A Nominal Demand Augmented Phillips Curve.

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Abstract

The New Keynesian Phillips curve (NKPC) explains inflation through current and future marginal costs and inflation expectations based on a time-dependent pricing model. I show that state-dependent menu cost pricing models give rise to a nominal demand augmented Phillips curve (NDPC), which adds nominal demand as an additional explanatory variable of inflation. I then estimate the NDPC using cross-sectional data for U.S. states. My estimates indicate that nominal demand is a significant determinant of inflation, that nominal demand is not a proxy for real marginal costs, and that nominal demand cannot be replaced with real demand. Instead, from an empirical NKPC perspective nominal demand maps into cost-push shocks. My findings on the role of nominal demand thus offer a new perspective on explaining inflation during several historical U.S. episodes and across countries. The conclusion offers some thoughts on policy implications.

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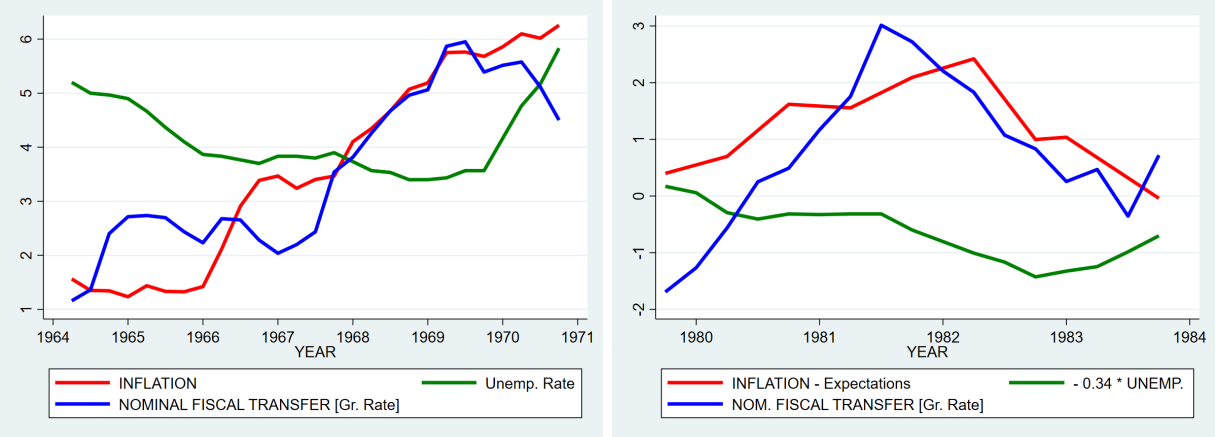
1 Introduction

What explains inflation? The Phillips curve in standard New Keynesian models provides a concise answer: the current and expected future real marginal cost gaps and long-run inflation expectations. Real marginal costs, typically measured through the unemployment rate, are then a sufficient statistic for inflation conditional on long-run expectations. All shocks affect inflation only through unemployment rates. If current and future unemployment rates are unaffected by a shock so is the inflation rate. If labor market slack and the unemployment increase then inflation decreases. And vice versa inflation rises if the slack and unemployment falls. Within a policy regime with fixed long-run expectations monetary policy moves the inflation rate only through moving unemployment rates.

U.S. inflation history suggests that the New Keynesian Phillips curve logic cannot account equally well for all historical episodes. In the second half of the 1960s the U.S. inflation rate was picking up although the unemployment rate remained quite flat (Panel (a) of Figure 1) so that the 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). 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 (a) of Figure 1). The high inflation rates and low unemployment rates in 2021 and 2022 point into the same direction.

At the same time the Phillips curve accounts very well for the co-movement of inflation and unemployment during the the 1990s and 2000s. In particular there is no missing inflation and missing disinflation during this period (Hazell et al., 2021), henceforth HHNS. These authors find the Phillips curve to be quite flat, explaining while the large 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 inflation in the late 2010s and the missing disinflation after the Great Recession, periods with high inflation 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, in particular since HHNS 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.



(a) 1964-197 (b) 1980-1984

Figure 1: Inflation, Unemployment and Nominal Fiscal Transfers

Note - Panel(a): CPI Core Inflation Rate; Unemployment Rate; Growth rate of nominal transfers using data on Personal Current Transfer Receipts from the BEA (SQINC35) and the estimates from Section 5. Panel (b): Core Inflation minus 10 year ahead CPI inflation expectation as in HHNS; unemployment rate multiplied with the slope of the Phillips curve estimated in HHNS; Growth rate of nominal transfers using data on Personal Current Transfer Receipts from the BEA (SQINC35) and the estimates from Section 5.

Fortunately, both data and existing theoretical work suggest a potential answer to this challenge: expansionary nominal fiscal policy as an additional determinant of inflation. A link between fiscal policy and inflation seems evident from a cross-country perspective even without resorting to the experience of many South American countries (Sargent et al., 2009; Kehoe and Nicolini, 2021). In the 2010s, Switzerland experienced very low inflation and unemployment rates whereas both inflation and unemployment rates were high in Turkey. A relationship between inflation and unemployment which is the opposite of what the Phillips curve would predict. In the middle of the 1970s inflation in Japan was twice as high as in Germany although both countries were energy importers and unemployment was low in Japan. Whereas the Phillips curve logic cannot account for these observations, the more expansionary fiscal policies in the high inflation countries suggest that a policy based explanation of inflation is promising to account for the data.

