphazised in HHNS, using regional data allows for adding time fixed effects which control for various aggregate effects including long-run inflation expectations.

3.1 The Model of Regional Inflation Rates and Fiscal Policy

The economy consists of two regionss, (H)ome and (F)oreign, which form a monetary and fiscal union. Each country has a population of one, which consists of two types of agent, savers and hand-to-mouth households. Firm behavior is as described in Section 2. All model ingredients such as preferences, production etc. except fiscal policy are identical in the two regions.

3.1.1 Households

Following Bilbiie (2019) a household i can be of two types $s_i \in \{\text{S, HtM}\}$, which differ in their access to financial markets. A fraction Ω is hand-to-mouth (s = HtM) and the mass of savers (s=S) is $1-\Omega$. Types change exogenously according to the transition matrix $\omega_{s,s'}$, so that $\omega_{S,S}$ is the probability of remaining a saver, $\omega_{S,HtM}$ is the probability of a saver to becoming HtM, $\omega_{HtM,S}$ the probability of switching from HtM to S and $\omega_{HtM,HtM}$ is the probability of remaining HtM, so that for the stationary distribution $\Omega = \frac{1-\omega_{S,S}}{2-\omega_{S,S}-\omega_{HtM,HtM}}$.

Both types derive instantaneous utility

$$u(C) - v(N)$$

from a composite consumption good C and labor N and discount the future at rate β. The Period t composite consumption good for type s in the home country, $C^{s}_{H,t}$, aggregates non-tradable consumption $C^{s,N}_{H,t}$ and tradeable consumption $C^{s,T}_{H,t}$:

$$C^{s}_{H,t} = \left(\mu_T^{\frac{1}{\rho}} (C^{s,T}_{H,t})^{\frac{\rho-1}{\rho}} + \mu_N^{\frac{1}{\rho}} (C^{s,N}_{H,t})^{\frac{\rho-1}{\rho}} \right)^{\frac{\rho}{\rho-1}},$$

where the tradable consumption aggregates tradables produced at home, $C^{s,TH}_{H,t}$, and foreign produced tradable goods, $C^{s,TF}_{H,t}$,

$$C^{s,T}_{H,t} = \left(\tau^{\frac{1}{\rho}} (C^{s,TH}_{H,t})^{\frac{\rho-1}{\rho}} + (1-\tau)^{\frac{1}{\rho}} (C^{s,TF}_{H,t})^{\frac{\rho-1}{\rho}} \right)^{\frac{\rho}{\rho-1}},$$

where for simplicity, the steady-state expenditure share on home and foreign tradables is $\tau = 1/2$, such that the countries are symmetric and there is no home bias in tradable consumption. The steady-state expenditure shares on non-tradable and tradable consumption are μ_N and μ_T respectively. The elasticity of substitution between tradables and non-tradables and between home and foreign tradables is ρ.

Non-tradable consumption $C^{s,N}_{H,t}$ is in turn an index given by

$$C^{S,N}_{H,t} = \left(\int_0^1 (C^{S,N}_{H,t}(j))^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}},$$

where $C^{S,N}_{H,t}(j)$ is non-tradable consumption of variety j, which sells at a price $P^{N}_{H,t}(j)$. The parameter ϵ is the elasticity of substitution between the different varieties.

Similarly for tradable consumption, $C^{s,TH}_{H,t}$ and $C^{s,TF}_{H,t}$ are indices,

$$C^{S,TH}_{H,t} = \left(\int_0^1 (C^{S,TH}_{H,t}(j))^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}}, \quad C^{S,TF}_{H,t} = \left(\int_0^1 (C^{S,TF}_{H,t}(j))^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}},$$

where $C^{S,TH}_{H,t}(j)$ is tradable consumption produced at home of variety j and $C^{S,TF}_{H,t}(j)$ is tradable consumption produced abroad of variety j. The elasticity of substitution is again ϵ. The prices of the home and foreign-produced tradable varieties are $P^T_{H,t}(j)$ and $P^T_{F,t}(j)$.

The HtM households are excluded from financial markets, they can neither save nor obtain a credit.[14] HtM households thus maximize utility subject to the budget constraints

$$\begin{aligned} & P^N_{H,t} C^{HtM,N}_{H,t} + P^T_{H,t} C^{HtM,TH}_{H,t} + P^T_{F,t} C^{HtM,TF}_{H,t} \\ = \; & W_{H,t} N^{HtM}_{H,t} + \Upsilon^{HtM,N}_{H,t} + \Upsilon^{HtM,T}_{H,t} + T^{HtM}_{H} + (1+i_t)\tilde{B}_{H,t}, \end{aligned}$$

where $W_{H,t}$ is the nominal wage, $N^{HtM}_{H,t}$ is hours, $T^{HtM}_{H,t} > 0$ is a nominal transfer, $\Upsilon^{HtM,N}_{H,t}$ is the nominal profit of the non-tradable sector and $\Upsilon^{HtM,T}_{H,t}$ is nominal profit of the tradable sector producing at home accruing to HtM households and $\tilde{B}_{H,t}$ is the bonds acquired by a Period $t-1$ saver who becomes a Period t HtM household. The price indices of home non-tradable and home and foreign tradable goods are $P^N_{H,t}$, $P^T_{H,t}$ and $P^T_{F,t}$.[15]

A saver can acquire bonds $B_{H,t}$ such that their Period t budget constraint equals

$$\begin{aligned} & P^N_{H,t} C^{S,N}_{H,t} + P^T_{H,t} C^{S,TH}_{H,t} + P^T_{F,t} C^{S,TF}_{H,t} + B_{H,t+1} \\ = \; & \chi W_{H,t} N^S_{H,t} + \Upsilon^{S,N}_{H,t} + \Upsilon^{S,T}_{H,t} + T^S_{H,t} + (1+i_t) B_{H,t} \mathcal{I}_t, \end{aligned}$$

where $\chi > 1$ is the productivity of savers and $\mathcal{I}_t = 1$ if the household was also a Period $t-1$ saver and $\mathcal{I}_t = 0$ otherwise. Savers are the high-income households, so that becoming a HtM household is a negative income shock which leads to a binding credit constraint. Note that the amount of bonds carried to Period t could be individual-specific, but I simplify the notation and drop this dependence. The nominal transfer to savers $T^S_{H,t} < 0$ and $\Upsilon^{S,N}_{H,t}$ is the nominal profit of the non-tradable sector and $\Upsilon^{S,T}_{H,t}$ is nominal profit of the tradable sector producing at home accruing to savers. Savers in both countries do not face credit constraints, enabling trade in bonds between home and foreign savers. Since both regions are fully symmetric and I assume a zero net supply of bonds, all households hold zero assets

[14] If HtM households are the low-income ones, then imposing a credit constraint instead of a full exclusion from financial markets is sufficient, since there is no desire to save anyway.

[15] The price indices $P^N_{H,t}$, $P^T_{H,t}$ and $P^T_{F,t}$ are given by

$$P^N_{H,t} = \left(\int_0^1 (P^N_{H,t}(j))^{1-\rho} dj \right)^{\frac{1}{1-\rho}}, P^T_{H,t} = \left(\int_0^1 (P^T_{H,t}(j))^{1-\rho} dj \right)^{\frac{1}{1-\rho}}, P^T_{F,t} = \left(\int_0^1 (P^T_{F,t}(j))^{1-\rho} dj \right)^{\frac{1}{1-\rho}}.$$

in a steady state.[16]

Using the price index

$$P_{H,t} = \left(\mu_N (P^N_{H,t})^{1-\rho} + \mu_T \tau (P^T_{H,t})^{1-\rho} + \mu_T \tau (P^T_{F,t})^{1-\rho}\right)^{\frac{1}{1-\rho}}$$

for the composite home good allows rewriting households' maximization problem in terms of the composite good. HtM households maximize utility subject to the budget constraint

$$P_{H,t} C^{HtM}_{H,t} = W_{H,t} N^{HtM}_{H,t} + \Upsilon^{HtM,N}_{H,t} + \Upsilon^{HtM,T}_{H,t} + T^{HtM}_{H,t} + (1+i_t)\tilde{B}_{H,t},$$

so that their consumption equals

$$C^{HtM}_{H,t} = \frac{W_{H,t} N^{HtM}_{H,t} + \Upsilon^{HtM,N}_{H,t} + \Upsilon^{HtM,T}_{H,t} + T^{HtM}_{H,t} + (1+i_t)\tilde{B}_{H,t}}{P_{H,t}}.$$

The saver maximization problem can be written recursively

$$\begin{aligned} V^S_H(B^S_H) = & \max_{C^S_H \geq 0, (B^S_H)' \geq 0} u(C^S_H) - v(N^S_H) + \beta\left\{\omega_{S,S} V^S_H((B^S_H)') + \omega_{S,HtM}[u((C^{HtM}_H)') - v((N^{HtM}_H)')]\right\} \\ & \text{subj. to} \quad P_H C^S_H + (B^S_H)' = (1+i) B^S_H \mathcal{I} + \chi W_H N^S_H + \Upsilon^{S,N}_H + \Upsilon^{S,T}_H + T^S_H \\ & \qquad\qquad \text{No Ponzi condition,} \\ & \qquad\qquad \text{Transition matrix } \omega. \end{aligned}$$

The foreign household sector is symmetric and thus not described in detail.

Wage Setting and Regional Labor Market Labor is fully mobile *within* a region but immobile *across* regions. To take type heterogeneity into account I follow Hagedorn et al. (2017) and assume that in each country a middleman (for example, a union) assigns the same amount of labor $N^S_{H,t} = N^{HtM}_{H,t} = N_{H,t}$ to both types and sets the wage per efficiency unit as a weighted average of marginal rates of substitution,

$$\frac{W_{H,t}}{P_{H,t}} = u'(C^S_{H,t}) \frac{v'(N_{H,t})}{u'(C^S_{H,t})} + u'(C^{HtM}_{H,t}) \frac{v'(N_{H,t})}{u'(C^{HtM}_{H,t})} = v'(N_{H,t}).$$

This approach ensures the same labor supply curve as in the representative agent model in HHNS, such that regional labor supply is the only regional variable affecting regional

[16] Note that this is a steady-state result and that outside steady states, savers might hold positive or negative amounts of assets. While one can impose conditions to ensure zero asset holdings outside steady states, the results in this paper do not require this property.

marginal costs.

3.1.2 Firms

Firms in the non-tradable and tradable sectors operate as described in the price-setting model in Section 2.1, which took nominal demand as given. I therefore first use the results from the previous Section on households to derive the nominal demand for home and foreign non-tradables and tradables.

Sectoral and Regional Demand

The aggregate nominal demand of home households is the sum of the demand of savers and HtM households located in the home region:

$$\begin{aligned} D_{H,t} &= (1-\Omega)\Big(\chi W_{H,t}N_{H,t} + \Upsilon^{S}_{H,t} + T^{S}_{H,t}\Big) + \Omega\Big(W_{H,t}N_{H,t} + \Upsilon^{HtM}_{H,t} + T^{HtM}_{H,t}\Big) \\ &+ (1+i_t)\int_{s_{t-1,i}=S} B^{S}_{H,t,i}di - \int_{s_{t,i}=S} B^{S}_{H,t+1,i}, \end{aligned} \tag{16}$$

where $B^{S}_{H,t+1,i}$ is bonds acquired by a saver household i in Period t (type $s_{t,i} = S$) and $\Upsilon^{S}_{H,t}$ and $\Upsilon^{HtM}_{H,t}$ are all nominal profits accruing to savers and HtM households respectively. Similarly for foreign households

$$\begin{aligned} D_{F,t} &= (1-\Omega)\Big(\chi W_{F,t}N_{F,t} + \Upsilon^{S}_{F,t} + T^{S}_{F,t}\Big) + \Omega\Big(W_{F,t}N_{F,t} + \Upsilon^{HtM}_{F,t} + T^{HtM}_{F,t}\Big) \\ &+ (1+i_t)\int_{s_{t-1,i}=S} B^{S}_{F,t,i}di - \int_{s_{t,i}=S} B^{S}_{F,t+1,i}. \end{aligned} \tag{17}$$

Household optimization implies that the nominal demand for home and foreign non-tradables equals

$$D^{N}_{H,t} = \mu_N\Big(\frac{P^{N}_{H,t}}{P_{H,t}}\Big)^{1-\rho} D_{H,t}; \quad D^{N}_{F,t} = \mu_N\Big(\frac{P^{N}_{F,t}}{P_{F,t}}\Big)^{1-\rho} D_{F,t}, \tag{18}$$

and the nominal demand for home produced tradables

$$D^{T,H}_{t} = \mu_T\tau\Bigg\{\Big(\frac{P^{T}_{H,t}}{P_{H,t}}\Big)^{1-\rho} D_{H,t} + \Big(\frac{P^{T}_{H,t}}{P_{F,t}}\Big)^{1-\rho} D_{F,t}\Bigg\}, \tag{19}$$

and for foreign produced tradables

$$D^{T,F}_{t} = \mu_T\tau\Bigg\{\Big(\frac{P^{T}_{F,t}}{P_{H,t}}\Big)^{1-\rho} D_{H,t} + \Big(\frac{P^{T}_{F,t}}{P_{F,t}}\Big)^{1-\rho} D_{F,t}\Bigg\}. \tag{20}$$

Non-tradable Good Producers

There is a measure-one continuum of firms in the home non-tradable sector indexed by $j \in [0,1]$ facing the same price-setting problem laid out in Section 2.1. Household optimization implies that a firm $j \in [0,1]$ with price $P^N_{H,t}(j)$ for variety j faces demand

$$Y^N_{H,t}(j) = \left(\frac{P^N_{H,t}(j)}{P^N_{H,t}}\right)^{-\epsilon} \frac{D^N_{H,t}}{P^N_{H,t}} \tag{21}$$

and uses the linear production function in effective labor $N^N_{H,t}(j)$,

$$Y^N_{H,t}(j) = N^N_{H,t}(j),$$

so that the nominal cost of producing $Y^N_{H,t}(j)$ units of real output is

$$W_{H,t} Y^N_{H,t}(j)$$

and the Period t nominal profit equals

$$\Gamma^N_{H,t}(P^N_{H,t}(j), P^N_{H,t}, D^N_{H,t}) = (P^N_{H,t}(j) - W_{H,t}) Y^N_{H,t}(j).$$

The Period t value function after price adjustment

$$\bar{V}^N_{H,t}(P^N_{H,t}(j), P^N_{H,t}, D^N_{H,t}) = \Gamma^N_{H,t}(P^N_{H,t}(j), P^N_{H,t}, D^N_{H,t}) + \beta E_t V^N_{H,t+1}(P^N_{H,t}(j), P^N_{H,t+1}, D^N_{H,t+1}),$$

where $V^N_{H,t}(P^N_{H,t}(j), P^N_{H,t}, D^N_{H,t})$ is the Period $t+1$ value function before price adjustment. The optimal Period t price $(P^N_{H,t})^*$ of a firm in the home non-tradable sector maximizes $\bar{V}^N_{H,t}$,

$$(P^N_{H,t})^* = \underset{P^N_{H,t}(j)}{\operatorname{argmax}} \, \bar{V}^N_{H,t}.$$

The price adjustment decision then amounts to comparing the value at the optimal price minus nominal adjustment costs, $P^N_{H,t}\xi$, and the value at the inherited price without adjustment costs:

$$V^N_{H,t+1}(P^N_{H,t}(j), P^N_{H,t+1}, D^N_{H,t+1}) = \max\{\bar{V}^N_{H,t}((P^N_{H,t}(j))^*, P^N_{H,t}, D^N_{H,t}) - P^N_{H,t}\xi, \bar{V}^N_{H,t}(P^N_{H,t-1}(j), P^N_{H,t}, D^N_{H,t})\}.$$

Tradable Good Producers

The price setting of firms in the tradable sector is also analogous to the non-tradable sector. Household optimiztion implies that firm $j \in [0,1]$ with price $P^N_{H,t}(j)$ faces demand for variety j:

$$Y^T_{H,t}(j) = \Big(\frac{P^T_{H,t}(j)}{P^T_{H,t}}\Big)^{-\epsilon} \frac{D^T_{H,t}}{P^T_{H,t}}. \tag{22}$$

The production function of firm j is linear in effective labor $N^T_{H,t}(j)$,

$$Y^T_{H,t}(j) = N^T_{H,t}(j),$$

marginal costs equal $W_{H,t}Y^T_{H,t}(j)$ and the Period t nominal profit equals

$$\Gamma^T_{H,t}(P^T_{H,t}(j), P^T_{H,t}, D^T_{H,t}) = (P^T_{H,t}(j) - W_{H,t})Y^T_{H,t}(j).$$

The Period t value function for the tradable firm after price adjustment satisfies

$$\bar{V}^T_{H,t}(P^T_{H,t}(j), P^T_{H,t}, D^T_{H,t}) = \Gamma^T_{H,t}(P^T_{H,t}(j), P^T_{H,t}, D^T_{H,t}) + \beta E_t V^T_{H,t+1}(P^T_{H,t}(j), P^T_{H,t+1}, D^T_{H,t+1}),$$

where $V^T_{H,t}(P^T_{H,t}(j), P^T_{H,t}, D^T_{H,t})$ is the Period $t+1$ value function before price adjustment. The optimal Period t price

$$(P^T_{H,t})^* = \operatorname*{argmax}_{P^T_{H,t}(j)} \bar{V}^T_{H,t}.$$

The price adjustment decision then amounts to comparing the value at the optimal price minus nominal adjustment costs, $P^T_{H,t}\xi$, and the value at the inherited price without adjustment costs:

$$V^T_{H,t+1}(P^T_{H,t}(j), P^T_{H,t+1}, D^T_{H,t+1}) = \max\{\bar{V}^T_{H,t}((P^T_{H,t})^*, P^T_{H,t}, D^T_{H,t}) - P^N_{H,t}\xi, \bar{V}^T_{H,t}(P^T_{H,t-1}(j), P^T_{H,t}, D^T_{H,t})\}.$$

The foreign production sectors are symmetric and thus not described in detail.

