Stock Market Wealth and the Real Economy: A Local Labor Market Approach*

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Abstract

We provide evidence of the stock market wealth effect on consumption by using a local labor market analysis and regional heterogeneity in stock market wealth. An increase in local stock wealth driven by aggregate stock prices increases local employment and payroll in nontradable industries and in total, while having no effect on employment in tradable industries. In a model with consumption wealth effects and geographic heterogeneity, these responses imply a marginal propensity to consume out of a dollar of stock wealth of 3.2 cents per year. We also use the model to quantify the aggregate effects of a stock market wealth shock when monetary policy is passive. A 20% increase in stock valuations, unless countered by monetary policy, increases the aggregate labor bill by at least 1.7% and aggregate hours by at least 0.7% two years after the shock.

JEL Classification: E44, E21, E32

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1 Introduction

According to a recent textual analysis of FOMC transcripts by Cieslak and Vissing-Jorgensen (2017), many U.S. policymakers believe that stock market fluctuations affect the labor market through a consumption wealth effect. In this view, a decline in stock prices reduces the wealth of stock-owning households, causing a reduction in spending and hence in employment. While apparently an important driver of U.S. monetary policy, this channel has proved difficult to establish empirically. The main challenge arises because stock prices are forward-looking. Therefore, an anticipated decline in future economic fundamentals could also lead to both a negative stock return and a subsequent decline in household spending and employment.

We use a local labor market analysis to address this empirical challenge and provide quantitative evidence on the stock market consumption wealth effect. Our empirical strategy combines regional heterogeneity in stock market wealth with aggregate movements in stock prices. This regional approach identifies the causal effects under weaker assumptions than aggregate time-series analyses, while providing direct evidence that asset prices affect labor market outcomes, which is of central interest to policymakers. In addition, our approach appropriately accounts for heterogeneity in marginal propensities to consume (MPC) across households—a feature emphasized in the recent literature—because the regional labor market response already reflects the wealth-weighted average MPC across stockholders in the region. Finally, we develop a heterogeneous area two-agent New Keynesian model that relates the regional outcomes to the household-level MPC out of stock wealth as well as to the aggregate labor market effects of stock wealth changes. Interpreted through this model, our empirical estimates map into a household-level annual MPC of 3.2 cents per dollar of stock wealth and imply that annual aggregate payroll increases by 1.7% following a yearly standard deviation increase in the stock market, unless countered by monetary policy.

It helps to begin by describing the consumption wealth effect in our model setting. The environment features a continuum of areas, a tradable good and a nontradable good, stockholders and hand-to-mouth workers, and two factors of production, capital and labor. The only heterogeneity across regions is in their ownership of capital, which also equates to stock wealth. The aggregate price of capital is endogenous and fluctuates due to changes in households' beliefs about the expected *future* productivity of capital. An increase in stock wealth increases local spending on nontradable goods, and more so in areas with greater capital ownership. Higher spending drives up the labor bill and increases labor in the nontradable sector and in total. Local wages increase (weakly) more in high wealth areas, which induces a (weak) fall in tradable labor.

In the data, we measure changes in county-level stock market wealth in three steps. In the first step, we capitalize dividend income reported on tax returns aggregated to the county level to arrive at a county-level measure of taxable stock wealth. Our capitalization method improves on existing work such as in Saez and Zucman (2016) by allowing for heterogeneity in dividend yields by wealth, which we obtain using a sample of account-level portfolio holdings from a large discount broker. In the second step, we adjust this measure of taxable stock wealth to account for non-taxable (e.g., retirement) stock wealth, using information on the relationship between taxable and total stock wealth and demographics in the Survey of Consumer Finances. In the final step, we multiply the total county stock wealth with the return on the market (CRSP value-weighted) portfolio and a county-specific portfolio beta constructed from county demographic information and variation in betas across the age distribution in the data from the discount broker. This provides a measure of the change in county stock wealth driven by the aggregate stock return. Motivated by our theoretical analysis, we then divide this change by the county labor bill to arrive at our main regressor.

Our empirical specification identifies the effect of changes in stock wealth on local labor market outcomes by exploiting the substantial variation in the aggregate stock return that occurs independent of other macroeconomic variables. In particular, we allow high wealth areas to exhibit greater sensitivity to changes in aggregate bond wealth, aggregate housing wealth, and aggregate labor income and non-corporate business income, and also control for county fixed effects, state-by-quarter fixed effects, and a Bartik-type industry employment shift-share. Our identifying assumption is that, conditional on these controls, areas with high stock market wealth do not experience unusually rapid employment or payroll growth following a positive aggregate stock return for reasons other than the stock market wealth effect on local spending.

An increase in local stock wealth induced by a positive stock return increases total local employment and payroll. Seven quarters after an increase in stock market wealth equivalent to 1% of local labor market income, local employment is 0.77 basis points higher and local payroll is 2.18 basis points higher. Because stock returns are nearly i.i.d., these responses reflect the short-run effect of a permanent change in stock market wealth. Motivated by the theory, we also investigate the effect on employment and the labor bill in the nontradable and tradable industries, following the sectoral classifications in Mian and Sufi (2014). Consistent with the theory, the employment response in nontradable industries exceeds the overall response, while employment in tradable industries does not increase. We also report a large response in the residential construction sector, consistent with a household demand channel.

The main threat to a causal interpretation of these findings is that high wealth areas respond differently to other aggregate variables that co-move with the stock market. This concern motivates the variables included in our baseline specification. The absence of "pre-trend" differences in outcomes in the quarters before a positive stock return and the non-response of employment in the tradable sector support a causal interpretation of our findings. We report additional robustness along a number of dimensions, including: using a more parsimonious specification that excludes the parametric controls; including interactions of stock market wealth with TFP growth to allow wealthier counties to have different loadings on this variable; controlling for local house prices; using only within commuting zone variation in stock market wealth; subsample analysis including dropping the wealthiest counties and the quarters with the most volatile stock returns; and not weighting the regression. A decomposition along the lines of Andrews et al. (2017) shows that no single state drives the results. We also report a quantitatively similar response using cross-state variation and state-level consumption expenditure from the Bureau of Economic Analysis.

Our baseline analysis assumes a homogeneous treatment effect across areas. A natural question concerns what this specification identifies in the presence of possible MPC heterogeneity across households—as in a growing literature that emphasizees liquidity constraints or behavioral frictions. An advantage of a regional approach is that it already reflects the wealth-weighted average MPC in a region. Because stock wealth heterogeneity is substantially greater within than across counties, this means that the cross-county regression approximately reflects the wealth-weighted average MPC across *all* stockholders—the MPC that matters for *aggregate* stock wealth fluctuations. We substantiate this result quantitatively in a Monte Carlo exercise on simulated data that matches the empirical distributions of stock market participation and stock wealth across households and the cross-county distribution of average stock wealth.

We combine our empirical results with the theoretical model to calibrate two key parameters: the household-level stock wealth effect and the degree of local wage adjustment. To calibrate the stock wealth effect, we provide a separation result from our model that decomposes the empirical coefficient on the *nontradable* labor bill into the product of three terms: the household-level marginal propensity to consume out of stock market wealth, the local Keynesian multiplier (equivalent to the multiplier on local government spending), and the labor share of income.[1] This decomposition applies to more general changes in local consumption demand and therefore may be of use outside our particular setting. We use standard values from previous literature to calibrate the labor share of income and the local Keynesian multiplier. Given these values, the empirical response of the nontradable labor bill implies that in partial equilibrium a one dollar increase in stock-market wealth increases

[1] In general, there may be an additional term reflecting the response of output in the tradable sector when relative prices change across areas. This term disappears in our benchmark calibration, which features Cobb-Douglas preferences across tradable goods produced in different regions. Allowing for a non-unitary elasticity of substitution across regions does not meaningfully change our conclusions.

annual consumption expenditure by about 3.2 cents two years after the shock. For the degree of wage adjustment, comparing the response of total employment with the response of the total labor bill suggests that a 1 percent increase in labor (total hours worked) is associated with a 0.9 percent increase in wages at a two year horizon.

Finally, we use the model to quantify the *aggregate* effects that stock price shocks would generate if monetary policy (or other demand-stabilization policies) did not respond to the shock. We first show that a one dollar increase in stock market wealth has the same *proportional* effect on the *local nontradable* and *aggregate total* labor bills, up to an adjustment for the difference in the local and aggregate spending multipliers. This result does not depend on the particular calibration of the direct household-level wealth effect just described. It does require homothetic preferences and production across the nontradable and tradable sectors, and we provide evidence in support of this assumption at the level of the broad sectoral groupings we use in the data. Next, we show how the local response of wages informs about the aggregate wage Phillips curve in our model. Since labor markets are local, the aggregate wage response is similar to the local wage response, with an adjustment due to the fact that demand shocks impact aggregate inflation and local inflation differently. We then consider a 20% positive shock to stock valuations—approximately the yearly standard deviation of stock returns. Using our empirical estimate for the nontradable labor bill, and applying a bounding argument for moving from local to aggregate effects similar to that in Chodorow-Reich (2019), this shock would increase the aggregate labor bill by at least 1.7% two years after the shock. Combining this effect with the degree of aggregate wage adjustment implied by our local estimates, the shock would also increase aggregate hours by at least 0.7%.

The rest of the paper proceeds as follows. After discussing the related literature, we present the empirical analysis. Section 2 describes the data sets and the construction of our main variables. Section 3 details the baseline empirical specification and discusses conditions for causal inference. Section 4 contains the empirical results. We then turn to the theoretical analysis and the structural interpretation. Section 5 describes our model. Section 6 uses the empirical results to calibrate the model and derive the household-level wealth effect. Section 7 calculates the implied aggregate wealth effects, and Section 8 concludes.

Related literature. Our paper contributes to a large literature that investigates the relationship between stock market wealth, consumption, and the real economy. A major challenge is to disentangle whether the stock market has an effect on consumption over a relatively short horizon (the direct wealth effect), or whether it simply predicts future changes in productivity, income, and consumption (the leading indicator effect). The challenge is compounded by the scarcity of data sets that contain information on household consumption and financial wealth. The recent literature has tried to address these challenges in various ways (see Poterba (2000) for a survey of the earlier literature).

The literature using aggregate time series data finds mixed evidence (see e.g. Poterba and Samwick, 1995; Davis and Palumbo, 2001; Lettau et al., 2002; Lettau and Ludvigson, 2004; Carroll et al., 2011). Davis and Palumbo (2001) and Carroll et al. (2011) estimate a wealth effect of up to around 6 cents. On the other hand, Lettau and Ludvigson (2004) argue for more limited wealth effects. However, an aggregate time series approach introduces two complications: First, in an environment in which monetary policy effectively stabilizes aggregate demand fluctuations, as in our model, there can be strong wealth effects and yet no relationship between asset price shocks and aggregate consumption. Second, stock market fluctuations may affect aggregate demand via an investment channel (see Cooper and Dynan (2016) for other issues with using aggregate time series in this context).

Another strand of the literature uses household level data and exploits the heterogeneity in household wealth to isolate the stock wealth effect. Dynan and Maki (2001) use Consumer Expenditure Survey (CE) data to compare the consumption response of stockholders with non-stockholders. They find a relatively large marginal propensity to consume (MPC) out of stock wealth—around 5 to 15 cents per dollar per year. However, Dynan (2010) re-examines the evidence by extending the CE sample to 2008 and finds weaker effects. More recently, Di Maggio et al. (forthcoming) use detailed individual-level administrative wealth data for Sweden to identify the stock wealth effect from variation in individual-level portfolio returns. They find substantial effects: the top 50% of the income distribution, who own most of the stocks, have an estimated MPC of around 5 cents per dollar per year.[2]

We complement these studies by focusing on *regional* heterogeneity in stock wealth. We show how the regional empirical analysis can be combined with a model to estimate the household-level stock wealth effect. The MPC implied by our analysis (3.2 cents per dollar per year) is close to estimates from the recent literature. An important advantage of our approach is that it directly estimates the local *general equilibrium* effect. In particular, by examining the labor market response, we provide direct evidence on the margin most important to monetary policymakers.

Case et al. (2005) and Zhou and Carroll (2012) also use regional variation to estimate financial wealth effects. Case et al. (2005) overcome the absence of geographic data on financial wealth by using state-level mutual fund holdings data from the Investment Company Institute (ICI) and measure state consumption using retail sales data from the Regional Financial Associates. Zhou and Carroll (2012) criticize the data construction and empirical

[2]See also Bostic et al. (2009) and Paiella and Pistaferri (2017) for similar analyses of stock wealth effects in different contexts.

specification in Case et al. (2005) and construct their own data set using proprietary data on state-level financial wealth and retail sales taxes as a proxy for consumption. Both papers find negligible stock wealth effects and a sizable housing wealth effect. Relative to these papers, we exploit the much greater variation in financial wealth across counties than across states and provide evidence on the labor market margin directly. Other recent papers use regional variation but focus only on estimating housing wealth effects (Mian et al., 2013; Mian and Sufi, 2014; Guren et al., 2020b).[3]

Our estimate for the household-level MPC out of stock market wealth is broadly in line with the quantitative predictions from frictionless models such as the permanent income hypothesis, but considerably smaller than the estimated MPCs out of liquid income found in the recent literature (Parker et al., 2013), even among higher income households (Kueng, 2018; Fagereng et al., 2019). One interpretation is that households that hold stock wealth are affected relatively less by borrowing constraints or by behavioral frictions that increase MPCs. Another possibility is that these households are subject to similar frictions as other households, but stock wealth is associated with more severe transaction costs (such as tax frictions or information frictions) that lead to lower MPCs than other types of liquid income. The latter view is consistent with recent evidence from Di Maggio et al. (forthcoming), who argue that Swedish households respond to capital gains significantly less than they respond to dividend payouts.

Our focus on the consumption wealth channel complements research on the investment channel of the stock market that dates to Tobin (1969) and Hayashi (1982). Under the identifying assumptions we articulate below, our local labor market analysis absorbs the effects of changes in Tobin's Q or the cost of equity financing on investment into a time fixed effect, allowing us to isolate the consumption wealth channel.

Our theoretical framework builds upon the model in Mian and Sufi (2014) by incorporating several features important for a structural interpretation of the results, including endogenous changes in wealth, monetary policy, partial wage adjustment, households with heterogeneous MPCs, and imperfectly substitutable tradable goods. Our framework also shares features with models of small open economies with nominal rigidities (e.g. Gali and Monacelli, 2005) adapted to the analysis of monetary unions by Nakamura and Steinsson (2014) and Farhi and Werning (2016), but differs from these papers by including a fully

[3]See also Case et al.(2005; 2011), Campbell and Cocco (2007), Mian and Sufi (2011), Carroll et al. (2011), and Browning et al. (2013), among others. In terms of comparison of wealth effects from stock wealth versus housing wealth, Guren et al. (2020b) estimate an MPC out of housing wealth of around 2.7 cents during 1978-2017, which is comparable in magnitude to our estimate of the stock wealth effect. This is substantially lower than the estimates in Mian et al. (2013) and Mian and Sufi (2014), which are in the range of 7 cents. See Guren et al. (2020b) for a discussion of the possible drivers of these differences.

nontradable sector. This feature facilitates the structural interpretation and aggregation of the estimated local general equilibrium effects.

Our structural interpretation and aggregation results represent methodological contributions that apply beyond our particular model. First, and similar to the approach in Guren et al. (2020b) and formalized in Guren et al. (2020a), we illustrate how the estimated local general equilibrium effects can be combined with external estimates of the local income multiplier (e.g., estimates from local government spending shocks) to obtain the direct household-level spending effect.[4] Our decomposition differs from theirs in that it applies to the coefficient for the nontradable labor bill—a variable that is easily observable at the regional level—and therefore includes an adjustment for the labor share of income. Second, we show how, under standard assumptions, the response of the local labor bill in the *non-tradable* sector provides a direct and transparent bound for the response of the aggregate effect across *all* sectors when monetary policy does not react.

2 Data

In this section we explain how we measure the key objects in our empirical analysis: the ratio of geographic stock market wealth to labor income, the stock market return, employment, and payroll. Our geographical unit is a U.S. county. This level of aggregation leaves ample variation in stock market wealth while being large enough to encompass a substantial share of spending by local residents. The U.S. contains 3,142 counties using current delineations. Table A.4 reports summary statistics for the variables described next.

2.1 Stock Market Wealth

We denote our main regressor as $S_{a,t-1}R_{a,t-1,t}$, where $S_{a,t-1}$ is stock market wealth in county a in period $t-1$ normalized by the period $t-1$ labor bill and $R_{a,t-1,t}$ is the portfolio return between $t-1$ and t. In Section 5, we show that regressions of log changes in local labor market outcomes on this variable yield coefficients tightly related to the key parameters of our model.

We construct local stock market wealth by capitalizing taxable dividend income and then adjusting for stock wealth held in non-taxable accounts. We summarize our methodology here and provide additional detail of the data, sample construction, and adjustments in Appendix A.1. Our capitalization method involves multiplying observed taxable dividend

[4] In contemporaneous work, Wolf (2019) formally establishes (in a closed economy setting) conditions under which the multiplier effects from private spending are exactly the same as the multiplier effects from public spending.

income by a price-dividend ratio to arrive at stock wealth held in taxable accounts.[5] We start with IRS Statistics of Income (SOI) data containing county aggregates of annual dividend income reported on individual tax returns, over the period 1989-2015. Dividend income as reported on form 1040 includes any distribution from a C-corporation. It excludes distributions from partnerships, S-corporations, or trusts, except in rare circumstances where S-corporations that converted from C-corporations distribute earnings from before their conversion. While we cannot separate distributions from publicly-traded and privately-held C-corporations, we show in Appendix A.1.4 that equity in privately-held C-corporations is too small (less than 7% of total equity of C-corporations) to meaningfully affect our results.

We construct a county-specific capitalization factor as the product of the price-dividend ratio on the value-weighted CRSP portfolio and a time-varying county-specific adjustment. The CRSP portfolio contains all primary listings on the NYSE, NYSE MKT, NASDAQ, and Arca exchanges and, therefore, covers essentially the entire U.S. equity market. The county-specific adjustment recognizes that older individuals both have higher average wealth and hold higher dividend-yield stocks, as first conjectured in Miller and Modigliani (1961) and documented in Graham and Kumar (2006). We believe we are the first to apply such an adjustment in capitalizing equity wealth. To do so, we follow Graham and Kumar (2006) and use the Barber and Odean (2000) data set of individual account-level stock holdings from a large discount broker over the period 1991-1996.[6] Specifically, as we describe in more detail in Appendix A.1.2, we merge the Barber and Odean (2000) data set with CRSP stock and mutual fund data and compute average dividend yields for five age groups, separately for each Census Region. The dividend yield slopes upward with age, with individuals 65 and over holding stocks with a dividend yield about 10% (*not* p.p.) higher than the market average and individuals 35 and younger holding stocks with a dividend yield about 10%

[5]The literature has proposed other income measures and capitalization factors. Mian et al. (2013) and Mian and Sufi (2014) group dividends, interest, and other non-wage income together and use the ratio of total household financial wealth in the Financial Accounts of the United States (FAUS) to the national aggregate of this combined income measure as a single capitalization factor for all financial wealth. Saez and Zucman (2016) and Smith et al. (In progress) use both dividends and capital gains to allocate directly held corporate equities in the FAUS, with Smith et al. arguing forcefully for a low weight on the capital gains component because realized capital gains include many transactions other than sales of corporate equity. Relative to these alternatives, capitalizing dividends using a price-dividend ratio isolates the income stream most closely related to corporate equity wealth and facilitates the adjustment for heterogeneous dividend yields described below.

[6]The data are a random sample of accounts at the brokerage and have been used extensively to study individual trading behavior (Barber and Odean, 2000, 2001; Graham and Kumar, 2006; Barber and Odean, 2007; Mitton and Vorkink, 2007; Kumar, 2009; Seasholes and Zhu, 2010; Kent et al., 2019). Graham and Kumar (2006) compare the data with the 1992 and 1995 waves of the SCF and show that the stock holdings of investors in the brokerage data are fairly representative of the overall population of retail investors. We consider taxable accounts with at least one dividend-paying stock to mimic the dividends observed in the IRS data.

lower than the market average. Importantly, variation by age accounts for essentially all of the variation in dividend yields across the wealth distribution, as shown in Figure A.1 and Table A.1. We combine the age-specific dividend yields with county-level demographic information and wealth by age group from the Survey of Consumer Finances (SCF). We then adjust the CRSP dividend yield in each county-year by the age-wealth-weighted average of the age-specific dividend yields.

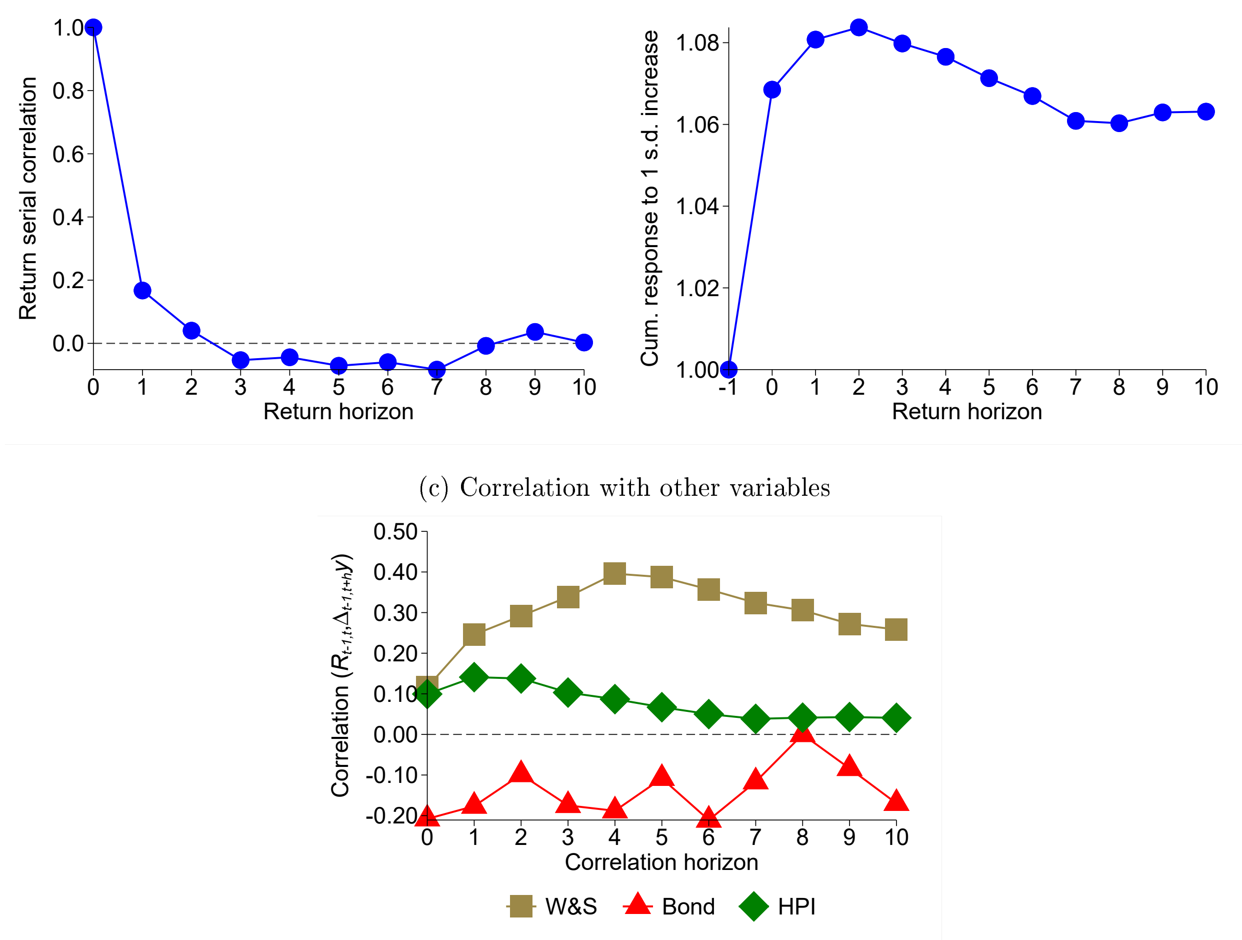
We next adjust county taxable stock market wealth to account for wealth held in non-taxable accounts, primarily in defined contribution pension plans.[7] We do not include wealth in defined benefit pension plans, since household claims on that wealth do not fluctuate directly with the value of the stock market. Roughly one-third of total household stock market wealth is held in non-taxable accounts (see Figure A.4). In Appendix A.1.3, we estimate the relationship at the household level between total stock market wealth, taxable stock market wealth, and household demographic characteristics, using the SCF. Total and taxable stock market wealth vary almost one-to-one, reflecting statutory limits on contributions to non-taxable accounts that make non-taxable wealth much more evenly distributed than taxable wealth. The variables also explain total wealth well, with an R^2 above 0.9. We combine the coefficients on taxable wealth and demographic characteristics from the SCF with our county-level measure of taxable stock wealth and county-level demographic characteristics to produce our final measure of total county stock market wealth. Finally, we divide this measure by SOI (annual) county labor income to arrive at our measure of local stock market wealth relative to labor income, $S_{a,t}$.