Within the U.S., Romer (2007) describes the dramatic changes of policy views in the 1960s which also led to an expansion of transfer payments, at the same when inflation rates started to increase after many years of low inflation rates (Panel (a) of Figure 1). Similarly, the growth rate of nominal transfers increased in the early 1980s (Panel (b) of Figure 1). While these two episodes suggest a link between fiscal policy and inflation within the U.S., empirical evidence is largely missing. This paper aims at filling this gap.

Establishing a theoretical causal link between fiscal transfer payments and inflation has two aspects. 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 unemployment and nominal demand are determinants of the inflation rate. While the literature has largely focused on how state-dependent and time-dependent pricing affects the slope of the New Keynesian Phillips curve, the implications for the specification of the Phillips curve have been widely neglected. Based on the findings on state-dependent pricing models in (Caballero and Engel, 1993, 2007), I provide several examples to show that inflation has two determinants: Real marginal costs and nominal demand; that higher nominal demand growth implies higher inflation; that nominal demand cannot be replaced with real demand; and that real marginal costs and inflation can be negatively correlated if nominal demand is not taken into account.

The examples also elucidate several theoretical results. State-dependent pricing models can be mapped into a standard New Keynesian Phillips curve with a positive coefficient on the real marginal cost gap only under strong distributional assumptions (e.g. Caplin and Leahy, 1991). The frequency of price changes and the selection effect (e.g. Golosov and Lucas, 2007), i.e. which prices change, depend on nominal demand and cannot be written as a function of real marginal costs. Consistent with the evidence in Nakamura and Steinsson (2008), Nakamura et al. (2018) and Alvarez et al. (2019) the frequency of price adjustment is increasing in the nominal demand growth rate. Furthermore the connection between the state and time-dependent pricing models weakens the higher is the inflation rate, consistent with the results in Alvarez et al. (2017).[1] Inflation and real marginal costs are even fully disconnected in the Caplin and Spulber (1987) state-dependent pricing model due to monetary neutrality. Even though the Caplin and Spulber (1987) model also imposes strong assumptions, its main lesson carries over to more realistic environments: Nominal demand is a determinant of inflation in addition to real marginal costs.

This motivates deriving 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). Inflation is then determined through marginal costs,

[1]State-dependent menu-cost models also explain the link between the frequency of price adjustment and the level and variance of demand (Ball et al., 1988) and why inflation depends on the skewness of the shock distribution (Ball and Mankiw, 1995). A link between the frequency of price adjustment and the properties of nominal demand also exists in other models, e.g. in the famous imperfect information model in Lucas (1972).

nominal demand and inflation expectations.

The empirical analysis provides corroborating evidence for the specification of the NDPC using US cross-sectional data, building on recent work of HHNS. My empirical implementation uses the US state-level consumer price indices constructed by HHNS instead of city-level inflation or retail sector inflation as in previous research,[2] the Bartik-type instrument developed in HHNS and conducts panel data regressions with time fixed effects to absorb aggregate effects including long-run inflation expectations and US monetary policy as in HHNS.[3]

But instead of estimating the NKPC as in HHNS, I estimate the NDPC. Consistent with the theoretical model, estimating the NDPC requires adding state-level transfer payments to an other wise standard NKPC. The theory also shows that the inflationary effect depends on how much much an increase in transfers raises demand. This effect is the 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.

The theoretical analysis shows that the NKPC and NDPC are not equivalent. The empirical analysis adds the quantitative importance of nominal demand as a determinant of regional inflation rates. To convey an idea of the economic significance of the estimates, the two panels in Figure 1 show the contribution of nominal growth to inflation using the empirical results in Section 5. 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; the estimated coefficient on marginal costs is biased if nominal demand is not included in the regression. 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]

[2]For example Fitzgerald et al. (2014), McLeay and Tenreyro (2020) and Hooper et al. (2019). Beraja et al. (2019) use regional wage instead of inflation data.

[3]See Fitzgerald et al. (2014) and McLeay and Tenreyro (2020) among others for the benefits of using regional data in understanding inflation.

[4]Complementary theories of cost-push shocks are offered by Rubbo (2020) who shows that a multi-

Section 2 presents a selective review of the literature focused on the implications for the Phillips curve and derives the nominal demand augmented Phillips curve. The regional incomplete markets model with state-dependent pricing laid out in Section 3 gives rise to the regional Phillips curve with nominal demand. Section 4 uses the regional Phillips curve to derive the empirical specification, describes the data, visualizes the relationship between nominal demand and inflation and explains the identifying approach. Section 5 shows the empirical results. Section 6 concludes.

2 Inflation, Nominal Demand and the Phillips Curve

The aim of this Section is understanding 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 several examples motivated by findings of 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 - nominal demand - bias for standard Phillips curves, 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 Section5 under which conditions this is the case. Before turning to the examples in Section 2.2, I first lay out a state-dependent pricing model in Section 2.1.

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.