3.1.3 Fiscal and Monetary Policy

The specification of monetary and fiscal policy differs from most previous work which builds on a representative agent for the whole economy or for each region (for example HHNS). Monetary policy sets the nominal interest for the whole economy, so that both regions are subject to the same monetary policy. Since the nominal interest rate "differences-out" in the cross-sectional empirical analysis, the shape of the aggregate interest rate rule would only affect aggregate variables but not the difference between regions, the relevant variable in the empirical analysis. I therefore assume for simplicity that the nominal interest rate is constant:

$$1 + i_t = 1 + \bar{i} \geq 1.$$

Typically, researchers assume that the interest rate rule has to satisfy the Taylor principle to ensure local determinacy, but Hagedorn (2016, 2020) shows that such a restrictive specification is not necessary in incomplete markets under assumptions on fiscal policy which are satisfied here.

In contrast to many standard approaches and HHNS, fiscal policy, albeit its parsimonious specification, plays a significant role here. The net supply of government bonds and government spending are zero, and fiscal policy is restricted to paying nominal transfers, which have to satisfy the budget constraints

$$(1-\Omega)T^{S}_{H,t} + \Omega T^{HtM}_{H,t} + (1-\Omega)T^{S}_{F,t} + \Omega T^{HtM}_{F,t} = 0. \tag{23}$$

Note that this specification allows for cross-regional transfers and does not require a balanced budget for each region.

3.1.4 Equilibrium

In a *competitive equilibrium*, households maximize utility taking prices and policy as given, firms maximize profits taking aggregate prices and policies as given, wages are set by middlemen, the government budget constraint (23) holds and all markets clear:

1. $(1-\Omega)C^{S,N}_{H,t} + \Omega C^{HtM,N}_{H,t} = Y^{N}_{H,t} = \frac{D^{N}_{H,t}}{P^{N}_{H,t}}$ [Home Non-tradable goods]
2. $(1-\Omega)C^{S,N}_{F,t} + \Omega C^{HtM,N}_{F,t} = Y^{N}_{F,t} = \frac{D^{N}_{F,t}}{P^{N}_{F,t}}$ [Foreign Non-tradable goods]
3. $(1-\Omega)[C^{S,TH}_{H,t} + C^{S,TH}_{F,t}] + \Omega[C^{HtM,TH}_{H,t} + C^{HtM,TH}_{F,t}] = Y^{T}_{H,t} = \frac{D^{T}_{H,t}}{P^{T}_{H,t}}$ [Home tradable goods]
4. $(1-\Omega)[C^{S,TF}_{H,t} + C^{S,TF}_{F,t}] + \Omega[C^{HtM,TF}_{H,t} + C^{HtM,TF}_{F,t}] = Y^{T}_{F,t} = \frac{D^{T}_{F,t}}{P^{T}_{F,t}}$ [Foreign tradable goods]
5. $\int N^{N}_{H,t}(j)dj + \int N^{T}_{H,t}(j)dj = ((1-\Omega)\chi + \Omega)N_{H,t}$ [Home labor market]
6. $\int N^{N}_{F,t}(j)dj + \int N^{T}_{F,t}(j)dj = ((1-\Omega)\chi + \Omega)N_{F,t}$ [Foreign labor market]

7. $\int_{s_{t,i}=S} B^S_{H,t+1,i}di + \int_{s_{t,i}=S} B^S_{F,t+1,i}di = 0$ [Bond market]

In a symmetric steady state, all time indices are dropped and fiscal transfers satisfy

$$T^{HtM}_{H,t} = T^{HtM}_{F,t} =: T,$$
$$T^S_{H,t} = T^S_{F,t} = -\frac{\Omega}{1-\Omega}T,$$

and all agents i hold zero bonds $B^S_{H,i} = B^S_{F,i} = 0$. Following HHNS, I define unemployment in country H and F simply as $u_{H,t} = 1 - N_{H,t}$ and $u_{F,t} = 1 - N_{F,t}$ so that to first-order $\hat{u}_{H,t} = -\hat{N}_{H,t}$ and $\hat{u}_{F,t} = -\hat{N}_{F,t}$.

In incomplete markets models, precautionary savings drives a wedge between the steady-state interest rates in complete and incomplete markets,

$$1 + \bar{i} < 1/\beta.$$

To ensure the existence of a steady state for all interest rates $1 + i \geq 1$, I assume that precautionary savings demand is sufficiently strong, requiring a sufficiently high χ:

$$\omega_{S,HtM}\Big(\frac{u'(N_{H,ss})}{u'(\chi N_{H,ss})} - 1\Big) > \frac{1-\beta}{\beta}, \tag{24}$$

where $N_{H,ss}$ is steady-state labor supply.[17]

While a general equilibrium analysis of an economy in real terms delivers all relative prices, it requires a normalization of one price. Instead, price level determinacy does not impose a normalization but links the price to fundamentals. A full determinacy analysis of incomplete markets models can be found in Bilbiie (2019) and Hagedorn (2016, 2020). It is however, instructive to briefly convey the basics to understand why and how fiscal transfers determine and move the inflation rate. To establish steady-state price level determinacy, it would be sufficient to show determinacy of any of the steady-state price levels $P^N_{H,ss}, P^N_{F,ss}, P^T_{H,ss}, P^T_{F,ss}$ using one of the market clearing conditions 1-4. In a symmetric steady state, it is however more informative to show how the steady-state price index of home consumers, $P_{H,ss}$, is determined, since all relative prices are equal to one.

The steady-state price level $P_{H,ss}$ equates demand and supply,

$$\frac{D_{H,ss}}{P_{H,ss}} = Y^N_{H,ss} + \frac{Y^T_{H,ss}}{2} + \frac{Y^T_{F,ss}}{2} = Y^N_{H,ss} + Y^T_{H,ss} = ((1-\Omega)\chi + \Omega)N_{H,ss}. \tag{25}$$

[17] For $u() = log()$ this condition is equivalent to $\chi - 1 > \frac{1-\beta}{\beta(1-\omega_{S,S})}$.

where home households consume half of both home and foreign tradables in a symmetric steady state, $\frac{Y^T_{H,ss}}{2} = \frac{Y^T_{F,ss}}{2}$.

In equilibrium, total profits in the home region $\Upsilon_{H,ss} = (P_{H,ss} - W_{H,ss})((1-\Omega)\chi + \Omega)N_{H,ss}$ and $B^S_{H,ss,i} = 0$ for all households, so that $\frac{D_{H,ss}}{P_{H,ss}} = ((1-\Omega)\chi + \Omega)N_{H,ss}$ and (25) clearly holds. However, there is only one price level $P_{H,ss}$ which constitutes an equilibrium, as it implies that households do not save, $B^S_{H,ss,i} = 0$, or equivalently that their demand equals supply. For all other price levels, $B^S_{H,ss,i}$ would be either strictly positive or negative. The consumption Euler equation of the saver describes the saving behavior and can thus be used to determine the price level. Following (Werning, 2015) and assuming for simplicity $\Upsilon^S_{H,ss} = \frac{\chi}{(1-\Omega)\chi+\Omega}\Upsilon_{H,ss}$ and $\Upsilon^{HtM}_{H,ss} = \frac{1}{(1-\Omega)\chi+\Omega}\Upsilon_{H,ss}$:

$$
\begin{aligned}
& u'(\chi N_{H,ss} - \frac{T_{H,ss}}{P_{H,ss}}) = u'(C^S_{H,ss}) \\
= \;& \beta(1+i)\big(\omega_{S,S}u'(C^S_{H,ss}) + \omega_{S,HtM}u'(C^{HtM}_{H,ss})\big) \\
= \;& \beta(1+i)\big(\omega_{S,S}u'(\chi N_{H,ss} - \frac{T_{H,ss}}{P_{H,ss}}) + \omega_{S,HtM}u'(N_{H,ss} + \frac{T_{H,ss}}{P_{H,ss}})\big),
\end{aligned} \tag{26}
$$

which is equivalent to

$$
(1-\beta(1+i)\omega_{S,S})u'(\chi N_{H,ss} - \frac{T_{H,ss}}{P_{H,ss}}) = \beta(1+i)\omega_{S,HtM}u'(N_{H,ss} + \frac{T_{H,ss}}{P_{H,ss}}). \tag{27}
$$

To see that this equation holds for one price level $P_{H,ss}$ note that the LHS converges to infinity if the price approaches a level where $\chi N_{H,ss} - \frac{T_{H,ss}}{P_{H,ss}} = 0$. On the other hand, (24) implies that RHS > LHS if the price converges to infinity, implying that an intermediate value solves the equation. The solution is unique, since the RHS is increasing in $P_{H,ss}$ and the LHS is decreasing in $P_{H,ss}$. Symmetry implies that the same arguments apply to $P_{F,ss}$ and that $P_{H,ss} = P_{F,ss}$.[18]

3.2 The Regional Phillips Curve with Nominal Demand

The empirical analysis in Section 4 estimates the effect on inflation of a transfer to the home region. The theoretical model describes the causal relationship between inflation, nominal demand and nominal fiscal transfers. The firm sector described in Section 2.1 shows how nominal demand maps into inflation. The household sector described in Section 3.1.1 maps

[18] While ruling out $P_{H,ss} = \infty$ is necessary for global determinacy, it is not yet sufficient, and a full global analysis resorts to the arguments in Obstfeld and Rogoff (1983, 2017). For a local determinacy analysis of TANK/incomplete markets models with nominal fiscal policy, see (Bilbiie, 2019; Hagedorn, 2020).

nominal transfers into nominal demand.

3.2.1 Inflation and Nominal Demand

Using the derivations in Section 2.3 yields a log-linearized nominal demand-augmented Phillips curve for the non-tradabale inflation rate $\pi^N = \hat{P}^N_{H,t} - \hat{P}^N_{H,t-1}$ as a function of regional marginal cost in the non-tradable sector, $\hat{mc}^N_{H,t}$, and nominal demand growth $\Delta D^N_{H,t-k} = \log\big(D^N_{H,t-k}\big) - \log\big(D^N_{t-k-1}\big)$ for home non-tradables

$$\pi^N_{H,t} \;=\; E_t \sum_{k=0}^{\infty} \beta^k (\zeta \hat{mc}^N_{H,t+k}) + \Phi^0_D \Delta D^N_{H,t} + \sum_{k=1}^{\infty} \Phi^k_D \Delta D^N_{H,t-k}, \tag{28}$$

where marginal costs in the non-tradable sector equal $\hat{mc}^N_{H,t} = \varphi^{-1}\hat{N}_{H,t} - \hat{p}^N_{H,t} = -\varphi^{-1}\hat{u}_{H,t} - \hat{p}^N_{H,t}$ for a Frisch household labor supply elasticity φ and $\hat{p}^N_{H,t}$ is the percentage deviation from steady state of the relative price $\frac{P^N_{H,t}}{P_{H,t}}$. While marginal costs for the whole region are proportional to unemployment, moving to the non-tradable sector requires adding the relative price term to obtain the correct measure of marginal costs in the non-tradabale sector.[19]

3.2.2 Nominal Fiscal Multiplier and Inflation

A household sector operating in an incomplete markets environment delivers two implications which are relevant for the empirical analysis. Firstly, aggregate nominal demand is well-defined, in the sense that every level of nominal demand implies a unique market clearing price level, i.e. the price level is determinate. Note that this mapping between nominal demand and price levels is without invoking a Taylor rule, which induces determinacy in complete markets models. Nominal demand is thus a meaningful concept due to incomplete markets and nominal fiscal policy. Secondly, the empirical analysis uses transfers and not demand as a regressor. The model shows how household optimization relates nominal fiscal transfers to nominal demand. The *marginal propensities of demand* describe how a change in nominal transfers leads to a change in household nominal demand (omitting the region

[19] Marginal costs in the non-tradable sector equal the nominal regional wage divided by the non-tradable price level, whereas regional marginal costs equal the nominal regional wage divided by the regional price index. Adding the relative price term to regional marginal costs thus delivers non-tradable marginal costs.

subscript):

$$\begin{aligned}\bar{D}\Delta D &= (1-\Omega)mpd^S\bar{T}^S\Delta T^S + \Omega mpd^{HtM}\bar{T}^{HtM}\Delta T^{HtM} \\ &= mpd[(1-\Omega)\bar{T}^S\Delta T^S + \Omega\bar{T}^{HtM}\Delta T^{HtM}],\end{aligned} \tag{29}$$

where $\bar{D}$, $\bar{T}^S$ and $\bar{T}^{HtM}$ are steady-state levels of D, T^S and T^{HtM} in Period $t = -1$ and $\Delta T^S = \log(T^S) - \log(T^S_{-1})$ and $\Delta T^{HtM} = \log(T^{HtM}) - \log(T^{HtM}_{-1})$ are the growth rates of transfers of savers and hand-to-mouth households respectively. The marginal propensity of demand for a HtM household, $mpd^{HtM} = 1$, indicating that all income is spent. The marginal propensity of demand for the saver, mpd^S, is significantly smaller and approaches $1-\beta$ if $\omega_{S,S} \to 1$.[20] The last equality of (29) defines the aggregate country marginal propensity to spend mpd_H in response to a change in total regional transfers

$$\bar{T}\Delta T := (1-\Omega)\bar{T}^S\Delta T^S + \Omega\bar{T}^{HtM}\Delta T^{HtM},$$

the concept typically used in quantitative and empirical work. Note however, that the mpd is nominal here, as it describes the nominal response to a nominal impulse.

The total effect on inflation combines the effect of demand on inflation and the effect of transfers on demand captured through the mpds. Since mpds are heterogeneous across the population, the aggregate mpd and thus the inflation response depends on the recipient of the transfer. If transfers are paid to savers with low mpds, then the response of demand and thus of inflation is rather small. If on the other hand, HtM households with high mpd receive the transfer, the response of demand and thus of inflation is larger.

Using the simple model with a uniform distribution in Section 2.2, small changes in nominal demand have either no or only small effects on inflation, but larger changes in nominal demand lead to almost proportional changes in inflation, suggesting a convex relationship between nominal demand and inflation. Although the inflation-nominal demand relationship is convex in this example, it is not so under different assumptions as Section 2.2 also shows. Furthermore, taking into account that the empirical analysis uses nominal transfers and not nominal demand renders the relationship even less convex. Higher transfers are likely to lead to lower marginal propensities to consume and thus to a smaller increase in demand. This is what theory predicts (Hagedorn et al., 2017) and is consistent with empirical evidence that large lottery wins induce permanent-income-hypothesis-type

[20] Whereas the expression for mpd^S becomes rather complicated for intermediate values of $\omega_{S,S}$ and $\omega_{S,HtM}$, we obtain for $u(\cdot) = \log(\cdot)$, $mpd^S \to \frac{1+r}{2+r}$ if $\omega_{S,HtM} \to 1$.

behavior (Golosov et al., 2021), whereas small transfers can feature substantial marginal propensities to consume.

These are partial equilibrium responses in order to explain the workings of the model and the transmission from fiscal policy to inflation. Firms set prices taking demand as given, and households make consumption/savings decisions taking prices as given. In equilibrium, prices adjust to clear the markets, so that demand taken as given by firms, is actually household demand, and prices taken as given by households are actually the prices set by firms.

4 Empirical Approach

I now use the model results on the relationship between inflation, nominal demand and nominal fiscal transfer to derive the empirical specification. I then describe the data, which combine that used and provided by HHNS, with regional fiscal transfer data from the BEA.

4.1 Estimating the Inflation Response

I start with the NDPC derived in (28)

$$\pi^N_{H,t} = E_t \sum_{k=0}^{\infty} \beta^k (\zeta \hat{mc}^N_{H,t+k}) + \Phi^0_D \Delta D^N_t + \sum_{k=1}^{\infty} \Phi^k_D \Delta D^N_{t-k}, \tag{30}$$

and then rewrite it following Section 2.3 as:

$$\pi^N_{H,t} = E_t \sum_{k=0}^{\infty} \beta^k (\zeta \hat{mc}^N_{H,t+k}) + \Phi^0_D (\Delta D^N_t - g_{H,\infty}) + \sum_{k=1}^{\infty} \Phi^k_D (\Delta D^N_{t-k} - g_{H,\infty}) + E_t \pi_{H,\infty}, \tag{31}$$

where $g_{H,\infty} = E_t \lim_{s\to\infty} \Delta D^N_s = E_t \lim_{s\to\infty} \Delta T_s$ is the expected long-run growth rate of nominal demand and nominal transfers respectively, which equals the expected long-run inflation rate corrected for expected long-run growth, $E_t \pi_{H,\infty}$.