2.2 Stock Market Return

We write the stock market return in county a as $R^*_{a,t-1,t} = \alpha_a + R^f_{t-1,t} + b_{a,t} \times (R^m_{t-1,t} - R^f_{t-1,t}) + e_{a,t-1,t}$, where $R^f_{t-1,t}$ is the risk-free rate in period t, $R^m_{t-1,t}$ is the market return, $b_{a,t}$ is a county-specific portfolio beta, and $e_{a,t-1,t}$ is an idiosyncratic component of the return. We do not observe $R^*_{a,t-1,t}$. Instead, we define the variable $R_{a,t-1,t}$ that enters into our main regressor as $R_{a,t-1,t} = R^f_{t-1,t} + b_{a,t} \times (R^m_{t-1,t} - R^f_{t-1,t})$. To operationalize $R_{a,t-1,t}$, we equate the risk-free rate $R^f_{t-1,t}$ with the interest rate on a 3-month Treasury bill, the market return $R^m_{t-1,t}$ with the total return on the value-weighted CRSP portfolio, and construct the county-specific portfolio beta $b_{a,t}$ using the relationship between market beta and age in the Barber and Odean (2000) data set and our measure of the county age-wealth distribution. This adjustment incorporates the tendency for older, wealthier households to hold stocks with lower betas, a pattern we document in Figure A.6 of the online appendix. Ignoring it would

[7] This adjustment is appropriate if the marginal propensities to consume out of taxable and non-taxable stock wealth are the same. We revisit this assumption at the end of our analysis (see Footnote 41.)

Figure 1: Attributes of Quarterly Stock Returns



(a) Serial correlation of returns

(b) Cumulative return response

(c) Correlation with other variables

Notes: Panel (a) reports the coefficients β_h from estimating the regression $R_{t+h-1,t+h} = \alpha_h + \beta_h R_{t-1,t} + e_h$ at each quarterly horizon h shown on the lower axis, where $R_{t+h-1,t+h}$ is the total return on the value-weighted CRSP portfolio between quarters $t+h-1$ and $t+h$. Panel (b) reports the transformation $\Pi_{h=0}^{j}(1+\beta_h\sigma_R)$ at each quarterly horizon j shown on the lower axis, where σ_R is the standard deviation of the CRSP return. Panel (c) reports the correlation coefficients of $R_{t-1,t}$ and $y_{t-1,t+h}$ at each quarterly horizon h shown on the lower axis, where $y_{t-1,t+h}$ is the log change in aggregate labor compensation, the holding return on the 5 year Treasury, or the change in aggregate house prices between $t-1$ and $t+h$.

result in systematic over-counting of changes in wealth in high wealth areas when the stock market changes, leading to an under-estimate of the consumption wealth effect, although this effect turns out to be small in practice as the $b_{a,t}$ all lie between 0.97 and 1.03.

We now discuss the differences between the true county return $R^*_{a,t-1,t}$ and the measured return $R_{a,t-1,t}$ and why these differences do not affect the validity of our empirical analysis. Three possible differences exist. First, the true county return includes a county-specific α_a, reflecting differences in portfolio characteristics and the possibility that high wealth areas have systematically better portfolios, as suggested by Fagereng et al. (2016). Our empirical specification will include county fixed effects to absorb permanent heterogeneity along this dimension.[8] Second, high wealth areas could have systematically riskier or less risky stock portfolios beyond the correlation due to age, in which case we would systematically mis-measure $b_{a,t}$. While previous work has documented that wealthy households have portfolios tilted toward riskier asset classes than the general population (Carroll, 2000; Calvet and Sodini, 2014), here what matters is risk-taking *within* stock portfolios. Figure A.6 shows this correlation using the Barber and Odean (2000) data set. Except for the bottom wealth decile, who typically hold only one or two securities and have very low beta portfolios, there is a nearly flat relationship between beta and wealth decile within age bins. Therefore, this source of heterogeneity does not appear important in practice. Third, the true return $R^*_{a,t-1,t}$ contains an idiosyncratic component $e_{a,t-1,t}$, reflecting differences in portfolio allocation arising, for example, from home bias as documented in Coval and Moskowitz (1999) or from differences in market beta uncorrelated with wealth. This component has no impact on our empirical results because it gives rise to idiosyncratic changes in wealth that are uncorrelated with our main regressor. This statement remains true even if the idiosyncratic part of the return correlates with local economic activity, as might occur due to home bias in portfolio allocation.[9]

Figure 1a shows the serial correlation in the quarterly return on the CRSP portfolio and Figure 1b the cumulative return following a one standard deviation increase in the stock market during our sample period. As is well known, stock returns are nearly i.i.d., a result confirmed by the almost complete absence of serial correlation in Figure 1a. This pattern facilitates interpretation of our empirical results since it implies that a stock return in period t has a roughly permanent effect on wealth, and we mostly ignore the small momentum and subsequent reversal shown in Figure 1b in what follows. Figure 1c shows the correlation of

[8] While the fixed effect absorbs permanent heterogeneity, in fact wealth is highly persistent over time, with a within-state correlation between $S_{a,1990}$ and $S_{a,2015}$ of 0.81.

[9] Formally, assume the true structural model is $y_a = \beta\left(S_a R^*_a\right) + \epsilon_a$ and $R^*_a = R_a + e_a$, where y_a is an outcome, e_a is a mean-zero component of the return independent of wealth S_a or the measured part of the return R_a, and the structural residual ϵ_a is independent of the measured change in wealth $S_a R_a$. (We have dropped time subscripts and ignored the component α_a to simplify notation and without loss of generality). Substituting, we have $y_a = \beta\left(S_a R_a\right) + u_a$, where $u_a = \beta S_a e_a + \epsilon_a$ is a composite residual. Therefore, the coefficient $\hat{\beta}$ from regressing y_a on $S_a R_a$ asymptotes to β, since $Cov\left(S_a e_a, S_a R_a\right) = Cov\left(\epsilon_a, S_a R_a\right) = 0$ by the independence assumptions on e_a and ϵ_a. Alternatively, one can think of $S_{a,t-1}R_{t-1,t}$ as the excluded instrument and $S_{a,t-1}R^*_{a,t-1,t}$ as the endogenous variable in an instrumental variables design. Under the assumption of purely idiosyncratic heterogeneity, the first stage regression of $S_{a,t-1}R^*_{a,t-1,t}$ on $S_{a,t-1}R_{t-1,t}$ would yield a coefficient of 1, in which case the IV coefficient coincides with the reduced form coefficient that we estimate. Importantly, this argument extends straightforwardly to mis-measurement of $S_{a,t}$ due to heterogeneity in the price-dividend ratio uncorrelated with true wealth. Finally, the argument makes no assumption on the correlation between the idiosyncratic component of the return e_a and the structural residual ϵ_a, as might occur in the context of home bias in portfolio allocation. Hyslop and Imbens (2001) provide a more general discussion of measurement error that does not lead to biased estimation.

the period t stock return with the changes in other macroeconomic aggregate variables over the horizon $t-1$ to $t+h$. In our sample, the stock market return is positively correlated with aggregate labor income and house prices, and negatively correlated with fixed income returns. However, the correlation coefficients are all well below one, reflecting the substantial movement in stock prices independent of these other factors (Shiller, 1981; Cochrane, 2011; Campbell, 2014).

2.3 Outcome Variables

Our main outcome variables are log employment and payroll from the Bureau of Labor Statistics Quarterly Census of Wages and Employment (QCEW). The source data for the QCEW are quarterly reports filed with state employment security agencies by all employers covered by unemployment insurance (UI) laws. The QCEW covers roughly 95% of total employment and payroll, making the data set a near universe of administrative employment records. We use the NAICS-based version of the data, which start in 1990, and seasonally adjust the published county-level data by sequentially applying Henderson filters using the algorithm contained in the Census Bureau's X-11 procedure.[10]

An important element of our analysis is to distinguish between responses in sectors affected by local demand shocks, which we refer to as "nontradable" sectors, and "tradable" sectors unlikely to be affected by local demand shocks. We follow Mian and Sufi (2014) and label NAICS codes 44-45 (retail trade) and 72 (accommodation and food services) as nontradable and NAICS codes 11 (agriculture, forestry, fishing and hunting), 21 (mining, quarrying, and oil and gas extraction), and 31-33 (manufacturing) as tradable.[11] The retail trade sector includes a wide variety of establishments that cover essential (e.g. grocery stores, drug stores) and luxury (e.g. specialty food stores, jewelry stores) expenditure and everything in between (e.g. auto dealers, furniture stores, clothing stores). Nonetheless, this classification is conservative in the sense that it leaves a large amount of employment unclassified. This is in line with our model calibration, which depends only on having a subset of industries that produce truly nontradable goods. On the other hand, even most manufacturing shipments occur within the same *zip code* (Hillberry and Hummels, 2008),

[10] The NAICS version of the QCEW contains a number of transcription errors prior to 2001. We follow Chodorow-Reich and Wieland (2020, Appendix F) and hand-correct these errors before applying the seasonal adjustment procedure.

[11] Mian and Sufi (2014) exclude NAICS 721 (accommodation) from their definition of nontradable industries. We leave this industry in our measure to avoid complications arising from the much higher frequency of suppressed data in NAICS 3 than NAICS 2 digit industries in the QCEW data. The national share of nontradable employment and payroll in NAICS 721 are both less than 8% and we have verified using counties with non-suppressed data that including this sector does not affect the nontradable responses reported below.

which suggests local consumption demand could impact our measure of tradables. We report robustness to using a classification scheme based on the geographic concentration of employment in an industry.

3 Econometric Methodology

This section provides a formal discussion of causal identification, presents our baseline specification, and discusses the main threats to identification.

3.1 Framework

Motivated by the model in Section 5, we assume a true data generating process of the form:

$$\Delta_{a,t-1,t+h}y = \beta_h[S_{a,t-1}R_{a,t-1,t}] + \Gamma_h' X_{a,t-1} + \epsilon_{a,t-1,t+h}, \tag{1}$$

where $\Delta_{a,t-1,t+h}y = y_{a,t+h} - y_{a,t-1}$ is the change in variable y in area a between $t-1$ and $t+h$, $S_{a,t-1}$ is stock market wealth in area a in period $t-1$ relative to labor market income in the area, $R_{a,t-1,t} = b_{a,t}R^m_{t-1,t} + (1-b_{a,t})R^f_{t-1,t}$ is the measured return on the stock portfolio, $X_{a,t-1}$ collects included covariates determined (from the perspective of a local area) as of time $t-1$, β_h and Γ_h are coefficients (with the latter possibly vector-valued), and $\epsilon_{a,t-1,t+h}$ contains unmodeled determinants of the outcome variable. We will discuss identification of β^h under the maintained assumption of a homogenous treatment effect across areas. We explore treatment heterogeneity explicitly in Section 4.4 and argue there that the county-level specification will approximately reflect the wealth-weighted average MPC out of stock wealth even if this MPC varies across individuals with the level of stock wealth.

Let $\hat{\beta}_h$ and $\hat{\Gamma}_h$ denote the coefficients from treating $\epsilon_{a,t-1,t+h}$ as unobserved and Eq. (1) as a Jordà (2005) local projection to be estimated by OLS. Because the local portfolio betas $\{b_{a,t}\}$ all lie close to 1 and $R^f_{t-1,t}$ is much less volatile than $R^m_{t-1,t}$, we can use the approximation $S_{a,t-1}R_{a,t-1,t} \approx S_{a,t-1}b_{a,t}R^m_{t-1,t}$ in Eq. (1).[12] In that case, Eq. (1) has an approximate shift-share structure with a single national shifter given by the market return $R^m_{t-1,t}$, and the identifying assumption for $plim\hat{\beta}_h = \beta_h$ takes the form:

$$E\left[R^m_{t-1,t}\mu_t\right] = 0, \tag{2}$$

[12] That is, for any (de-meaned) variable $v_{a,t}$, $E[S_{a,t-1}R_{a,t-1,t}v_{a,t}] = E[S_{a,t-1}b_{a,t}R^m_{t-1,t}v_{a,t}] + E[S_{a,t-1}(1-b_{a,t})R^f_{t-1,t}v_{a,t}] \approx E[S_{a,t-1}b_{a,t}R^m_{t-1,t}v_{a,t}]$, where the term $E[S_{a,t-1}(1-b_{a,t})R^f_{t-1,t}v_{a,t}]$ is negligible because $1-b_{a,t} \approx 0$ and $Var(R^f_{t-1,t}) << Var(R^m_{t-1,t})$. In fact, our results below change imperceptibly whether or not we include the term $S_{a,t-1}(1-b_{a,t})R^f_{t-1,t}$.

where $\mu_t \equiv E\left[S_{a,t-1} b_{a,t} \epsilon_{a,t-1,t+h}\right]$ is a time t cross-area average of the product of the beta-adjusted stock wealth–to–income $b_{a,t} S_{a,t-1}$ and the unobserved component $\epsilon_{a,t-1,t+h}$.[13] Intuitively, this condition will not hold if the outcome variable (e.g., employment or payroll) grows faster for unmodeled reasons ($\epsilon_{a,t-1,t+h} > 0$) in high wealth areas ($\Rightarrow \mu_t > 0$) in periods when the stock return is positive, and vice versa when the stock return is negative.

The econometrics of shift-share designs have recently received renewed attention in Goldsmith-Pinkham et al. (2018) and Borusyak et al. (2018). Condition (2) coincides with the exogeneity condition in Borusyak et al. (2018) in the case of a single national observed shock and multiple (asymptotically infinite) areas and time periods. As in their framework, the condition recasts the identifying assumption from a panel regression into a single time series moment by defining the cross-area average μ_t. Borusyak et al. (2018) defend the validity of shift-share instruments when the shifter is exogenous, a seemingly natural assumption in our setting given that stock market returns are nearly i.i.d. Nonetheless, since stock market returns are equilibrium outcomes (as most shifters are), identification of β_h also requires that other aggregate variables correlated with $R^m_{t-1,t}$ and not controlled for in X impact areas with high and low stock market wealth uniformly. Importantly, we do *not* require that stock market wealth be distributed randomly, and show in Table A.5 that $S_{a,t}$ correlates with the share of a county's population with a college education and the median age, among other variables. Instead, as illustrated by Eq. (2), we require that high and low wealth areas not be heterogeneously affected by other aggregate variables that co-move with stock returns. This insight motivates our baseline specification and robustness analysis.

3.2 Baseline Specification

Our baseline specification implements Eq. (1) at the county level and at quarterly frequency, with outcome y either log employment or log quarterly payroll. We include the following controls in $X_{a,t-1}$: a county fixed effect, a state $\times$ quarter fixed effect, and eight lags of the "shock" variable $\{S_{a,t-j-1} R_{a,t-j-1,t-j}\}_{j=1}^{8}$. We also include interactions of $S_{a,t-1}$ with changes in other forms of aggregate wealth: the holding return on a 5 year Treasury bond, the log growth of national house prices between $t-1$ and t, and the log change in national labor income and non-corporate business income from $t-1$ to the cumulative total over the next 12

[13] To derive this condition, let $\boldsymbol{Y}$ denote the $AT \times 1$ vector of $\Delta_{a,t-1,t+h} y$ stacked over A areas and T time periods, $\boldsymbol{S}$ the $AT \times T$ matrix containing the vector $\begin{pmatrix} b_{1,t} S_{1,t-1} & \ldots & b_{A,t} S_{A,t-1} \end{pmatrix}'$ in rows $A(t-1)+1$ to At of column t and zeros elsewhere, $\boldsymbol{R}$ the $T \times 1$ vector of stock market returns, $\boldsymbol{X}$ the $AT \times K$ matrix of K covariates stacked over areas and time periods, and $\boldsymbol{\epsilon}$ the $AT \times 1$ stacked vector of $\epsilon_{a,t-1,t+h}$. Then we can rewrite Eq. (1) in matrix form as $\boldsymbol{Y} = \beta_h \boldsymbol{S}\boldsymbol{R} + \boldsymbol{X}\Gamma_h + \boldsymbol{\epsilon}$. It follows that $plim \hat{\beta}_h = \beta_h$ if $0 = \lim_{A,T\to\infty} (\boldsymbol{S}\boldsymbol{R})' \boldsymbol{\epsilon} = \lim_{A,T\to\infty} \boldsymbol{R}'\boldsymbol{S}'\boldsymbol{\epsilon} = \lim_{A,T\to\infty} \sum_t R_{t-1,t} \sum_a b_{a,t} S_{a,t-1} \epsilon_{a,t-1,t+h} = E\left[R_{t-1,t}\mu_t\right]$.

quarters (to capture human capital and private business wealth).[14] Finally, we also include a Bartik (1991) shift-share measure of predicted employment growth at horizon h based only on industry composition, $\Delta_{a,t-1,t+h}e^{B}$.[15] We weight regressions by 2010 population and report standard errors two-way clustered by time and county. Clustering by county accounts for any residual serial correlation in stock market returns and has a small effect on the standard errors in practice. Clustering by time allows for areas with high or low stock market wealth to experience other common shocks and accords with the recommendation of Adão et al. (2019) in the special case of a single national shifter. Finally, we exclude from our baseline sample counties in the top 5% of the share of employees working at large (500+) firms, as these firms can have direct exposure to the stock market.[16]

3.3 Threats to Identification and Motivation for Covariates

Our identifying assumption is that following a positive stock return, areas with high stock market wealth relative to labor income do not experience unusually rapid employment or payroll growth—relative to their own mean and to other counties in the same state, and conditional on the included covariates—for reasons other than the wealth effect on local consumption expenditure. As emphasized by Goldsmith-Pinkham et al. (2018), this requirement mirrors the parallel trends assumption in a continuous difference-in-difference design with multiple treatments. Two main threats to identification exist.

The first threat occurs because stock prices are forward-looking, so fluctuations in the stock market may reflect news about deeper economic forces such as productivity growth

[14]Specifically, we interact $S_{a,t-1}$ with (i) the holding return on a 5 year zero coupon Treasury bond using the updated Gürkaynak et al. (2006) data set, (ii) the log change in the Case-Shiller national house price series, and (iii,iv) $\ln\left(\sum_{j=0}^{11}\mathcal{R}^{-j}A_{t+j}\right)-\ln A_{t-1}$ for A_t=aggregate labor compensation (NIPA code A4002C) or aggregate non-corporate business income (nonfarm sole proprietor income and partnership income, NIPA code A041RC) and a quarterly discount factor $\mathcal{R}=1.03^{1/4}$. To see the rationale for the last two controls, let $H_t^{\infty}=\sum_{j=0}^{T}\mathcal{R}^{-j}A_{t+j}$ denote the discounted stream of labor (or private business) income A_t. The revision to human capital (or private business) wealth in period t is $\frac{E_t[H_t^{\infty}]-E_{t-1}[H_t^{\infty}]}{E_{t-1}[H_t^{\infty}]}\simeq\ln E_t\left[H_t^{\infty}\right]-\ln E_{t-1}\left[H_t^{\infty}\right]$. Relative to this definition, our control (i) truncates the horizon at $T=11$ (truncating at longer horizons gives similar results); (ii) replaces $E_t\left[H_t^{11}\right]$ with its perfect-forecast counterpart H_t^{11} (under rational expectations, this provides an unbiased measure of expected wealth); and (iii) replaces $E_{t-1}\left[H_t^{11}\right]$ with income in the last period, A_{t-1}. Under the efficient market hypothesis, this last step does not matter because both $E_{t-1}\left[H_t^{\infty}\right]$ and A_{t-1} are determined in period $t-1$ and therefore should be orthogonal to the stock return $R_{t-1,t}^{m}$.

[15]The Bartik (1991) industry shift-share predicted employment growth between $t-1$ and $t+h$ is defined as $\Delta_{a,t-1,t+h}e^{B}=\sum_{i\in\text{NAICS 3}}\left(\frac{E_{a,i,t-1}}{E_{a,t-1}}\right)\left(\frac{E_{i,t+h}-E_{i,t-1}}{E_{i,t-1}}\right)$, where $E_{a,i,t}$ denotes the (seasonally unadjusted) level of employment in NAICS 3-digit industry i in county a and period t, $E_{a,t}$ is total employment in county a, and $E_{i,t}$ is seasonally-adjusted total national employment in industry i.

[16]Data on payroll by firm size come from the Census Bureau's Quarterly Work Force Indicators. Because this data set has less historical coverage than our baseline sample, we use the time series mean share for each county. This step contains little loss of information because the large payroll share is extremely persistent at the county level, with an R^2 of 0.85 from a regression of the quarterly share on county fixed effects.

that independently affect consumption and investment. This "leading indicator" channel confounds interpretation of the relationship between consumption and the stock market in aggregate time series data. Our cross-sectional research design requires only the weaker condition that areas with high and low stock wealth to labor income ratios not load differently on other aggregate variables that co-move with the stock market. Conceptually, such differential loading could occur if stock wealth correlates with other forms of wealth and the return on the stock market correlates with the returns on other forms of wealth. Inclusion in $X_{a,t-1}$ of interactions of $S_{a,t-1}$ with other aggregate variables directly addresses the possible heterogeneity in exposure to changes in four other types of wealth: human capital wealth, non-corporate business wealth, fixed income wealth, and housing wealth.[17] For example, controlling for the interaction of $S_{a,t-1}$ and aggregate earnings addresses the possibility of high wealth areas having different exposure to aggregate earnings risk. Similarly, the Bartik variable controls for the possibility of high wealth counties concentrating in industries with higher stock market betas than those in low wealth counties or in industries that drive overall market returns, and the state-quarter fixed effects control non-parametrically for aggregate shocks that have heterogeneous impacts on different states. Finally, inclusion of the lags of $S_{a,t-1}R_{t-1,t}$ controls for the small serial correlation in stock returns shown in Figure 1a.