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 HHNS, (Bilbiie, 2008, 2017, 2019), nominal fiscal policy and state dependent pricing so that nominal demand is a meaningful and endogenous object. 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,

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

Each period the household chooses $c_t i$ to maximize C_t taking the 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 is

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

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

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

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

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

where MC_t is real marginal costs, which only depend on real aggregate demand D_t/P_t and are thus common to all firms.[5] To focus on aggreate demand, idiosyncratic or 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 output. The Period t nominal profit of firm i with price p_t equals

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

2.1.3 Price Settting

Each firm inherits a price $p_{t-1}(i)$ from the previous period but can set a new price at a fixed i.i.d. idiosyncratic adjustment cost ξ drawn from the distribution Υ, where $\Upsilon(x) = Prob(\xi \leq x)$ is the probability that the adjustment cost ξ is less or equal to x. The distribution Υ is not necessarily continuous and can have mass points. 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 $\bar{V}^f$,

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

[5]This holds in the full model since the real marginal cost equals the real wage, and all firms use the identical linear (in labor) production function.

The price adjustment decision then amounts to comparing the value at the optimal price minus adjustment costs and 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 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 $P_t = D_t$.

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

$$\begin{aligned}
\Pi_t^{1-\epsilon} - 1 &= \frac{P_t^{1-\epsilon} - P_{t-1}^{1-\epsilon}}{P_{t-1}^{1-\epsilon}} \qquad (5)\\
&= \frac{\left[\int_0^1 p_t^*(i)^{1-\epsilon}\Lambda(p_{t-1}(i), P_t, D_t) + p_{t-1}(i)^{1-\epsilon}(1 - \Lambda(p_{t-1}(i), P_t, D_t))di\right] - \int_0^1 p_{t-1}(i)^{1-\epsilon}di}{P_{t-1}^{1-\epsilon}}\\
&= \frac{\left[\int_0^1 [p_t^*(i)^{1-\epsilon} - p_{t-1}(i)^{1-\epsilon}]\Lambda(p_{t-1}(i), P_t, D_t)di\right.}{P_{t-1}^{1-\epsilon}}\\
&= \int_0^1 [\Big(\frac{p_t^*(i)}{P_{t-1}}\Big)^{1-\epsilon} - \Big(\frac{p_{t-1}(i)}{P_{t-1}}\Big)^{1-\epsilon}]\Lambda(p_{t-1}(i), P_t, D_t)di.
\end{aligned}$$

2.2 Nominal Demand, Marginal Costs and Inflation: Examples

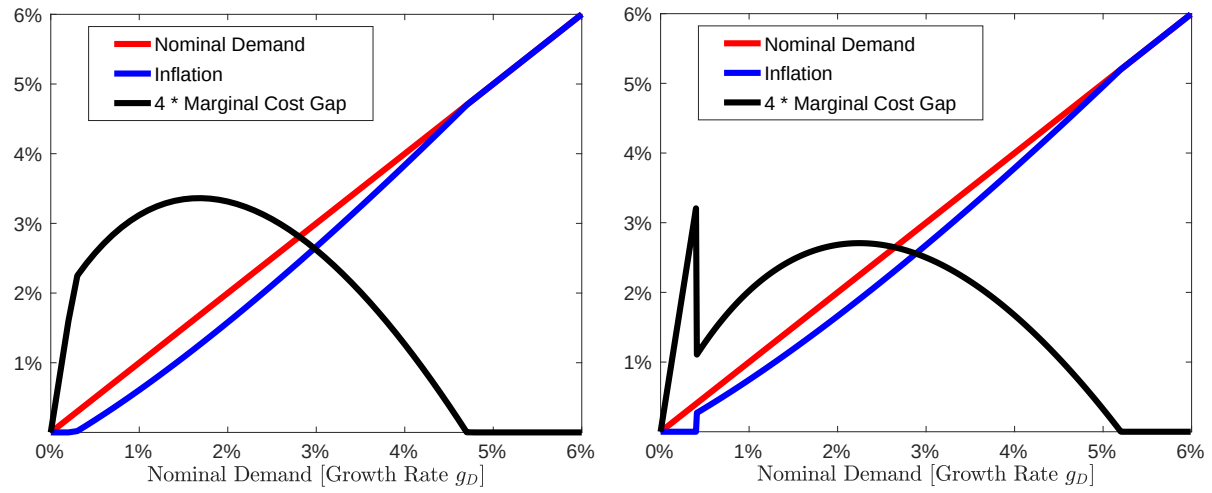
This Section provides several examples of the non-linear price setting model to illustrate that

- Inflation has two determinants: Real marginal costs and nominal demand.
- Higher nominal demand growth implies higher inflation.
- Real marginal costs and inflation can be negatively correlated.
- Nominal demand cannot be replaced with real demand.

Many arguments in this Section are known (to the experts in the fields), rendering this Section to some degree a selective literature review, but here with a new focus on the implications of state dependent pricing for the Phillips curve.

Several of my arguments can be already illustrated in a one-period version of the model where the current Period t is the last period of this economy. In the first two examples 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 keeps 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. 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 half, 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 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



(a) Uniform Price Distribution

(b) Mass Point

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

Note - The figures show the response of inflation and the marginal cost gap to an unexpected nominal demand growth rate M.I.T. shock g_D. 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.

marginal costs are higher for $g_D = 2\%$ than for $g_D = 1\%$, showing a positive relationship for low inflation rates.

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. Simple modifications of the example can be added so that marginal costs can even fall to negative values while inflation is positive and increasing at the same time.