The next step uses the theoretical result of the previous Section, that regional transfers ΔT_t move demand for all goods including non-tradables. I therefore replace the change in demand with the change in transfers in (31):

$$\pi^N_{H,t} \;=\; E_t \sum_{k=0}^{\infty} \beta^k (\zeta \hat{mc}^N_{H,t+k}) + \Phi^0_T(\Delta T_t - g_{H,\infty}) + \sum_{k=1}^{\infty} \Phi^k_T(\Delta T_{t-k} - g_{H,\infty}) + E_t \pi_{H,\infty}, \tag{32}$$

To understand the relationship between using demand as a regressor in (31) and transfers in (32), consider a simple scenario in which firms exist just for one period, as in the two examples in Section 2.2. Under this assumption $\Delta D_t = mpd\frac{\bar{T}}{\bar{D}}\Delta T_t$ and the estimated coefficient of interest would be

$$\Phi^0_T = \Phi^0_D \frac{\bar{T}}{\bar{D}} mpd.$$

In line with the theoretical model, the magnitude of inflation response depends on the magnitude of two channels. These are the size of effect of demand on inflation, Φ^0_D, and the marginal propensity of demand, *mpd*. For example, a large transfer can have only modest inflationary effects if paid to low mpd households, although demand has sizeable effects on inflation, Φ^0_D is large. With infinitely living firms, a change in current transfers will be spent over several periods, affecting not only current but also future demand. If this mechanism is operating in the data and firms take it into account, the estimated coefficient also captures these expectational effects.

The benchmark empirical specification equals

$$\pi^N_{r,t} \;=\; \kappa E_t \sum_{k=0}^{K} \beta^k \hat{mc}^N_{r,t+k} + \Phi \Delta T_{r,t-4} + \gamma \pi^N_{r,t-4} + \alpha_r + \gamma_t + \epsilon_{rt} \tag{33}$$

where a subscript r denotes the region r and ϵ_{rt} is a residual term which also captures measurement and expectational errors. As in HHNS, the infinite sum of marginal costs is truncated at $k = K$. I follow the standard approach in panel data regressions and include region fixed effects α_r for each region r and time fixed effects γ_t. The time fixed effects capture all aggregate effects. In particular long-run inflation expectations are "differenced-out" using time-fixed effects, since they are independent of current conditions. Balassa-Samuelson arguments would induce permanent differences in long-run inflation across regions, reflecting permanent regional growth differences. These constant growth differentials are captured by the state fixed effects α_r. I also use the growth rate of transfers ΔT_t instead of $\Delta T_t - g_{H,\infty}$ since the same arguments imply that fixed effects pick up $g_{H,\infty}$.[21] Including state and time

[21] Note that permanent inflation differences between two regions with identical productivity growth rates

fixed effects also means that the coefficients κ and Φ are identified from variation of the regressors across states, which are not due to aggregate effects or permanent differences within states.

Note that the benchmark specification captures the effect of future marginal costs on current inflation, consistent with the New Keynesian Phillips curve. As explained before, the nominal demand channel does not allow for such a neat theoretical derivation of expectational effects without imposing strong assumptions. The coefficient Φ on ΔT thus also captures expectational effects, such that the estimated coefficient is a combination of contemporaneous and expectational effects. To be consistent with HHNS and other previous studies, I use the beginning-of-period transfer growth rate over the last 4 quarters, $\Delta T_{t-4} = \log(T_{t-4}) - \log(T_{t-8})$ to explain the subsequent 4-quarter inflation rate, $\log(P_t) - \log(P_{t-4})$. To alleviate potential concerns that transfer growth is just a proxy for lagged inflation rates, I also include the lagged inflation rate $\pi^N_{r,t-4}$. The coefficient γ captures the degree of inflation indexation in standard models (or some form of adaptive expectations), while at the same time taking nominal demand effects into account.

HHNS provide a neat derivation for the different slopes of the regional and aggregate New Keynesian Phillips curves. The demand augmentation of the Phillips curve does not allow for a simple relationship between regional and aggregate coefficients of nominal demand. One reason is that the inflation response depends on the size of the fiscal (transfer) multiplier and there is no simple mapping from cross-sectional to aggregate numbers (Nakamura and Steinsson, 2014). Furthermore, there is not just one multiplier, but many multipliers depending on the properties of the transfers, such as the characteristics of the transfer recipients (Section 3.2.2) and the persistence of the transfers (Dotsey et al., 1999; Hagedorn et al., 2017). The objective of the empirical analysis is therefore more modest as it does not aim at identifying a deep model parameter but at establishing that nominal demand shifts the Phillips curve.

4.2 Data

The empirical analysis relies on several data sources for state-level inflation rates, transfer receipts and labor market data.

are solely due to permanent inflation differences in the non-tradable sector. This would be inconsistent with a steady state and would instead suggest a divergence of the relative size of the non-tradable sectors between the two regions.

4.2.1 State-Level Inflation Rates and Price Indices

I use US state-level price indices constructed by HHNS. They use micro-price data available from the CPI Research Database, provided by the US Bureau of Labor Statistics (BLS) for the period 1978-2018, to construct non-shelter state inflation rates.[22] For each state they calculate tradable and non-tradable inflation rates. The product categories used to construct the non-tradable inflation rate are described in Appendix B.4 of HHNS and are similar to the BLS service definition, including education, telephone, medical and recreational services. For details of the data construction see HHNS. The quarterly state non-tradable inflation rate is the outcome variable in the empirical analysis. Choosing non-tradable inflation also follows HHNS based on the argument that tradable goods are priced nationally, rendering them less responsive to regional demand conditions.

4.2.2 Regional Transfers

To match the frequency of the inflation data, I use the quarterly series of Personal Current Transfer Receipts from the BEA (SQINC35) and not the annual version (SAINC35).[23] My measure of transfers is the sum of "State unemployment insurance compensation" and "All other personal current transfer receipts", as these contain the income maintenance programs which best match the theoretical counterpart of (helicopter drop) transfers. Such transfers are known to feature high marginal propensities to consume and are therefore expected to be a significant driver of demand and inflation. The quarterly dataset does not allow for a finer split of "All other personal current transfer receipts", which includes income maintenance benefits such as Supplemental Security Income (SSI) support, Earned Income Tax Credit (EITC) and Supplemental Nutritional Assistance (SNAP). This transfer category also includes the Alaska Permanent Fund benefits and transfers as part of the American Recovery and Reinvestment Act of 2009 (ARRA). The appendix describes the various transfers in more detail. My transfer measure does not include Social Security benefits which are indexed to the U.S. inflation rate and Medical benefits and Medicaid payments, as those are linked to actual medical expenses and thus do not resemble a helicopter drop.[24]

[22]For a detailed description of the CPI Research Database, see Nakamura and Steinsson (2008) and Klenow and Kryvtsov (2008).

[23]Available at `https://www.bea.gov/data/income-saving/personal-income-by-state`.

[24]The indexation of Social Security to U.S. inflation would be captured by the time fixed effects in my panel regressions. Lagged inflation would therefore not be a suitable instrument in my analysis. Nonetheless, this indexation of Social Security payments can explain the persistence of U.S. inflation

4.2.3 Labor market data

I use the same labor market data as in HHNS, which are provided by the U.S. Bureau of Labor Statistics (BLS). To construct marginal costs, I use state-level unemployment rates from the Local Area Unemployment Statistics (LAUS).[25] I also use state-industry level employment data from the Quarterly Census of Employment and Wages (QCEW) to construct the Bartik type instrument described in Section 4.3.[26]

4.2.4 Visualizing the Relationship between Inflation and Transfers

The theoretical model claims a positive relationship between state-level non-tradable inflation and the growth rate of nominal transfers. Before proceeding to the formal econometric analysis, Figure 3 visualizes this relationship using the data just described. The scatterplot in the left panel (a) shows a positive significant relationship using raw data. A similar significant relationship is found in the right panel (b) using the residuals of regressions of inflation and transfer growth on state and time fixed effects. The findings in the Figure are both consistent with the theoretical model. While on the hand encouraging, the results are only suggestive. Both figures fail to control for marginal costs and do not use instrumental variable to address the endogeneity of the regressors. In addition, the left panel does not control for long-run expectations, as time effects are omitted. These issues are addressed in the next Section 4.3 and in the econometric analysis in Section 5.

4.3 Identifying Assumptions

The empirical analysis uses two instruments, a Bartik type instrument and past unemployment rates. This section explains how the instruments are constructed and the identifying assumptions which render them valid.

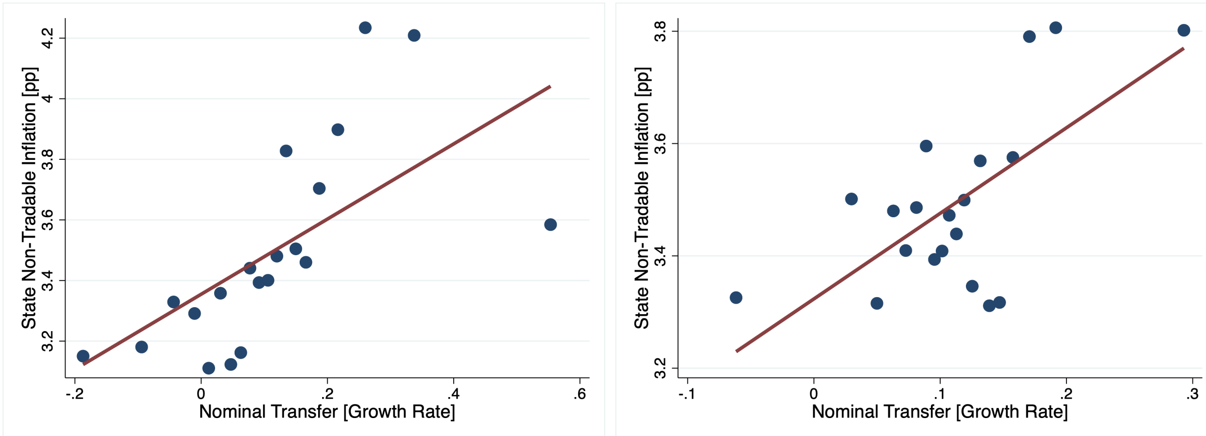
The Bartik type instrument is constructed following HHNS in order to capture variations in real demand which in turn move real marginal costs in the non-tradable sector. The tradable Bartik type instrument in region r in period t,

$$\mathcal{B}_{r,t} := \sum_{l} \bar{z}_{l,r} \times g_{-r,l,t},$$

rates, as I argue in Section 5.5.

[25] Available at https://www.bls.gov/lau/

[26] Available at https://www.bls.gov/cew/



(a) No State and Time Fixed Effects (b) State and Time Fixed Effects

Figure 3: Scatterplots: Non-Tradable Inflation and Nominal Transfers

Note - Binned scatterplot (using STATA binscatter) of state non-tradable inflation and the (2-year) growth rate of nominal transfers. Panel (a) uses raw data and Panel (b) residualizes inflation and transfers against state and time effects.

where $\bar{z}_{l,r}$ is the time-average employment share of industry l in the tradable sector in region r and $g_{-r,l,t}$ is the Period t 3-year growth of industry r national employment leaving out region r. The idea building on Bartik (1991) is that an aggregate shock to a specific tradable sector has differential effects on states, depending on the size $\bar{z}_{l,r}$ of this tradable sector in this state, implying differential effects on the demand for non-tradabale goods in those states. This differential exposure of the state demand for non-tradable goods implies that the instrument is relevant.

The identifying assumption requires the instrumental variable to be uncorrelated with the error, conditional on the time and regional fixed effects, the standard exogeneity assumption in differences-in-differences designs. A shock which is both correlated over time with the aggregate shifter $g_{-r,l,t}$ and with the shares $\bar{z}_{l,r}$ in the cross section is not correlated with the change over time of the cross-sectional difference in marginal costs. Using the example in HHNS, an increase in the oil price will differentially affect Texas and Illinois (relevance assumption). Exogeneity then means that there is no correlation with the change over time in the cost-difference of restaurants in Texas and Illinois.

Nominal transfer growth ΔT_t of a state could be endogenous after accounting for state and time fixed effects, since the change in transfer payments could depend on current economic conditions which at the same time affect the inflation rate. This argument is somewhat weakened, since I use lagged transfer growth which is less likely to respond to current shocks. While it cannot be ruled out that some transfer increases might be an immediate response to adverse shocks, a large fraction of transfers is triggered in response to past economic conditions.

For unemployment insurance, past state unemployment rates (before 1981 in combination with national unemployment rates) trigger extended benefit payments under federal law. Other transfers are mainly income maintenance programs and are also triggered in bad economic conditions for the low income population, i.e. if the unemployment rate is elevated. This reasoning motivates using past unemployment rates, u_{t-k}, as additional instruments. The institutional environment shows that past unemployment rates are partially correlated with current changes in nominal transfers. This correlation has to be sufficiently strong to avoid running into weak-instrument issues. I will test this assumption in the empirical analysis below and report the F-statistics which show that the instruments are strong.

A second important condition for $u_{H,t-k}$ to be a valid instrument is that it be uncorrelated with the error term ϵ_{rt}. To understand the economics behind this assumption, first assume that the unemployment rate fully captures the marginal cost gap. Then $u_{H,t-k}$ is uncorrelated with the error term ϵ_{rt} within the theoretical model. Current and future marginal costs are the determinants of inflation in the New Keynesian Phillips curve, implying that past unemployment rates are irrelevant to explaining current inflation rates and are thus uncorrelated with the error term ϵ_{rt}. That does not mean that the unconditional correlation between past unemployment rates and current inflation is zero. Only the correlation conditional on current and future unemployment/marginal costs is zero.

While this property holds in my model and also in related theoretical models under certain conditions, more general models do not necessarily imply that the unemployment rate $u_{H,t}$ fully captures the real marginal cost gap $\hat{mc}^N_{H,t}$. There could be variables other than unemployment that move marginal costs, and marginal costs could differ from the marginal cost gap if supply shocks are important, and marginal costs in the non-tradable sector differ from regional marginal costs.

To fix these ideas, it seems useful to think of the benchmark regression (33) containing an omitted variable $mc^{res}_{H,t}$, which is orthogonal to unemployment such that the real marginal cost gap can be decomposed as,

$$\hat{mc}^N_{H,t} = u_{H,t} + mc^{res}_{H,t}.$$

The orthogonality conditions needed for the validity of the instrument $u_{H,t-k}$,

$$E(u_{H,t-k}\epsilon_{rt}) = 0, \quad k = \underline{k}, \underline{k}+1, \ldots, \overline{k}.$$

then require

$$E(u_{H,t-k}mc^{res}_{H,t}) = 0, \quad k = \underline{k}, \underline{k}+1, \ldots, \overline{k}.$$

In words, the real marginal cost residual $mc^{res}_{H,t}$ which by construction is orthogonal to Period t unemployment, $u_{H,t}$, also has to be orthogonal to Period $t-k$ unemployment, $u_{H,t-k}$. This would be satisfied in the theoretical model. What this assumption rules out is that a Period $t-k$ shock which moves Period $t-k$ unemployment, but is orthogonal to the Period $t-k$ marginal cost residual, is correlated with the Period t marginal cost residual $mc^{res}_{H,t}$ conditional on Period t unemployment. The assumption in a nutshell: Variables orthogonal in Period $t-k$ are also orthogonal in Period t.[27]

Being a valid instrumental variable means that $u_{H,t-k}$ is redundant in (33) and thus affects inflation only indirectly through ΔT_t. Note that in a standard New Keynesian Phillips curve, this is satisfied if the economy is driven by demand shocks. The current inflation rate then depends on the current and future unemployment rates, but not on past rates, and the unemployment rate and the unemployment rate gap move one-for-one. The assumption here is that adding nominal transfers to the Phillips curve does not change this property. Instead, past unemployment rates do not matter directly for the current inflation rate, but only indirectly, since they move nominal transfers. Since the model is overidentified, the overidentifying assumptions can and will be tested and are found to confirm the theoretical predictions.

The orthogonality assumption is also satisfied if ϵ_{rt} contains a (cost-push) shock, which moves the inflation rate, but does not move any real variables such as the unemployment rate or real marginal costs. By definition such a shock is unrelated to past unemployment rates, and the orthogonality assumption is satisfied.[28]

Using past unemployment as an instrument also alleviates potential concerns due to

[27] For illustrative purposes, consider a Period $t-k$ shock z and decompose it into pairwise orthogonal shocks, $z_{t-k} = z^u_{t-k} + z^{mc}_{t-k} + z^{res}_{t-k}$, with $z^u_{t-k} = \frac{E(u_{H,t-k}z_{t-k})}{E(u_{H,t-k}u_{H,t-k})}u_{H,t-k}$ and $z^{mc}_{t-k} = \frac{E(mc^{res}_{H,t-k}z_{t-k})}{E(mc^{res}_{H,t-k}mc^{res}_{H,t-k})}mc^{res}_{H,t-k}$ and z^{res}_{t-k} is the orthogonal residual. For this shock, the identification assumption $E(u_{H,t-k}mc^{res}_{H,t}) = 0$ means $E(z^u_{t-k}z^{mc}_t) = 0$ taking into account that $E(z^u_{t-k}z^{mc}_{t-k}) = 0$ and $E(z^u_t z^{mc}_t) = 0$.