The second threat to identification concerns the separation of a consumption wealth effect from firm investment or hiring responding directly to the change in the cost of equity financing. Indeed, the response of total national employment to an increase in the stock market cannot separately identify these two channels. Our local labor market analysis absorbs changes in the cost of issuing equity common across areas into the time fixed effect. Nonetheless, firms in high stock wealth areas may have a cost of capital more sensitive to the value of the stock market. Two aspects of our research design make such a correlation an

[17] For non-corporate business wealth, fixed income wealth, and housing wealth, we could alternatively try to control directly for changes in the local values of these variables. This alternative has two deficiencies. First, these variables may endogenously respond to local stock market wealth, making them an over-control. Second, measuring local business wealth and fixed income wealth poses a more formidable challenge than measuring local stock market wealth, because of the much larger variation in capitalization factors for the income streams generated by these variables and the particular sensitivity of fixed income wealth to the capitalization factor at interest rates near zero (Kopczuk, 2015; Smith et al., In progress). While this difficulty precludes estimation of the local labor market effects of changes in these other types of wealth, including interactions with the aggregate values of other wealth is still sufficient for identifying the stock market wealth effect. The reason is that heterogeneity in holdings of other wealth matters for our purpose only insofar as returns on such wealth correlate with our main regressor. Formally, denoting by $S^o_{a,t-1}R^o_{t-1,t}$ the change in some other type of wealth o, we can write $S^o_{a,t-1}R^o_{t-1,t} = \gamma S_{a,t-1}R^o_{t-1,t} + S^{o,\perp}_{a,t-1}R^o_{t-1,t}$, where $\gamma S_{a,t-1}$ is the fitted value from a regression of $S^o_{a,t-1}$ on $S_{a,t-1}$ and so by construction $S^{o,\perp}_{a,t-1}$ is orthogonal to $S_{a,t-1}$. Therefore, omitting the part $S^{o,\perp}_{a,t-1}R^o_{t-1,t}$ from the change in wealth of type o has no impact on the remaining variables in the regression (and note that we do not need to separately identify the parameter γ). As an example, interacting the Treasury return with stock wealth directly amounts to allowing for an arbitrary correlation between the levels of stock wealth and fixed income wealth across counties.

unlikely driver of our results: (i) we find an employment response in nontradable but not in tradable industries, so differential access to capital markets would have to occur within areas and align with the tradable/nontradable sectoral distinction, and (ii) our baseline sample excludes counties in the top 5% of the share of employees working at large (500+) employee firms that might have greater access to public capital markets.

4 Results

4.1 Baseline Results

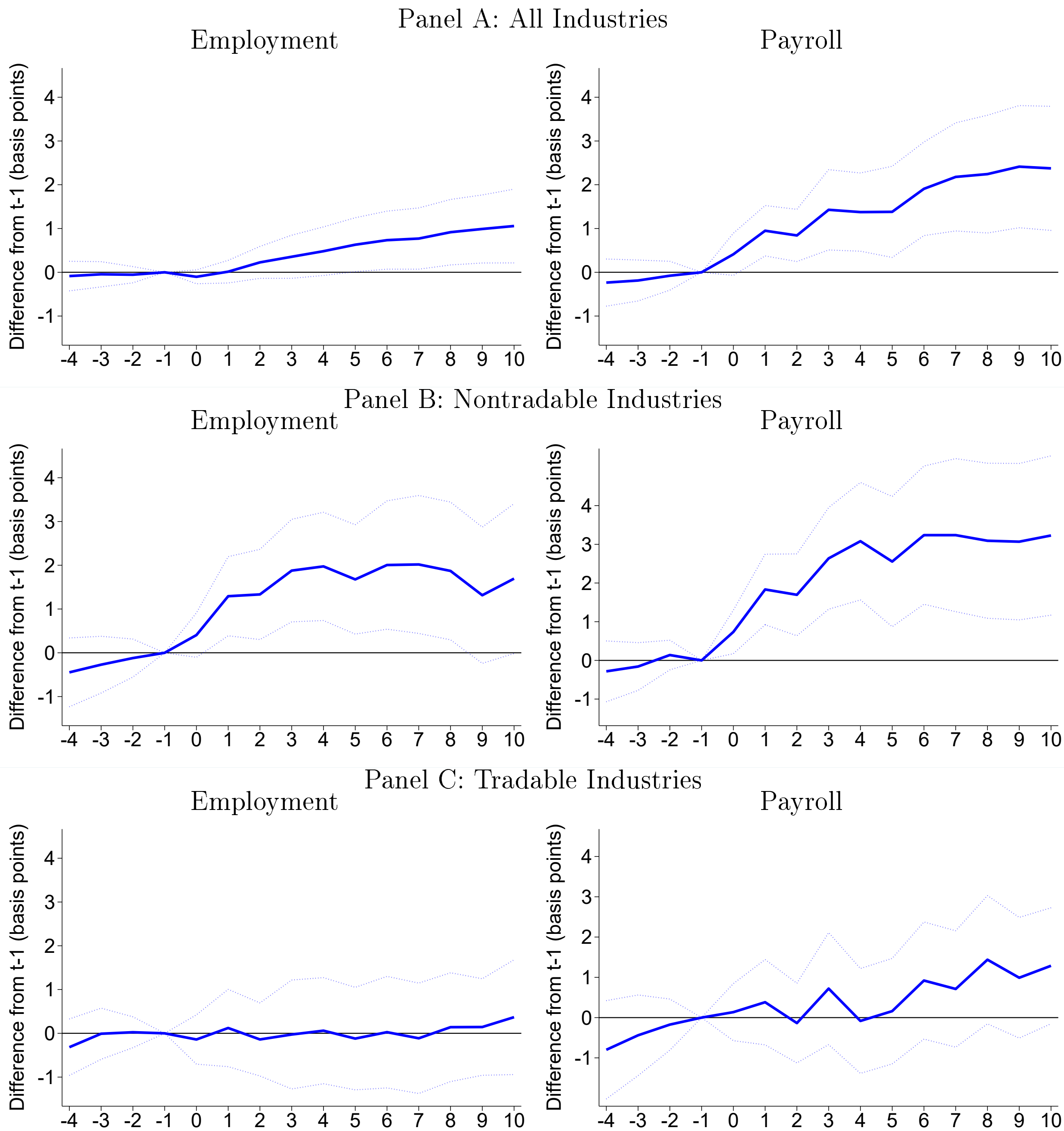
In this section we report our baseline results: (i) an increase in the stock market causes faster employment and payroll growth in counties with higher stock market wealth, (ii) the response is pronounced in industries that produce nontradable goods and in residential construction, and (iii) there is no increase in employment in industries that mostly produce tradable goods.

Figure 2 reports the time paths of responses of quarterly employment and payroll to an increase in stock market wealth; formally, the coefficients $\hat{\beta}_h$ from estimating Eq. (1). Table 1 reports the corresponding coefficients and standard errors for $h = 7$, where the stock market return occurs in period 0. Because the stock market is close to a random walk (Figure 1b), these time paths should be interpreted as the dynamic responses to a permanent change in stock market wealth. Panel A of Figure 2 shows no pre-trends in either total employment or payroll, consistent with the parallel trends assumption. Both series start increasing in period 1. Payroll responds more than employment, reflecting either rising hours per employee or rising compensation per hour. The point estimates indicate that a rise in stock market wealth in quarter t equivalent to 1% of labor income increases employment by 0.0077 log point (i.e. an approximately 0.77 basis point increase) and payroll by 0.0218 log point in quarter $t + 7$. The increases appear persistent.

Panels B and C examine the responses in industries classified as producing nontradable or tradable output, respectively. Employment and payroll in nontradable industries rise by more than the total effect. In contrast, the responses in tradable industries are flat following a positive stock market return. The horizon 7 differences between the tradable and nontradable employment and payroll coefficients are both significant at the 1% level. These patterns accord with the predictions of the theoretical model presented in the next section. They also militate against a leading indicator or cost-of-capital explanation since such confounding forces would have to apply only to the nontradable sector.

Figure 3 shows a large response of employment and payroll in the residential building

Figure 2: Baseline Results



Notes: The figure reports the coefficients β_h from estimating Eq. (1) for quarterly employment (left panel) and wages (right panel) at each quarterly horizon h shown on the lower axis. Panel A includes all covered employment and payroll; Panel B includes employment and payroll in NAICS 44-45 (retail trade) and 72 (accommodation and food services); Panel C includes employment and payroll in NAICS 11 (agriculture, forestry, fishing and hunting), NAICS 21 (mining, quarrying, and oil and gas extraction), and NAICS 31-33 (manufacturing). The shock occurs in period 0 and is an increase in stock market wealth equivalent to 1% of annual labor income. The dashed lines show the 95% confidence bands based on standard errors two-way clustered by county and quarter.

Table 1: Baseline Results

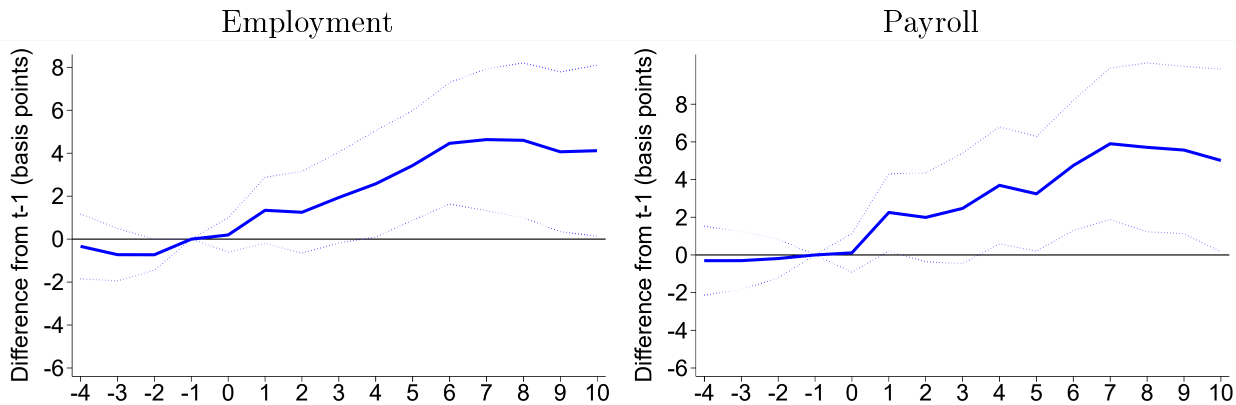
Sector:	All		Non-traded		Traded	
Dep. var.:	Emp.	W&S	Emp.	W&S	Emp.	W&S
	(1)	(2)	(3)	(4)	(5)	(6)
Right hand side variables:						
$S_{a,t-1}R_{a,t-1,t}$	0.77*	2.18**	2.02*	3.24**	−0.11	0.71
	(0.36)	(0.63)	(0.80)	(1.01)	(0.64)	(0.74)
Horizon h	Q7	Q7	Q7	Q7	Q7	Q7
Pop. weighted	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes
State × time FE	Yes	Yes	Yes	Yes	Yes	Yes
Shock lags	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.66	0.64	0.39	0.48	0.35	0.36
Counties	2,901	2,901	2,896	2,896	2,877	2,877
Periods	92	92	92	92	92	92
Observations	265,837	265,837	263,210	263,210	252,928	252,928

Notes: The table reports coefficients and standard errors from estimating Eq. (1) for $h = 7$. Columns (1) and (2) include all covered employment and payroll; columns (3) and (4) include employment and payroll in NAICS 44-45 (retail trade) and 72 (accommodation and food services); columns (5) and (6) include employment and payroll in NAICS 11 (agriculture, forestry, fishing and hunting), NAICS 21 (mining, quarrying, and oil and gas extraction), and NAICS 31-33 (manufacturing). The shock occurs in period 0 and is an increase in stock market wealth equivalent to 1% of annual labor income. All columns also include eight lags $\{S_{a,t-j-1}R_{a,t-j-1,t-j}\}_{j=1}^{8}$, interactions of $S_{a,t-1}$ with the log change in national labor income and with non-corporate business income from $t-1$ to the cumulative total over the next 12 quarters, the interaction of $S_{a,t-1}$ and the holding return on a 5 year Treasury bond, the interaction of $S_{a,t-1}$ and the log growth of national house prices between $t-1$ and t, and a Bartik (1991) shift-share measure of predicted employment growth. For readability, the table reports coefficients in basis points. Standard errors in parentheses and double-clustered by county and quarter. * denotes significance at the 5% level, and ** denotes significance at the 1% level.

construction sector (NAICS 2361). We show this sector separately because, while it also produces output consumed locally, the magnitude does not easily translate into our theoretical model since the sector produces a capital good (housing) that provides a service flow over many years. Thus, a desire by local residents to increase their consumption of housing services following a positive wealth shock will result in a front-loaded response of employment in the construction sector. Nonetheless, the large response of residential construction provides additional evidence of a local demand channel at work. We find no corresponding response in construction sectors unrelated to residential building.[18]

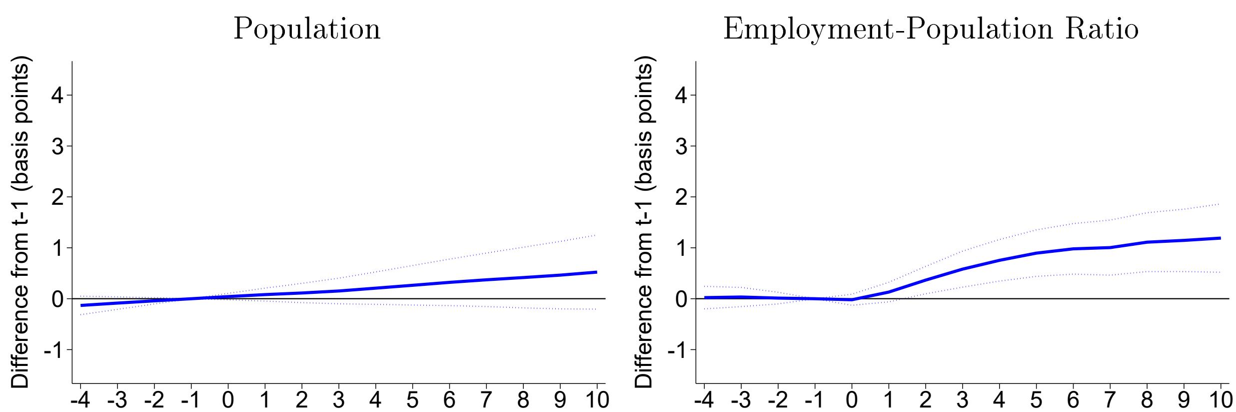
[18] In unreported results, we find smaller but statistically significant positive responses in specialty trade contractors (NAICS 238), a category that includes a number of sectors (electrical contractors, plumbers, etc.)

Figure 3: Response of Residential Construction



Notes: The figure reports the coefficients β_h from estimating Eq. (1) for residential building construction (NAICS 2361) employment and payroll at each quarterly horizon h shown on the lower axis. The shock occurs in period 0 and is an increase in stock market wealth equivalent to 1% of annual labor income. The dashed lines show the 95% confidence interval bands.

Figure 4: Response of Population and Employment-Population Ratio



Notes: The figure reports the coefficients β_h from estimating Eq. (1) for total county population (left panel) and the ratio of employment to county population (right panel) at each quarterly horizon h shown on the lower axis. The shock occurs in period 0 and is an increase in stock market wealth equivalent to 1% of annual labor income. The dashed lines show the 95% confidence interval bands.

Figure 4 reports the responses of population and the employment-population ratio.[19] The response of population lies well below the response of total employment and the data cannot reject no population response at the horizon we examine. As a result, the employment-population-ratio closely tracks the response of total employment.

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involved in the construction of residential buildings. In sharp contrast, there is a flat or slightly negative response in heavy and civil engineering construction (NAICS 237). We also find a large and statistically significant response of new building permits using the Census Bureau residential building permits survey.

[19]The Census Bureau reports population by county for July 1 of each year. We linearly interpolate these data to obtain a quarterly series. We construct the employment-population ratio by dividing the employment measure previously described by this population series.

Table 2: Robustness to Covariates

Dependent variable:	Total		Nontradable		Tradable	
	Emp.	Payroll	Emp.	Payroll	Emp.	Payroll
Specification:						
1. Baseline	0.77*	2.18**	2.02*	3.24**	−0.11	0.71
	(0.36)	(0.63)	(0.80)	(1.01)	(0.64)	(0.74)
2. Only county & stateXquarter FE	1.04*	2.82**	1.21	2.92**	0.02	1.55
	(0.40)	(0.74)	(1.06)	(1.06)	(0.87)	(1.04)
3. Control high earners	0.59	1.65**	1.90*	2.83**	−0.06	0.30
	(0.35)	(0.58)	(0.81)	(0.94)	(0.65)	(0.70)
4. Aggregate TFP sensitivity	0.66*	2.06**	1.84*	3.02**	−0.11	0.74
	(0.31)	(0.62)	(0.76)	(0.95)	(0.58)	(0.71)
5. Control local house prices	0.70+	2.15**	1.50*	2.82**	−0.45	0.35
	(0.37)	(0.65)	(0.64)	(0.92)	(0.62)	(0.70)
6. Control large firm share	0.70*	2.05**	1.93*	3.10**	−0.17	0.67
	(0.34)	(0.59)	(0.76)	(0.96)	(0.61)	(0.71)
7. Control lagged outcomes	0.75*	2.17**	2.10*	3.19**	−0.19	0.75
	(0.35)	(0.62)	(0.81)	(0.99)	(0.70)	(0.74)
8. CzoneXtime FE	1.09**	2.24**	2.41*	3.69**	−0.37	0.24
	(0.38)	(0.67)	(0.96)	(1.11)	(0.64)	(0.86)

Notes: The table reports alternative specifications to the baseline for $h = 7$. The shock occurs in period 0. Each cell reports the coefficient and standard error from a separate regression with the dependent variable indicated in the table header and the specification described in the left-most column. For readability, the table reports coefficients in basis points. Standard errors in parentheses and double-clustered by county and quarter. + denotes significance at the 10% level, * denotes significance at the 5% level, and ** denotes significance at the 1% level.

4.2 Robustness

Tables 2 and 3 report results from a number of robustness exercises for the horizon $h = 7$ overall, nontradable, and tradable responses of employment and payroll. The first row of each table reproduces the baseline specification.

Table 2 shows robustness to the covariates included in the baseline specification. Rows 2 expands the variation used to identify the response by removing the interactions of $S_{a,t-1}$ with changes in aggregate labor income, non-corporate income, bond wealth, and house prices, and the Bartik control. The results are similar to the baseline specification. The insensitivity reflects a combination of two forces: (i) the loadings on the other aggregate variables do not vary too much with stock wealth, and (ii) as illustrated in Figure 1c, while stock prices are not strictly exogenous, much of the volatility in the stock market and hence the variation in our main regressor occurs for reasons unrelated to other aggregate variables.

The remaining rows add additional control variables to the baseline specification to address particular concerns. While our baseline specification already includes a linear interaction of stock wealth/income and aggregate labor earnings, previous work has found especially high sensitivity among very high earners (Guvenen et al., 2014). To address this concern, row 3 includes an indicator for being in the top 5% of counties by share of returns with greater than $200,000 in adjusted gross income, interacted with time fixed effects. This row illustrates that controlling flexibly for cyclical patterns of counties with a large share of high earners has a small impact on the coefficients. Motivated by theories of news-driven business cycles (Beaudry and Portier, 2006), row 4 adds an interaction of $S_{a,t-1}$ with the Fernald (2012) measure of TFP growth between $t-1$ and $t+7$, again with little effect. Row 5 adds contemporaneous and 12 lags of local house prices. While our baseline specification controls for the sensitivity of wealthier areas to the aggregate housing cycle, adding the local controls allows this sensitivity to vary with the performance of the stock market.[20] Row 6 controls for the share of payroll in a county at establishments belonging to large (500+ employee) firms interacted with the stock market return. Large firms are more likely to have publicly traded equity and thus experience a direct reduction in their cost of capital when the stock market rises; the stability of coefficients indicates that our results do not reflect an investment response by such firms. Row 7 includes lagged outcomes to control directly for any pre-trends.[21] Row 8 replaces the state-by-quarter fixed effects with commuting zone-by-quarter fixed effects. In this specification, identification comes from comparing the responses of high and low wealth counties within the same commuting zone. Adding these controls has a minor effect on the point estimates.

Table 3 collects other robustness exercises. Rows 2 and 3 show that the quarters with the most extreme stock returns and the counties with the largest and smallest values of $S_{a,t}$ do not drive the results, although excluding these quarters and counties increases the standard errors. Rows 4 excludes counties in which at least one S&P 500 constituent firm has its headquarters, while row 4 excludes counties headquartering a firm on the Forbes list of the largest private companies. The coefficients remain qualitatively similar, although the payroll responses drop somewhat when excluding S&P 500 headquarter counties. We suggest

[20]We use the Federal Housing Finance Agency (FHFA) annual county-level repeat sales house price index and interpolate to obtain a quarterly series. In unreported results, we also find the response of residential construction remains quantitatively robust to controlling for contemporaneous and lags of house price growth so that the construction response does not merely reflect a run-up in local house prices in high wealth areas before the stock market rises.

[21]We include both a county fixed effect and lags of the dependent variable because of the large time dimension (roughly 100 quarters) of the data (Alvarez and Arellano, 2003).

Table 3: Other Robustness

Dependent variable:	Total		Nontradable		Tradable	
	Emp.	Payroll	Emp.	Payroll	Emp.	Payroll
Specification:						
1. Baseline	0.77*	2.18**	2.02*	3.24**	−0.11	0.71
	(0.36)	(0.63)	(0.80)	(1.01)	(0.64)	(0.74)
2. Keep if $R_{t-1,t} \in [P5, P95]$	1.15*	2.98**	3.54**	5.14**	0.30	1.87
	(0.46)	(0.93)	(1.01)	(1.25)	(0.97)	(1.24)
3. Trim top/bottom 1% of $S_{a,t}$	1.03*	2.93**	2.65*	4.56**	0.53	1.34
	(0.51)	(0.91)	(1.15)	(1.40)	(1.06)	(1.11)
4. Drop S&P 500 HQs	0.30	0.69+	1.68*	1.98**	0.03	0.72
	(0.21)	(0.39)	(0.67)	(0.68)	(0.81)	(0.88)
5. Drop Forbes Top Private HQs	0.40	0.89*	1.88*	2.66**	0.29	0.75
	(0.25)	(0.42)	(0.76)	(0.84)	(0.78)	(0.85)
6. Unweighted	0.48	0.85*	2.97*	2.86**	0.10	0.55
	(0.31)	(0.42)	(1.20)	(1.03)	(0.84)	(1.05)
7. Trim by population	0.83**	1.84**	2.15**	3.04**	0.52	1.52
	(0.31)	(0.56)	(0.79)	(0.91)	(0.74)	(0.94)
8. Price component only	0.67+	2.05**	1.80*	2.94**	−0.12	0.74
	(0.35)	(0.61)	(0.78)	(0.98)	(0.59)	(0.71)
9. IV with lagged wealth	0.75*	1.91**	1.61*	2.61**	−0.22	0.43
	(0.37)	(0.60)	(0.77)	(0.96)	(0.57)	(0.72)
10. IV with fixed dividends/income	0.88**	2.61**	1.64**	2.89**	0.23	1.22*
	(0.12)	(0.18)	(0.21)	(0.25)	(0.42)	(0.51)
11. Concentration-based T/NT	0.77*	2.18**	2.13**	4.26**	−0.72	0.62
	(0.36)	(0.63)	(0.62)	(1.00)	(0.98)	(1.61)
12. Across CBSAs	0.44	1.80+	2.56+	3.00+	0.68	1.95
	(0.47)	(1.03)	(1.53)	(1.63)	(1.61)	(1.73)

Notes: The table reports alternative specifications to the baseline for $h = 7$. The shock occurs in period 0. Each cell reports the coefficient and standard error from a separate regression with the dependent variable indicated in the table header and the specification described in the left-most column. For readability, the table reports coefficients in basis points. Standard errors in parentheses and double-clustered by county and quarter. + denotes significance at the 10% level, * denotes significance at the 5% level, and ** denotes significance at the 1% level.

caution in interpreting these results, however, because these 130 counties account for more than half of total stock wealth and payroll, so that excluding them substantially alters the characteristics of the sample. Rows 5 and 6 show robustness to not weighting the regressions and to trimming at the 1st and 99th percentile of county population.