Alvarez et al. (2017) 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

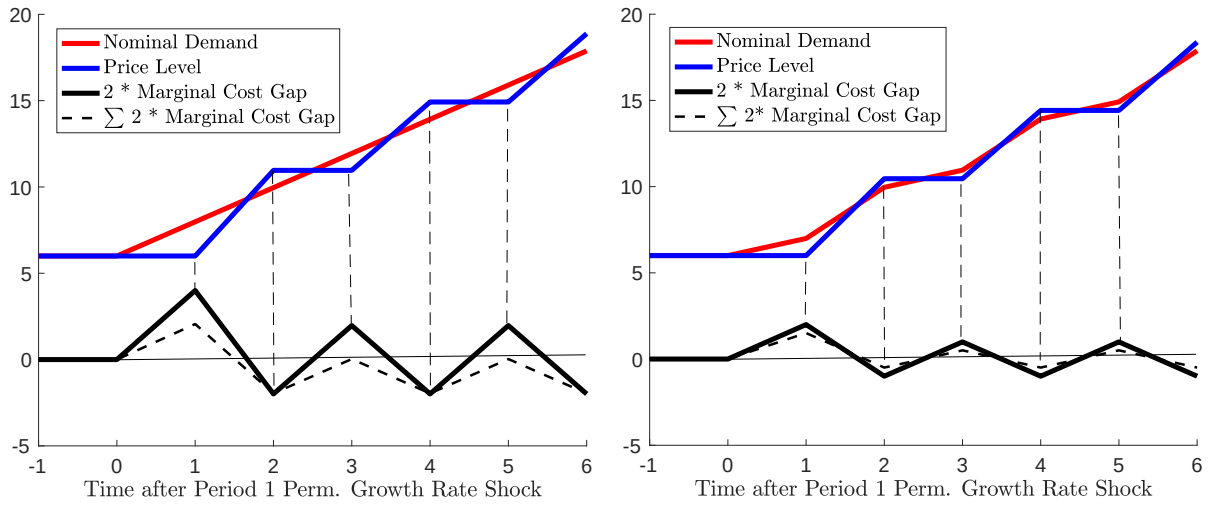
distribution of prices and do not assume a steady-state distribution of prices.

The differences between the Calvo model and state-dependent models become even more evident in the infinite horizon case which allows considering the Caplin and Spulber (1987) model and permanent shocks to the level and the growth rate of nominal demand. Maybe unsurprisingly, allowing for growth rate shocks moves the model closer to the Caplin and Spulber (1987) environment and further away from the Calvo model.

For a permanent shock to the level of nominal demand, the experiment considered in Alvarez et al. (2017), the conclusions from the one-period example carry over to this infinite horizon examples. In particular, it is nominal and not real demand determining inflation. Likewise, the inflation response depends on the persistency of the nominal demand innovation as shown by Dotsey et al. (1999). In terms of the empirical approach the infinite horizon example thus adds another reason for why there is not 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.

The distributional assumptions in Caplin and Spulber (1987) ensure a steady state with a constant inflation rate equal to the growth rate of nominal demand and real output is at its flexible price level. Since the inflation rate, nominal demand growth and real output are constant in a steady state this result extends to all state-dependent pricing models with idiosyncratic productivity shocks. Real activity is unrelated to the inflation rate. However, Caballero and Engel (2007) show that the neutrality result in Caplin and Spulber (1987) hinges on their distributional assumption which ensures that the inflation response to nominal demand innovations is time-invariant. Nominal demand grows at a constant rate g_D and so do prices. Any deviation from this distributional assumption adds a time-varying inflation rate. Since the inflation rate has to be equal to g_D on average, periods with inflation rates less than g_D and thus high real output will be followed by periods with inflation rates above g_D and low real activity as the next example illustrates, a non-surprising finding given the Average Neutrality Result in Caballero and Engel (1993).

Panel (a) of Figure 3 considers a permanent growth rate shock to nominal demand to illustrate two points. First, consistent with Figure 2 in Caballero and Engel (2007), that different assumptions on the distribution and adjustment costs can lead to a time-varying inflation rate although nominal demand grows at a constant rate. Marginal costs (gaps) are negatively correlated with inflation. Marginal costs are negative when inflation is high, and positive when inflation is negative, establishing again that marginal costs and inflation are not necessarily positively related and marginal costs are thus not a sufficient statistic for



(a) Constant Demand Growth (b) Cyclicl Demand Growth

Figure 3: Inflation and Marginal Costs

Note - The figures show the response of the price level and marginal cost gaps to an unexpected permanent nominal demand growth rate M.I.T. shock g_D. Both figures use $\epsilon = 8$, the aggregate real output elasticity of real marginal costs equals 1 and all firms face the same adjustment costs and charge the same price in a symmetric equilibrium. Before the shock in period 1 there is no price adjustment in the zero inflation, $g_D = 0$, steady state. Panel (a) considers a permanent $g_D = 2\%$ shock and (b) adds cyclical demand growth with g_D alternating between 1% and 3%.

inflation. Second that the transition to a new steady state involves an adjustment, here one period, where real marginal costs increase significantly although inflation is still zero as in the old steady state and so below the new long-run level. As pointed out by Caballero and Engel (2007) this example describes quite general model properties. Output is on average but not always at the flexible price level. Sometimes it is above and sometimes it is below the flexible price level. Correspondingly the price level is sometimes above and sometimes below the nominal demand line, requiring that the price curve cuts the nominal demand line from below at some points in time so that the slope of the price line - the inflation rate - is higher than the growth rate of nominal demand. In other words at this point in time real marginal costs are below average while inflation is above average.