[28] A microfoundation of cost-push shocks is provided by Rubbo (2020). She shows that a multi-sector model generates endogenous cost-push shocks which generate inflation without affecting aggregate real output or unemployment and thus satisfy the orthogonality assumption of the instrumental variable.

endogenous mobility. Whereas higher transfers in a state might induce immigration into this state, higher unemployment rates and thus lower wages and fewer jobs have the opposite effect. Therefore, the migration response to an increase in transfers triggered by an increase in the unemployment rate is ambiguous. Hagedorn et al. (2013) confirm this hypothesis and find that mobility decisions are not significantly affected by the generosity of unemployment insurance payments even at the county level. Furthermore, Hagedorn et al. (2014) find that households do not switch the state in which they shop in response to a change in unemployment insurance benefits.

5 Empirical Results

5.1 Benchmark Results

The state-level non-tradable inflation rate is the change in prices for all non-tradable items over the last 4 quarters. As in HHNS, using 4-quarter differences reduces the amount of measurement error, avoids seasonality and renders the analysis more robust towards lags in the price responses. The transfer data are also four-quarter changes to match the frequency of the inflation data. This section provides the estimates for the benchmark specification derived in the previous section:

$$\pi^N_{r,t} = \kappa E_t \sum_{k=0}^{K} \beta^k \hat{mc}^N_{r,t+k} + \Phi \Delta T_{r,t-4} + \gamma \pi^N_{r,t-4} + \alpha_r + \gamma_t + \epsilon_{rt}. \quad (34)$$

Implementing this specification requires specifying a value for the discount rate β and for the Frisch labor supply elasticity φ to construct the marginal cost sum. I set standard values $\beta = 0.99$ and $\varphi = 1$ as my benchmark, but also consider $\beta = 0.95, 0.9$ and $\varphi = 1/2, 2$ below.

Column 1 of Table 1 shows the result for the benchmark specification. A one percentage point increase in the annual growth rate of nominal transfers leads to a significant 0.12 percentage point increase in the annual inflation rate and to a $0.03 = 0.12/4$ percentage point increase in quarterly inflation. Since the empirical approach controls for long-run inflation expectations following HHNS, this estimate does not take into account the effect of changes in nominal fiscal policy on long-run expectations. As explained in the previous section, the estimated effect though, takes into account equilibrium effects and short-run expectations as far as these are operating in the data.

Table 1: Nominal Demand Phillips Curve Estimates

	Benchmark	Additional Lags	No Lagged Inflation	No Marginal Costs	No Nominal Demand
	(1)	(2)	(3)	(4)	(5)
Nom. Transfers	0.115	0.145	0.130	0.052	
	(0.037)	(0.017)	(0.042)	(0.012)	
$\sum$ Marginal Cost	0.049	0.067	0.052		0.021
	(0.020)	(0.015)	(0.025)		(0.171)
Lagged Inflation	0.081	0.058		0.086	0.080
	(0.111)	(0.268)		(0.106)	(0.107)
Lagged Nom. Transfers		0.115			
		(0.036)			
			Specification Tests		
Underidentification test	0.019	0.007	0.028	0.011	0.001
Weak Identification (F-Test)	47.851	21.801	46.776	87.818	156.5
Overidentification test	0.287	0.912	0.282	0.211	0.030

Note - The inflation rate (annual), the growth rate of nominal transfers (annual) and the unemployment rate are all measured in percentage points. All regressions use 4 lags of unemployment and the Bartik-type variable $\mathcal{B}_{r,t-4}$ as instruments. Column (1),(3)-(5) use $(u_{r,t-5}, \dots u_{r,t-8})$ for unemployment and column (2) uses $(u_{r,t-5}, u_{r,t-6}, u_{r,t-9}, u_{r,t-10})$ to capture lagged transfers. All regressions include state and time fixed effects. P-values in (parentheses) are clustered at the state level.
Column (1) - Benchmark,
Column (2) - Added Regressor: Lagged Transfers,
Column (3) - Omitted Regressor: Lagged inflation,
Column (4) - Omitted Regressor: Marginal Costs,
Column (5) - Omitted Regressor: Nominal Demand.

To understand the coefficient for marginal costs and how it relates to the findings in HHNS, we have to divide the $\kappa = 0.049$ of Table 1 by 4 to obtain the effect on quarterly inflation, which is reported to be 0.0062 in HHNS. Taking into account the effect of nominal transfers on inflation thus steepens the Phillips curve by a factor of 2 ($0.049/4 = 0.0123$ vs. 0.0062). To relate this finding to the Phillips curve literature which relates the unemployment rate to inflation, I first regress $\sum_{k=0}^{K} \beta^k \hat{mc}^N_{r,t+k}$ on $u_{r,t}$ including state and time fixed effects which yields a coefficient of $\xi = -9.5$. Rewriting equation (34) to assess the relationship between the unemployment rate and inflation,

$$\pi_{it}^{N} = \kappa\xi u_{i,t} + \Phi\Delta T_{r,t-4} + \gamma\pi_{r,t-4}^{N} + \ldots$$

Multiplying the two coefficients yields a coefficient for unemployment of $\kappa\xi = -0.049*9.5 = -0.466$ for annual non-shelter inflation, significantly larger than -0.153, the corresponding number reported in HHNS. Combining $\kappa\xi = -0.466$ with the higher estimate in HHNS for annual shelter inflation of -0.0972, yields a slope of -0.658, again significantly higher than -0.34 reported in HHNS.[29]

The coefficient on the lagged inflation rate is quite small and even insignificant, suggesting that indexation is not an important factor in explaining inflation. This is in contrast to the literature using aggregate data (e.g. Gali et al., 2005) which finds a significant coefficient of at least a third, much higher than the 0.0814 estimate using regional data. The benchmark specification thus shows not only that indexation is largely irrelevant, but also that the estimated significant effect of nominal demand do not capture the effect of lagged inflation.

Consistent with the findings in Chodorow-Reich et al. (2021), Bellifemine et al. (2022) and Fleck (2021) adjusting for statewide stock wealth, for the share of non-tradables or the progressivity of the state tax and transfer systems respectively delivers different coefficients for ΔT. States with stock wealth above the average have a 0.036 higher ΔT coefficient, states with an above average share of non-tradables have a 0.002 higher ΔT coefficient, and states which have a more progressive tax and transfer system than the average U.S. state have a -0.013 lower coefficient than the average.[30] However, the difference in coefficients is statistically insignificant since the estimates combine the effect on aggregate demand for non-tradables and on firms' price setting.[31]

All specification tests pass. The underidentification tests rejects the null that the model

[29] This number is calculated as $-0.658 = -(0.58 * 0.049 + 0.42 * 0.0972) * 9.5$, where 0.42 and 0.58 are the shelter and non-shelter expenditure weights reported in HHNS.

[30] The stock wealth data are from Chodorow-Reich et al. (2021) and were gratefully provided by Plamen Nenov, the non-tradable shares are from the Hazell et al. (2021) dataset described in section 4.2 and the state data on the progressivity of the tax and transfer system are from Fleck et al. (2021) and were gratefully provided by Johannes Fleck.

[31] Borusyak and Jaravel (2017) and Borusyak et al. (2021) show that "forbidden comparisons", i.e. using previously treated households as a control group, leads to an upward bias of the MPC estimates of Broda and Parker (2014). See also Orchard et al. (2022), who reach a similar conclusion in their application to the CEX data used by Parker et al. (2013). This bias does not arise here since all states are continuously treated, the relevant comparison is between states treated with different intensities and thus there are no "forbidden comparisons".

is not identified. The F-test shows no sign of weak identification as it clearly exceeds the standard threshold of 10. Finally the overidentification test cannot reject the null hypothesis that the instruments are valid and uncorrelated with the error term. The assumed exclusion restriction that past unemployment rates have no effect on inflation after taking into account the marginal cost sum and nominal demand is confirmed in the data. The same conclusion is reached if the regression residual is regressed on the instruments. All lagged unemployment rates are found to be jointly insignificant as the exclusion restriction requires. Consistent with the theoretical models, the effect of past unemployment rates on the current inflation rate thus operates only through transfers, rendering transfers a sufficient statistic for this (unemployment) history dependence.

The theoretical model also implies that additional lags of transfers could have explanatory power for inflation.[32] Column (2) of Table 1 shows the results of adding an additional lag. Not only is the coefficient on the additional regressor significant and positive, but the coefficients on the other regressors, transfers $\Delta T_{r,t-4}$ and marginal costs $\sum_{k=0}^{K} \beta^k \hat{mc}^N_{r,t+k}$ also increase in magnitude.[33] Repeating the same calculation as above for the slope of the Phillips curve yields a coefficient on unemployment of -0.757 and $\kappa\xi = -0.64$.

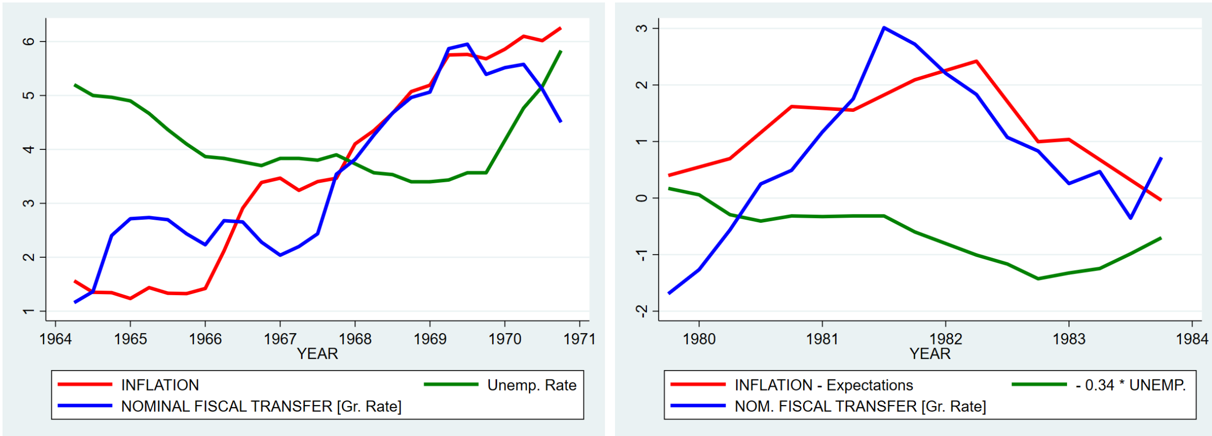
5.1.1 The NDPC and U.S. Inflation

To get an idea of the magnitude of the estimated coefficient for nominal transfers, I consider two historical U.S. inflation episodes.

Firstly, the second half of the 1960s, when the U.S. inflation rate was picking up, although the unemployment rate remained quite flat (Panel (a) of Figure 4), so that the New Keynesian Phillips curve would imply a constant inflation rate. Inflation expectations only responded sluggishly and can thus be ruled out as a driving force of the inflation rise (Reis, 2021). In terms of fiscal policy, Romer (2007) describes the dramatic changes of policy views in the 1960s, which also led to an expansion of transfer payments, at the same time when inflation rates started to increase after many years of low inflation rates. The blue "Nominal Fiscal Transfer" line in Panel (a) of Figure 4 uses the estimates of Table 1 to generate the predicted inflation, π^{pred} due to nominal U.S. fiscal transfer growth $\Delta T^{U.S.}$

[32] The theoretical model predictions for non-linear effects are less strong and so are the empirical results. Adding a squared transfer term to the benchmark regression yields a positive but insignificant coefficient.

[33] Adding a further lag again delivers significant and sizeable coefficients for all regressors, but the F-statistic drops to 12.5 close to the threshold of 10, and the underidentification test yields a quite high p-value of 9.3%.



(a) 1964-1970 (b) 1980-1984

Figure 4: Inflation, Unemployment and Nominal Fiscal Transfers

Note - Panel(a): CPI Core Inflation Rate; Unemployment Rate; Growth rate of lagged nominal transfers using data on Personal Current Transfer Receipts from the BEA (SQINC35) and the estimates of Table 1 in Section 5 to construct predicted inflation, π^{pred}, defined in (35).
Panel (b): Core Inflation minus 10-year-ahead CPI inflation expectation as in HHNS; unemployment rate multiplied by the slope of the Phillips curve estimated in HHNS; Growth rate of (lagged) nominal transfers using data on Personal Current Transfer Receipts from the BEA (SQINC35) and the estimates of Table 1 in Section 5 to construct predicted inflation, π^{pred}, defined in (35).

as

$$\pi_t^{pred} = const + 0.145\Delta T_{t-4}^{U.S.} + 0.115\Delta T_{t-8}^{U.S.}. \tag{35}$$

Secondly, the early 1980s were an episode of high inflation rates even after accounting for long-run inflation expectations and at the same time, high unemployment rates which according to the Phillips curve, should imply low inflation rates (Panel (b) of Figure 4). As in the late 1960s, the growth rate of nominal transfers increased in the early 1980s and Panel (b) of Figure 4 shows the predicted inflation rate π^{pred} defined in (35).

The two Figures show that nominal transfers are a promising candidate to account for inflation both in terms of magnitude and in the timing, as transfer increases lead inflation increases. It is important to reiterate that this experiment's sole purpose is to convey an idea of the economic magnitude of the estimates and their potential to account for US inflation. At this stage the experiment of Figure 4 is not even close to a proper aggregation exercise, since the relationship between the regional and aggregate effects is much more complicated for fiscal policy than for the standard New Keynesian Phillips curve.

5.2 Understanding Nominal Demand, Inflation and Marginal Costs

To understand the contribution of the three regressors - nominal demand, marginal costs and lagged inflation - columns (3)-(5) of Table 1 each omit one of the three regressors. Column (3) shows that dropping the lagged inflation rate π^N_{t-4} has only minor effects on the other estimates, confirming the finding that indexation is not an important driver of inflation.

Columns (4) and (5) omit one of the two determinants of inflation, nominal demand and marginal costs respectively. The theoretical model predicts that these experiments induce an omitted variable bias and the estimation confirms this theoretical result. To understand the sign of the bias, one has to take into account that transfers are high when the unemployment rate is high and thus marginal costs are low, implying a negative correlation between ΔT and MC. Combining this negative correlation with the positive coefficients in column (1) explains why the coefficients fall. An increase in transfers which has a sizeable positive effect shown in column (1), now also picks up the effect of marginal costs. The bias is negative, since marginal costs have a positive sign (column 1) and the policy-induced correlation between transfers and marginal costs is negative. Analogously, dropping transfers from the regression implies that marginal costs pick up the effect of transfers. The bias is negative, since transfers have a positive sign (column 1) and the policy-induced correlation between transfers and marginal costs is negative, implying a smaller positive and now even insignificant coefficient in column (5). The marginal costs coefficient in column (5) is similar but not identical to HHNS, since marginal costs here include the relative price of non-tradables, and a larger set of instruments is used. In terms of the co-movement of unemployment and inflation, a policy-induced increase in nominal demand looks like a negative supply shock, although constituting a demand increase, since inflation and unemployment are both elevated. Or like a cost-push shock in a model with a New Keynesian Phillips curve.

Note also that the overidentification test confirms the exclusion restriction as long as transfers are included in the regression in columns (1)-(4), but fails in column (5), consistent with the identification assumptions that transfers are a sufficient statistic, but marginal costs are not.

5.3 Alternative Measures of Marginal Cost

Table 2 considers alternative assumptions in order to construct the sum of marginal costs. Columns (1) and (2) assume different discount rates, $\beta = 0.95$ and $\beta = 0.99$, and show that a lower discount rate leads to larger coefficients for marginal costs, mechanically implying somewhat smaller coefficients for transfers.

Columns (3) and (4) use different Frisch elasticities of labor supply, 0.5 and 2, to construct marginal costs in the non-tradable sector. Using a Frisch labor supply elasticity of 0.5 cuts the estimated coefficient by half to -0.025. The estimate of the marginal cost sum on the unemployment rate however, roughly doubles to 18.976, such that the product is almost unaffected. Similarly, the coefficient on marginal costs doubles using a Frisch elasticity of 2, but the regression coefficient falls by half to 4.767. The proportional scaling of the coefficients and the invariance of the estimate for the nominal transfers show that the magnitude of the Frisch elasticity is irrelevant to the effects of fiscal policy.

Overall, these robustness analyses confirm the benchmark findings that nominal transfers are a sizeable and significant driver of inflation.