The next three rows alter the shock variable. Row 8 uses only the price component of the S&P 500 return with similar results. Row 9 instruments $S_{a,t-1}R_{a,t-1,t}$ with $S_{a,t-8}R_{a,t-1,t}$ and row 10 uses the within-county mean ratio of dividend income to labor income interacted with the time-varying price-dividend ratio and return as an instrument. Because the dividend-labor income ratio changes little over time, instrumenting with the lagged wealth variable or fixing this ratio has a small effect on the results.

Row 11 uses an alternative classification of industries into tradable and nontradable, based on their geographic concentration. Intuitively, if locations all have similar preferences, then industries with concentrated production must sell to buyers in other regions. This idea traces back at least to Krugman (1991, p. 55) and has been pursued in Ellison and Glaeser (1997), Jensen and Kletzer (2005), and Mian and Sufi (2014), among others. We follow these authors and define a tradability index for industry i as $G_i = \sum_a (s_{a,i} - x_a)^2$, where $s_{a,i}$ denotes the share of employment in industry i located in county a and x_a denotes the share of total employment located in county a, and classify industries in the bottom quartile of this index as nontradable and industries in the top quartile as tradable. We obtain responses very similar to those using our baseline categorization.[22]

The last row returns to the baseline specification but expands the geographic unit to a Core Based Statistical Area (CBSA).[23] The point estimates change little except in the tradable sector where they rise slightly, while the standard errors increase substantially. The larger standard errors reflect the decrease in wealth variation after averaging across counties within a CBSA and the smaller sample size. The larger coefficients in the tradable sector could reflect spending on tradable goods produced outside of a resident's county but within the CBSA; however, the data do not reject equality of the coefficients in the county and CBSA specifications.

[22] We construct the index at the NAICS 3 digit level and group industries such that the share of total employment in each quartile is the same. The classification has substantial overlap with our baseline categorization: 7 of the 12 least-concentrated industries are in NAICS 44-45 or 72, and 27 of the 45 most-concentrated industries are in NAICS 11, 21, or 31-33 (the concentrated industries are smaller on average). Even at the 3 digit level, disclosure limitations affect the number of industries reporting employment and payroll in each period. We restrict to county-quarters with the same number of industries reporting non-missing employment and wages in periods $t-1$ and $t+7$, resulting in a final sample about one-half as large as our baseline and explaining why we prefer the simpler 2 digit-based classification for our baseline.

[23] The Office of Management and Budget (OMB) defines CBSAs as areas "containing a large population nucleus and adjacent communities that have a high degree of integration with that nucleus" and has designated 917 CBSAs of which 381 (covering 1,166 counties) are Metropolitan Statistical Areas (MSAs) and the remainder (covering 641 counties) are Micropolitan Statistical Areas (MiSAs). An MSA is a CBSA with an urban core of at least 50,000 people. The remaining counties not affiliated with a CBSA are rural. Because CBSA's may contain counties from multiple states (e.g. the Boston-Cambridge-Newton MSA contains five counties in MA and two counties in NH), the specification in this row replaces the state×quarter fixed effects with quarter fixed effects.

4.3 Decomposing Variation

In this section we provide evidence on whether certain areas "drive" the results in the sense of Andrews et al. (2017). Consider the specification reported in row 2 of Table 2 in which $X_{a,t}$ includes only a county fixed effect and state-by-quarter fixed effect. In this case, letting $\tilde{z}_{a,t}$ denote $S_{a,t-1}R_{t-1,t}$ demeaned by county and state-by-quarter, $\Delta_{a,t}\tilde{y}$ the outcome after demeaning with respect to county and state-by-quarter (where for notational simplicity we have suppressed the dependence of Δ on the horizon h), π_a the 2010 population in county a, and s index states, we can decompose the OLS coefficient as follows:

$$\beta = \sum_s w_s \beta_s$$

where

$$\beta_s \equiv \left(\sum_{a \in s} \sum_t \pi_a \tilde{z}_{a,t}^2 \right)^{-1} \sum_{a \in s} \sum_t \pi_a \tilde{z}_{a,t} \Delta_{a,t} \tilde{y},$$

$$w_s \equiv \left(\sum_{a'} \sum_t \pi_{a'} \tilde{z}_{a',t}^2 \right)^{-1} \left(\sum_{a \in s} \sum_t \pi_a \tilde{z}_{a,t}^2 \right).$$

Here, β_s is the regression coefficient obtained by using only observations from state s and the weight w_s is the contribution to the total (residual) variation in the regressor from state s.[24] The weights $\{w_s\}$ are all positive and sum to one.

Table 4 reports the ten states with the largest weight in the regression. Not surprisingly, since the regression weights by population, California, Texas, and Florida rank among the states with the highest weights. More surprisingly, Florida, with 6% of the 2010 population, has a weight in the regression above 30%. This high share reflects the large variation across Florida counties in stock market wealth. On the other hand, Florida does *not* drive the finding of a positive regression coefficient, as the Florida-only nontradable labor bill coefficient is *smaller* than the overall coefficient. Hence excluding Florida from the sample would *raise* the estimated coefficient. Virginia also receives a larger weight in the regression than its population share, reflecting the contrast in the state between wealthier northern suburbs of D.C. and poorer southern counties. Notably, all 10 of the states with the largest weight have $\beta_s > 0$. Thus, no one or two states drive the overall result.

[24] We could have done this decomposition for the baseline specification after partialing out the interactions of $S_{a,t-1}$ with other aggregate variables and the Bartik employment variable. In that case, the coefficient β_s would no longer equate to the coefficient from estimating the regression in state s only because the coefficient on these additional controls would differ across states. The alternative of re-estimating the baseline specification while dropping one state at a time yields conclusions similar to those obtained from Table 4.

Table 4: Ten States with Largest Weight

State	Population share	Weight	β_s, nontradable wage bill
Florida	0.061	0.313	0.30
California	0.121	0.081	5.01
Virginia	0.026	0.050	2.36
Texas	0.081	0.039	1.98
Ohio	0.037	0.034	1.90
North Carolina	0.031	0.032	3.14
Missouri	0.019	0.031	3.23
Illinois	0.042	0.027	7.88
Washington	0.022	0.027	8.46
Maryland	0.019	0.026	5.46

4.4 Heterogeneity

This section considers heterogeneity in the labor market response. Figure 5 reports results for the coefficients on nontradable payroll, the variable most directly used in our theoretical analysis, from augmenting Eq. (1) by replacing $\beta_h[S_{a,t-1}R_{a,t-1,t}]$ with $\sum_{m=1}^{M}\beta_h^m \times \mathbb{I}\{o_{a,t} \in m\} \times [S_{a,t-1}R_{a,t-1,t}]$, where $\mathbb{I}\{o_{a,t} \in m\}$ is an indicator for observation $o_{a,t}$ belonging to set m. The dimensions of heterogeneity considered are whether the stock return is positive or negative, the sample period, and wealth level.

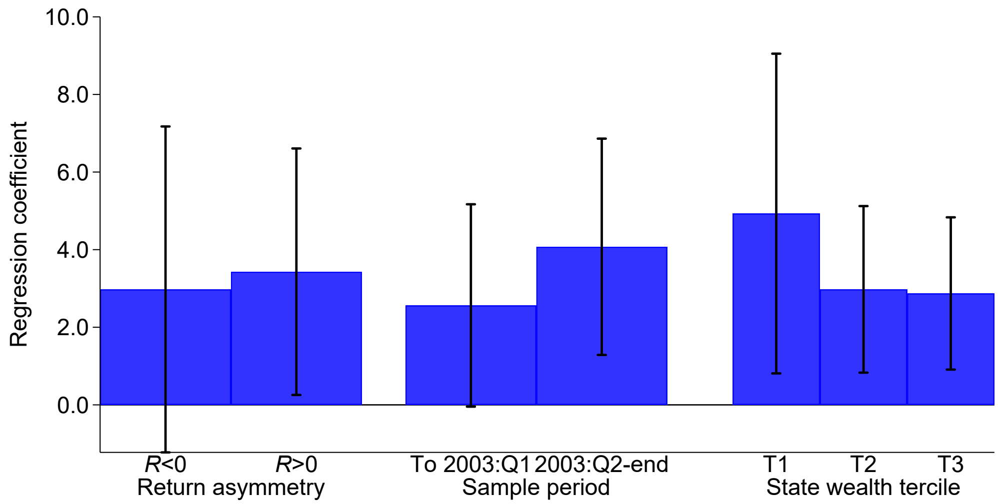
The left bars show a similar response of nontradable payroll to a negative or positive stock return. Nearly 75% of quarters in our sample contain a positive return, explaining the higher precision around the coefficient on positive returns. The middle bars show the response split before and after the end of the NASDAQ bust. The response is slightly larger in the more recent period, but not statistically significantly different.[25]

Many theories of consumption predict higher MPCs for less wealthy households. In the context of stock market wealth, Di Maggio et al. (forthcoming) find a higher MPC in Sweden among households in the lower half of the wealth distribution. In our regional context, such heterogeneity could also arise from local general equilibrium amplification declining in wealth (since, all else equal, a smaller MPC also leads to a smaller multiplier effect). The right bars show that the coefficient indeed declines in tercile of state wealth, although the differences are not statistically significant.[26]

[25]Not shown, this pattern holds across other outcomes except total employment, which responds much more strongly in the latter period. Our theory can rationalize a larger response of employment if the more recent period featured greater wage rigidity.

[26]We split states by tercile of their time-averaged real (deflated by the price index for personal consumption

Figure 5: Heterogeneity



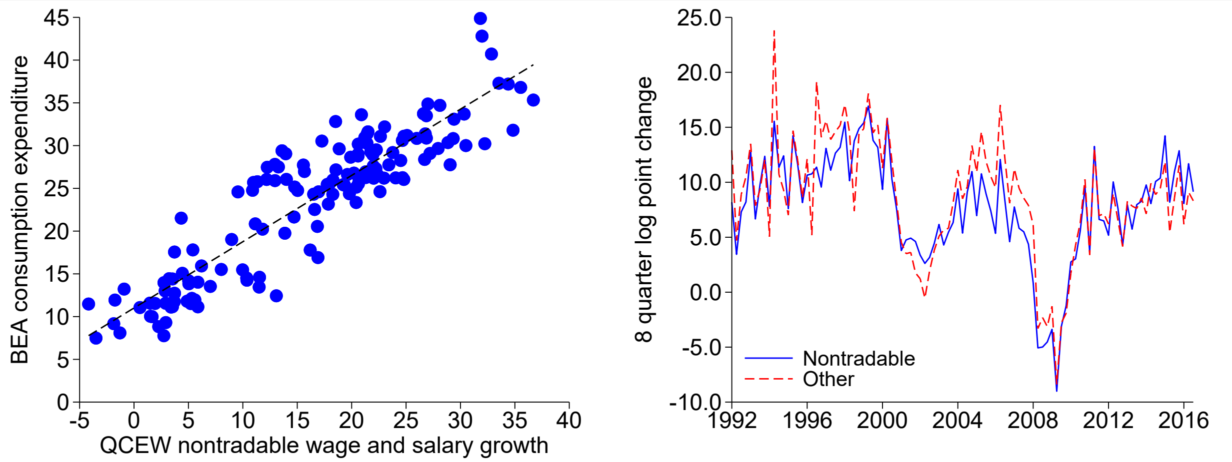
Notes: The figure reports the coefficients β_h^m from estimating Eq. (1) for the nontradable wage bill at horizon $h = 7$, where m indexes positive versus negative stock return (left bars), before or after 2003:Q2 (middle bars), or tercile of the state's per capita wealth distribution (right bars). The whiskers show the 95% confidence intervals.

The possibility of heterogeneous MPCs also has implications for the interpretation of our baseline coefficients. In general, when treatment effects are correlated with the regressor, the OLS coefficient in a specification without treatment effect heterogeneity need not lie in the convex hull of the individual treatment effects; intuitively, if low wealth areas have high MPCs and high wealth areas have low MPCs, an increase in the stock market could induce the same change in spending in both low and high wealth areas. However, an advantage of a regional approach is that it already reflects the wealth-weighted average MPC in a region. Because stock wealth heterogeneity is substantially greater within than across counties, this means that the cross-county regression approximately reflects the wealth-weighted average MPC across *all* stockholders—the MPC that matters for *aggregate* stock wealth fluctuations. Appendix A.5 establishes this claim quantitatively in Monte Carlo exercises on simulated data that match the empirical distributions of stock market participation in each county, stock wealth-by-income of stockholders, and the cross-county distribution of average stock wealth. We first show that with heterogeneity in the MPC of stockholders not correlated with stock wealth, our empirical design exactly reflects the true wealth-weighted MPC. Second,

expenditure) dividends per capita. Splitting by state wealth level maintains the identification of each coefficient as coming only from within-state variation. The terciles are: Alabama, Arkansas, Delaware, Georgia, Idaho, Indiana, Kentucky, Louisiana, Mississippi, New Mexico, North Carolina, North Dakota, Oklahoma, Tennessee, Texas, Utah, West Virginia (tercile 1); Alaska, Arizona, California, Hawaii, Iowa, Maine, Michigan, Montana, Nebraska, New York, Ohio, Oregon, Rhode Island, South Carolina, South Dakota, Wisconsin, Wyoming (tercile 2); Colorado, Connecticut, Florida, Illinois, Kansas, Maryland, Massachusetts, Minnesota, Missouri, Nevada, New Hampshire, New Jersey, Pennsylvania, Vermont, Virginia, Washington (tercile 3).

Figure 6: Nontradable Payroll, Consumption Expenditure, and Total Payroll

Nontradable payroll versus consumption   Nontradable versus other payroll



Notes: The left panel presents a scatter plot of five-year log changes in state-level QCEW nontradable wages and salaries and state-level BEA personal consumption expenditure, for each five-year period corresponding to processed quinquennial Economics Censuses (1997-2002, 2002-2007, 2007-2012). The right panel shows 8 quarter log changes in national QCEW wages and salaries in the nontradable sector (NAICS 44-45 and 72) and all other sectors.

when the household-level MPC declines in stock wealth, our design understates the true wealth-weighted MPC, making our estimates if anything a lower bound. However, even for a strong negative relationship, the difference in coefficients is less than 10%.

4.5 Labor Income versus Consumption Expenditure

Our analysis so far has focused on the impact on labor market variables. Shortly, we will use economic theory to relate the response of payroll in the nontradable sector to the MPC out of stock market wealth. Before turning to that analysis, we establish in this section a tight empirical connection between labor market outcomes and consumption and present direct empirical evidence of a consumption expenditure response.

We first show that nontradable payroll growth (that we estimate) closely tracks consumption expenditure growth at the state level. The left panel of Figure 6 presents a scatter plot of five-year log changes in state-level QCEW nontradable wages and salaries and state-level BEA personal consumption expenditure (the lowest level of aggregation at which BEA reports consumption expenditure), for each five-year period corresponding to processed quinquennial Economics Censuses (1997-2002, 2002-2007, 2007-2012). We restrict attention to these five-year intervals in which consumption expenditure reflects actual sales data (Awuku-Budu et al., 2016). The two series exhibit a strong positive relationship.

Next, our theoretical analysis in Section 7 will require an assumption of homotheticity across nontradable and other sectors. The right panel of Figure 6 shows evidence of this relationship by plotting 8 quarter log changes of national nontradable payroll and total payroll in all other sectors in the QCEW. At the local level, these two series exhibit different responses to increases in stock wealth, with nontradable payroll rising more sharply. At the national level these series co-move uniformly over time, with a regression coefficient of 0.96 (Newey-West standard error 0.077) and R^2 of 0.79. The similarities in the mean growth rates and high frequency movements of these two series signify homotheticity across locally-nontradable spending and other categories. We will use this property to infer the response of national spending from the response of local nontradable spending.

Appendix A.6 provides further evidence of preference homotheticity across nontradable and other sectors using the Consumer Expenditure Survey. Table A.8 reports Engel curves for selected expenditure categories. Our theoretical analysis will not require homotheticity across all expenditure categories, and we confirm in Table A.8 that our nontradable grouping includes both luxury (jewelry, restaurants) and necessity (food at home) items. However, the overall nontradable category of retail and restaurants moves close to proportionally with total expenditure across households. Table A.9 extends the Dynan and Maki (2001) analysis of securities-owning households in the Consumer Expenditure Survey to estimate the effect of the stock market separately for these households' retail expenditure and other expenditure. Again consistent with homotheticity holding for the broad category of retail and restaurants, we find similar total responses across the two types of expenditure.

Finally, we provide direct evidence of the response of consumption expenditure to stock wealth in Table 5, using the BEA state-level data. These data start in 1997 and have an annual frequency, resulting in a very large reduction in both the cross-section (roughly 3000 counties to 50 states) and time (93 quarters to 18 years) dimensions relative to our baseline, county-quarter specification. Guided by the theoretical model in the next section, we also modify Eq. (1) by replacing $S_{a,t-1}$ with $S^C_{a,t-1}$, defined as the ratio of stock wealth to consumption expenditure in state a and year $t-1$.

We estimate a cross-state coefficient of 4.8. As we will see, this magnitude accords extremely well with the coefficient on nontradable payroll of 3.2 estimated in our baseline specification, providing additional support for the homotheticity assumption and the theoretical mapping of our baseline specification into the MPC out of stock wealth in the next section. From an econometric identification standpoint, this coincidence is remarkable, as our baseline specification uses only within-state variation while Table 5 uses only cross-state variation for identification. However, the coefficient is estimated less precisely than in our baseline, reflecting the large reduction in sample size. Moreover, since we have few clusters in the time dimension (18 years), the conventional clustered standard errors reported in

Table 5: Cross-state Expenditure Results

Coefficient	Conventional two-way clustered standard error	LZ2 two-way clustered standard error	BM degrees of freedom
4.82	1.97	2.85	4.50

The table reports results from estimating $\Delta_{a,t-1,t+h} y = \beta_h [S^C_{a,t-1} R_{a,t-1,t}] + \Gamma'_h X_{a,t-1} + \epsilon_{a,t-1,t+h}$, where y is total consumption expenditure in state a, $h = 2$ years, $S^C_{a,t-1}$ is the ratio of stock wealth to consumption expenditure in state a in period $t-1$, and the remaining variables are analogous to our baseline specification. The first column reports the regression coefficient. The second column reports the standard error clustered by state and year using the conventional degrees of freedom adjustment. Column (3) reports the standard error using the "LZ2" adjustment recommended by Imbens and Kolesár (2016) for samples with relatively few clusters. Column (4) reports the Imbens and Kolesár (2016) suggested degrees of freedom for the t-distribution implied by columns (1) and (3).

column (2) might be biased. We address this issue by reporting in column (3) the standard error using the "LZ2" bias-reduction adjustment recommended by Imbens and Kolesár (2016) for samples with relatively few clusters and in column (4) the Imbens and Kolesár (2016) suggested degrees of freedom for the t-distribution implied by columns (1) and (3).

5 Theoretical Model

This section develops a stylized theoretical model to interpret the empirical analysis. We present the main equations and results in the main text and relegate additional details to Appendix B. We use the model to illustrate the cross-sectional effects of changes in aggregate stock prices and to validate our empirical specification. In subsequent sections, we calibrate the model and structurally interpret our empirical findings.

We start with a brief overview of the model's ingredients and their role in our analysis. There is a continuum of areas denoted by subscript a; infinite number of periods denoted by subscript $t \in \{0, 1, 2, ..\}$; two factors of production, labor L and capital K; two goods denoted by superscripts $\{N, T\}$, nontradables and tradables; and two types of agents in each area denoted by superscript $i \in \{s, h\}$, "stockholders" and "hand-to-mouth" households.

Our focus is on period 0, which we interpret as the "short run" with the key feature that labor is specific to the area and nominal wages are (potentially) partially sticky. We assume (for now) that monetary policy stabilizes aggregate demand by stabilizing the average wage at a nominal target level. However, since areas are not symmetric, monetary policy does not stabilize demand in each area. Therefore, local labor market outcomes in period 0 are determined by local demand. In contrast, we interpret periods $t \geq 1$ as the "long run" in which labor is fully mobile and the macroeconomic outcomes in each area are determined solely by productivity. Capital is fully mobile across areas in all periods and has a single (aggregate) price, although this assumption is inessential to our analysis.

The aggregate price of capital in period 0 ("the stock market") is endogenous and can change due to fluctuations in its expected productivity in periods $t \geq 1$. Importantly, initial capital ownership ("stock wealth") is heterogeneous across areas. Our goal is to analyze how changes in the aggregate price of capital affect local labor market outcomes. The nontradable sector plays a central role in this analysis and in our calibration.

Finally, "stockholders" make endogenous consumption-savings and portfolio decisions and provide labor exogenously. "Hand-to-mouth" households spend their income in every period, while supplying labor endogenously (with partially sticky wages). These features isolate the stock wealth effect on consumption from wealth effects on labor supply and allow the model to generate empirically reasonable Keynesian multiplier effects and changes in labor.

5.1 Environment and Equilibrium

Each area contains a representative stockholding household with relative mass $1-\theta$ and hand-to-mouth household with relative mass θ. In each period t and area a, each household $i \in \{s, h\}$ divides its consumption $C_{a,t}^{i}$ between a nontradable good that must be consumed in the area where it is produced, $C_{a,t}^{i,N}$, and a tradable good that can be transported costlessly across areas, $C_{a,t}^{i,T}$, to maximize the consumption aggregator:

$$C_{a,t}^{i} = \left(C_{a,t}^{i,N}/\eta\right)^{\eta} \left(C_{a,t}^{i,T}/\left(1-\eta\right)\right)^{1-\eta}.$$

Here, η denotes the share of nontradables in consumption.

The nontradable good is produced by competitive firms using labor $L_{a,t}^{N}$ and capital $K_{a,t}^{N}$ and the Cobb-Douglas technology:

$$Y_{a,t}^{N} = \left(K_{a,t}^{N}/\alpha^{N}\right)^{\alpha^{N}} \left(L_{a,t}^{N}/\left(1-\alpha^{N}\right)\right)^{1-\alpha^{N}}.$$

Here, $1-\alpha^{N}$ denotes the share of labor in the nontradable sector. The tradable good can be produced by a technology that uses tradable inputs produced in each area using local labor $L_{a,t}^{T}$ and capital $K_{a,t}^{T}$ and the Cobb-Douglas technology:

$$\begin{aligned} Y_{t}^{T} &= \left(\int_{a} \left(Y_{a,t}^{T}\right)^{\frac{\varepsilon-1}{\varepsilon}} da\right)^{\frac{\varepsilon}{\varepsilon-1}} \\ \text{where } Y_{a,t}^{T} &= \left(K_{a,t}^{T}/\alpha^{T}\right)^{\alpha^{T}} \left(L_{a,t}^{T}/\left(1-\alpha^{T}\right)\right)^{1-\alpha^{T}}. \end{aligned}$$

The elasticity of substitution $\varepsilon > 0$ governs the effect of unit costs in an area on the exports from that area. The term $1 - \alpha^T$ captures the share of labor in the tradable sector.

Starting from period 1 onward, the tradable good can also be produced with another technology that uses only capital:

$$\tilde{Y}_t^T = D^{1-\alpha^T} \tilde{K}_t^T \text{ for } t \geq 1.$$

The (future) productivity parameter D determines the rental rate of capital in periods $t \geq 1$. This technology does not play an important role beyond the asset pricing side of the model. Specifically, we will obtain changes in stock prices in period 0 by varying the future productivity, D. The normalizing power $1 - \alpha^T$ simplifies the expressions.[27]

Areas are identical except for their initial capital wealth. The representative stockholder in area a enters period 0 owning $\frac{1+x_{a,0}}{1-\theta}$ units of capital, where $\int_a x_{a,0} da = 0$ (so that the area owns $1 + x_{a,0}$ units of capital). We let Q_0 denote the (cum-dividend) price of capital at the beginning of period 0 and normalize the aggregate capital supply to one. Therefore, $(1 + x_{a,0}) Q_0$ denotes the value of capital and, hence, the stock market wealth held by all stockholders in area a at the start of period 0. Consequently, the distribution of capital ownership, $\{x_{a,0}\}_a$, determines the cross sectional heterogeneity of stock wealth.