To understand why this reasoning depends on a positive nominal demand growth rate and does not extend to the zero inflation case it is instructive to recall the working of the Caplin and Spulber (1987) and Caballero and Engel (2007) results using discrete instead of continuous time. In each period t only a fraction of firms with the lowest prices adjust their prices upwards by $N * g_D$ and then remains inactive until period $t + N$. The large adjustment of prices by $N * g_D$ arises for two reasons. First, adjusting firms have to catch-

up since they did not adjust for N periods and the price level has been growing at rate g_D during this non-adjustment period. Second, preemptive price increases are necessary since the adjusting firm will not adjust the prices before period $t+N$ while the price level will grow at rate g_D per period. Obviously, both these reasons are absent if $g_D = 0$. There is no catch-up and no preemptive price-setting since changes in aggregate conditions is the only reason for adjustment and aggregate conditions are constant. In particular inflation is constant and equal to zero in a $g_D = 0$ steady state.

The arguments extend to a model with cyclical growth in nominal demand as panel (b) of Figure 3 shows. Again real marginal costs and the discounted sum of marginal costs are negatively correlated with inflation.

2.3 Nominal Demand Augmented Phillips Curve

Although the non-linearity of inflation matters as the previous examples illustrate, I consider now log-linearized prices dynamics to ease comparison with the New Keynesian Phillips curve. I proceed in two steps to better convey the intuition for why higher nominal demand growth implies higher inflation. First, I consider a model where 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 a variable with a hat denotes its percentage deviation from steady state, $\tilde{p}_{t-1}(i) = \frac{p_{t-1}(i)}{P_{t-1}}$ and $\bar{\Lambda}$ and ϕ depend on the distribution of period $t-1$ prices $p_{t-1}(i)$. To be consistent with the steady-state analysis in the infinite horizon model below I assume that $\Pi_t = 1$ if $D_t = D_{t-1}$, $P_{t-1} = D_{t-1}$ and $p_{t-1}^* = P_{t-1}$, so that p_t^* is the log deviation of the optimal Period t price due to changed demand conditions 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 of firm i due to a change in the price level and nominal demand. 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 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

$$\epsilon_{MC(Y),Y} \geq \max\{\bar{p}, 1 + (\epsilon - 1)(1 - \underline{p})\}$$

for a Period $t-1$ price distribution within the interval $[\underline{p} \cdot p^*, \bar{p} \cdot p^*]$.[6] 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's price is below the optimal price, $\tilde{p}_{t-1}(i) < 1$ then this firm wants 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 too low prices relative to the optimal one are more likely to increase their price.

If firm $i's$ previous period's price is above the optimal price, $\tilde{p}_{t-1}(i) > 1$ then this firm

[6]The condition on marginal costs is sufficient to rule out coordination equilibria where firms set a price just because all other firms do so. Such a coordination equilibrium is more likely if ϵ is large or firms have extreme markups and thus large incentives to adjust their prices. A sufficiently steep margin cost curve rules this out. For example if $[\underline{p} \cdot p^*, \bar{p} \cdot p^*] = [p^*/\mathcal{M}, \mathcal{M}p^*]$ then the condition reads

$$\epsilon_{MC(Y),Y} \geq \max\{1 + \frac{1}{\mathcal{M}}, \mathcal{M}\}.$$

wants 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 too high prices relative to the optimal one are now less likely to decrease their price since the nominal expansion pushes towards price increases. 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 the fixed point problem 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 in addition nominal demand. The coefficients on both determinants are non-negative but can equal zero for small changes in nominal demandas the examples in Section 2.2 illustrate. The average effects, for example obtained in a regression including larger changes in nominal demand, are positive though:

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

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. No theorem can be formulated that shows that $\hat{mc}_t$ and ΔD_t have the sign. As the examples in Section 2.2 show, it can very 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.

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 $\Xi = \frac{1}{\sum_{k=0}^{\infty} \beta^k \lambda_{k,t}}$.[7]

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

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

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

[7] 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 in 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) I can rewrite equation (13) 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 countries, (H)ome and (F)oreign, which form a monetary and fiscal union. Each country has a population of one which consists of two type of agents, savers and hand-to-mouth households. Firms 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 $s_i \in \{\text{S, HtM}\}$, who 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 to stay a saver, $\omega_{S,HtM}$ is the probability for a saver to become HtM, $\omega_{HtM,S}$ the probability to switch from HtM to S and $\omega_{HtM,HtM}$ is the probability to stay 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-tradabale consumption $C^{s,N}_{H,t}$ and tradable 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 tradabales 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 whch 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,

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

where $C_{H,t}^{S,TH}(j)$ is tradable consumption produced at home of variety j and $C_{H,t}^{S,TF}(j)$ 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 $P_{H,t}^{T}(j)$ and $P_{F,t}^{T}(j)$.