Table 2: Different Marginal Cost Measures

	Marginal Costs $\beta = 0.95$	Marginal Costs $\beta = 0.9$	Marginal Costs $\varphi = 1/2$	Marginal Costs $\varphi = 2$
	(1)	(2)	(3)	(4)
Nom. Transfers	0.108	0.098	0.115	0.115
	(0.023)	(0.013)	(0.037)	(0.037)
$\sum$ Marginal Cost	-0.060	-0.074	-0.024	-0.097
	(0.010)	(0.005)	(0.020)	(0.020)
		Specification Tests		
Underidentification test	0.009	0.006	0.019	0.019
Weak Identification (F-Test)	57.070	66.903	47.834	47.877
Overidentification test	0.309	0.317	0.287	0.288

Note - All Regressions include state and time fixed effects and use the benchmark instruments. P-values in (parentheses) are clustered at the state level.
Column (1) - Marginal Cost: Discount rate $\beta = 0.95$,
Column (2) - Marginal Cost: Discount rate $\beta = 0.9$,
Column (3) - Marginal Cost: Labor Supply Elas $\varphi = 1/2$.
Column (4) - Marginal Cost: Labor Supply Elas $\varphi = 2$.

5.4 Nominal vs. Real Transfers

The theoretical analysis emphasized that nominal and not real transfer growth is a determinant of inflation. The results reported in Tables 1 and 2 confirmed the first part of this prediction for nominal transfers. To establish the second part, column (1) of Table 3 replaces nominal with real transfer growth, $T^{real}_{r,t-4} = T_{r,t-4} - \pi_{r,t-4}$ for regional inflation $\pi_{r,t-4}$, in the benchmark regression,[34]

$$\pi^N_{r,t} \quad = \quad \kappa E_t \sum_{k=0}^{K} \beta^k \hat{mc}^N_{r,t+k} + \Phi^{real} \Delta T^{real}_{r,t-4} + \gamma \pi^N_{r,t-4} + \alpha_r + \gamma_t + \epsilon_{rt} \qquad (36)$$

The estimated coefficient for real transfer growth is highly insignificant. All three specification tests fail. First, the null of no identification cannot be rejected. Second, the F-test yields a number below the threshold of 10 and thus cannot rule out weak identification.

[34]Note that the real transfer growth rate uses the total regional inflation rate, since this is the correct deflator in each region.

Third, the null that the instruments are valid is rejected.

Column (2) of Table 3 addresses the potential concern that nominal transfers are just a proxy for real marginal costs not captured through unemployment. The estimated coefficient for ΔT would then not be positive for the theoretical reasons explained in Section 3.2, but simply because marginal costs increase and thus inflation increases through the standard Phillips curve channel. If this were correct, the real value of transfers should then be the correct regressor. First, the Phillips curve relates real marginal costs and inflation, implying that real variables and not their nominal counterparts are the correct explanatory variables. Thus, according to this theory, real and not nominal transfers should be included. Second, the Phillips curve explains inflation through the current and future levels of real marginal costs and not through past growth rates. Thus, the theory would require that the current level of real transfers and not past growth rates be included. Note that column (1) already rejected the idea of including the past growth rate of real transfers. Column (2) therefore substitutes the real value of transfers for the nominal growth rate in the benchmark regression. The negative and highly insignificant coefficient shows that the level of transfers does not matter and that instead, the nominal growth rate is the relevant determinant of inflation and does not proxy for real marginal costs.

Table 3: REAL Demand Phillips Curve Estimates

	Real Transfer Growth	Real Transfer Level
	(1)	(2)
Real Transfer Growth	0.164	
	(0.938)	
Real Transfer Level		-39.075
		(0.454)
$\sum$ Marginal Cost	-0.023	0.180
	(0.292)	(0.508)
	Specification Tests	
Underidentification test	0.165	0.044
Weak Identification (F-Test)	7.474	0.547
Overidentification test	0.016	0.764

Note - All regressions include state and time fixed effects and use the benchmark instruments. P-values in (parentheses) are clustered at the state level. Real transfers are adjusted for state-specific (quarterly) seasonality and aggregate time effects. This adjustment has no bearing on the conclusions drawn from this table.
Column (1) - Benchmark with Real Demand Growth [instead of Nominal Demand Growth],
Column (2) - Benchmark with Real Demand (Level) [instead of Nominal Demand Growth],

5.5 Indexation and Aggregate Inflation Dynamics

Results based on aggregate US time series data typically find a sizeable and significant role for lagged inflation rates in determining the current inflation rate (see e.g. Gali et al., 2005, and further references therein). The interpretation of this result within New Keynesian DSGE models with Calvo pricing is that it reflects price indexation to the lagged inflation rate. Firms which cannot optimize their price due to the Calvo assumption, instead mechanically increase their price by the past inflation rate.

This paper suggests an alternative "omitted variable" interpretation of this finding. Nominal disposable income, nominal demand and nominal fiscal transfers are, on the one hand, partially driven by past price movements and on the other hand, drive current prices. The lagged inflation term captures this mechanism if nominal transfers are omitted from the empirical analysis. Prices are then only indirectly linked to past inflation rates. A higher past inflation rate is associated with higher nominal transfers and nominal wages, and thus with higher nominal demand, inducing firms to increase prices. Inflation is persistent, because the determinants are persistent, and not because of explicit price indexation. The results in Section 5.1 corroborate the alternative interpretation. In contrast to the time series evidence, the lagged inflation rate is an insignificant and small determinant of inflation in my panel regressions.

The empirical specification (33) in Section 4.1 includes time fixed effects, which could capture indexation to the U.S.-CPI or determinants of nominal demand like social security payments or personal income, which are not included in the regression. Consistent with the conjecture that time fixed effects could capture important aggregate dynamics, regressing non-tradable inflation $\pi^N_{r,t}$ on its own lagged and including state but not time fixed effects, yields a significant and sizeable coefficient of 0.451. However, adding the lagged U.S.-CPI inflation rate $\pi_{US,t}$ renders this coefficient on lagged non-tradable inflation small and insignificant (0.060), whereas lagged U.S.-CPI inflation is significant (coefficient 0.503).[35]

This motivates looking under the hood of the time fixed effects and investigating how they are related to lagged inflation, nominal income and transfers. Indeed, the first column of Table 4 shows a significant coefficient, 0.658, for a regression of the estimated time fixed effect $\hat{\gamma}_t$ on the lagged U.S.-CPI inflation rate. This finding is consistent with the empirical time-series literature and with the associated interpretation that prices are indexed to the lagged U.S. inflation rate. However, adding further determinants, lagged U.S. social security payments and lagged U.S. personal nominal income,[36] to the regression yields a small and insignificant coefficient on lagged inflation as column 2 of Table 4 shows.[37] The same conclusion is reached if a second and third lag of inflation are added to the regression, as columns (3)-(6) of Table 4 show.[38] This finding in turn supports the alternative hypothesis proposed in this paper, that inflation appears persistent due to the properties

[35]The U.S. inflation rate is derived from the quarterly seasonally adjusted Consumer Price Index for All Urban Consumers, CPIAUCSL, available at `https://fred.stlouisfed.org/series/CPIAUCSL`.

[36]Available at the BEA (SQINC35), `https://www.bea.gov/data/income-saving/personal-income-by-state`.

[37]Further adding survey of professional forecasters inflation expectations, available at `https://www.philadelphiafed.org/surveys-and-data/real-time-data-research/inflation-forecasts`, to this regression delivers a negative and insignificant coefficient for the lagged U.S.-CPI inflation rate. Consistent with the findings of a large literature on inflation expectations (Surveyed in Coibion et al., 2018), regressing $\hat{\gamma}_t$ on inflation expectations and lagged inflation yields a small and insignificant coefficient, 0.068, for lagged inflation.

[38]The third lag of inflation is significant with a p-value of 0.074 in column (6), but the sign is negative, in contrast to the indexation argument, which suggests a positive coefficient.

Table 4: Inflation Indexation and Nominal Income Growth

	1 LAG	1 LAG + Nom. Inc.	2 LAGS	2 LAGS + Nom. Inc.	3 LAGS	3 LAGS + Nom. Inc.
	(1)	(2)	(3)	(4)	(5)	(6)
Lag. Inflation, $\pi_{US,t-4}$	0.658	0.103	0.510	0.133	0.525	0.168
	(0.000)	(0.531)	(0.002)	(0.443)	(0.001)	(0.315)
Lag. Pers. Income gr.		0.284		0.305		0.309
		(0.017)		(0.012)		(0.012)
Lag. Social Security gr.		0.505		0.663		0.756
		(0.004)		(0.001)		(0.001)
2-Lag. Inflation, $\pi_{US,t-8}$			0.239	-0.250	0.263	-0.254
			(0.203)	(0.114)	(0.195)	(0.138)
3-Lag. Inflation, $\pi_{US,t-12}$					-0.077	-0.257
					(0.554)	(0.074)

Note - Lagged Nominal Personal Income Growth is $\log(T^{PC}_{t-4}) - \log(T^{PC}_{t-8})$, where T^{PC}_t is Period t (quarter) Nominal Personal Income from BEA (SQINC35). Lagged Nominal Social Security Growth is $\log(T^{SS}_{t-4}) - \log(T^{SS}_{t-8})$, where T^{SS}_t is Period t (quarter) Nominal Social Security Benefits from BEA (SQINC35). Robust p-values in parentheses.

of its determinants and not because of explicit indexation. Higher lagged social security payments and higher lagged personal income increase current nominal demand and thus induce higher inflation.

Note that using the estimated time effects of the panel regressions means that the contribution of marginal costs is already removed and thus, the regressions in Table 4 do not require controlling for marginal costs. This approach thus overcomes the difficulty of time-series approaches which have to simultaneously estimate the coefficients on lagged inflation and marginal costs, leading to (severe) identification problems (Mavroeidis et al., 2014). Similarly, the $\hat{\gamma}_t$ regressions do not require adding the same type of transfers already included in the panel regressions.

6 Concluding Remarks

This paper derives a nominal demand-augmented Phillips curve (NDPC) which explains inflation through real marginal cost (gaps), the sole determinant of inflation in the New Keynesian Phillips curve, and a new variable, nominal demand growth. I estimate the NDPC in the cross-section of U.S. states and corroborate the theoretical predictions. Both real marginal costs and nominal demand growth are significant determinants of inflation. Removing either real marginal costs or nominal demand from the estimated NDPC leads to a downward-biased estimate of the coefficient of the remaining variable. Adding nominal demand to the Phillips curve leads to a larger coefficient on real marginal costs, a steeper Phillips curve. Removing real marginal costs from the NDPC leads to a smaller coefficient on nominal demand. I also estimate that lagged inflation has only a small effect on current inflation, in contrast to a large literature using time series evidence, which finds this effect to be sizeable. This new finding is consistent with the theoretical model which suggests that inflation persistence is not due to explicit price indexation but caused by the persistence in the determinants of inflation such as nominal demand.

The NDPC can explain temporary and permanent high inflation rates during historical U.S. episodes or across countries through high nominal demand growth, without necessarily linking inflation to the size of the marginal cost gap or the unemployment rate. Taking into account that nominal fiscal policy is a driver of nominal demand, assigns a new role to fiscal policy in determining inflation. A fiscal stimulus leads to higher nominal demand, which through the NDPC, materializes in higher inflation rates. In particular, inflation can rise due to expansionary fiscal policy without large movements in the unemployment rate.

The paper thus offers a possible rationalization of the March 16 2022 Fed projections, which forecast unemployment rates of about 3.5% for the next few years, and at the same time, declining inflation rates. Viewed through the lens of my theory, some of the 2021/22 inflation increase was caused by the checks sent out by the Treasury in response to the Covid pandemic. Once the effects of this stimulus on nominal demand fade, and without further demand stimulus such as higher nominal wage growth or further fiscal transfers, inflation will start to fall. Consistent with my findings on the importance of fiscal stimulus for inflation, Di Giovanni et al. (2023), building on Di Giovanni et al. (2022) and Baqaee and Farhi (2022), show that aggregate demand accounts for about two-thirds whereas sectoral supply shocks account for only one-third of U.S. inflation observed during the 2020-21 episode.

More generally, the NDPC suggests rethinking fiscal and monetary policy. If inflation is elevated not because the economy is overheating and unemployment is too low, but because of expansionary fiscal policy, is increasing the nominal interest rate to cool down the economy, i.e. increase the unemployment rate, the best policy? The results in this paper suggest not.

Bibliography

Alvarez, F., M. Beraja, M. Gonzalez-Rozada, and P. A. Neumeyer (2019): "From hyperinflation to stable prices: Argentina's evidence on menu cost models," *The Quarterly Journal of Economics*, 134, 451–505.

Alvarez, F. and F. Lippi (2014): "Price Setting With Menu Cost for Multiproduct Firms," *Econometrica*, 82, 89–135.

Alvarez, F., F. Lippi, and J. Passadore (2017): "Are State- and Time-Dependent Models Really Different?" *NBER Macroeconomics Annual*, 31, 379–457.

Auclert, A., R. Rigato, M. Rognlie, and L. Straub (2022): "New Pricing Models, Same Old Phillips Curves?" mimeo.

Ball, L. and D. Romer (1991): "Sticky Prices as Coordination Failure," *The American Economic Review*, 81, 539–552.

Baqaee, D. and E. Farhi (2022): "Supply and demand in disaggregated Keynesian economies with an application to the covid-19 crisis," *American Economic Review*, 112, 1397–1436.

Bartik, T. J. (1991): *Who benefits from state and local economic development policies? Kalamazoo, MI: WE Upjohn Institute for Employment Research.*

Bellifemine, M., A. Couturier, and R. Jamilov (2022): "The Regional Keynesian Cross," Tech. rep., Working Paper.

Beraja, M., E. Hurst, and J. Ospina (2019): "The aggregate implications of regional business cycles," *Econometrica*, 87, 1789–1833.

Bilbiie, F. O. (2008): "Limited asset markets participation, monetary policy and (inverted) aggregate demand logic," *Journal of Economic Theory*, 140, 162 – 196.

——— (2017): "The New Keynesian Cross: Understanding Monetary Policy with Hand-to-Mouth Households," CEPR Discussion Paper No. 11989.

——— (2019): "Monetary Policy and Heterogeneity: An Analytical Framework," mimeo.

Blanco, A., C. Boar, C. Jones, and V. Midrigan (2022): "Nonlinear Inflation Dynamics in Menu Cost Economies," .

Borusyak, K. and X. Jaravel (2017): "Revisiting event study designs," *Available at SSRN 2826228*.

Borusyak, K., X. Jaravel, and J. Spiess (2021): "Revisiting event study designs: Robust and efficient estimation," *arXiv preprint arXiv:2108.12419*.

Broda, C. and J. A. Parker (2014): "The economic stimulus payments of 2008 and the aggregate demand for consumption," *Journal of Monetary Economics*, 68, S20–S36.

Caballero, R. J. and E. M. Engel (1993): "Heterogeneity and output fluctuations in a dynamic menu-cost economy," *The Review of Economic Studies*, 60, 95–119.

——— (2007): "Price stickiness in Ss models: New interpretations of old results," *Journal of Monetary Economics*, 54, 100–121, supplement issue: October 20-21 2006 Research Conference on 'Microeconomic Adjustment and Macroeconomic Dynamics' Sponsored by the Swiss National Bank (http://www.snb.ch) and Study Center Gerzensee (www.szgerzensee.ch).

Caplin, A. S. and D. F. Spulber (1987): "Menu costs and the neutrality of money," *The Quarterly Journal of Economics*, 102, 703–725.

Chodorow-Reich, G., P. T. Nenov, and A. Simsek (2021): "Stock market wealth and the real economy: A local labor market approach," *American Economic Review*, 111, 1613–57.

Coibion, O., Y. Gorodnichenko, and R. Kamdar (2018): "The formation of expectations, inflation, and the phillips curve," *Journal of Economic Literature*, 56, 1447–91.

Del Negro, M., A. Gleich, S. Goyal, A. Johnson, and A. Tambalotti (2022): "Drivers of Inflation: The New York Fed DSGE Model's Perspective," Federal Reserve Bank of New York Liberty Street Economics, March 1, 2022, https://libertystreeteconomics.newyorkfed.org/2022/03/drivers-of-inflation-the-new-york-fed-dsge-models-perspective/.

Di Giovanni, J., Ş. Kalemli-Özcan, A. Silva, and M. Yildirim (2022): "Global supply chain pressures, international trade, and inflation," Tech. rep., National Bureau of Economic Research.

——— (2023): "Quantifying the Inflationary Impact of Fiscal Stimulus under Supply Constraints," Working paper.

Dotsey, M., R. G. King, and A. L. Wolman (1999): "State-Dependent Pricing and the General Equilibrium Dynamics of Money and Output," *The Quarterly Journal of Economics*, 114, 655–690.

Fitzgerald, T. J., J. P. Nicolini, et al. (2014): *Is there a stable relationship between unemployment and future inflation?: Evidence from US cities*, Citeseer.

Fleck, J. (2021): "State Tax and Transfer Progressivity and the Household Consumption Response to Fiscal Stimulus," Working Paper.

Fleck, J., J. Heathcote, K. Storesletten, and G. L. Violante (2021): "Tax and Transfer Progressivity at the US State Level," Working Paper.