Stockholders supply labor exogenously, $L_{a,t}^s = \overline{L}$ for each a, at the equilibrium wage denoted by $W_{a,t}$. They choose the paths of their consumption, $\left\{C_{a,t}^s\right\}_{t=0}^{\infty}$, and capital holdings, $\left\{\frac{1+x_{a,t}}{1-\theta}\right\}_{t=1}^{\infty}$, (with their residual savings invested in the risk-free asset), to maximize a time-separable log utility function,

$$\sum_{t=0}^{\infty} (1-\rho)^t \log C_{a,t}^s, \tag{3}$$

subject to standard budget constraints that we relegate to the appendix [cf. $(B.9)$]. Here, $1-\rho \in (0,1)$ denotes the one-period discount factor. The elasticity of intertemporal substitution of one simplifies the analysis and is empirically plausible.

Hand-to-mouth households are myopic and spend their labor income in all periods, $P_{a,t} C_{a,t}^h = W_{a,t} L_t$, and do not hold any financial assets. We model their labor supply to incorporate both some degree of wage stickiness and disutility of labor. Specifically, the representative hand-to-mouth household in an area is subdivided into a continuum of worker types denoted by $\nu \in [0,1]$. A worker of type ν supplies specialized labor services $L_{a,t}^h(\nu)$ subject to a constant elasticity labor demand curve determined by the aggregate demand for

[27] We exclude this technology from period 0 (our focus) to ensure the production side is homothetic. This homotheticity simplifies the analysis and plays a role for some of our results (as we describe subsequently).

labor in the area as well as the elasticity of substitution ε_w between specialized labor types. A fraction $1-\lambda_w$ of the labor types (the sticky workers) supply labor at the preset wage $\overline{W}$, which is the average nominal wage level targeted by monetary policy (as we describe subsequently). The remainder (the flexible workers) set a wage $W^h_{a,t}(\nu)$ to maximize:

$$C^h_{a,t} - \frac{\chi}{1+\varphi^h} \int_0^1 L^h_{a,t}(\nu)^{1+\varphi^h} d\nu,$$

where φ^h denotes the inverse of the Frisch elasticity of labor supply. Thus, the worker chooses labor according to Greenwood et al. (1988) preferences, which omit a wealth effect on labor supply.

Finally, the risk-free asset is in zero net supply. We denote the gross nominal risk-free interest rate between periods t and $t+1$ with R^f_t. Monetary policy sets R^f_t to stabilize the average nominal wage at the target level:

$$\int_a W_{a,t} da = \overline{W} \text{ for each } t.$$

When areas are symmetric, this policy ensures labor supply in each area is at its "frictionless" level—the level that obtains without nominal rigidities (since the sticky workers set wages equal to the policy target). With asymmetries across areas, the policy stabilizes the labor supply across areas "on average."[28] Appendix B.1 completes the description of the setup and defines the equilibrium.

Appendix B.2.2 characterizes the equilibrium in periods $t \geq 1$ in which labor (as well as capital) is mobile across areas. The economy immediately reaches a steady state in which nominal wages are equal to the monetary policy target, $W_{a,t} = \overline{W}$, and the equilibrium interest rate and the price of capital are constant, $R^f_t = \frac{1}{1-\rho}$ and $Q_t = \frac{\overline{W}D}{\rho}$ [cf. Proposition 1]. We next turn to our focus, period 0.

5.2 Consumption Wealth Effect

Appendix B.2.3 characterizes the equilibrium and establishes that aggregate consumption in the area ($C_{a,0}$) satisfies:

$$P_{a,0}C_{a,0} = \theta W_{a,0} L^h_{a,0} + (1-\theta)\rho \left[\left(W_{a,0}\overline{L} + \frac{1}{R^f_0} \frac{\overline{WL}}{\rho} \right) + \left(\frac{1+x_{a,0}}{1-\theta} \right) Q_0 \right]. \tag{4}$$

[28]To simplify the exposition, we do not explicitly model money or its liquidity services. These features can be added to the model without changing anything substantive (see Woodford (1998) for further discussion).

Here, the two terms capture spending by hand-to-mouth households and stockholders, respectively. The term in brackets illustrates the consumption wealth effect. With log utility, stockholders' consumption expenditure is a fraction of lifetime wealth, which consists of their human capital wealth (in parenthesis) and their stock wealth. Their marginal propensity to consume (MPC) is given by ρ. In particular, a change in the price of capital Q_0 affects local consumption through the stockholders. We next solve for the equilibrium further, first in a benchmark case in which areas have common wealth and then by linearizing the equilibrium equations around that benchmark.

5.3 Common Wealth Benchmark

First suppose all areas have the same stock wealth, $x_{a,0} = 0$ for each a. In this case, the equilibrium allocations and prices are the same across areas, so we drop the subscript a. With symmetry and active monetary policy, hand-to-mouth labor supply is at its frictionless level everywhere. We choose parameters such that this level equals stockholders' exogenous labor, $L_0^h = \overline{L}$ (cf. $(B.30)$). Thus, the aggregate wages and labor satisfy:

$$W_0 = \overline{W}, \quad L_0 = L_0^h = \overline{L}.$$

Appendix B.3 characterizes the rest of the equilibrium and establishes:

$$\begin{aligned}
L_0^N/\overline{L} &= \frac{1-\alpha^N}{1-\overline{\alpha}}\eta \text{ and } L_0^T/\overline{L} = \frac{1-\alpha^T}{1-\overline{\alpha}}(1-\eta) \qquad (5)\\
Q_0/\overline{W} &= \frac{\overline{\alpha}}{1-\overline{\alpha}}\overline{L} + \frac{1}{R_0^f}\frac{D}{\rho} \\
R_0^f &= \frac{1}{1-\rho}\frac{1-\overline{\alpha}}{1-(1-\overline{\alpha})\theta}\frac{(1-\theta)\overline{L}+D}{\overline{L}} \\
\text{where } \overline{\alpha} &= \eta\alpha^N + (1-\eta)\alpha^T. \qquad (6)
\end{aligned}$$

Here, $\overline{\alpha}$ denotes the weighted average capital share across sectors. The first line shows that the share of labor employed in each sector is determined by the sectoral shares in household spending, adjusted by the differences in labor shares across sectors. The remaining lines characterize the equilibrium price of capital and the interest rate ("rstar").

We focus on the fluctuations in the price of capital Q_0 that result from changes in the *future* productivity of capital, D. Eqs. (5) illustrate that an increase in D increases Q_0 (despite the endogenous response of R_0^f) while leaving the *aggregate* labor market outcomes unchanged. We next investigate how this change affects *local* labor market outcomes.[29]

5.4 Heterogeneous Wealth and Cross-Sectional Predictions

Next consider the empirically-relevant case of a heterogeneous distribution of stock wealth. To analyze this case, in Appendix B.4 we log-linearize the equations that characterize the equilibrium around the common wealth benchmark for a given level of D. Specifically, we let $w_{a,0} = \log\left(W_{a,0}/\overline{W}\right)$, $p_{a,0} = \log\left(P_{a,0}/P_0\right)$ and $l_{a,0} = \log\left(L_{a,0}/\overline{L}\right)$ denote the log-deviations of nominal wages, nominal prices, and total labor for each area. We define $l^N_{a,0}$ and $l^T_{a,0}$ similarly for the nontradable and tradable sectors.

We first derive a reduced form labor supply relation. Log-linearizing hand-to-mouth agents' optimal labor supply, we obtain:

$$w_{a,0} = \lambda\left(p_{a,0} + \varphi l_{a,0}\right) \text{ where } \varphi = \frac{\varphi^h}{\theta}. \tag{7}$$

Here, $\lambda \equiv \frac{\lambda_w}{1+(1-\lambda_w)\varphi^h\varepsilon_w} \in [0,1]$ is a meta-parameter that is an inverse measure of wage stickiness. When $\lambda = 0$, wages are fully sticky. When $\lambda = 1$, wages are fully flexible and the equation reduces to a neoclassical labor supply curve. The parameter, φ, is the effective inverse labor elasticity across all households. Since stockholders supply labor inelastically, the weighted-average labor elasticity is $1/\varphi = (1-\theta)\times 0 + \theta \times 1/\varphi^h = \theta/\varphi^h$. We also have that local prices scale local wages,

$$p_{a,0} = \eta\left(1-\alpha^N\right) w_{a,0}. \tag{8}$$

Combining Eqs. (7) and (8), we obtain the reduced form relation:

$$w_{a,0} = \kappa l_{a,0}, \text{ where } \kappa = \frac{\lambda\varphi}{1-\lambda\eta\left(1-\alpha^N\right)}. \tag{9}$$

Here, κ is a composite wage adjustment parameter that combines the effect of inverse wage stickiness, λ, and the (effective) inverse labor supply elasticity, φ.

Our key predictions correspond to the comparative statics as the future productivity of

[29] In Appendix B.8, we generalize the model to incorporate uncertainty over D and show that our analysis is robust to other sources of fluctuations in Q_0, such as changes in the level of uncertainty or changes in risk aversion. Specifically, a reduction in households' perceived uncertainty about D increases Q_0 and R^f_0. With more general Epstein-Zin preferences, a decrease in households' relative risk aversion parameter increases Q_0 and R^f_0 (see Proposition 4). Finally, conditional on generating the same increase in Q_0, the decline in risk or risk aversion has the same *quantitative* effects on local labor market outcomes as in our baseline model.

capital changes from D^{old} to some D^{new}, giving rise to a change in the stock price of ΔQ_0:

$$\Delta\left(w_{a,0}+l_{a,0}\right)=\frac{1+\kappa}{1+\kappa\zeta}\mathcal{M}\left(1-\alpha^{N}\right)\eta\rho\frac{x_{a,0}\Delta Q_0}{\overline{WL}}, \tag{10}$$

$$\Delta l_{a,0}=\frac{1}{1+\kappa}\Delta\left(w_{a,0}+l_{a,0}\right), \tag{11}$$

$$\Delta\left(w_{a,0}+l_{a,0}^{N}\right)=\mathcal{M}\left(1-\overline{\alpha}\right)\rho\frac{x_{a,0}\Delta Q_0}{\overline{WL}}+\left(\mathcal{M}-1\right)\frac{1-\alpha^{T}}{1-\alpha^{N}}\frac{1-\eta}{\eta}\Delta\left(w_{a,0}+l_{a,0}^{T}\right), \tag{12}$$

$$\Delta\left(w_{a,0}+l_{a,0}^{T}\right)=-\left(\varepsilon-1\right)\left(1-\alpha^{T}\right)\Delta w_{a,0}, \tag{13}$$

$$\text{where } \mathcal{M}=\frac{1}{1-\left(1-\alpha^{N}\right)\eta\left\{\frac{\theta\kappa+1}{\kappa+1}+\rho\frac{\kappa(1-\theta)}{\kappa+1}\right\}}$$

$$\text{and } \zeta=1+\left(\varepsilon-1\right)\frac{\left(1-\alpha^{T}\right)^{2}}{1-\overline{\alpha}}\left(1-\eta\right)\mathcal{M}.$$

Here, $\Delta y\equiv y^{new}-y^{old}$ denotes the change in equilibrium variable y. In particular, $\Delta Q_0 = Q_0^{new}-Q_0^{old}$ denotes the dollar change in the aggregate stock wealth. Thus, $x_{a,0}\Delta Q_0$ denotes the change in stock wealth in area a relative to other areas. The equations describe how the (relative) stock wealth change normalized by the labor bill, $\frac{x_0\Delta Q_0}{\overline{WL}}$, affects the (relative) local labor market outcomes in the area.

These equations are intuitive. Eq. (10) shows that an increase in stock wealth in an area increases the total labor bill. To understand the coefficient, note that one more dollar of stock wealth in an area leads to ρ dollars of additional total spending (cf. Eq. (4)), of which $\eta\rho$ is spent on nontradable goods produced locally. The increase in spending, in turn, increases the local labor bill by $\left(1-\alpha^{N}\right)\eta\rho$ dollars. This direct effect gets amplified by the local Keynesian income multiplier, denoted by $\mathcal{M}$.[30] The remaining term, $\frac{1+\kappa}{1+\kappa\zeta}$, reflects potential adjustments to the labor bill due to changes in exports to other areas. Specifically, an increase in local wages makes the areas's goods more expensive, which reduces (resp. increases) the tradable labor bill (and thus the total labor bill) when tradable inputs are gross substitutes, $\varepsilon>1$ (resp. gross complements, $\varepsilon<1$).

Eq. (11) is a rearrangement of the reduced-form labor supply relation in (9). In particular, how much employment responds relative to the total labor bill (given a change in stock wealth) will discipline the wage adjustment parameter κ in our calibration exercise.

Eqs. (12) and (13) characterize the effects on the labor bill separately for the nontradable

[30] In the expression for the multiplier, the term in set brackets is a weighted-average of the MPC out of labor income of hand-to-mouth households (MPC of 1) and of stockholders (MPC of ρ). The weights $\frac{\theta\kappa+1}{\kappa+1}$ and $\frac{\kappa(1-\theta)}{\kappa+1}$ capture the extent to which additional labor income falls on hand-to-mouth households and stockholders. This depends not only on the population share θ but also on the wage adjustment parameter κ, because agents have different labor supply elasticities.

and tradable sectors. These equations are particularly simple when tradable inputs have unit elasticity, $\varepsilon = 1$. In this case, the effect on the tradable labor bill is zero, $\Delta\left(w_{a,0} + l^T_{a,0}\right) = 0$. We can then decompose the coefficient multiplying the wealth change for the nontradable labor bill into three terms: the direct household-level MPC out of stock market wealth ρ, the weighted average labor share of income $1 - \overline{\alpha}$, and the local multiplier $\mathcal{M}$. In Section 6 we use this decomposition to recover the household-level MPC given externally calibrated $1-\overline{\alpha}$ and $\mathcal{M}$. Notably, the expression does not require information on the share of nontradables in spending η or the share of labor in the nontradable sector $1-\alpha^N$ (see Section 6 for intuition).

When $\varepsilon \neq 1$, the decomposition for the nontradable sector does not hold exactly. In this case, as illustrated by Eq. (13), the stock wealth shock can affect the tradable labor bill if it has an effect on wages. As illustrated by Eq. (12), this affects local households' income and, therefore, creates knock-on effects in the nontradable sector. These knock-on effects depend on $\mathcal{M}-1$. Intuitively, the direct impact of spending on tradables is absorbed by the tradable labor bill, but the multiplier effects are local and absorbed by the nontradable labor bill. However, if wages do not adjust much, then the tradable adjustment has a small impact on the analysis even when ε is somewhat different from 1.

5.5 Summary and Mapping into the Empirical Analysis

According to Eqs. (10) to (13), an increase in *national* stock prices driven by, e.g., changes in expected *future* productivity of capital or in risk aversion, increases the *current* total labor bill and nontradable labor bill by more in areas with greater stock market wealth. The effect on the tradable labor bill is ambiguous and depends on whether tradable inputs are gross substitutes or complements. In Appendix B.4, we derive the additional predictions that nontradable labor, total labor, and wages weakly increase, and tradable labor weakly falls. All of these predictions accord with our empirical results.

The model also explains the functional form of our empirical regressions. In particular, define $S_{a,0} \equiv \frac{x_{a,0}Q_0}{\overline{WL}}$ as area a's (relative) stock wealth divided by its labor bill and $R_0 \equiv \frac{\Delta Q_0}{Q_0}$ as the stock return. Then, we have:

$$S_{a,0}R_0 = \frac{x_{a,0}\Delta Q_0}{\overline{WL}}. \tag{14}$$

This variable corresponds to our main regressor, the change in the stock wealth of the area normalized by the local labor bill. Eqs. (10) to (13) illustrate that the empirical coefficients using this regressor have a tight mapping into the key parameters of the model.[31] We next

[31] In the model, there is only one type of capital so all areas are associated with the same stock return, $R_{a,0} = R_0$ for each a. In the empirical exercise, we allow areas to have heterogenous risky portfolios and

exploit this mapping and provide a structural interpretation of our empirical findings.[32]

6 Calibration and Structural Interpretation

In this section, we use our empirical results from Section 4 to calibrate two key parameters of the model: the strength of the direct stock wealth effect, ρ, and the degree of wage adjustment, κ. We only need two model equations to recover these parameters. Therefore, our calibration also applies in richer models as long as these equations hold. Throughout, we choose the coefficients reported in Table 1 as our calibration targets. As shown in Figure 2, the first few quarters of the impulse response feature sluggish adjustment for reasons outside the model, due e.g. to adjustment costs, consumer habit, or delayed recognition of the stock wealth changes, as found in Brunnermeier and Nagel (2008) and Alvarez et al. (2012). By quarter 7 adjustment is complete and the effect is relatively stable thereafter.

6.1 Direct Stock Wealth Effect

To determine the stock wealth effect parameter, we consider the nontradable labor bill in the special case with $\varepsilon = 1$ (cf. Eqs. (12) and (14)):

$$\begin{aligned} \Delta\left(w_{a,0} + l^N_{a,0}\right) &= \mathcal{M}\left(1-\overline{\alpha}\right)\rho \times S_{a,0}R_0, \\ \text{where } S_{a,0} &= \frac{x_{a,0}Q_0}{\overline{WL}}, R_0 = \frac{\Delta Q_0}{Q_0}. \end{aligned} \tag{15}$$

Here, we interpret the denominator of $S_{a,0}$, $\overline{WL}$, as the labor bill *per year* as in the empirical implementation. Therefore, for calibration purposes we interpret the length of period 0 as one year and the parameter, ρ, as the MPC out of stock market wealth *per year*.[33]

In particular, the empirical coefficient can be decomposed into the product of three terms: the household-level MPC out of stock market wealth ρ, the weighted-average labor share of

thus heterogeneous stock returns, $R_{a,0}$. Eqs. (10) to (13) would naturally generalize to a richer setting that features multiple risky assets and heterogeneous portfolios.

[32]As emphasized by Dynan and Maki (2001), such "dollar-dollar" specifications arise naturally in consumption-wealth models. An alternative approach would be to estimate an elasticity and to convert back into a dollar-dollar coefficient using the sample average ratio of stock market wealth to labor income (or consumption). This alternative has the drawback that the actual ratio varies substantially over time as the stock market booms and busts, a problem noted in the very different context of fiscal multipliers by Ramey and Zubairy (2018).

[33]We could estimate the MPC out of stock wealth over different horizons (by adjusting our regressor), as long as the horizon is sufficiently short that the supply side adjustment to a local demand shock is incomplete. Thus, we think of the length of period 0 as the time in which labor remains largely specific to the area and wages partially rigid following a demand shock.

income $1-\overline{\alpha}$, and the local Keynesian multiplier $\mathcal{M}$—equivalent to the multiplier on local government spending. We set the weighted-average labor share to a value standard in the literature, $1-\overline{\alpha}=2/3$, and choose the nontradable share η and the hand-to-mouth share θ to achieve a multiplier $\mathcal{M}$ =1.5, in line with empirical estimates (Nakamura and Steinsson, 2014; Chodorow-Reich, 2019).We then calculate ρ by combining Eq. (15) with the empirical coefficient for the nontradable labor bill.

Specifically, using the coefficient from Table 1, we obtain:

$$\mathcal{M}\left(1-\overline{\alpha}\right)\rho=\frac{\Delta\left(w_{a,0}+l_{a,0}^{N}\right)}{S_{a,0}R_{0}}=3.23\%. \tag{16}$$

Substituting $1-\overline{\alpha}=2/3$ and $\mathcal{M}$ =1.5, yields

$$\rho=3.23\%.$$

Hence, our estimates suggest that a one dollar increase in stock wealth increases household spending by about 3.23 cents per year (at a horizon of two years). The implied magnitude is in line with the yearly discount rates typically assumed in the literature. It is also close to the estimates of the stock wealth effect on consumption for wealthy households in Sweden estimated in Di Maggio et al. (forthcoming).

We make five remarks on this approach. First, it does not depend on the labor supply block of the model. Second, we do not have to parameterize the spending share of nontradables, η, or the labor share in the nontradable sector, $1-\alpha^{N}$. To understand why, rewrite Eq. (15) as:

$$\frac{\Delta\left(W_{a,0}L_{a,0}^{N}\right)}{\overline{W}L_{0}^{N}}\overline{W}L_{0}^{N}=\mathcal{M}\rho\left(1-\alpha^{N}\right)\eta\left(x_{a,0}\Delta Q_{0}\right)\ \text{where}\ \frac{\overline{W}L_{0}^{N}}{\overline{WL}}=\eta\frac{1-\alpha^{N}}{1-\overline{\alpha}}. \tag{17}$$

This expression illustrates that the effect of stock market wealth on the nontradable labor bill *in dollars*, $\Delta\left(W_{a,0}L_{a,0}^{N}\right)$, does depend on both η and $1-\alpha^{N}$. However, with homothetic preferences and production across sectors, we have $\frac{\overline{W}L_{0}^{N}}{\overline{WL}}=\eta\frac{1-\alpha^{N}}{1-\overline{\alpha}}$: that is, the nontradable labor bill as a fraction of the total labor bill reflects the nontradable spending share as well as the sectoral differences in labor share. Therefore, since Eq. (15) normalizes the stock wealth change with the total labor bill, η and $1-\alpha^{N}$ drop out of the equation. Intuitively, with homothetic preferences a sector's *average* share of the labor bill equals its *marginal* share of changes in the labor bill. As a consequence, the decomposition in (15) is robust to the nontradable spending share as well as the sectoral differences in labor share.[34] Moreover,

[34]Eq. (17) suggests the decomposition is also robust to (certain types of) cross-county heterogeneity in

since the decomposition does not depend on η, it applies as long as we observe the response in a subset of nontradable sectors.

Third, when $\varepsilon \neq 1$, Eq. (15) applies up to an adjustment (see Eq. (12)). The adjustment reflects the possibility that the change in the tradable labor bill—due to the change in local wages—affects local households' income and creates knock-on effects on the nontradable labor bill. If wages are sufficiently rigid, then the tradable adjustment does not change the analysis by much even if ε is somewhat different from 1. In practice, the value we obtain for κ (described next) implies little loss of generality in ignoring this adjustment for empirically reasonable levels of ε, consistent with the small and statistically insignificant response of tradable payroll we estimate in the data. Therefore, we adopt $\varepsilon = 1$ as our baseline calibration in the main text and relegate the more general case to the appendix.[35]

Fourth, the simplicity of Eq. (16) makes it transparent to assess sensitivity to alternative targets for the labor share or local multiplier. For example, using a labor share of 0.6 and a local multiplier of 1.33 instead yields $\rho = 3.23/(0.6 \times 1.33) = 4.04$.