The HtM households are excluded from financial markets, they can neither save nor get a credit.[8] HtM households thus maximize utility subject to the budget constraints

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

where $W_{H,t}$ is the nominal wage, $N_{H,t}^{HtM}$ is hours, $T_{H,t}^{HtM} > 0$ is a nominal transfer, $\Upsilon_{H,t}^{HtM,N}$ is the nominal profit of the non-tradable sector and $\Upsilon_{H,t}^{HtM,T}$ 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 $P_{H,t}^{N}$, $P_{H,t}^{T}$ and $P_{F,t}^{T}$.[9]

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

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

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 $T_{H,t}^{S} < 0$ and $\Upsilon_{H,t}^{S,N}$ is the nominal profit of the non-tradable sector and $\Upsilon_{H,t}^{S,T}$ 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

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

[9] The price indices $P_{H,t}^{N}$, $P_{H,t}^{T}$ and $P_{F,t}^{T}$ are given by

$$P_{H,t}^{N} = \left(\int_0^1 (P_{H,t}^{N}(j))^{1-\rho}dj\right)^{\frac{1}{1-\rho}}, P_{H,t}^{T} = \left(\int_0^1 (P_{H,t}^{T}(j))^{1-\rho}dj\right)^{\frac{1}{1-\rho}}, P_{F,t}^{T} = \left(\int_0^1 (P_{F,t}^{T}(j))^{1-\rho}dj\right)^{\frac{1}{1-\rho}}.$$

in a steady state.[10]

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

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

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 middlemen (for example a union) assigns the same amount of labor to both types $N^S_{H,t} = N^{HtM}_{H,t} = N_{H,t}$ 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 so that regional labor supply is the only regional variable affecting regional marginal

[10] Note that this is a steady-state result and that outside steady states savers might hold positive or negative amount 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.

costs.

3.1.2 Firms

The firms in the non-tradable and tradable sector 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 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:

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

where $B^S_{H,t+1,i}$ is bonds acquired by household i in Period t 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

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

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

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

and the nominal demand for home produced tradables

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

and for foreign produced tradables

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

Non-tradable Good Producers

There is a measure one 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

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

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

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

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) show 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, has 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 existence of a steady state for all interest rates $1 + i \geq 1$, I assume that precautionary savings demand is sufficiently strong, requiring a high enough 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.[11]

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; 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 $P_{H,ss}$ simply equates demand and supply,

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

[11] 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 $P_{H,ss} = P_{F,ss}$.[12]

3.2 The Regional Phillips Curve with Nominal Demand

The empirical analysis in Section 4 estimates the effect of a transfer to the home region on inflation. 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

[12]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).

3.1.1 maps 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 $\Delta D^N_{t-k} = \log\big(D^N_{t-k}\big) - \log\big(D^N_{t-k-1}\big)$ for home non-tradables

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

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 is 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.[13]

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 to induce determinacy. Nominal demand is thus a meaningful concept due to incomplete markets and nominal fiscal policy. Second, 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 change in household nominal demand:

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

[13] 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.

where $\bar{D}$, $\bar{T}^S$ and $\bar{T}^{HtM}$ are steady-state levels of D, T^S and T^{HtM} in Period -1 and $\Delta T^S = \log\big(T^S\big) - \log\big(T^S_{-1}\big)$ and $\Delta T^{HtM} = \log\big(T^{HtM}\big) - \log\big(T^{HtM}_{-1}\big)$ are the growth rates of transfers of savers and hand-to-mouth households respectively. The marginal propensity of demand for a HtM household, $mpd^{HtM} = 1$, reflecting that all income is spent. The marginal propensity of demand for the saver, mpd^S, is significantly smaller and approaches $1 - \beta$ if $\omega_{S,S} \to 1$.[14] The last equality of (29) defines the aggregate country marginal propensity to spend mpd_H in response to a change in total regional transfers

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

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, then small changes in nominal demand have no or 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 under different assumptions as the examples in Section 2.2 show. Taking into account that the empirical analysis uses nominal transfers and not nominal demand further weakens the convexity. Higher transfers are likely to lead to lower marginal propensities to consume and thus 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 behavior (Golosov et al., 2021) whereas small transfer can feature substantial marginal propensities to consume.

These are partial equilibrium responses 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,

[14] 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 $\omega_{S,HtM} \to 1$.

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 data 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 first 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

$$\Phi_T^0 = \Phi_D^0 \frac{\bar{T}}{\bar{D}} mpd.$$

In line with the theoretical model the magnitude of the inflation response depends on the magnitude of two channels. The size of the effect of demand on inflation, Φ_D^0, 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_D^0 is large. With infinitely lived 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

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

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 $g_{H,\infty}$.[15] Including state and time 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 ex-

[15]Note that permanent inflation differences between two regions with identical productivity growth rates are solely due to permanent inflation differences in the non-tradable sector. This would be inconsistent with a steady state and would instead suggest divergence of the relative size of the non-tradable sectors in the two regions.

pectational 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 one multiplier but there are 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 (Section 2.2).

4.2 Data

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

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.[16] 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 the details of the data construction see HHNS. The quarterly state non-tradable inflation rate is the outcome variable in the empirical analysis. Choosing

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

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).[17] 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. 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 inflation rates and Medical benefits and Medicaid payments as those are linked to actual medical expenses and thus do not resemble a helicopter drop.