Galí, J. (2015): *Monetary Policy, Inflation, and the Business Cycle: An Introduction to the New Keynesian Framework and Its Applications, Second Edition*, Princeton University Press.

Gali, J., M. Gertler, and J. D. Lopez-Salido (2005): "Robustness of the estimates of the hybrid New Keynesian Phillips curve," *Journal of Monetary Economics*, 52, 1107–1118.

Gertler, M. and J. Leahy (2008): "A Phillips curve with an Ss foundation," *Journal of political Economy*, 116, 533–572.

Golosov, M., M. Graber, M. Mogstad, and D. Novgorodsky (2021): "How Americans Respond to Idiosyncratic and Exogenous Changes in Household Wealth and Unearned Income," .

Golosov, M. and R. E. Lucas (2007): "Menu costs and Phillips curves," *Journal of Political Economy*, 115, 171–199.

Hagedorn, M. (2016): "A Demand Theory of the Price Level," CEPR Discussion Paper No. 11364.

——— (2020): "Theory in HANK," mimeo, University of Oslo.

Hagedorn, M., J. Handbury, and I. Manovskii (2014): "Demand Stimulus and Inflation: Empirical Evidence," mimeo, University of Pennsylvania.

Hagedorn, M., K. Harmenberg, and K. Mitman (2022): "Menu costs, new Phillips curves and inflation persistence," mimeo.

Hagedorn, M., F. Karahan, I. Manovskii, and K. Mitman (2013): "Unemployment Benefits and Unemployment in the Great Recession: The Role of Macro Effects," NBER Working Papers 19499, National Bureau of Economic Research, Inc.

Hagedorn, M., I. Manovskii, and K. Mitman (2017): "The Fiscal Multiplier," Working Paper 25571, National Bureau of Economic Research.

Hazell, J., J. Herreño, E. Nakamura, and J. Steinsson (2021): "The Slope of the Phillips Curve: Evidence from U.S. States," Forthcoming quarterly journal of economics.

Hooper, P., F. S. Mishkin, and A. Sufi (2019): "Prospects for Inflation in a High Pressure Economy: Is the Phillips Curve Dead or is It Just Hibernating?" Working Paper 25792, National Bureau of Economic Research.

Klenow, P. J. and O. Kryvtsov (2008): "State-dependent or time-dependent pricing: Does it matter for recent US inflation?" *The Quarterly Journal of Economics*, 123, 863–904.

Mavroeidis, S., M. Plagborg-Møller, and J. H. Stock (2014): "Empirical Evidence on Inflation Expectations in the New Keynesian Phillips Curve," *Journal of Economic Literature*, 52, 124–88.

McLeay, M. and S. Tenreyro (2020): "Optimal inflation and the identification of the Phillips curve," *NBER Macroeconomics Annual*, 34, 199–255.

Midrigan, V. (2011): "Menu costs, multiproduct firms, and aggregate fluctuations," *Econometrica*, 79, 1139–1180.

Nakamura, E. and J. Steinsson (2008): "Five facts about prices: A reevaluation of menu cost models," *The Quarterly Journal of Economics*, 123, 1415–1464.

——— (2014): "Fiscal stimulus in a monetary union: Evidence from US regions," *American Economic Review*, 104, 753–92.

Obstfeld, M. and K. Rogoff (1983): "Speculative Hyperinflations in Maximizing Models: Can We Rule Them Out?" *Journal of Political Economy*, 91, 675–687.

——— (2017): "Revisiting Speculative Hyperinflations in Monetary Models," Working paper, London, Centre for Economic Policy Research.

Orchard, J., V. A. Ramey, and J. Wieland (2022): "Micro MPCs and Macro Counterfactuals: The Case of the 2008 Rebates," Tech. rep., Working Paper.

Parker, J. A., N. S. Souleles, D. S. Johnson, and R. McClelland (2013): "Consumer spending and the economic stimulus payments of 2008," *American Economic Review*, 103, 2530–53.

Reis, R. (2021): "Losing the inflation anchor," CEPR Discussion Papers 16664, C.E.P.R. Discussion Papers.

Romer, C. D. (2007): "Macroeconomic policy in the 1960s: The causes and consequences of a mistaken revolution," in *Lyndon B. Johnson Presidential Library, Economic History Association Annual Meeting*, Citeseer, vol. 7.

Rubbo, E. (2020): "Networks, Phillips Curves and Monetary Policy," Working paper.

Stroebel, J. and J. Vavra (2019): "House prices, local demand, and retail prices," *Journal of Political Economy*, 127, 1391–1436.

Werning, I. (2015): "Incomplete Markets and Aggregate Demand," Working paper.

Woodford, M. (2003): *Interest and Prices: Foundations of a Theory of Monetary Policy*, Princeton: Princeton University Press.

APPENDIX

A Theoretical Appendix

A.1 Nominal Demand Phillips Curve: Inflation Dynamics

The log-linearization of equation (5)

$$\Pi_t^{1-\epsilon} - 1 = \int_0^1 [\Big(\frac{p_t^*(i)}{P_{t-1}}\Big)^{1-\epsilon} - \Big(\frac{p_{t-1}(i)}{P_{t-1}}\Big)^{1-\epsilon}]\Lambda(p_{t-1}(i), P_t, D_t)di$$

for the one period model still holds in the infinite horizon case and yields equation (6) in the main text:

$$\pi_t = (\hat{p}_t^* - \hat{P}_{t-1})\underbrace{\int_0^1 \Lambda(p_{t-1}(i), P_{t-1}, D_{t-1})di}_{=\bar{\Lambda}} + \underbrace{\int_0^1 \frac{1-\tilde{p}_{t-1}(i)^{1-\epsilon}}{1-\epsilon}\hat{\Lambda}(i)di}_{=\phi_t} \quad \text{(A1)}$$

$$= (\hat{p}_t^* - \hat{P}_{t-1})\bar{\Lambda} + \phi_t. \quad \text{(A2)}$$

The optimal price setting has to take into account future expected marginal costs. It holds using the optimal price derivation in Dotsey et al. (1999), $\pi_{t+k} = \hat{P}_{t+k} - \hat{P}_{t-1}$, $\lambda_{1,t} = 1 - \bar{\Lambda}$, since all firms in a steady state charge the same (optimal) price and $\frac{\lambda_{k,t}}{\lambda_{1,t}} = \lambda_{k-1,t+1}$:

$$\begin{aligned}
(\hat{p}_t^* - \hat{P}_{t-1}) &= \Xi E_t \sum_{k=0}^{\infty} \beta^k \lambda_{k,t} [\hat{mc}_{t+k} + (\hat{P}_{t+k} - \hat{P}_{t-1})] \\
&= \Xi E_t \sum_{k=0}^{\infty} \beta^k \lambda_{k,t} \hat{mc}_{t+k} + E_t \sum_{k=0}^{\infty} \beta^k \lambda_{k,t} E_t \pi_{t+k} \\
&= \Xi \hat{mc}_t + \pi_t + \Xi E_t \sum_{k=1}^{\infty} \beta^k \lambda_{k,t} \hat{mc}_{t+k} + E_t \sum_{k=1}^{\infty} \beta^k \lambda_{k,t} E_t \pi_{t+k} \\
&= \Xi \hat{mc}_t + \pi_t + \Xi \lambda_{1,t} E_t \sum_{k=1}^{\infty} \beta^k \frac{\lambda_{k,t}}{\lambda_{1,t}} \hat{mc}_{t+k} + \lambda_{1,t} E_t \sum_{k=1}^{\infty} \beta^k \frac{\lambda_{k,t}}{\lambda_{1,t}} E_t \pi_{t+k} \\
&= \Xi \hat{mc}_t + \pi_t + \Xi (1 - \bar{\Lambda}) E_t \sum_{k=1}^{\infty} \beta^k \lambda_{k-1,t+1} \hat{mc}_{t+k} + (1 - \bar{\Lambda}) E_t \sum_{k=1}^{\infty} \beta^k \lambda_{k-1,t+1} E_t \pi_{t+k} \\
&= \Xi \hat{mc}_t + \pi_t + \Xi (1 - \bar{\Lambda}) \beta E_t \sum_{k=0}^{\infty} \beta^k \lambda_{k,t+1} \hat{mc}_{t+1+k} + (1 - \bar{\Lambda}) \beta E_t \sum_{k=0}^{\infty} \beta^k \lambda_{k,t+1} E_t \pi_{t+1+k} \\
&= \Xi \hat{mc}_t + \pi_t + (1 - \bar{\Lambda}) \beta (\hat{p}_{t+1}^* - \hat{P}_t) \\
&= \Xi \hat{mc}_t + \pi_t + (1 - \bar{\Lambda}) \beta \frac{\pi_{t+1} - \phi_{t+1}}{\bar{\Lambda}}.
\end{aligned}$$

Thus

$$\begin{aligned}
\pi_t &= \bar{\Lambda}(\hat{p}_t^* - \hat{P}_{t-1}) + \phi_t \\
&= \bar{\Lambda}[\Xi \hat{mc}_t + \pi_t + (1 - \bar{\Lambda}) \beta \frac{\pi_{t+1} - \phi_{t+1}}{\bar{\Lambda}}] + \phi_t
\end{aligned}$$

and solving for π_t:

$$\pi_t = \frac{\bar{\Lambda}\ \Xi}{1 - \bar{\Lambda}} \hat{mc}_t + \beta(\pi_{t+1} - \phi_{t+1}) + \frac{1}{1 - \bar{\Lambda}} \phi_t.$$

Recursively substituting for $\pi_{t+1}, \pi_{t+2}, \ldots$ yields

$$\begin{aligned}
\pi_t &= \frac{\bar{\Lambda}\ \Xi}{1 - \bar{\Lambda}} \hat{mc}_t + \beta(\pi_{t+1} - \phi_{t+1}) + \frac{1}{1 - \bar{\Lambda}} \phi_t \\
&= \frac{\bar{\Lambda}\ \Xi}{1 - \bar{\Lambda}} (\hat{mc}_t + \beta \hat{mc}_{t+1}) + \beta^2 (\pi_{t+2} - \phi_{t+2}) + \frac{\beta \bar{\Lambda}}{1 - \bar{\Lambda}} \phi_{t+1} + \frac{1}{1 - \bar{\Lambda}} \phi_t \\
&= \ldots \qquad \ldots \\
&= \frac{\bar{\Lambda}\ \Xi}{1 - \bar{\Lambda}} \sum_{k=0}^{\infty} \beta^k \hat{mc}_{t+k} + \frac{1}{1 - \bar{\Lambda}} \phi_t + \frac{\beta \bar{\Lambda}}{1 - \bar{\Lambda}} \sum_{k=1}^{\infty} \beta^k \phi_{t+k}.
\end{aligned}$$

Properties of Extensive Margin / Selection component ϕ_t

Equation (6) defines

$$\phi_t = \int_0^1 \frac{1-\tilde{p}_{t-1}(i)^{1-\epsilon}}{1-\epsilon}\hat{\Lambda}(i)di,$$

where $\tilde{p}_{t-1}(i) = \frac{p_{t-1}(i)}{P_{t-1}}$ is the relative Period $t-1$ price of firm i and $\hat{\Lambda}(i) = \Lambda(p_{t-1}(i), P_t, D_t) - \Lambda(p_{t-1}(i), P_{t-1}, D_{t-1})$ is the change in the adjustment probability, which depends on the change in the aggregate price level and in nominal demand.

I now show that $\hat{\Lambda}(i)$ is increasing in $D_t - D_{t-1}$ and decreasing in $P_t - P_{t-1}$ if $\tilde{p}_{t-1}(i) < 1$ and decreasing in $D_t - D_{t-1}$ and increasing in $P_t - P_{t-1}$ if $\tilde{p}_{t-1}(i) > 1$. This implies that ϕ_t is increasing in $D_t - D_{t-1}$ and decreasing in $P_t - P_{t-1}$ since

$$\begin{aligned}\phi_t &= \int_{\{i|\tilde{p}_{t-1}(i)<1\}} \frac{1-\tilde{p}_{t-1}(i)^{1-\epsilon}}{1-\epsilon}[\Lambda(p_{t-1}(i), P_{t-1}, D_t) - \Lambda(p_{t-1}(i), P_{t-1}, D_{t-1})]di \\ &+ \int_{\{i|\tilde{p}_{t-1}(i)>1\}} \frac{1-\tilde{p}_{t-1}(i)^{1-\epsilon}}{1-\epsilon}[\Lambda(p_{t-1}(i), P_{t-1}, D_t) - \Lambda(p_{t-1}(i), P_{t-1}, D_{t-1})]di\end{aligned}$$

and the integrands in both ingtegrals are positive. Similarly, for price changes

$$\begin{aligned}\phi_t &= \int_{\{i|\tilde{p}_{t-1}(i)<1\}} \frac{1-\tilde{p}_{t-1}(i)^{1-\epsilon}}{1-\epsilon}[\Lambda(p_{t-1}(i), P_t, D_{t-1}) - \Lambda(p_{t-1}(i), P_{t-1}, D_{t-1})]di \\ &+ \int_{\{i|\tilde{p}_{t-1}(i)>1\}} \frac{1-\tilde{p}_{t-1}(i)^{1-\epsilon}}{1-\epsilon}[\Lambda(p_{t-1}(i), P_t, D_{t-1}) - \Lambda(p_{t-1}(i), P_{t-1}, D_{t-1})]di\end{aligned}$$

the integrands in both integrals are negative.

$\hat{\Lambda}(i)$ and $D_t - D_{t-1}$:

Real profits of a firm setting price $\hat{p}$ are

$$\Gamma^{real}(\hat{p}, P, Y) = \big(\frac{\hat{p}}{P}\big)^{1-\epsilon} Y - mc(Y)Y\big(\frac{\hat{p}}{P}\big)^{-\epsilon}.$$

This firm adjusts the price from $\hat{p}$ to the optimal price p^* if

$$\Gamma^{real}(\hat{p}, P, Y) \leq \Gamma^{real}(p^*, P, Y) - \xi,$$

so that the probability of adjusting before knowing the realization of ξ equals

$$\Lambda = \Upsilon\Big(\Gamma^{real}(p^*, P, Y) - \Gamma^{real}(\hat{p}, P, Y)\Big),$$

implying that this probability increases iff $\Gamma^{real}(p^*, P, Y) - \Gamma^{real}(\hat{p}, P, Y)$ increases.

The derivative with respect to real demand Y, using $\frac{\partial \Gamma^{real}(p^*,P,Y)}{\partial p} = 0$,

$$\begin{aligned}
&\frac{\partial[\Gamma^{real}(p^*,P,Y) - \Gamma^{real}(\hat{p},P,Y)]}{\partial Y} \\
= \quad & \frac{\Gamma^{real}(p^*,P,Y) - \Gamma^{real}(\hat{p},P,Y)}{Y} - \frac{\partial mc(Y)}{\partial Y} Y[(\frac{p^*}{P})^{-\epsilon} - (\frac{\hat{p}}{P})^{-\epsilon}],
\end{aligned}$$

which shows for $\hat{p} < p^*$ that

$$\frac{\partial[\Gamma^{real}(p^*,P,Y) - \Gamma^{real}(\hat{p},P,Y)]}{\partial Y} > 0.$$

If $\hat{p} > p^*$, further derivations are needed:

$$\begin{aligned}
&\frac{\partial[\Gamma^{real}(p^*,P,Y) - \Gamma^{real}(\hat{p},P,Y)]}{\partial Y} \\
= \quad & [(\frac{p^*}{P})^{-\epsilon} - (\frac{\hat{p}}{P})^{-\epsilon}][-mc(Y) - \frac{\partial mc(Y)}{\partial Y} Y] + [(\frac{p^*}{P})^{1-\epsilon} - (\frac{\hat{p}}{P})^{1-\epsilon}] \\
= \quad & [(\frac{\hat{p}}{P})^{-\epsilon} - (\frac{p^*}{P})^{-\epsilon}] mc(Y)[1 + \epsilon_{mc(Y),Y}] - [(\frac{\hat{p}}{P})^{1-\epsilon} - (\frac{p^*}{P})^{1-\epsilon}] \\
= \quad & \frac{p^*}{P}[(\frac{\hat{p}}{P})^{-\epsilon} - (\frac{p^*}{P})^{-\epsilon}]\frac{1}{\mathcal{M}}[1 + \epsilon_{mc(Y),Y}] - [(\frac{\hat{p}}{P})^{1-\epsilon} - (\frac{p^*}{P})^{1-\epsilon}],
\end{aligned}$$

where the last line uses $mc(Y) = \frac{p^*}{\mathcal{M}P}$ for the mark-up $\mathcal{M}$.