Fifth, we can compare our preferred ρ of 3.23 obtained from Eq. (16) to the ρ implied by the estimation using state-level consumption data. Following similar steps as in the derivation of Eq. (16), we obtain (see Eq. $(B.87)$ in the appendix)

$$\Delta \left(p_{a,0} + c_{a,0}\right) = \mathcal{M}\rho \times S^{C}_{a,0} R_0. \tag{18}$$

Here, $p_{a,0} + c_{a,0}$ denotes log nominal consumption expenditure and $S^{C}_{a,0} = \frac{x_{a,0}Q_0}{P_0 C_0}$ denotes the ratio of area a's (relative) stock wealth to its consumption expenditure. Notably, the labor share does not enter into Eq. (18). Using $\mathcal{M} = 1.5$ and the coefficient from Table 5, we obtain a nearly identical ρ of $4.82/1.5 = 3.21$.

labor shares. For instance, suppose that areas with high stock wealth ($x_{a,0} > 0$) feature greater labor share in nontradables ($1 - \alpha^N_a > 1 - \alpha^N$)—perhaps because they spend more on high-quality goods that are more labor intensive as recently shown by Jaimovich et al. (2019). Then, the average labor bill of nontradables in these areas is also greater than average ($\overline{W}L^N_{a,0} > \overline{W}L^N_0$). As long as the average labor bill is proportional to the labor share, $\frac{\overline{W}L^N_{a,0}}{\overline{W}L^N_0} = \eta\frac{1-\alpha^N_a}{1-\alpha^N}$, Eq. (17) would still give the decomposition in (15).

[35] Specifically, in Appendix B.6.2 we consider alternative calibrations with $\varepsilon = 0.5$ and $\varepsilon = 1.5$. In these cases, since trade adjustment affects the analysis, the implied ρ also depends on the share of tradables, η. We allow this parameter to vary over a relatively large range, $\eta \in [0.5, 0.8]$, and show that the implied ρ remains within 5% of its baseline level. As expected, the greatest deviations from the baseline occur when η is low (that is, when the area is more open).

6.2 Wage Adjustment

We use Eq. (11) to determine the wage adjustment parameter κ,

$$\Delta l_{a,0} = \frac{1}{1+\kappa}\Delta\left(w_{a,0} + l_{a,0}\right) \ . \tag{19}$$

Recall that κ is a composite parameter that combines inverse wage stickiness and inverse labor supply elasticity [cf. Eq. (9)]. Therefore, it captures wage adjustment over the estimation horizon. One caveat is that, while the model makes predictions for total labor supply including changes in hours per worker, in the data we only observe employment. A long literature dating to Okun (1962) finds an elasticity of total hours to employment of 1.5. Applying this adjustment and using the coefficients for total employment and the total labor bill from Table 1 yields:

$$\begin{aligned} \frac{\Delta l_{a,0}}{S_{a,0}R_0} &= 1.5 \times 0.77\% \\ \frac{\Delta\left(w_{a,0} + l_{a,0}\right)}{S_{a,0}R_0} &= 2.18\%. \end{aligned}$$

Combining these with Eq. (19), we obtain:

$$\kappa = 0.9. \tag{20}$$

Thus, a one percent change in labor is associated with a 0.9% change in wages at a horizon of two years.[36]

7 Aggregation when Monetary Policy is Passive

We next describe the effect of stock market changes on *aggregate* outcomes. In our model so far, these effects appear only in the interest rate ("rstar") because monetary policy adjusts to ensure aggregate labor supply remains at the frictionless level. We now consider an alternative scenario in which monetary policy is passive and leaves the interest rate unchanged in response to changes in stock prices. In this case, stock wealth changes affect aggregate labor market outcomes. These aggregate responses are of direct interest to monetary policymakers

[36] We can also estimate κ from the response of tradable employment [cf. Eq. (B.86)]. Intuitively, tradable employment declines only insofar as local wages and prices rise, so the response of l^T provides information about κ. Auclert et al. (2019) implement this approach in a different empirical setting. We prefer not to rely on this relationship because in practice (unlike in our model) even tradable goods may be influenced by local demand due to home bias, non-zero transportation costs, and supply chains. Nonetheless, the flat response of employment in the industries we classify as tradable in the data accords with a low value of κ.

considering whether or not to accommodate a change in the stock market.

Our aggregation result for the labor bill is straightforward and relies on two observations. First, given homothetic preferences and production across sectors, a one dollar increase in stock market wealth has the same *proportional* effect on the *aggregate total* labor bill and the *local nontradable* labor bill, up to an adjustment for the difference in the aggregate and local spending multipliers. Second, for a wide range of parameters the aggregate spending multiplier in our calibration is greater than the local multiplier (this inequality also holds in many related models). Therefore, our empirical estimate of the effect on the local nontradable labor bill is a lower bound for the effect on the aggregate total labor bill. Notably, this aggregation result does not depend on any particular calibration of the local spending multiplier such as we needed to assume in the previous section.

Our aggregation result for labor combines this finding with a third observation: since labor markets are local, the structural labor supply equation (7) remains unchanged as we switch from local to aggregate analysis (as emphasized by Beraja et al. (2016)). The reduced form labor supply equation in (9) changes slightly because shocks impact aggregate inflation and local inflation differently.

Formally, let $\overline{R}_0^f$ denote the equilibrium interest rate in our earlier analysis corresponding to a particular level of productivity $\overline{D}$ [cf. (5)]. Suppose D changes but monetary policy keeps the nominal interest rate in period 0 constant at $\overline{R}_0^f$. In periods $t \geq 1$, monetary policy follows the same rule as before. Appendix B.7 characterizes the aggregate equilibrium variables in period 0, (Q_0, L_0, W_0, P_0). Log-linearizing this equilibrium around the frictionless benchmark, $D = \overline{D}$, we obtain closed-form solutions for labor bill and labor that describe the effect of a change in stock wealth on *aggregate* labor market outcomes:

$$\Delta (w_0 + l_0) = \mathcal{M}^A (1 - \overline{\alpha}) \rho \frac{\Delta Q_0^A}{\overline{WL}}, \tag{21}$$

$$\Delta l_0 = \frac{1}{1 + \kappa^A} \Delta (w_0 + l_0), \tag{22}$$

$$\text{where } \mathcal{M}^A \equiv \frac{1}{1 - (1 - \overline{\alpha}) \left\{ \frac{\theta \kappa^A + 1}{\kappa^A + 1} + \rho \frac{(1-\theta)\kappa^A}{\kappa^A + 1} \right\} - \overline{\alpha} \rho}$$

$$\text{and } \kappa^A \equiv \frac{\lambda (\varphi + \overline{\alpha})}{1 - \lambda}.$$

Here, $l_0 = \log \left(L_0 / \overline{L}\right)$ and $w_0 = \log \left(W_0 / \overline{W}\right)$ denote log deviations of aggregate labor and wages from the frictionless benchmark. As before, $\Delta y \equiv y^{new} - y^{old}$ denotes the change in equilibrium variable y when expected future productivity of capital changes. The variable

Q_0^A is the log-linear approximation to the exogenous part of stock wealth, $\frac{1}{R_0^f}\frac{\overline{W}D}{\rho}$.[37] The parameters $\mathcal{M}^A$ and κ^A denote the aggregate multiplier and wage adjustment, respectively.

Eq. (21) shows that the effect on the aggregate labor bill closely parallels its local counterpart (Eq. (11)), with three differences. First, the direct spending effect is greater in the aggregate than at the local level, $(1-\overline{\alpha})\,\rho > \eta\left(1-\alpha^N\right)\rho$. Intuitively, some spending falls on goods that are tradable across local areas but nontradable in the aggregate. Second, the aggregate labor bill does not feature the export adjustment term $\frac{1+\kappa}{1+\kappa\zeta}$. Third, the aggregate multiplier is different and (with our calibration) greater than the local multiplier, $\mathcal{M}^A > \mathcal{M}$. This is because spending on tradables (as well as the mobile factor, capital) diminish the local but not the aggregate multiplier.[38]

Likewise, Eq. (22) shows that the reduced-form labor supply equation closely parallels its local counterpart (cf. Eqs. (11) and (9)). In fact, since labor markets are local, the structural labor supply equation (7) that features the nominal price in addition to the nominal wage does not change as we switch from local to aggregate analysis. The difference stems from the equation for the nominal price, which is different than its local counterpart and given by $p_0 = (1-\eta)p_0^T + \eta p_0^N = \overline{\alpha} l_0 + w_0$. The aggregate price increases more than the wage, due to a fixed supply of capital in the aggregate. In contrast, the local price increases less than the wage, $p_{a,0} = \eta p_{a,0}^N = \eta\left(1-\alpha^N\right) w_{a,0}$ [cf. (8)], because only changes in the price of nontradables affect the local price level and because the local area faces a perfectly elastic supply of capital. Therefore, the real wage $w_0 - p_0$ decreases in the aggregate but increases locally, which creates a negative neoclassical labor supply response at the aggregate level and a positive one at the local level.

To quantify this difference, we rewrite the expressions for κ and κ^A to eliminate the wage

[37] In our model, the price of capital satisfies $Q_0 = R_0 + \frac{1}{R_0^f}\frac{\overline{W}D}{\rho}$, where R_0 is the rental rate of capital [cf. (5)]. In this setting, a one dollar increase in $\frac{1}{R_0^f}\frac{\overline{W}D}{\rho}$ increases the equilibrium stock price, Q_0, by more than one dollar. This is because the increase in aggregate demand and output in period 0 also increases R_0. We focus on the comparative statics for a one dollar change in the exogenous component of the stock wealth (as opposed to actual stock wealth) as the appropriate counterfactual scenario for what would happen if monetary policy did not react to an observed stock price shock in an environment where it usually stabilizes the demand effects of these shocks.

[38] In our model, there is a counteracting force when aggregate and local wage adjustment differ, $\kappa^A \neq \kappa$. Because of the simplifying assumption that stockholders supply labor less elastically than hand-to-mouth households, a smaller local wage adjustment ($\kappa < \kappa^A$) implies a lower share of additional labor income going to stockholders, who have a lower MPC, than in the aggregate. These distributional differences do not overturn the multiplier inequality in our model for a wide range of parameters (see Appendix $B.7$ for details). The inequality $\frac{\mathcal{M}^A}{\mathcal{M}} \geq 1$ is a robust feature of settings with constrained monetary policy (Chodorow-Reich, 2019).

stickiness parameter, λ, to obtain:

$$\frac{1}{\kappa^A} = \frac{1}{1+\overline{\alpha}/\varphi}\left\{\frac{1}{\kappa} - \frac{1}{\varphi}\left(1-\eta\left(1-\alpha^N\right)\right)\right\}.$$

The extent to which the aggregate labor response is smaller than the local response depends on the Frisch elasticity $1/\varphi$ as well as the parameters $\overline{\alpha}, \eta, 1-\alpha^N$ (that determine the differences in price adjustment). Setting the Frisch elasticity $\varphi^{-1} = 0.5$ (Chetty et al., 2012), labor shares $1-\overline{\alpha} = 1-\alpha^N = 2/3$, and the nontradable share $\eta = 0.5$ (a conservative value), and substituting $\kappa = 0.9$ from (20), we obtain:[39]

$$\kappa^A = 1.5. \tag{23}$$

Hence, our estimation and calibration imply that the aggregate labor response to a change in the aggregate labor bill is not too different than the corresponding local response despite the counteracting neoclassical effect.

We now use our estimates further to quantify the effect on the aggregate labor bill (which we then combine with (23) to describe the effect on aggregate labor). To relate Eq. (21) to our empirical estimates, we rewrite it as follows:

$$\begin{aligned} \Delta\left(w_0 + l_0\right) &= \mathcal{M}^A\left(1-\overline{\alpha}\right)\rho \times S_0^A R_0^A \qquad (24)\\ \text{where } S_0^A &= \frac{Q_0^A}{\overline{WL}_0} \text{ and } R_0^A = \frac{\Delta Q_0^A}{Q_0^A}. \end{aligned}$$

Here, S^A is the ratio of aggregate stock wealth to the aggregate labor bill and R^A is the shock to stock valuations. Hence, $S_0^A R_0^A$ is the aggregate analog of $S_{a,0}R_0$.

The coefficient in Eq. (24) is the same as its local counterpart in Eq. (15) for the *local nontradable* labor bill, up to an adjustment for the differences in the local and aggregate spending multipliers. Hence, we can combine our estimate for the local nontradable labor bill (for quarter 7) with the inequality $\frac{\mathcal{M}^A}{\mathcal{M}} \geq 1$ to bound the coefficient from below:

$$\mathcal{M}^A\left(1-\overline{\alpha}\right)\rho = 3.23\%\frac{\mathcal{M}^A}{\mathcal{M}} \geq 3.23\%.$$

[39] As we have emphasized, the nontradable share of consumption expenditure η is a difficult parameter to calibrate given available regional data. Dupor et al. (2019) use the Commodity Flow Survey to estimate that two-thirds of shipments remain within a metropolitan area and 61% remain within a county. This estimate excludes the services component of consumption, which likely has a higher nontradable share. On the other hand, it may include some shipments within a local supply chain that eventually produces a tradable good. Our baseline calibration, $\eta = 0.5$, is conservative in the sense that a greater η would result in a smaller κ^A and a larger aggregate employment response. In Appendix B.7, we consider a wider range, $\eta \in [0.5, 0.8]$, and show that the implied κ^A remains within 10% of our baseline calibration.

Therefore, if not countered by monetary policy, a one dollar increase in stock valuations increases the aggregate labor bill per year by at least 3.23 cents. Why does the effect on the *local nontradable* labor bill provide information about the implied effect on the *aggregate total* labor bill? With homothetic preferences and production technologies (and ignoring trade effects, $\varepsilon = 1$), a given amount of spending generates the same proportional change in the labor bill in *both* sectors. In particular, the proportional change in the labor bill in the nontradable sector—which we estimate with our local labor market approach—is the same as the proportional change in the labor bill in the tradable sector, which we cannot estimate directly due to demand slippage to other regions. Importantly, while clearly convenient for aggregation, the assumption of homotheticity across these broad sectors also has empirical grounding, as we demonstrated in Section 4.5.

We now describe the effect on aggregate labor. Eqs. (22) and (24) imply,

$$\begin{aligned} \Delta l_0 = \frac{1}{1+\kappa^A}\Delta\left(w_0 + l_0\right) &= \frac{1}{1+\kappa^A}\mathcal{M}^A\left(1-\overline{\alpha}\right)\rho \times S_0^A R_0^A \\ &= \frac{3.23\%}{2.5}\frac{\mathcal{M}^A}{\mathcal{M}} \times S_0^A R_0^A \end{aligned} \tag{25}$$

Here, the second line substitutes $\kappa^A = 1.5$ [cf. Eq. (23)] and the response of the labor bill. Therefore, a one dollar increase in stock valuations increases aggregate labor (total hours worked) by the equivalent of at least 1.3 cents (i.e. the labor bill for the additional hours worked is at least 1.3 cents) if monetary policy does not respond.

We can combine these estimates with the ratio of aggregate stock wealth to the aggregate yearly labor bill, S_0^A, to obtain the responses to a stock return, R_0^A. Using data from 2015 (weighting counties by their income), we obtain $S^A = 2.67$.[40] Substituting this value into Eqs. (24) and (25), we obtain:

$$\begin{aligned} \Delta\left(w_0 + l_0\right) &= 3.23\%\frac{\mathcal{M}^A}{\mathcal{M}} \times 2.67 \times R_0^A \geq 8.6\% \times R_0^A, \\ \Delta l_0 &\geq \frac{3.23\%}{2.5}\frac{\mathcal{M}^A}{\mathcal{M}} \times 2.67 \times R_0^A \geq 3.45\% \times R_0^A. \end{aligned}$$

Therefore, if not countered by monetary policy, a 20% stock return—approximately the yearly standard deviation of the return on the market portfolio—would increase the aggregate labor bill by at least 1.7%, and aggregate hours by at least 0.7%, at a horizon of two years.[41]

[40] This value coincides almost exactly with the corresponding ratio of 2.63 obtained using C-corporation equity wealth in the FAUS and total wages and salaries in NIPA, the latter which increased to 2.89 in 2018.

[41] The magnitude of this calculation changes slightly if we instead assume consumption only responds to changes in taxable stock wealth. In that case, we would recover a larger marginal effect on payroll

8 Conclusion

We estimate the effect of stock market wealth on labor market outcomes by exploiting regional heterogeneity in stock wealth across U.S. counties. An increase in stock wealth in a county increases local employment and the labor bill, especially in nontradable industries but also in total, but does not increase employment in tradable industries. The analysis is robust to MPC hetereogeneity across stockholders because in the data stock wealth heterogeneity is substantially greater within than across counties. We develop a theoretical model to convert the estimated local general equilibrium effect into a household-level MPC out of stock market wealth of around 3.2 cents per year. We also calculate the aggregate general equilibrium effects of the stock wealth consumption channel on the labor market: a 20% change in stock valuations, unless countered by monetary policy, affects the aggregate labor bill by at least 1.7% and aggregate hours by at least 0.7% two years after the shock.

Our findings that stock price changes affect labor market outcomes support "the Fed put"—the central banks' tendency to cut interest rates after stock market declines unrelated to productivity (see e.g., Rigobon and Sack (2003); Bjørnland and Leitemo (2009); Cieslak and Vissing-Jorgensen (2017)). Specifically, our estimates and aggregation results can be used to calibrate the appropriate interest rate response. If the interest rate is constrained, e.g., due to the zero lower bound or fixed exchange rates, then our analysis implies that stock price declines would induce a sizeable reduction in aggregate labor bill and employment (see Caballero and Simsek (2020) for a related dynamic setup that illustrates the downturn would be further amplified by feedbacks between output and asset prices).

An important question for policymakers concerns the speed at which stock wealth changes affect the economy. We find evidence of sluggish adjustment, with the effect on labor markets starting after 1 to 2 quarters and stabilizing between quarters 4 and 8. This pattern suggests that large stock price declines that quickly reverse course—such as the stock market crash of 1987 or the Flash crash of 2010—are unlikely to impact labor markets, whereas more persistent price changes—such as the NASDAQ boom in the late 1990s or the stock market boom during the recovery from the Great Recession—have more sizeable effects.

On the other hand, our focus on the consumption channel and our empirical design omit factors that could further increase the effect of stock market wealth changes on aggregate labor markets. First, as discussed by Chodorow-Reich (2019), the Keynesian multiplier effects are likely greater at the aggregate level (when monetary policy is passive) than at

(intuitively, a larger consumption response would be required to rationalize the same cross-county changes in labor income given smaller wealth), but we would multiply that response by a smaller change in wealth given a 20% change in the stock market. Combining these changes, we would find that a 20% stock return increases the aggregate labor bill by at least 1.3%.

the local level. Second, other channels, such as the response of investment, also create a positive relationship between stock prices and aggregate demand (see Caballero and Simsek, 2020). Relatedly, while our industry-level analysis mostly focuses on sectors that produce nondurable goods and services, we also find that stock price changes have a large effect on the construction sector. The construction response provides further qualitative evidence that stock wealth affects the economy by changing local demand and inducing an accelerator-type effect on housing investment (see Rognlie et al., 2018; Howard, 2017). We leave a quantitative assessment of these additional factors for future work.

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Stock Market Wealth and the Real Economy: A Local Labor Market Approach

Online Appendix

Gabriel Chodorow-Reich Plamen Nenov Alp Simsek

A Data Appendix

A.1 Details on the Capitalization Approach

A.1.1 Details on the IRS SOI

The IRS Statistics of Income (SOI) reports tax return variables aggregated to the zip code for 2004-2015 (and selected years before) and to the county for 1989-2015. Beginning in 2010 for the county files and in all available years for zip code files, the data aggregate all returns filed by the end of December of the filing year. Prior to 2010, the county files aggregate returns filed by the end of September of the filing year, corresponding to about 95% to 98% of all returns filed in that year. In particular, the county files before 2010 exclude some taxpayers who file form 4868, which allows a six month extension of the filing deadline to October 15 of the filing year.[1] To obtain a consistent panel, we first convert the zip code files to a county basis using the HUD USPS crosswalk file. We then implement the following algorithm: (i) for 2010 onward, use the county files; (ii) for 2004-2009, use the zip code files aggregated to the county level and adjusted by the ratio of 2010 dividends in the county file to 2010 dividends in the zip code aggregated file; (iii) for 1989-2003, use the county file adjusted by the ratio of 2004 dividends as just calculated to 2004 dividends in the county files. We implement the same adjustment for labor income. We exclude from the baseline sample 74 counties in which the ratio of dividend income from the zip code files to dividend income in the county files exceeds 2 between 2004 and 2009, as the importance of late filers in these counties makes the extrapolation procedure less reliable for the period before 2004.[2]

[1] See `https://web.archive.org/web/20171019013107/https://www.irs.gov/statistics/soi-tax-stats-county-income-data-users-guide-and-record-layouts` and `https://web.archive.org/web/20190111012726/https://www.irs.gov/statistics/soi-tax-stats-individual-income-tax-statistics-zip-code-data-soi` for data and documentation pertaining to the county and zip code files, respectively. For additional information on the timing of tax filings, see `https://web.archive.org/web/20190211151353/https://www.irs.gov/newsroom/2019-and-prior-year-filing-season-statistics`.

[2] Anecdotally, the filing extension option is primarily used by high-income taxpayers who may need to wait for additional information past the April 15 deadline (see e.g. Dale, Arden, "Late Tax Returns Common for the Wealthy," *Wall Street Journal*, March 29, 2013). Consistent with this, we find much less discrepancy in labor income than dividend income reported in the zip code and county files before 2010. Our results

Finally, since our benchmark analysis is at the quarterly frequency and the SOI income data is yearly data, we linearly interpolate the SOI data to obtain a quarterly series. Because the cross-sectional income distribution is persistent, measurement error arising from this procedure should be small.

A.1.2 Dividend yield adjustment

This section describes the county-specific dividend yield adjustment used in the capitalization of taxable county dividends. We start with the Barber and Odean (2000) data set, which contains a random sample of accounts at a discount brokerage, observed over the period 1991-96. The data contain monthly security-level information on financial assets held in the selected accounts. Graham and Kumar (2006) compare these data with the 1992 and 1995 waves of the SCF and show that the stock holdings of investors in the brokerage data are fairly representative of the overall population of retail investors.

We keep taxable individual and jointly owned accounts and remove margin accounts. We merge the monthly account positions data with the monthly CRSP stock price data and CRSP mutual funds data obtained from WRDS. Since our merge is based on CUSIP codes and mutual fund CUSIP codes are sometimes missing, we use a Fund Name-CUSIP crosswalk developed by Terry Odean and Lu Zheng. Additionally, we use an algorithm developed in Di Maggio et al. (forthcoming) based on minimizing the smallest aggregate price distance between mutual fund prices in household portfolios and in the CRSP fund-month data.[3] We drop household-month observations for which the value of total identified CRSP stocks and mutual funds is less than 95% of the value of the household's equity and mutual fund assets and also keep only identified CRSP stocks and mutual funds.[4] Finally, to be consistent with what we observe in the IRS-SOI data, we drop household-month observations with a zero dividend yield. Such households tend to be younger, hold few securities (around two on average), and hold only around 10% of total equity in the brokerage data.

We compute dividend yields by household and month using these data. Figure A.1 shows the average dividend yield by age of the household head (left panel) and by stock wealth percentile separately for different age bins (right panel), where household stock wealth is the total position equity in all accounts. As the figure shows, dividend yields increase with age. Moreover, within age bins, dividend yields have a weak relationship with wealth. These patterns motivate our focus on age.