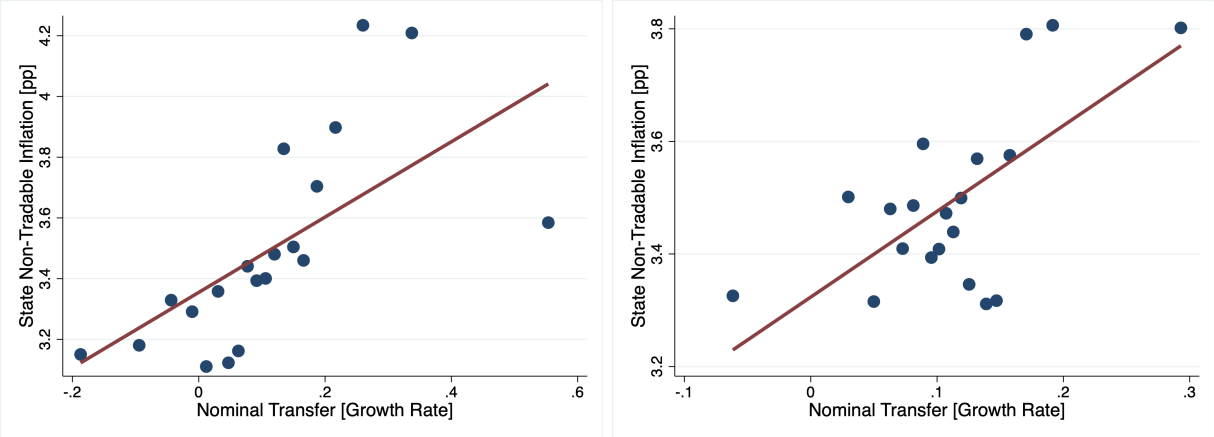
4.2.3 Labor market data

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).[18] 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.[19]

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 4 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

[17] Available at `https://www.bea.gov/data/income-saving/personal-income-by-state`.
[18] Available at `https://www.bls.gov/lau/`
[19] Available at `https://www.bls.gov/cew/`



(a) No State and Time Fixed Effects

(b) State and Time Fixed Effects

Figure 4: Scatterplots: Non-Tradable Inflation and Nominal Transfers

Note - Binned scatterplot 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.

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 omit 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 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 instrument are constructed and the identifying assumptions which render them valid instruments.

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

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

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 three-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 the relevance of the instrument.

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 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 largely 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 instruments 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 is uncorrelated with the error term ϵ_{rt}. To understand the economics behind this assumption, first assume that the unemployment rate fully captures marginal costs. 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 un-

employment rates are irrelevant to explain 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 $\hat{u}_{H,t}$ fully captures the real marginal cost gap $\hat{mc}^N_{H,t}$. There could be variables other than unemployment moving marginal costs, 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 ideas, it seems useful to think of the benchmark regression (33) containing an omitted variable $mc^r_{H,t}$, which is orthogonal to unemployment such that real marginal costs can be decomposed as,

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

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

$$E(u_{H,t-k}\epsilon_{rt}) = 0, \quad t = 1, 2, \ldots, T,$$

then require

$$E(u_{H,t-k}mc^r_{H,t}) = 0, \quad t = 1, 2, \ldots, T.$$

In words, the real marginal cost residual $mc^r_{H,t}$ 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 $mc^r_{H,t}$ conditional on Period t unemployment. The assumption in a nutshell: What is orthogonal in Period $t-k$ is also orthogonal in Period t.

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 findings in HHNS suggest this assumption to be valid for the sample period. The

assumption here is that adding nominal transfers to the Phillips curve does not change this property. Instead past unemployment rates matter for the current inflation rate only 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 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.[20]

Using past unemployment as an instrument also alleviates potential concerns due to 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 where 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 four-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:

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

[20] 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.

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 $\beta = 0.99$ and $\varphi = 1$ as my benchmark values 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 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	0.00111
Weak Identification (F-Test)	47.851	21.801	46.776	87.818	156.5
Overidentification test	0.287	0.912	0.282	0.211	0.0302

Note - The inflation rate (annual), the growth rate of nominal transfers (annual) and the unemployment rate are all measured in percentage points. All regressions usr 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,

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

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.[21]

The coefficient on the lagged inflation rate is quite small and even insignificant, suggesting that indexation is not an important factor in explaining inflation. In contrast to the literature using aggregate data (e.g. Gali et al., 2005) which assigns a minor role to indexation but still finds a significant coeffcient of about 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 is not capturing the effect of lagged inflation.

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

The theoretical model also implies that additional lags of transfers could have explanatory power for inflation.[22] 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 $\sum_{k=0}^{K} \beta^k \hat{mc}_{r,t+k}^{N}$ also increase in magnitude.[23] Repeating the same calculation as above for the slope of the

[21] 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.

[22] 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.

[23] 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

Phillips curve yields a coefficient on unemployment of -0.757 and $\kappa\xi = -0.64$.

To get an idea of the magnitude of the estimated coefficient for nominal transfer, note that Figure 1 in the Introduction use these estimates and applies them to the corresponding aggregate US data. The two Figures show that the 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. Of course it is important to reiterate that this experiment's sole purpose is conveying an idea of the economic magnitude of the estimates and their potential to account for US inflation. At this stage the experiment of Figure 1 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 leave out 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) leave out 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 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

p-value of 9.3%.

(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 supply shock although being a demand increase. 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 to construct the sum of marginal costs. Column (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.

Column (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 0.5 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 for 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,[24]

$$\pi^N_{r,t} = \kappa E_t \sum_{k=0}^{K} \beta^k \hat{mc}^N_{r,t+k} + \Phi^{real} \Delta T^{real}_{r,t-4} + \gamma \pi^N_{r,t-4} + \alpha_r + \gamma_t + \epsilon_{rt} \tag{35}$$

The estimated coefficient for real transfer growth is negative and has thus the wrong sign and 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

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

thus cannot rule out weak identification. 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 inflation increases through the standard Phillips curve channel. If this was correct them the real value of transfers should 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 should 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],

6 Concluding Remarks

This paper derives a nominal demand augmented Phillips curve (NDPC) which explains inflation through real marginal cost (gaps) and expected inflation, the New Keynesian Phillips curve explanatory variables, 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.