Since $\hat{p} > p^*$

$$\frac{p^*}{P}[(\frac{\hat{p}}{P})^{-\epsilon} - (\frac{p^*}{P})^{-\epsilon}] = \frac{p^*}{P}(\frac{\hat{p}}{P})^{-\epsilon} - (\frac{p^*}{P})^{1-\epsilon} \leq (\frac{\hat{p}}{P})^{1-\epsilon} - (\frac{p^*}{P})^{1-\epsilon} < 0,$$

so that

$$\frac{\partial \Gamma^{real}(p^*,P,Y) - \Gamma^{real}(\hat{p},P,Y)}{\partial Y} \leq \frac{p^*}{P}[(\frac{\hat{p}}{P})^{-\epsilon} - (\frac{p^*}{P})^{-\epsilon}][\frac{1}{\mathcal{M}} + \frac{\epsilon_{mc(Y),Y}}{\mathcal{M}} - 1] < 0,$$

if $[\frac{1}{\mathcal{M}} + \frac{\epsilon_{mc(Y),Y}}{\mathcal{M}} - 1] > 0$ or equivalently $\epsilon_{mc(Y),Y} \geq \mathcal{M} - 1$.

Finally, for not necessarily small output changes, $Y_1 > Y_0$,

$$\begin{aligned}
&[\Gamma^{real}(p^*,P,Y_1) - \Gamma^{real}(\hat{p},P,Y_1)] - [\Gamma^{real}(p^*,P,Y_0) - \Gamma^{real}(\hat{p},P,Y_0)] \\
= \quad & \int_{Y_0}^{Y_1} \frac{\partial \Gamma^{real}(p^*(Y),P,Y) - \Gamma^{real}(\hat{p},P,Y)}{\partial Y} dY \quad \begin{cases} > 0 & \text{if } \hat{p} < p^* \\ = 0 & \text{if } \hat{p} = p^* \\ < 0 & \text{if } \hat{p} > p^* \end{cases}
\end{aligned}$$

Since real demand $Y = \frac{D}{P}$ and thus $\frac{\partial Y}{\partial D} = \frac{1}{P} > 0$, we have shown that for $D_t > D_{t-1}$

with $D_t - D_{t-1}$ not necessarily small,

$$\Lambda(p_{t-1}(i), P_{t-1}, D_t) - \Lambda(p_{t-1}(i), P_{t-1}, D_{t-1}) \quad \begin{cases} > 0 & \text{if } \hat{p} < p^*_{t-1} \\ = 0 & \text{if } \hat{p} = p^*_{t-1} \\ < 0 & \text{if } \hat{p} > p^*_{t-1} \end{cases}$$

implying that

$$\frac{1 - \tilde{p}_{t-1}(i)^{1-\epsilon}}{1-\epsilon}[\Lambda(p_{t-1}(i), P_{t-1}, D_t) - \Lambda(p_{t-1}(i), P_{t-1}, D_{t-1})] > 0$$

and thus

$$\phi_t > 0$$

in response to an increase in nominal demand D given the aggregate price level P_{t-1}.

$\hat{\Lambda}(i)$ and $P_t - P_{t-1}$:

Next, I consider the response of ϕ_t to an increase in the aggregate price level from P_{t-1} to P_t. Again, the response of $\Gamma^{real}(p^*, P, Y) - \Gamma^{real}(\hat{p}, P, Y)$ to a change in P needs to be computed. Rewriting this difference in profits, using $mc(Y) = \frac{p^*}{P\mathcal{M}}$ and $\mathcal{M} = \frac{\epsilon}{\epsilon - 1}$

$$\begin{aligned} & \Gamma^{real}(p^*, P, Y) - \Gamma^{real}(\hat{p}, P, Y) \\ = \; & \big((p^*)^{1-\epsilon} - (\hat{p})^{1-\epsilon}\big)P^{\epsilon-1}Y - \big((p^*)^{-\epsilon} - (\hat{p})^{-\epsilon}\big)\frac{\epsilon - 1}{\epsilon}P^{\epsilon-1}Yp^*. \end{aligned}$$

Taking the derivative with respect to P using that $\frac{\partial\Gamma^{real}(p^*,P,Y)}{\partial p} = 0$,

$$\begin{aligned} & \frac{\partial\Gamma^{real}(p^*, P, Y) - \Gamma^{real}(\hat{p}, P, Y)}{\partial P} \\ = \; & -\frac{\partial p^*}{\partial P}\big((p^*)^{-\epsilon} - (\hat{p})^{-\epsilon}\big)\frac{\epsilon-1}{\epsilon}P^{\epsilon-1}Y \\ + \; & [(\epsilon - 1)P^{\epsilon-2}Y + P^{\epsilon-1}\frac{\partial Y}{\partial P}]\Big[\big((p^*)^{1-\epsilon} - (\hat{p})^{1-\epsilon}\big) - p^*\big((p^*)^{-\epsilon} - (\hat{p})^{-\epsilon}\big)\frac{\epsilon-1}{\epsilon}\Big] \end{aligned}$$

Using that $\Gamma^{real}(p^*, P, Y) - \Gamma^{real}(\hat{p}, P, Y)$ is proportional to

$$\Big[\big((p^*)^{1-\epsilon} - (\hat{p})^{1-\epsilon}\big) - p^*\big((p^*)^{-\epsilon} - (\hat{p})^{-\epsilon}\big)\frac{\epsilon-1}{\epsilon}\Big] > 0$$

and that, using $\frac{\partial p^*}{\partial P} < 0$ since $\epsilon_{mc(Y),Y} > 1$ and $Y = \frac{D}{P}$,

$$-\frac{\partial p^*}{\partial P}\big((p^*)^{-\epsilon} - (\hat{p})^{-\epsilon}\big) \begin{cases} < 0 & \text{if } \hat{p} < p^* \\ = 0 & \text{if } \hat{p} = p^* \\ > 0 & \text{if } \hat{p} > p^* \end{cases}$$

<u>It follows for $\hat{p} < p^*$:</u>

$$\begin{aligned} & \frac{\partial \Gamma^{real}(p^*, P, Y) - \Gamma^{real}(\hat{p}, P, Y)}{\partial P} \\ \leq \;& \epsilon_{p^*,P}\big((\hat{p})^{-\epsilon} - (p^*)^{-\epsilon}\big)\frac{\epsilon - 1}{\epsilon}P^{\epsilon-2}p^*Y \\ + \;& [(\epsilon - 1)P^{\epsilon-2}Y]\Big[\big((p^*)^{1-\epsilon} - (\hat{p})^{1-\epsilon}\big) - p^*\big((p^*)^{-\epsilon} - (\hat{p})^{-\epsilon}\big)\frac{\epsilon - 1}{\epsilon}\Big] \\ \leq \;& \big((\hat{p})^{-\epsilon} - (p^*)^{-\epsilon}\big)\frac{\epsilon - 1}{\epsilon}P^{\epsilon-2}p^*Y[\epsilon_{p^*,P} + (\epsilon - 1)(1 - \underline{p})] \leq 0, \end{aligned}$$

since

$$\epsilon_{p^*,P} = 1 - \epsilon_{mc(Y),Y} \quad \text{and} \quad \epsilon_{mc(Y),Y} \geq 1 + (\epsilon - 1)(1 - \underline{p})$$

and

$$\begin{aligned} & \frac{\hat{p}}{p^*}\Big(p^*(\hat{p}^{-\epsilon} - (p^*)^{-\epsilon})\Big) = \hat{p}^{1-\epsilon} - \hat{p}(p^*)^{-\epsilon} \\ = \;& \hat{p}^{1-\epsilon} - (p^*)^{1-\epsilon} + (p^* - \hat{p})(p^*)^{-\epsilon} \leq \hat{p}^{1-\epsilon} - (p^*)^{1-\epsilon} + \int_{\hat{p}}^{p^*} p^{-\epsilon}dp \\ = \;& \hat{p}^{1-\epsilon} - (p^*)^{1-\epsilon} + \frac{(p^*)^{1-\epsilon} - \hat{p}^{1-\epsilon}}{1 - \epsilon} = [\hat{p}^{1-\epsilon} - (p^*)^{1-\epsilon}](1 - \frac{1}{1 - \epsilon}) \\ = \;& [\hat{p}^{1-\epsilon} - (p^*)^{1-\epsilon}]\frac{\epsilon}{\epsilon - 1}, \end{aligned}$$

implying, using $\frac{\hat{p}}{p^*} \geq \underline{p}$ since $\hat{p} \in [\underline{p} \cdot p^*, \bar{p} \cdot p^*]$ and thus $((p^*)^{-\epsilon} - (\hat{p})^{-\epsilon})\frac{\hat{p}}{p^*} \leq ((p^*)^{-\epsilon} - (\hat{p})^{-\epsilon})\underline{p}$,

$$(p^*)^{1-\epsilon} - \hat{p}^{1-\epsilon} \leq p^*((p^*)^{-\epsilon} - (\hat{p})^{-\epsilon})\frac{\epsilon - 1}{\epsilon}\frac{\hat{p}}{p^*} \leq p^*((p^*)^{-\epsilon} - (\hat{p})^{-\epsilon})\frac{\epsilon - 1}{\epsilon}\underline{p}.$$

For $\hat{p} > p^*$:

$$
\begin{aligned}
& \frac{\partial \Gamma^{real}(p^*, P, Y) - \Gamma^{real}(\hat{p}, P, Y)}{\partial P} \\
\geq \;& \epsilon_{p^*,P}\big((\hat{p})^{-\epsilon} - (p^*)^{-\epsilon}\big)\frac{\epsilon-1}{\epsilon}P^{\epsilon-2}p^*Y \\
+ \;& [P^{\epsilon-1}\frac{\partial Y}{\partial P}]\Big[\big((p^*)^{1-\epsilon} - (\hat{p})^{1-\epsilon}\big) - p^*\big((p^*)^{-\epsilon} - (\hat{p})^{-\epsilon}\big)\frac{\epsilon-1}{\epsilon}\Big] \\
\geq \;& \epsilon_{p^*,P}\big((\hat{p})^{-\epsilon} - (p^*)^{-\epsilon}\big)\frac{\epsilon-1}{\epsilon}P^{\epsilon-2}p^*Y \\
+ \;& [P^{\epsilon-2}\epsilon_{Y,P}Y\frac{\epsilon-1}{\epsilon}]\Big[p^*\big((p^*)^{-\epsilon} - (\hat{p})^{-\epsilon}\big)(\bar{p}-1)\Big] \\
= \;& [P^{\epsilon-2}Yp^*\frac{\epsilon-1}{\epsilon}]\Big[\big((p^*)^{-\epsilon} - (\hat{p})^{-\epsilon}\big)\Big][(\bar{p}-1)\epsilon_{Y,P} - \epsilon_{p^*,P}] \\
= \;& [P^{\epsilon-2}Yp^*\frac{\epsilon-1}{\epsilon}]\Big[\big((p^*)^{-\epsilon} - (\hat{p})^{-\epsilon}\big)\Big][1 - \bar{p} - \epsilon_{p^*,P}] \\
\geq \;& 0.
\end{aligned}
$$

since

$$
\epsilon_{p^*,P} = 1 - \epsilon_{mc(Y),Y}, \quad \epsilon_{Y,P} = -1 \quad \text{and} \quad \epsilon_{mc(Y),Y} \geq \bar{p}
$$

and

$$
\begin{aligned}
& \frac{\hat{p}}{p^*}p^*\Big((p^*)^{-\epsilon} - (\hat{p}^{-\epsilon})\Big) = \hat{p}(p^*)^{-\epsilon} - \hat{p}^{1-\epsilon} \\
= \;& (p^*)^{1-\epsilon} - \hat{p}^{1-\epsilon} + (\hat{p} - p^*)(p^*)^{-\epsilon} \geq (p^*)^{1-\epsilon} - \hat{p}^{1-\epsilon} + \int_{p^*}^{\hat{p}} p^{-\epsilon}dp \\
\geq \;& (p^*)^{1-\epsilon} - \hat{p}^{1-\epsilon} + \frac{(\hat{p})^{1-\epsilon} - (p^*)^{1-\epsilon}}{1-\epsilon} \\
= \;& ((p^*)^{1-\epsilon} - \tilde{p}^{1-\epsilon})(1 - \frac{1}{1-\epsilon}) = ((p^*)^{1-\epsilon} - \tilde{p}^{1-\epsilon})\frac{\epsilon}{\epsilon-1},
\end{aligned}
$$

implying

$$
\frac{(p^*)^{1-\epsilon} - \hat{p}^{1-\epsilon}}{p^*((p^*)^{-\epsilon} - (\hat{p}^{-\epsilon}))\frac{\epsilon-1}{\epsilon}} \leq \frac{\hat{p}}{p^*} \leq \bar{p}
$$

We thus obtain for $P_1 > P_0$,

$$\begin{aligned}
&[\Gamma^{real}(p^*, P_1, Y) - \Gamma^{real}(\hat{p}, P_1, Y)] - [\Gamma^{real}(p^*, P_0, Y) - \Gamma^{real}(\hat{p}, P_0, Y)] \\
= \quad & \int_{P_0}^{P_1} \frac{\partial \Gamma^{real}(p^*(P), P, Y) - \Gamma^{real}(\hat{p}, P, Y)}{\partial P} dP \quad \begin{cases} < 0 & \text{if } \hat{p} < p^* \\ = 0 & \text{if } \hat{p} = p^* \\ > 0 & \text{if } \hat{p} > p^* \end{cases}
\end{aligned}$$

We have thus shown that for $P_t > P_{t-1}$ with $P_t - P_{t-1}$ not necessarily small,

$$\Lambda(p_{t-1}(i), P_t, D_{t-1}) - \Lambda(p_{t-1}(i), P_{t-1}, D_{t-1}) \quad \begin{cases} < 0 & \text{if } \hat{p} < p^*_{t-1} \\ = 0 & \text{if } \hat{p} = p^*_{t-1} \\ > 0 & \text{if } \hat{p} > p^*_{t-1} \end{cases}$$

ϕ , D and P

The selection term ϕ_t is a function of D_t and P_t. The previous analysis shows that it depends postively on $D_t - D_{t-1}$ and negatively on $P_t - P_{t-1}$,

$$\phi_t(\underset{(+)}{D_t - D_{t-1}}, \underset{(-)}{P_t - P_{t-1}}).$$

A change in demand $D_t - D_{t-1}$ has a direct positive effect and an indirect effect through inflation. To sign the total effect, note first that $\pi_t \geq 0$. Suppose in contrast that $\pi_t < 0$. This is a contradiction, since $D_t - D_{t-1} > 0$ and $P_t - P_{t-1} \leq 0$ would imply that both $\hat{mc}_t > 0$ and $\Delta\phi_t > 0$ and thus $\pi_t \geq 0$.

Now suppose that $\Delta\phi_t < 0$. Since $\pi_t \geq 0$ assuming $\Delta\phi_t < 0$ requires $\hat{mc}_t > 0$ and thus $\hat{Y}_t > 0$. Furthermore, since $\epsilon_{p^*,P}\big|_{Y fixed} = 1$, the previous derivations show that for ϕ written as a function of Y and P,

$$\phi_t(\underset{(+)}{Y_t - Y_{t-1}}, \underset{(+)}{P_t - P_{t-1}}),$$

so that ϕ_t does not decrease, which is a contradiction.[39]

Infinite Horizon

[39]Note that it is possible that for small demand increases, no firm decides to adjust its price and thus $\pi_t = 0$ and $\Delta\phi_t = 0$.

The aggregate price dynamics are described for $k \in \mathbb{N}_0$ by

$$\Pi_{t+k}^{1-\epsilon} - 1 = \frac{P_{t+k}^{1-\epsilon} - P_{t+k-1}^{1-\epsilon}}{P_{t+k-1}^{1-\epsilon}} \tag{A3}$$

$$= \frac{\left[\int_0^1 \left\{p_{t+k}^*(i)^{1-\epsilon}\Lambda(p_{t+k-1}(i), P_{t+k}, D_{t+k}) + p_{t+k-1}(i)^{1-\epsilon}(1 - \Lambda(p_{t+k-1}(i), P_{t+k}, D_{t+k}))\right\}di\right]}{P_{t+k-1}^{1-\epsilon}}$$

$$- \frac{\int_0^1 p_{t+k-1}(i)^{1-\epsilon}di}{P_{t+k-1}^{1-\epsilon}}$$

$$= \frac{\left[\int_0^1 [p_{t+k}^*(i)^{1-\epsilon} - p_{t+k-1}(i)^{1-\epsilon}]\Lambda(p_{t+k-1}(i), P_{t+k}, D_{t+k})di\right.}{P_{t+k-1}^{1-\epsilon}}$$

$$= \int_0^1 [\Big(\frac{p_{t+k}^*(i)}{P_{t+k-1}}\Big)^{1-\epsilon} - \Big(\frac{p_{t+k-1}(i)}{P_{t+k-1}}\Big)^{1-\epsilon}]\Lambda(p_{t+k-1}(i), P_{t+k}, D_{t+k})di.$$

Following the same steps shows that linearizing around Period $t-1$ values,

$$\pi_{t+k} = (\hat{p}_{t+k}^* - \hat{P}_{t+k-1}) \underbrace{\int_0^1 \Lambda(p_{t-1}(i), P_{t-1}, D_{t-1})di}_{=:\bar{\Lambda}} + \underbrace{\int_0^1 \frac{1 - \tilde{p}_{t+k-1}(i)^{1-\epsilon}}{1-\epsilon}\hat{\Lambda}_{t+k}(i)di}_{=:\phi_{t+k}}, \tag{A4}$$

where the functions are evaluated at $(p_{t-1}^*, P_{t-1}, D_{t-1})$, so that $\Big(\frac{p_{t+k}^*(i)}{P_{t+k-1}}\Big)^{1-\epsilon}$ is evaluated at $\Big(\frac{p_{t-1}^*(i)}{P_{t-1}}\Big)^{1-\epsilon} = 1$ and $\Big(\frac{p_{t+k-1}(i)}{P_{t+k-1}}\Big)^{1-\epsilon}$ is evaluated at $\tilde{p}_{t+k-1}(i) = \frac{p_{t+k-1}(i)}{P_{t-1}}$ and $\hat{\Lambda}_{t+k}(i) = \Lambda(p_{t+k-1}(i), P_{t+k}, D_{t+k}) - \Lambda(p_{t+k-1}(i), P_{t-1}, D_{t-1})$. In particular,

$$\frac{1 - \tilde{p}_{t+k-1}(i)^{1-\epsilon}}{1-\epsilon} > 0 \Leftrightarrow p_{t+k-1}(i) < p_{t-1}^* = P_{t-1} \Leftrightarrow \hat{\Lambda}_{t+k}(i) > 0$$

and

$$\frac{1 - \tilde{p}_{t+k-1}(i)^{1-\epsilon}}{1-\epsilon} < 0 \Leftrightarrow p_{t+k-1}(i) > p_{t-1}^* = P_{t-1} \Leftrightarrow \hat{\Lambda}_{t+k}(i) < 0$$

showing that the reasoning is the same for all periods $t+k-1$, since $\hat{\Lambda}$ is evaluated at Period $t-1$ steady-state values as in the one period model above and the only Period $t+k-1$ variable is $p_{t+k-1}(i)$.