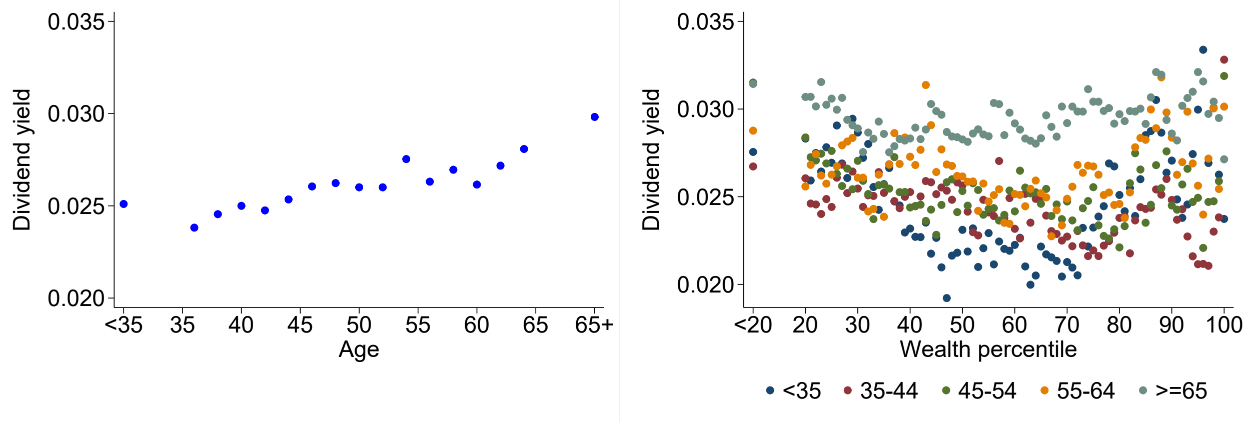
Table A.1 reports average dividend yields by age bin (weighted by wealth), separately for each Census Region. A few features merit mention. First, dividend yield increases with age, consistent

change little if we do not exclude the 74 counties from the analysis. For example, the coefficient for total payroll at the 7 quarter horizon changes from 2.18 to 2.27 (s.e.=0.67), and the coefficient for nontradable payroll changes from 3.23 to 2.67 (s.e.=0.83).

[3] We are grateful to Marco Di Maggio, Amir Kermani, and Kaveh Majlesi for sharing their codes.

[4] We are able to match more than 95% of equity and mutual fund position-months. The main type of equity assets that we cannot match are foreign stocks.

Figure A.1: Dividend Yield by Age and Wealth



Notes: The figures plot dividend yields by age and wealth quantile based on the Barber and Odean (2000) data from a discount brokerage firm merged with data on CRSP stocks and mutual funds. Wealth denotes the total position equity among all taxable accounts that a household has in the discount brokerage firm.

with the pattern shown in Figure A.1. Second, the age bin coefficients are precisely estimated and the R^2s are high. In column (5), which pools all geographic areas together, the five age bins explain 66% of the variation in dividend yield across households. Third, adding indicator variables for 10 wealth bins to the regression in column (6) has essentially no impact on the explanatory power of the regression or on the relative age bin coefficients.[5]

We combine the coefficients shown in columns (1)-(4) of Table A.1 with the county-year specific age structure from the Census Bureau and average wealth by age bin from the Survey of Consumer Finances (interpolated between SCF waves) to construct the wealth-weighted average of the age bin dividend yields in the county's Census region.[6] The resulting county-year yields account for time series variation in a county's age structure and in relative wealth of different age groups, but not for changes in market dividend yields over time. Therefore, we scale these dividend yields so that the average dividend yield in each year is equal to the dividend yield on the value-weighted CRSP portfolio.[7]

We end this section with a discussion of (implied) dividend yields in the SCF and how those compare to the dividend yield distribution in the Barber and Odean (2000) data. The SCF contains information on taxable dividend income reported on tax returns together with self-reported information on directly held stocks (and stock mutual funds). Therefore, it is tempting to use the SCF data directly to compute dividend yields by demographic groups and use those for the dividend yield adjustment or, even more directly, use the relationship between taxable dividend income

[5] The age bin coefficients shift uniformly up by 0.37 to 0.38, reflecting the incorporation of average wealth.

[6] County population-by-age is available from the Census Bureau Interncensal population estimates (1990-2010) and Postcensal population estimates (2010-.). See https://www.census.gov/programs-surveys/popest.html.

[7] We also experimented with allowing the age-specific yields to vary with the CRSP yield, with almost no impact on our results.

Table A.1: Dividend Yields By Age

	Region 1	Region 2	Region 3	Region 4	Pooled	Pooled
	(1)	(2)	(3)	(4)	(5)	(6)
Right hand side variables:						
Age <35	2.81**	2.21**	2.28**	2.51**	2.45**	2.83**
	(0.16)	(0.19)	(0.25)	(0.18)	(0.11)	(0.15)
Age 35-44	2.48**	2.25**	2.43**	2.50**	2.43**	2.81**
	(0.11)	(0.16)	(0.18)	(0.14)	(0.08)	(0.12)
Age 45-54	2.65**	2.27**	2.51**	2.50**	2.49**	2.86**
	(0.16)	(0.09)	(0.30)	(0.08)	(0.08)	(0.13)
Age 55-64	3.00**	2.39**	2.40**	2.82**	2.69**	3.07**
	(0.11)	(0.14)	(0.20)	(0.10)	(0.08)	(0.13)
Age 65+	2.91**	2.73**	2.96**	3.27**	3.03**	3.40**
	(0.12)	(0.12)	(0.17)	(0.11)	(0.07)	(0.12)
Wealth bins	No	No	No	No	No	Yes
R^2	0.73	0.69	0.62	0.63	0.66	0.66
Individuals	1,965	1,586	2,192	3,556	9,299	9,299
Observations	73,486	60,987	83,112	133,149	350,734	350,734

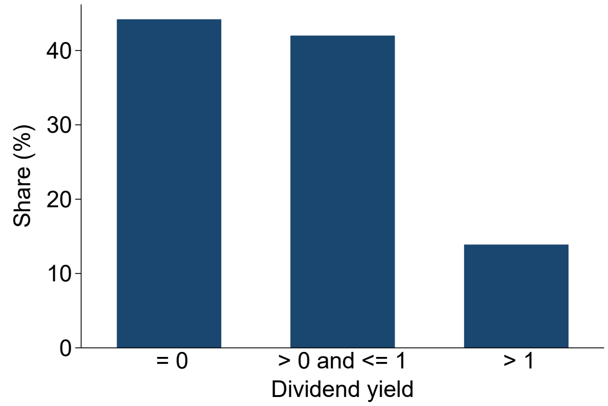
Notes: The table reports the coefficients from a regression of the account dividend yield on the variables indicated, at the account-month level. Standard errors in parentheses clustered by account. For readability, all coefficients multiplied by 100.

and total stock wealth in the SCF to impute total stock wealth directly from taxable dividends rather than doing the two-step procedure that we perform here. Unfortunately, there is one key difficulty in implementing this procedure with SCF data; in the SCF, stock wealth is reported for the survey year (more specifically, at the time of the interview), while taxable dividend income is based on the *previous* year's tax return. This creates biases in any dividend yields computed as the ratio of (previous year) dividend income to (current year) stock wealth. The bias is larger (in magnitude) for participants that (dis-)save more (either actively or passively through capital gains that the household does not respond to). Moreover, as we show in Figure A.2, a very large share of respondent-wave observations (more than 45%) report zero dividend income and positive stock wealth.[8] A large share of those are respondents that establish direct holdings of stocks (or mutual funds) some time between the end of the tax return year and the survey date. An analogous extensive margin adjustment may be taking place for respondents that report zero stock wealth and positive dividend income for the previous year. In that case the implied dividend yield is infinite.

Even if one disregards these two groups and only considers respondents for which the implied

[8]This is more than 2 times the account holders with zero dividend yield in the Barber and Odean (2000) data.

Figure A.2: SCF Implied Dividend Yield Categories



Notes: The figure shows the distribution of implied dividend yields in the SCF based on a comparison of the reported dividend income from tax returns against reported directly held stock market wealth.

dividend yield is between zero and one, there is still substantial dispersion (and a possible bias) in the implied dividend yields. Figure A.3 shows the median implied dividend yields and inter-quartile ranges for 5 age groups for the 1992 and 1995 waves of the SCF and compares them against the median dividend yields and inter-quartile ranges of (positive) dividend yields in the Barber and Odean (2000) data. Clearly the dividend yields in Barber and Odean (2000) are much more compressed around their median values compared to the SCF dividend yields. Moreover, the SCF dividend yields (conditional on being between zero and one) tend to be much higher than the Barber and Odean (2000) dividend yields.[9] Given these issues, we conclude that the SCF implied dividend yields cannot reliably be used for stock wealth imputation.

A.1.3 Non-taxable stock wealth adjustment

The SOI data exclude dividends held in non-taxable accounts (e.g. defined contribution retirement accounts). In this section, we describe how we adjust for non-taxable stock wealth to arrive at the stock market wealth variable we use in our empirical analysis.

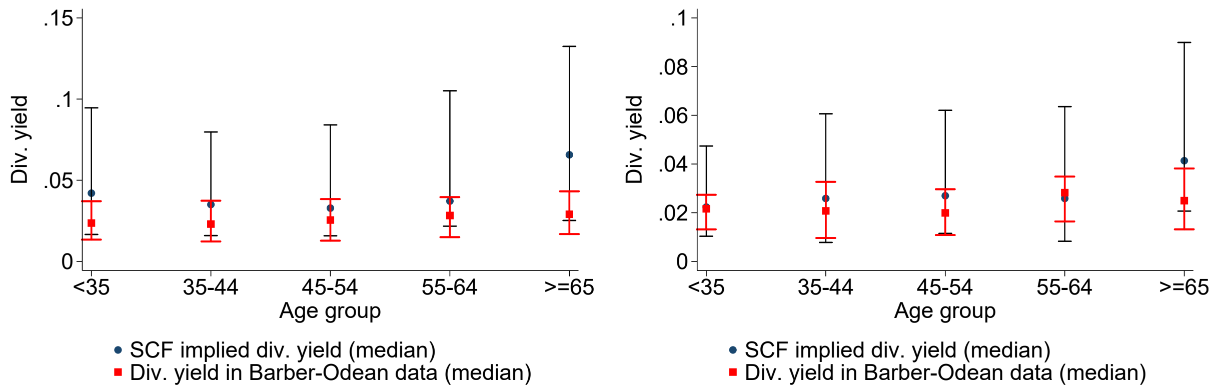
We begin by plotting in Figure A.4 the distribution of household holdings of corporate equity between taxable (directly held and non-IRA mutual fund) and non-taxable accounts using data from the Financial Accounts of the United States. Roughly 2/3 of corporate equity owned by households is held in taxable accounts.[10]

We next use data from the SCF to examine the relationship between total stock market wealth

[9]This is also reflected in the mean dividend yields (not shown) in the SCF, which are substantially higher than the medians, while in Barber and Odean (2000) the two are comparable.

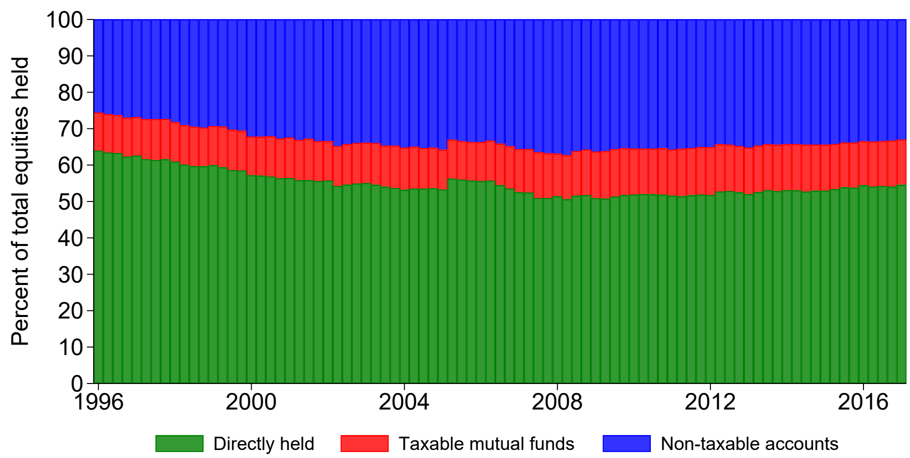
[10]Non-taxable retirement accounts here include only defined contribution accounts and exclude equity holdings of defined benefit plans. This definition accords with our empirical analysis since fluctuations in the market value of assets of defined benefit plans do not directly affect the future pension income of plan participants. The data plotted in Figure A.4 also include non-profit organizations, which hold about 10% of directly held equity and mutual fund shares.

Figure A.3: Dividend yield distributions by age group in the SCF and Barber and Odean (2000) data for 1992 (left) and 1995 (right)



Notes: Dots denote median values and bars show the inter-quartile range. The figures plot the distribution of implied dividend yields in the SCF (for dividend yields that are in (0, 1)) and dividend yields in the Barber and Odean (2000) data from a discount brokerage firm (for positive dividend yields) by age group for 1992 and 1995.

Figure A.4: Household Stock Market Wealth in the FAUS



Notes: The figure reports household equity wealth as reported in the Financial Accounts of the United States. We define stock market wealth as total equity wealth (table B.101.e line 14, code LM153064475Q) less the market value of S-corporations (table L.223 line 31, code LM883164133Q) and similarly define directly held stock market wealth as directly held equity wealth (table B.101.e line 15, code LM153064105Q) less the market value of S-corporations. Taxable mutual funds are total mutual fund holdings of equity shares (table B.101.e line 21, code LM653064155Q) less equity held in IRAs, where we compute the latter by assuming the same equity share of IRAs as of all mutual funds, IRA mutual fund equity = IRA mutual funds at market value (table L.227 line 16, code LM653131573Q) × total equities held in mutual funds /total value of mutual funds (table B.101.e line 21, code LM653064155Q + table B.101.e line 12, code LM654022055Q). Non-taxable accounts include equities held through life insurance companies (table B.101.e line 17, code LM543064153Q), in defined contribution accounts of private pension funds (table B.101.e line 18, code LM573064175Q), federal government retirement funds (table B.101.e line 19, code LM343064125Q), and state and local government retirement funds (table B.101.e line 20, code LM223064213Q), and through mutual funds in IRAs.

Table A.2: Summary Statistics (values are in 2016 dollars).

Variable	Mean	Std. Dev.	Min	Max
total stock wealth	119,402	1,144,358	0	9.87×10^8
taxable stock wealth	65,428	1,001,526	0	9.84×10^8

and stock market wealth held in taxable accounts in the cross-section of U.S. households. We pool all waves from 1992 to 2016, consistent with the sample period for our benchmark analysis. We use the definition for stock-market wealth used in the Fed Bulletins.[11] Following the Fed Bulletin definition of stock-market wealth, we define taxable stock wealth as the sum of direct holdings of stocks, stock mutual funds and other mutual funds, and 1/2 of the value of combination mutual funds. All variables are expressed in constant 2016 dollars. Table A.2 reports summary statistics for total stock wealth and taxable stock wealth.

Table A.3 reports the coefficients from regressions of total stock wealth on taxable stock wealth. There is a positive constant term, indicating that nontaxable stock market wealth is more evenly distributed than taxable wealth. The coefficient on taxable stock wealth is between 1.08 and 1.09 and the R^2 is around 0.91. Therefore, total stock wealth and taxable stock wealth vary almost one-for-one.

The high R^2 from these regressions suggests that we can use the relationship between total stock wealth, taxable stock wealth, and demographics in the SCF to account for non-taxable stock wealth at the county level. Specifically, we again use all waves of the SCF from 1992 to 2016. For each survey wave, we use a specification as in Column (2) of Table A.3. We then interpolate these coefficient estimates for years in which no survey took place. Finally, we use the estimate of (real) taxable stock wealth from capitalizing taxable dividend income and county-level demographic information on population shares in different age bins and the college share (interpolated at yearly frequency from the decadal census and also extrapolated past 2010) to arrive at real total stock wealth for each county and year.

A.1.4 Non-public companies

One remaining source of measurement error in our capitalization approach arises because dividend income reported on form 1040 includes dividends paid by private C-corporations. Such income accrues to owners of closely-held corporations and is highly concentrated at the top of the wealth distribution. Figure A.5 uses data from the Financial Accounts of the United States to plot the market value of equity issued by privately held C-corporations as a share of total equity issued

[11] The precise definition is available here: https://www.federalreserve.gov/econres/files/bulletin.macro.txt. Stock-market wealth appears as "financial assets invested in stock".

Table A.3: Total stock wealth and taxable stock wealth

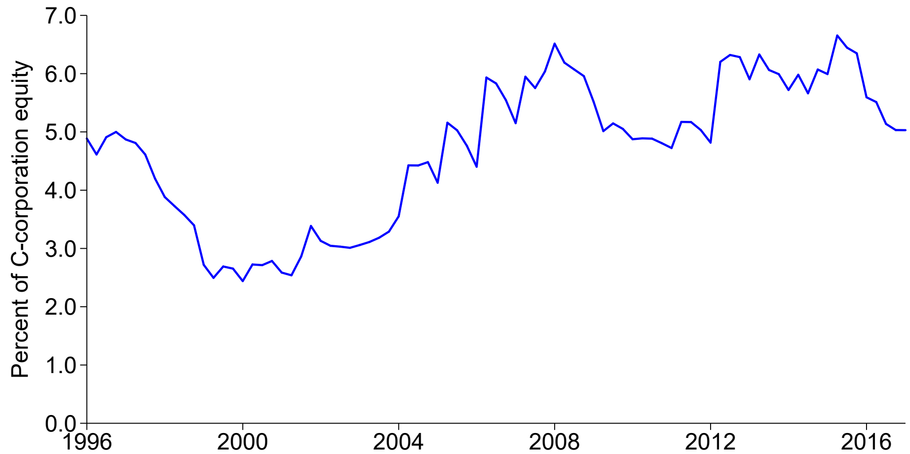
	(1)	(2)
Taxable stock wealth	1.09**	1.08**
	(0.01)	(0.01)
Age < 25		-12933.06**
		(1225.68)
Age 25-34		-22996.77**
		(1097.07)
Age 35-44		-2788.01*
		(1236.89)
Age 45-54		29412.54**
		(1790.46)
Age 55-64		64398.51**
		(2894.11)
Age 65+		34482.50**
		(2164.56)
College degree		102265.11**
		(2869.13)
Constant	48221.15**	
	(943.52)	
R^2	0.91	0.91
Observations	44,633	44,497

Notes: The table reports coefficient estimates from regressing (real) total stock wealth on (real) taxable stock wealth, and household head demographics in the SCF using the pooled 1992-2016 waves. Robust standard errors in parenthesis. * denotes significance at the 5% level, and ** denotes significance at the 1% level.

by domestic C-corporations.[12] This share never exceeds 7% of total equity, indicating that as a practical matter dividend income from non-public C-corporations is small. Moreover, as described in Appendix A.1 our baseline sample excludes a small number of counties with a substantial share of dividend income reported by late filers who disproportionately own closely-held corporations. Therefore, non-public C-corporation wealth does not appear to meaningfully affect our results.

[12]Since 2015, table L.223 of the Financial Accounts of the United States has reported equity issued by domestic corporations separately by whether the corporation's equity is publicly traded, with the series extended back to 1996 using historical data. While obtaining market values of privately held corporations necessarily requires some imputations (Ogden et al., 2016), we believe the results to be the best estimate of this split available and unlikely to be too far off.

Figure A.5: Equity of Privately Held C-Corporations



Notes: The figure reports the market value of equity of privately held C-corporations as a share of total (privately held plus publicly-traded) equity of domestic C-corporations as reported in the Financial Accounts of the United States table L.223 lines 29 and 32.

A.1.5 Return heterogeneity

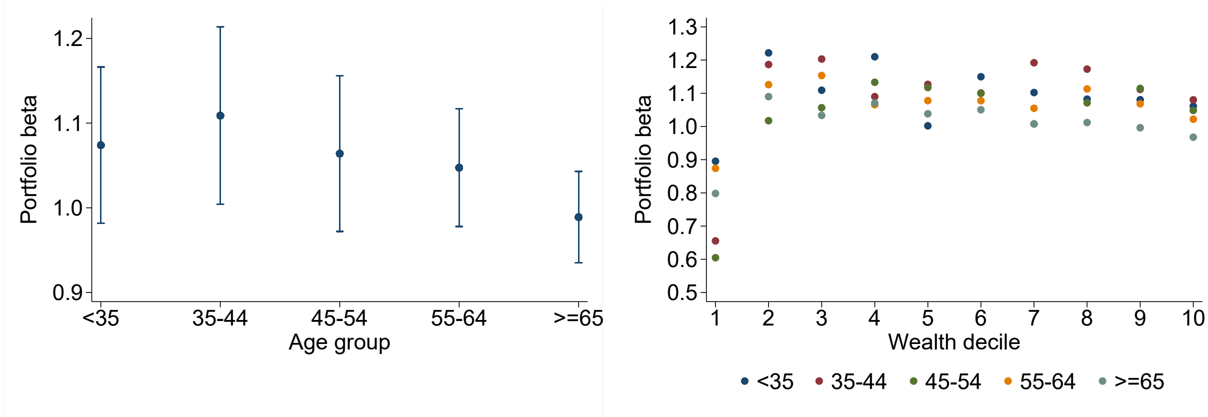
Similar to the dividend yield adjustment we also compute a county-specific stock market return. The systematic differences in dividend yields across households with different age that are the basis for our dividend yield adjustment in Appendix A.1.2 imply possible systematic differences in portfolio return characteristics across these same age groups. For example, it is well-known that stocks with higher dividend yields tend to be value stocks with a different return distribution than the stock market. Specifically, those stocks tend to have market betas below one. In that case the portfolio betas of households living in counties with predominantly older households will be lower than those of households living in counties with predominantly younger households. In this section we first present evidence using the Barber and Odean (2000) data set that there is indeed a systematic (although quite small) relation between portfolio betas and age. Second, as with the dividend yield adjustment from Appendix A.1.2 we use this relationship and county demographic information to construct a county-specific beta and compute a county-specific stock market return.

We use the household portfolio data described in Appendix A.1.2 and construct value-weighted portfolios by age group (for the same 5 age groups as in Appendix A.1.2).[13] We then construct monthly returns for these portfolios by computing the weighted one-month return on the underlying CRSP assets.[14] Using these monthly returns we estimate portfolio betas using the return on the CRSP value weighted index as the return on the market portfolio and the 3-month T-Bill yield as

[13] One difference relative to the sample we use in Appendix A.1.2 is that we also include household-month observations that have zero dividends. The reason for keeping these households in this case is that we want to construct a county-level stock market return that will be applied to county-level stock market wealth, which also includes the stock wealth of households that hold only non-dividend paying stocks in their portfolios.

[14] Household positions are recorded at the beginning of a month, so similar to Barber and Odean (2000) we implicitly assume that each household holds the assets in their portfolio for the duration of the month.

Figure A.6: Portfolio Beta by Age and Wealth



Notes: The figures plot the portfolio betas by age and wealth quantile based on the Barber and Odean (2000) data from a discount brokerage firm merged with data on CRSP stocks and mutual funds. Wealth denotes the total position equity among all taxable accounts that a household has in the discount brokerage firm.

the risk free rate. Figure A.6 (left panel) plots the estimated portfolio betas together with a 95% confidence intervals. As the Figure shows there is a negative (albeit small in magnitude) relationship between beta and age with younger households having portfolios with higher beta (and beta above one) compared to older households.

We next use this relationship to construct a county-specific beta and from it a county-specific stock market return. Specifically, as with the dividend-yield adjustment, we combine the estimated betas shown in the left panel of Figure A.6 with the county-year specific age structure from the Census Bureau and average wealth by age bin from the Survey of Consumer Finances (interpolated between SCF waves) to construct the wealth-weighted average of the age bin portfolio betas for each county and year. Finally, we scale these betas so that the average beta in each year is equal to one (that is, we assume that on average counties hold the market portfolio). We then multiply CRSP total stock return by these county-year specific betas to arrive at a county-specific stock-market return.

A.2 Summary Statistics

Table A.4 reports the mean and standard deviation of the 8 quarter change in the labor market variables. It also reports the standard deviation after removing county-specific means and state-quarter means, with the latter being the variation used in the main analysis.