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 are fading inflation starts falling. More generally, the NDPC suggests rethinking fiscal and monetary policy. If the 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 that maybe not.

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APPENDIX

A Theoretical Appendix

A.1 Nominal Demand Phillips Curve: Inflation Dynamics

Log-linearizing equation (5),

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

yields

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

Thus

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

such that

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

Properties of 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

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

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 wrt. real demand Y:

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

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:

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

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

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

so that

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

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

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

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

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}.

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

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 $MC(Y) = \frac{p^*}{P\mu}$,

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

Taking the derivative wrt. P:

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

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 $Y = \frac{D}{P}$,

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

it follows for $\hat{p} < p^*$:

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

since

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

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 $\frac{\hat{p}}{p^*} \geq \underline{\mu}$ and thus $((p^*)^{-\epsilon} - (\hat{p})^{-\epsilon})\frac{\hat{p}}{p^*} \leq ((p^*)^{-\epsilon} - (\hat{p})^{-\epsilon})\underline{\mu}$,

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

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

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

since

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

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

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

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 $\pi_t > 0$. Suppose in contrast that $\pi_t \leq 0$. This is a contradiction since both $\hat{mc}_t > 0$ and $\Delta\phi_t > 0$.

Now suppose that $\Delta\phi_t \leq 0$. Since $\pi_t > 0$ we must have $\hat{mc}_t > 0$ 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 that

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

so that ϕ_t increases, a contradiction.

Infinite Horizon

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

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

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

$$\pi_{t+k} = (\hat{p}_{t+k}^* - \hat{P}_{t+k-1}) \underbrace{\int_0^1 \Lambda(p_{t-1}(i), P_{t-1}, D_{t-1})di}_{=:\bar{\Lambda}} + \underbrace{\int_0^1 \frac{1 - \tilde{p}_{t-1}(i)^{1-\epsilon}}{1-\epsilon}\hat{\Lambda}_{t+k}(i)di}_{=:\phi_{t+k}}, \qquad \text{(A2)}$$

where $\Big(\frac{p_{t+k}^*(i)}{P_{t+k-1}}\Big)^{1-\epsilon}$ 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 $\hat{\Lambda}_{t+k}(i) = \Lambda(p_{t+k-1}(i), P_{t+k}, D_{t+k}) - \Lambda(p_{t-1}(i), P_{t-1}, D_{t-1})$ are both evaluated at $p_{t-1}^*, P_{t-1}, D_{t-1}$. In particular,

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

and

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

showing that the reason is exactly that $\hat{\Lambda}$ is evaluated at Period $t-1$ values as above and the only Period $t+k-1$ variable is then $p_{t+k-1}(i)$.

To determine the properties of Φ_t 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

$$\bar{V}^{real}(p_t, P_t, D_t) = \Gamma^{real}(p_t, P_t, D_t) + \beta E_t V^{real}(p_t, P_{t+1}, D_{t+1}). \tag{A3}$$

and

$$V^{real}(p_{t-1}, P_t, D_t) = \max\{\bar{V}^{real}(p^*_t, P_t, D_t) - \xi, \bar{V}^{real}(p_{t-1}, P_t, D_t)\}. \tag{A4}$$

A firm 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 $V^{real}(p^*, P, D) - V^{real}(\hat{p}, P, D)$ increases. Since I consider a perfect foresight MIT shocks I drop the expectation operator. The shock is

permanent so that $D' = D$:

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

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

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

since $\frac{\partial \bar{V}^{real}((p^*)',P',D)-\bar{V}^{real}(p^*,P',D)}{\partial D} = 0$ and thus

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

so that

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

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

Similarly,

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

so that

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

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 thus obtain that Φ_t is increasing in $(D_t - D_{t-1})$ and decreasing in $(P_t - P_{t-1})$ so that in linear form

$$\Delta\Phi_t = \alpha_P\pi_t + \alpha_D(D_t - D_{t-1})$$

for $\alpha_P < 0$ and $\alpha_D > 0$. Note that $D_t = D_{t+1} = D_{t+2} = \ldots$ so no future demand shocks are expected and future price level adjustments are already incorporated in the analysis. Inflation thus satisfies

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

Setting $\zeta = \frac{\bar{\Lambda}\ \Xi}{1-\bar{\Lambda}-\alpha_P}$ yields

$$\pi_t = \underbrace{\zeta E_t\sum_{k=0}^{\infty}\beta^k\hat{mc}_{t+k}}_{\text{Calvo}} + \underbrace{\alpha_D(D_t - D_{t-1})}_{\text{Extensive Demand Margin}} . \tag{A5}$$

A.2 Derivation: Regional Nominal Demand Augmented Phillips Curve

The analogous derivations for a firm in the non-tradable sector yield the non-tradbale 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 $D_t^N - D_{t-1}^N$ in the non-tradable sector

$$\pi_t^N = \zeta E_t \sum_{k=0}^{\infty} \beta^k \hat{mc}_{H,t}^N + \Phi_D^0 (D_t^N - D_{t-1}^N) + \sum_{k=1}^{\infty} \Phi_D^k (D_{t-k}^N - D_{t-k-1}^N). \quad \text{(A6)}$$

Using that 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 that for unemployment

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

yields

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

B Data Appendix

Table 4: 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 available at `https://www.bea.gov/system/files/methodologies/SPI-Methodology.pdf`

C Empirical Appendix

Table 5: 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.