To determine the properties of Φ_t and ϕ_{t+k}, we can apply the same arguments as above, since we can basically substitute the value function $\bar{V}^{real}$ for Γ^{real}, where $\bar{V}^{real}$ satisfies

$$\bar{V}^{real}(p_t, P_t, D_t) = \Gamma^{real}(p_t, P_t, D_t) + \beta E_t V^{real}(p_t, P_{t+1}, D_{t+1}). \tag{A5}$$

and

$$V^{real}(p_{t-1}, P_t, D_t) = \max\{\bar{V}^{real}(p_t^*, P_t, D_t) - \xi, \bar{V}^{real}(p_{t-1}, P_t, D_t)\}. \tag{A6}$$

A firm in Period $t+k$ adjusts the price from $\hat{p}$ to the optimal price p^* if

$$\bar{V}^{real}(\hat{p}, P, Y) \leq \bar{V}^{real}(p^*, P, Y) - \xi,$$

so that the probability of adjusting before knowing the realization of ξ equals

$$\Lambda(\hat{p}, P, D) = \Upsilon\Big(\bar{V}^{real}(p^*, P, D) - \bar{V}^{real}(\hat{p}, P, D)\Big),$$

implying that this probability increases iff $\bar{V}^{real}(p^*, P, D) - \bar{V}^{real}(\hat{p}, P, D)$ increases. Since I consider perfect foresight MIT shocks, I drop the expectation operator. The shock is permanent so that $D' = D$:

$$\begin{aligned}
& \bar{V}^{real}(p^*, P, D) - \bar{V}^{real}(\hat{p}, P, D) \\
= \; & \Gamma^{real}(p^*, P, \frac{D}{P}) - \Gamma^{real}(\hat{p}, P, \frac{D}{P}) + \beta V^{real}(p^*, P', D') - V^{real}(\hat{p}, P', D') \\
= \; & \Gamma^{real}(p^*, P, \frac{D}{P}) - \Gamma^{real}(\hat{p}, P, \frac{D}{P}) \\
+ \; & \beta[\bar{V}^{real}(p^*, P', D) - \bar{V}^{real}(\hat{p}, P', D)] \\
+ \; & \beta[\bar{V}^{real}((p^*)', P', D) - \xi - \bar{V}^{real}(p^*, P', D)]\Lambda(p^*, P', D) \\
- \; & \beta[\bar{V}^{real}((p^*)', P', D) - \xi - \bar{V}^{real}(\hat{p}, P', D)]\Lambda(\hat{p}, P', D) \\
= \; & \Gamma^{real}(p^*, P, \frac{D}{P}) - \Gamma^{real}(\hat{p}, P, \frac{D}{P}) \\
+ \; & \beta[\bar{V}^{real}(p^*, P', D) - \bar{V}^{real}(\hat{p}, P', D)] \\
+ \; & \beta[\bar{V}^{real}((p^*)', P', D) - \xi - \bar{V}^{real}(p^*, P', D)] \; \Upsilon\Big(\bar{V}^{real}((p^*)', P', D) - \bar{V}^{real}(p^*, P', D)\Big) \\
- \; & \beta[\bar{V}^{real}((p^*)', P', D) - \xi - \bar{V}^{real}(\hat{p}, P', D)] \; \Upsilon\Big(\bar{V}^{real}((p^*)', P', D) - \bar{V}^{real}(\hat{p}, P', D)\Big)
\end{aligned}$$

I now show that the P and D derivative of $\bar{V}^{real}(p^*, P, D) - \bar{V}^{real}(\hat{p}, P, D)$ have the same sign as the P and D derivatives of $\Gamma^{real}(p^*, P, \frac{D}{P}) - \Gamma^{real}(\hat{p}, P, \frac{D}{P})$.

$$
\begin{aligned}
& \frac{\partial[\bar{V}^{real}(p^*,P,D)-\bar{V}^{real}(\hat{p},P,D)]}{\partial D} \\
= \quad & \frac{\partial\Gamma^{real}(p^*,P,Y)-\Gamma^{real}(\hat{p},P,Y)}{\partial Y}\frac{1}{P} \\
+ \quad & \beta\frac{\partial\bar{V}^{real}(p^*,P',D)-\bar{V}^{real}(\hat{p},P',D)}{\partial D} \\
- \quad & \beta\frac{\partial\bar{V}^{real}(p^*,P,D)-\bar{V}^{real}(\hat{p},P,D)}{\partial D}\Upsilon\Big(\bar{V}^{real}(p^*,P,D)-\bar{V}^{real}(\hat{p},P,D)\Big) \\
- \quad & \beta[\bar{V}^{real}(p^*,P,D)-\xi-\bar{V}^{real}(\hat{p},P,D)]\cdot\Upsilon'\Big(\bar{V}^{real}(p^*,P,D)-\bar{V}^{real}(\hat{p},P,D)\Big)\cdot \\
& \quad \frac{\partial\bar{V}^{real}(p^*,P,D)-\bar{V}^{real}(\hat{p},P,D)}{\partial D}
\end{aligned}
$$

using $\frac{\partial\bar{V}^{real}((p^*)',P',D)-\bar{V}^{real}(p^*,P',D)}{\partial D}=0$ which follows from noting that the first argument of both value functions is evaluated at the same Period $t-1$ value. Rearranging and sorting terms then yields:

$$
\begin{aligned}
& \frac{\partial[\bar{V}^{real}(p^*,P,D)-\bar{V}^{real}(\hat{p},P,D)]}{\partial D} \\
& \cdot\Big[1-\beta(1-\Upsilon\Big(\bar{V}^{real}(p^*,P,D)-\bar{V}^{real}(\hat{p},P,D)\Big))] \\
& \quad +\beta[\bar{V}^{real}(p^*,P,D)-\xi-\bar{V}^{real}(\hat{p},P,D)]\Upsilon'\Big(\bar{V}^{real}(p^*,P,D)-\bar{V}^{real}(\hat{p},P,D)\Big)\Big] \\
= \quad & \frac{\partial\Gamma^{real}(p^*,P,Y)-\Gamma^{real}(\hat{p},P,Y)}{\partial Y}\frac{1}{P},
\end{aligned}
$$

showing that the two derivatives have the same sign, since the term in the big square brackets is positive.

Similarly,

$$
\begin{aligned}
& \frac{\partial[\bar{V}^{real}(p^*,P,D)-\bar{V}^{real}(\hat{p},P,D)]}{\partial P} \\
= \quad & \frac{\partial\Gamma^{real}(p^*,P,Y)-\Gamma^{real}(\hat{p},P,Y)}{\partial P} \\
+ \quad & \beta\frac{\partial\bar{V}^{real}(p^*,P,D)-\bar{V}^{real}(\hat{p},P,D)}{\partial P}\frac{\partial P'}{\partial P} \\
- \quad & \beta\frac{\partial\bar{V}^{real}(p^*,P,D)-\bar{V}^{real}(\hat{p},P,D)}{\partial P}\Upsilon\Big(\bar{V}^{real}(p^*,P,D)-\bar{V}^{real}(\hat{p},P,D)\Big)\frac{\partial P'}{\partial P} \\
- \quad & \beta[\bar{V}^{real}(p^*,P,D)-\xi-\bar{V}^{real}(\hat{p},P,D)]\Upsilon'\Big(\bar{V}^{real}(p^*,P,D)-\bar{V}^{real}(\hat{p},P,D)\Big)\cdot \\
& \quad \frac{\partial\bar{V}^{real}(p^*,P,D)-\bar{V}^{real}(\hat{p},P,D)}{\partial P}\frac{\partial P'}{\partial P}
\end{aligned}
$$

so that

$$\begin{aligned}
& \frac{\partial[\bar{V}^{real}(p^*,P,D)-\bar{V}^{real}(\hat{p},P,D)]}{\partial P} \\
& \Big[1-\beta\frac{\partial P'}{\partial P}(1-\Upsilon\Big(\bar{V}^{real}(p^*,P,D)-\bar{V}^{real}(\hat{p},P,D)\Big))] \\
+ \quad & \beta[\bar{V}^{real}(p^*,P,D)-\bar{V}^{real}(\hat{p},P,D)]\Upsilon'\Big(\bar{V}^{real}(p^*,P,D)-\bar{V}^{real}(\hat{p},P,D)\Big)\frac{\partial P'}{\partial P}\Big] \\
= \quad & \frac{\partial\Gamma^{real}(p^*,P,Y)-\Gamma^{real}(\hat{p},P,Y)}{\partial P},
\end{aligned}$$

where recursiveness of the firm problem implies that Period t and $t+1$ price response have the same sign when evaluated at Period $t-1$ values, $\frac{\partial P'}{\partial P} \geq 0$, showing that the two derivatives have the same sign, since the term in the big square brackets is positive.

We can now use this results for the infinite horizon model similarly to the one-period model above. Applying this analysis to ϕ_t delivers

$$\phi_t = \alpha_D^0 \Delta D_t + \alpha_P^0 \Delta P_t$$

with $\alpha_D^0 \geq 0$ and $\alpha_P^0 \leq 0$. Noting that $(D_t - D_{t-1} = D_{t+k} - D_{t-1}$ and that $E_t(P_{t+k} - P_{t-1}) = \alpha_\Delta^k P_t$ with $\alpha^k \geq 0$ alllows applying the same analysis to Period $t+k$:

$$\phi_{t+k} = \alpha_D^k \Delta D_t + \alpha_P^k \Delta P_t$$

with $\alpha_D^k \geq 0$ and $\alpha_P^k \leq 0$. Note that future demand and future price levels are taken into account in the analysis.

We thus obtain that all ϕ_{t+k} are increasing in ΔD_t and decreasing in ΔP_t and thus, this property carries over to Φ_t:

$$\Phi_t \quad = \quad \frac{1}{1-\bar{\Lambda}}\phi_t + \frac{\beta\bar{\Lambda}}{1-\bar{\Lambda}}\sum_{k=1}^{\infty}\beta^k\phi_{t+k} = \alpha_D \Delta D_t + \alpha_P \Delta P_t$$

for $\alpha_D > 0$ and $\alpha_P < 0$. Period t inflation $\pi_t = \Delta P_t$ thus satisfies

$$\pi_t(1-\bar{\Lambda}) = (\bar{\Lambda}\ \Xi)E_t\sum_{k=0}^{\infty}\beta^k\hat{mc}_{t+k} + \alpha_D\ \Delta D_t + \alpha_P\pi_t$$

Solving for π_t and setting $\zeta = \frac{\bar{\Lambda}\ \Xi}{1-\bar{\Lambda}-\alpha_P}$ yields

$$\pi_t \;=\; \underbrace{\zeta E_t \sum_{k=0}^{\infty} \beta^k \hat{mc}_{t+k}}_{\text{Calvo}} + \underbrace{\alpha_D\ \Delta D_t}_{\text{Extensive Demand Margin}} . \tag{A7}$$

A.2 Derivation: Regional Nominal Demand Augmented Phillips Curve

The analogous derivations for a firm in the non-tradable sector yield the non-tradable inflation rate $\pi^N_{H,t} = \hat{P}^N_{H,t} - \hat{P}^N_{H,t-1}$ as a function of real marginal costs $\hat{mc}^N$ and nominal demand growth $D^N_t - D^N_{t-1}$ in the non-tradable sector

$$\pi^N_t \;=\; \zeta E_t \sum_{k=0}^{\infty} \beta^k \hat{mc}^N_{H,t} + \Phi^0_D(D^N_t - D^N_{t-1}) + \sum_{k=1}^{\infty} \Phi^k_D(D^N_{t-k} - D^N_{t-k-1}). \tag{A8}$$

Using home marginal cost $\hat{mc}_{H,t} = \hat{W}_{H,t} - \hat{P}_{H,t}$, and log-linearization of the wage setting equation (16)

$$\hat{W}_{H,t} - \hat{P}_{H,t} \;=\; \varphi \hat{N}_{H,t},$$

and for unemployment

$$\hat{u}_{H,t} = -\hat{N}_{H,t},$$

yields

$$\begin{aligned}
\hat{mc}^N_t &= \hat{mc}_{H,t} + \hat{P}_{H,t} - \hat{P}^N_{H,t} \\
&= \hat{W}_{H,t} - \hat{P}_{H,t} + \hat{P}_{H,t} - \hat{P}^N_{H,t} \\
&= \varphi \hat{N}_{H,t} - \hat{p}^N_{H,t} \\
&= -\varphi \hat{u}_{H,t} - \hat{p}^N_{H,t}.
\end{aligned}$$

B Data Appendix

Table 5: BEA Transfer Data

Data Description	Share in 2020 Transfers Receipts
State unemployment insurance compensation	12.7 percent
All other personal current transfer receipts	
Income maintenance benefits	7.1 percent
Supplemental Security Income (SSI) support	
Earned Income Tax Credit (EITC)	
Supplemental Nutritional Assistance (SNAP)	
Other Income Maintenance benefits	
Veterans' benefits	3.4 percent
Veterans' pension and disability benefits	
Veterans' readjustment benefits	
Veterans' life insurance benefits	
Education and training assistance	1.7 percent
Other transfer receipts of individuals from governments	8.8 percent
Alaska Permanent Fund benefits	
American Recovery and Reinvestment Act of 2009 (ARRA)	
⋮ ⋮	
Current Transfer Receipts of Nonprofit Institutions	3.7 percent
Receipts from the Federal government	
Receipts from state and local governments	
Receipts from businesses	
Current Transfer Receipts of Individuals from Businesses	0.8 percent
Unemployment insurance compensation excluding state unemployment insurance compensation	0.02 percent
Other medical care benefits (excl. Medicaid and Medicare)	0.3 percent
Military medical insurance benefits	0.4 percent
Retirement and disability insurance benefits excluding Social Security benefits	0.8 percent

Note - Transfer data in the empirical analysis is the sum of "State unemployment insurance compensation" and "All other personal current transfer receipts", which in turn is the sum of the various programs listed in the table. Transfers do not include Social Security benefits, Medicare benefits and Medicaid. The detailed documentation is available at `https://www.bea.gov/system/files/methodologies/SPI-Methodology.pdf`.

C Empirical Appendix

Table 6: Nominal Demand Phillips Curve Estimates: State and Time Clustering

	Benchmark	Additional Lags	No Lagged Inflation	No Marginal Costs	No Nominal Demand
	(1)	(2)	(3)	(4)	(5)
Nom. Transfers	0.115	0.145	0.130	0.052	
	(0.049)	(0.019)	(0.055)	(0.020)	
$\sum$ Marginal Cost	-0.049	-0.067	-0.052		-0.021
	(0.022)	(0.016)	(0.027)		(0.167)
Lagged Inflation	0.081	0.058		0.086	0.080
	(0.148)	(0.326)		(0.116)	(0.149)
Lagged Nom. Transfers		0.115			
		(0.047)			
	Specification Tests				
Underidentification test	0.064	0.022	0.081	0.053	0.018
Weak Identification (F-Test)	47.851	21.801	46.776	87.818	156.5
Overidentification test	0.782	0.918	0.772	0.275	0.041

Note - The inflation rate (annual), the growth rate of nominal transfers (annual) and the unemployment rate are all measured in percentage points. All regressions include state and time fixed effects. P-values in (parentheses) are clustered at the state and time level.
Column (1) - Benchmark,
Column (2) - Added Regressor: Lagged Transfers,
Column (3) - Omitted Regressor: Lagged inflation,
Column (4) - Omitted Regressor: Marginal Costs,
Column (5) - Omitted Regressor: Nominal Demand.