A.3 County demographic characteristics and stock wealth

To more clearly illustrate that our empirical strategy does not depend on stock wealth to labor income being randomly assigned across counties, we correlate the (time-averaged) county level value of stock wealth to labor income with a number of county level demographics. Specifically,

Table A.4: Summary Statistics

Variable	Source	Mean	SD	Within county SD	Within county and state-quarter SD	Obs.
Quarterly total return on market	CRSP	0.019	0.067			94
Capitalized dividends/labor income	IRS SOI	2.316	1.177	0.628	0.309	269 057
Log empl., 8Q change	QCEW	0.025	0.053	0.047	0.032	272 942
Log payroll, 8Q change	QCEW	0.084	0.077	0.072	0.048	272 942
Log nontradable empl., 8Q change	QCEW	0.031	0.069	0.064	0.054	269 774
Log nontradable payroll, 8Q change	QCEW	0.081	0.089	0.084	0.064	269 774
Log tradable empl., 8Q change	QCEW	−0.018	0.130	0.123	0.106	258 856
Log tradable payroll, 8Q change	QCEW	0.045	0.158	0.151	0.128	258 856

Notes: The table reports summary statistics. Within county standard deviation refers to the standard deviation after removing county-specific means. Within county and state-quarter standard deviation refers to the standard deviation after partialling out county and state-quarter fixed effects. All statistics weighted by 2010 population.

we use time-averaged data from the 1990, 2000 and 2010 US Census to compute the county level shares of individuals 25 years and older with bachelor degree or higher, median age of the resident population, share of retired workers receiving social security benefits, share of females, and share of the resident population identifying themselves as white.[15] Table A.5 reports the coefficient estimates from population weighted regressions of stock wealth to labor income on each demographic characteristics as well as a regression including all demographic characteristics (last column). All regressions include state fixed effects. Unsurprisingly, the share of retired workers and share with college degree are robustly positively related with the average stock wealth to labor income ratio in a county. The share of females and white is negatively related with stock wealth to labor income although the effects are smaller. Median age does not co-move with stock wealth to income after controlling for the other demographic characteristics.

A.4 Coefficients on control variables

This appendix reproduces the baseline results in Table 1 including the coefficients on the main control variables.

[15]For the college share we use the American Community Survey rather than the 2010 US Census.

Table A.5: County demographics regressions

	(1)	(2)	(3)	(4)	(5)	(6)
Bachelor degree or higher (%)	0.06**					0.09**
	(0.01)					(0.01)
Median age		0.10*				−0.04*
		(0.04)				(0.02)
Retired (%)			0.12**			0.31**
			(0.04)			(0.03)
Female (%)				0.19**		−0.06*
				(0.04)		(0.03)
White (%)					−0.00	−0.02**
					(0.00)	(0.00)
Population weighted	Yes	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.31	0.21	0.22	0.18	0.15	0.54
Observations	3,141	3,141	3,141	3,141	3,141	3,141

Notes: The table reports coefficients and standard errors from regressing time-averaged total stock wealth by labor income on county demographics. Standard errors in parentheses are clustered by state. * denotes significance at the 5% level, and ** denotes significance at the 1% level.

A.5 Monte Carlo simulation

In this section we perform Monte Carlo simulations to assess the possible impact of household-level MPC heterogeneity on our empirical estimates. We start by constructing a simulated data set containing the full distribution of household wealth by county. To do so, we first stratify the 2016 SCF into eight groups based on total 2015 income (less than $75k, $75k-$100k, $100k-$200k, and $200k+) and whether the household had any 2015 dividend income. For each group, we compute the share of households with positive stock wealth in 2016 and fit a log-normal distribution to the stock wealth of the households with positive stock wealth. We then obtain from the 2015 IRS SOI data the number of tax returns by county that have adjusted gross income in the same four income groups as in the SCF and within each income group the number of returns with dividend income. For each return in a county and income group-by-dividend indicator category, we first simulate whether the household holds stocks or not based on the estimated share in that category in the SCF. Next, for each simulated household with positive stock wealth, we draw their level of stock wealth from a log-normal distribution with mean and variance from the SCF distribution of stock wealth for the respective category. This process yields a simulated data set with 148,978,310 observations, of which 76,680,922 have positive stock wealth.

Table A.7 compares several moments in the simulated data and the actual data (2016 SCF for

Table A.6: Baseline Results

	All		Non-traded		Traded	
	Emp.	W&S	Emp.	W&S	Emp.	W&S
	(1)	(2)	(3)	(4)	(5)	(6)
Right hand side variables:						
$S_{a,t-1}R_{a,t-1,t}$	0.77*	2.18**	2.02*	3.24**	−0.11	0.71
	(0.36)	(0.63)	(0.80)	(1.01)	(0.64)	(0.74)
Bartik predicted employment	0.86**	1.46**	0.59**	0.84**	1.66**	2.11**
	(0.08)	(0.14)	(0.10)	(0.10)	(0.19)	(0.25)
Labor income interaction	−1.11+	−2.65**	0.96	−0.92	1.70	1.92
	(0.62)	(0.87)	(0.99)	(1.19)	(1.92)	(2.12)
Business income interaction	1.08+	2.53**	−1.26	0.58	−1.63	−1.90
	(0.61)	(0.83)	(0.99)	(1.17)	(1.89)	(2.05)
Bond return interaction	−0.07	−0.14	3.58+	2.80	0.20	−0.51
	(0.82)	(1.39)	(1.87)	(2.32)	(1.20)	(1.81)
House price interaction	−1.55	5.45	−8.33*	2.29	−9.91	−4.88
	(3.28)	(4.40)	(4.14)	(5.25)	(6.32)	(6.87)
Horizon h	Q7	Q7	Q7	Q7	Q7	Q7
Pop. weighted	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes
State × time FE	Yes	Yes	Yes	Yes	Yes	Yes
Shock lags	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.66	0.64	0.39	0.48	0.35	0.36
Counties	2,901	2,901	2,896	2,896	2,877	2,877
Periods	92	92	92	92	92	92
Observations	265,837	265,837	263,210	263,210	252,928	252,928

Notes: The table reports coefficients and standard errors from estimating Eq. (1) for $h = 7$. Columns (1) and (2) include all covered employment and payroll; columns (3) and (4) include employment and payroll in NAICS 44-45 (retail trade) and 72 (accommodation and food services); columns (5) and (6) include employment and payroll in NAICS 11 (agriculture, forestry, fishing and hunting), NAICS 21 (mining, quarrying, and oil and gas extraction), and NAICS 31-33 (manufacturing). The shock occurs in period 0 and is an increase in stock market wealth equivalent to 1% of annual labor income. For readability, the table reports coefficients in basis points. Standard errors in parentheses and double-clustered by county and quarter. * denotes significance at the 5% level, and ** denotes significance at the 1% level.

the first 5 moments and county-level capitalized dividend income from the 2015 IRS SOI for the remaining 2 moments). The simulated data capture very well key features of the actual data.

We perform two experiments using the simulated data. In both experiments, we assume a structure of household-level MPC heterogeneity out of stock wealth.[16] We then simulate the con-

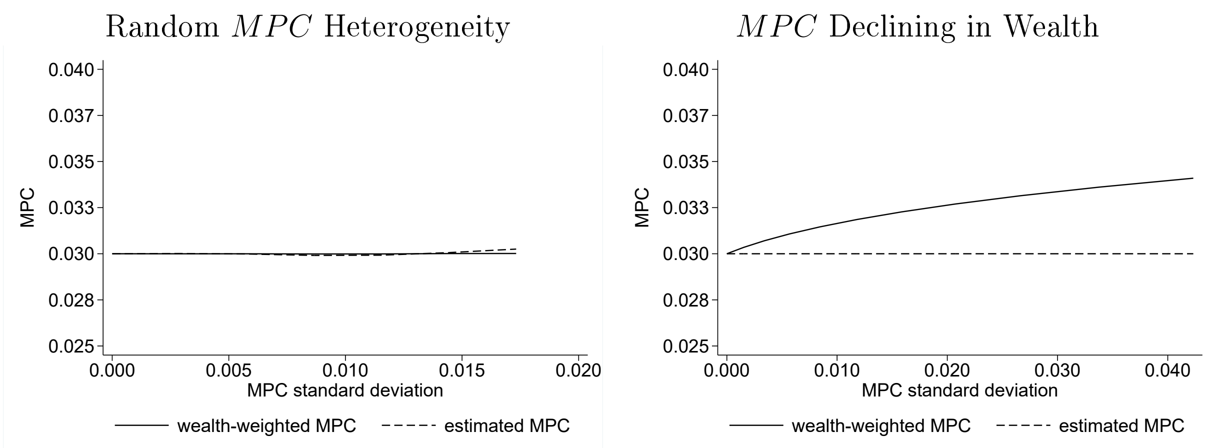
[16] We are agnostic in these experiments about the MPC of *non*-stock holders. In particular, as in our two

Table A.7: Comparison of simulated and actual data.

Moment	Simulated	Observed
Own stocks (percent)	51.5	53.6
Mean stock wealth	193,806	178,785
St. dev. stock wealth	1,682,979	1,680,982
Mean stock wealth (stocks>0)	376,533	333,667
St. dev. stock wealth (stocks>0)	2,331,120	2,285,270
Mean county stock wealth	140,077	121,557
St. dev. county stock wealth	63,871	84,879

Notes: Simulated moments are based on simulated household-level data that uses information on stock ownership and stock wealth by 2015 dividend income (no dividend income vs. some dividend income) and total gross income group (4 groups: less than \$75k, \$75k-\$100k, \$100k-\$200k, and \$200k+) from the 2016 SCF and county-level information on number of returns in each (adjusted) gross income group and number of returns with dividend income by income group from the 2015 IRS SOI data. Observed moments are based on the 2016 SCF (for first 5 moments) as well as the 2015 county-level stock wealth (for the last 2 moments) based on capitalized dividend income, where the capitalization approach is described in Appendix A.1.

Figure A.7: Wealth-weighted MPC Versus County-level Regression Estimate



Notes: The wealth-weighted MPC is computed based on simulated household-level data that uses information on stock ownership and stock wealth by 2015 dividend income (no dividend income vs. some dividend income) and total gross income group (4 groups: less than \$75k, \$75k-\$100k, \$100k-\$200k, and \$200k+) from the 2016 SCF and county-level information on number of returns in each (adjusted) gross income group and number of returns with dividend income by income group from the 2015 IRS SOI data. The estimated MPC is computed by aggregating the household-level changes in spending and wealth in response to a 1% stock return to the county level, dividing by the number of tax returns, and regressing the change in county-level spending per tax return on the change in county-level stock wealth per tax return and a constant term. In the left panel, household-level MPCs are drawn from a uniform distribution over $[0.03 - k, 0.03 + k]$, where k varies between 0 and 0.03. In the right panel, household-level MPCs are set to $MPC = bW^{-a}$, where W denotes stock wealth and a parameterizes the heterogeneity in MPCs and the strength of the relation between stock wealth and MPC, and is allowed to vary between 0 and 0.2, while b is chosen such that the county-level MPC estimate equals 0.03.

agent model, there could be large differences in the MPCs of non-stock holders and stock holders even if there is little or no heterogeneity in MPCs among the group of stock-holders.

sumption change to a 1% increase in stock wealth, aggregate the wealth and consumption changes across households in a county and divide by the total number of returns to obtain the county-level average consumption and wealth change, and regress the change in county-average consumption on the change in county-average wealth. This yields a cross-county coefficient that mirrors our actual empirical design.[17] We plot the regression coefficient and the true wealth-weighted average MPC as a function of the standard deviation of the MPC of stock holders.

The first experiment assumes the heterogeneity in MPCs is random across households. Specifically, MPCs are distributed uniformly over $[0.03 - k, 0.03 + k]$, where k is allowed to vary between 0 (no heterogeneity) and 0.03. The left panel of Figure A.7 plots the resulting regression coefficients and wealth-weighted MPCs as k varies. With random heterogeneity, the regression recovers an unbiased and precise estimate of the wealth-weighted average MPC out of stock wealth.

The second experiment assumes that the MPC declines in the amount of stock wealth according to the relationship $MPC = bW^{-a}$, where W denotes stock wealth and a parameterizes both the heterogeneity in MPCs and the strength of the relation between stock wealth and MPC. A value of $a = 0$ implies no heterogeneity, while positive values of a generate a negative relationship. For each value of a, we choose b such that the county-level regression coefficient roughly equals our empirical estimate of 0.03. The right panel of Figure A.7 plots the regression coefficient and the wealth-weighted average MPC against the MPC of stock holders, for different levels of a. With no dispersion, the cross-county regression again exactly recovers the wealth-weighted MPC. More interesting, the wealth-weighted MPC remains very close to the county-level coefficient even for substantial dispersion in MPCs among stock-wealth holders. For example, an MPC standard deviation of 0.02, shown in the middle of the plot, corresponds to an MPC of stock owners at the 50th percentile that is double the MPC of stock owners at the 99th percentile, but the county-level estimate remains within 10% of the wealth-weighted average MPC. The assumed negative relationship between MPC and stock wealth implies that the regression coefficient always lies below the wealth-weighted MPC, making our estimates if anything a lower bound.

A.6 Evidence of Unit Income Elasticity of Nontradable Consumption in the Consumer Expenditure Survey

This appendix describes our analysis of the income elasticity of nontradable consumption using the interview module of the Consumer Expenditure Survey (CE). The CE interviews sampled households for up to four consecutive quarters about all expenditures over the prior three months on a detailed set of categories. We perform two sets of exercises. The first reports Engel curve estimation for selected expenditure categories, including our nontradable grouping of retail and restaurants. The second extends the Dynan and Maki (2001) and Dynan (2010) analysis of the conditional

[17] Since we use change in county-level spending rather than growth in spending, we do not need to normalize the regressor by the level of spending as we do in Section 4.5.

Table A.8: Engel Curves in the Consumer Expenditure Survey

Category	Share	AIDS			Deviation	
		Coef.	SE	Elasticity	Elasticity	SE
Jewelry	0.21	0.003	0.000	2.269	1.913	0.079
Restaurants	3.80	0.015	0.000	1.401	1.198	0.013
Food at home	14.31	−0.081	0.001	0.437	0.418	0.005
Retail and restaurants	33.39	−0.007	0.002	0.978	0.895	0.008

Notes: The table estimates Engel curves for selected categories using the Consumer Expenditure Survey. In the AIDS specification, the dependent variable is the expenditure share on the category indicated. In the deviation specification, the dependent variable is the percent difference in expenditure on the category indicated from the sample mean. In both specifications, the endogenous variable is log total household expenditure, the excluded instruments are log of after-tax income and categories of income and the included instruments are categorical variables for age range, number of earners, and household size as well as a year fixed effect.

consumption expenditure response by stock holders to an increase in the stock market to consider different categories of consumption. Both exercises suggest a close to proportionate increase in consumption expenditure on nontradable and other goods.

Engel curve estimation. Table A.8 reports the elasticity of selected expenditure categories to total expenditure. We report two sets of specifications. The first uses the Almost Ideal Demand System of Deaton and Muellbauer (1980):

$$\frac{x_{i,j,t}}{X_{i,t}} = \alpha_{j,t} + \beta_j \ln X_{i,t} + \Gamma_j Z_i + u_{i,j,t}, \tag{A.1}$$

where $x_{i,j,t}$ is the expenditure by household i on good j in year t, $X_{i,t}$ is total expenditure by household i, $\alpha_{j,t}$ is a good-specific year fixed effect, and Z_i contains as included covariates categorical variables for age range, number of earners, and household size. To account for measurement error in $X_{i,t}$, we follow Aguiar and Bils (2015) and estimate Eq. (A.1) using instrumental variables with log after-tax income and income bins as excluded instruments. A value of β_j of 0 would indicate a unit income elasticity; more generally, the elasticity of good j at the sample mean expenditure share is equal to $\beta\times$expenditure share $+1$. The second Engel curve estimation procedure follows Aguiar and Bils (2015) and others and estimates:

$$\frac{x_{i,j,t} - \bar{x}_{j,t}}{\bar{x}_{j,t}} = \alpha_{j,t} + \beta_j \ln X_{i,t} + \Gamma_j Z_i + u_{i,j,t}, \tag{A.2}$$

where $\bar{x}_{j,t}$ is the cross-sectional average expenditure on good j in year t and estimation again proceeds via IV with the same set of excluded instruments. In this specification, β_j directly gives the elasticity.

We report Engel curve estimates for jewelry, restaurant meals, food purchased for home consumption, and the total category of retail and restaurants, which includes the first three categories as well as all other retail purchases. We report results corresponding to our full sample of 1990-2016; we obtain similar results in sub-samples that address the possibility of estimate stability, for example due to changes in relative prices. Table A.8 shows that homotheticity does not hold across all sub-categories within retail and restaurants. Jewelry is a luxury good, with an elasticity around 2 across specifications. Meals at restaurants also have an elasticity above 1. Food at home is a necessity, with an elasticity around 0.4. However, the combined category of retail and restaurants has an elasticity of close to 1 — 0.98 using the AIDS specification and 0.9 using the Aguiar and Bils (2015) specification.

Response to changes in the stock market. The CE does not ask directly about stock holdings. However, in the last interview the survey records information on security holdings. Dynan and Maki (2001) and Dynan (2010) use this information and the short panel structure of the survey to separately relate consumption growth of security holders and non-security holders to the change in the stock market. We follow the analysis in Dynan and Maki (2001) as closely as possible and extend it by measuring the response of retail and restaurant spending separately.[18]

The specification in Dynan and Maki (2001) is:

$$\Delta \ln C_{i,t} = \sum_{j=0}^{3} \beta_j \Delta \ln W_{t-j} + \Gamma' X_{i,t} + \epsilon_{i,t}, \tag{A.3}$$

where $\Delta \ln C_{i,t}$ is the log change in consumption expenditure by household i between the second and fifth CE interviews,[19] $\Delta \ln W_{t-j}$ is the log change in the Wilshire 5000 between the recall periods covered by the second and fifth interviews ($j = 0$) or over consecutive, non-overlapping 9 month periods preceding the second interview ($j = 1, 2, 3$), and $X_{i,t}$ contains monthly categorical variables to absorb seasonal patterns in consumption, taste shifters (age, age^2, family size), socioeconomic variables (race, high school completion, college completion), labor earnings growth between the second and fifth interviews, and year categorical variables. Thus, this specification attempts to address the causal identification challenge by controlling directly for contemporaneous labor income growth and including year categorical variables, the latter which isolate variation in recent stock performance for households interviewed during different months of the same calendar year. Following Mankiw and Zeldes (1991), the specification is estimated separately for households above and below a cutoff value for total securities holdings.

[18]The Dynan and Maki (2001) sample covers the period 1983-1998. Dynan (2010) finds negligible consumption responses when extending the sample through 2008, possibly reflecting the deterioration in the quality of the CE sample in the more recent years and the difficulty in recruiting high income and high net worth individuals to participate. Since our purpose is to compare the responses of different categories of consumption, we restrict to periods when the data can capture an overall response.

[19]The first CE interview introduces the household to the survey but does not collect consumption information. Therefore, the span between the second and fifth interviews is the longest span available.

Table A.9: Consumption Responses in the Consumer Expenditure Survey

	Non-durable goods and services		Retail and restaurants	
	SH	Other	*SH*	Other
	(1)	(2)	(3)	(4)
Right hand side variables:				
Stock return	0.369**	−0.015	0.198	−0.038
	(0.133)	(0.048)	(0.277)	(0.100)
Lag 1	0.385*	0.074	0.519+	0.121
	(0.151)	(0.053)	(0.312)	(0.109)
Lag 2	0.252+	0.050	0.447	0.065
	(0.134)	(0.047)	(0.278)	(0.097)
Lag 3	0.039	0.038	0.104	0.135+
	(0.103)	(0.037)	(0.220)	(0.077)
Sum of coefficients	1.044	0.146	1.268	0.283
R^2	0.02	0.01	0.02	0.01
Observations	4,086	28,329	4,026	28,376

Notes: The estimating equation is: $\Delta \ln C_{i,t} = \sum_{j=0}^{3} \beta_j \Delta \ln W_{t-j} + \Gamma' X_{i,t} + \epsilon_{i,t}$, where $\Delta \ln C_{i,t}$ is the log change in consumption expenditure by household i between the second and fifth CE interviews in the consumption category indicated in the table header and $\Delta \ln W_{t-j}$ is the log change in the Wilshire 5000 between the recall periods covered by the second and fifth interviews ($j = 0$) or over consecutive, non-overlapping 9 month periods preceding the second interview ($j = 1, 2, 3$). All regressions include controls for calendar month and year of the final interview, age, age^2, family size, race, high school completion, college completion, and labor earnings growth between the second and fifth interviews. The sample is 1983-1998. Columns marked *SH* include households with more than $10,000 of securities.

Table A.9 reports the results. The left panel contains our replication of table 2 in Dynan and Maki (2001) and Dynan (2010). We find very similar results to those papers. Notably, expenditure on nondurable goods and services rises on impact for households categorized as stock holders and continues to rise over the next 18 months following a positive stock return. This sluggish response accords with the sluggish adjustment of labor market variables in our main analysis. Summing over the contemporaneous and lag coefficients, the total elasticity of expenditure to increases in stock market wealth is about 1. In contrast, total expenditure by non-stock holders does not increase.

The right panel replaces the consumption measure with purchases of non-durable and durable goods from retail stores and purchases at restaurants. These categories provide the closest correspondence to all purchases made at stores in the retail or restaurant sectors.[20] The cumulative consumption responses of purchases of goods from retail stores and at restaurants are very similar

[20]Because we include durable goods, the categories in the right panel are not a strict subset of the categories in the left panel. We have experimented with excluding durable goods from the basket and obtain similar results.

to the responses of total non-durable goods and services, albeit estimated with less precision.

Overall, these results provide support for our assumption that expenditure on retail and restaurants moves proportionally with total expenditure, which we use to structurally interpret our empirical estimates in the paper. This conclusion holds both across households in the Engel curve analysis and within households in response to stock market changes. Even if one questions the causal identification of the Dynan and Maki (2001) framework for stock market changes, their specification still has the interpretation of the relative responses across categories to general demand shocks rather than to the stock market in particular.

B Model Details

In this appendix, we present the full model. In Section B.1, we describe the environment and define the equilibrium. For completeness, we repeat the key equations shown in the main text. In Section B.2, we provide a general characterization: specifically, we fully describe the long-run equilibrium, and we derive the equations for the short-run equilibrium that we solve subsequently. In Section B.3, we provide a closed-form solution for a benchmark case in which areas have the same stock wealth. In Section B.4, we log-linearize the equilibrium around the common-wealth benchmark and provide closed-form solutions for the log-linearized equilibrium with heterogeneous stock wealth. In Section B.5, we use our results to characterize the cross-sectional effects of shocks to stock prices. In Section B.6, we establish the robustness of the benchmark calibration of the model that we present in the main text. In Section B.7, we analyze the aggregate effects of shocks to stock prices (when monetary policy is passive) and compare the results with our earlier results on the cross-sectional effects. Finally, in Section B.8, we extend the model to incorporate uncertainty, and we show that our results are robust to obtaining the stock price fluctuations from alternative sources such as changes in households' risk aversion or perceived risk.

B.1 Environment and Definition of Equilibrium

Basic Setup and Interpretation. There are two factors of production: capital and labor. There is a continuum of measure one of areas (counties) denoted by subscript a. Areas are identical except for their initial ownership of capital.

There is an infinite number of periods $t \in \{0, 1, 2...\}$. We view period 0 as the "the short run" with the key features that labor is specific to the area and nominal wages are (potentially) partially sticky. Therefore, local labor bill and the local labor in the short run are influenced by local aggregate demand. In contrast, periods $t \geq 1$ are "the long run" in which both factors are mobile cross areas. With appropriate monetary policy (that we describe subsequently), this mobility assumption implies outcomes in periods $t \geq 1$ are determined solely by productivity. (For simplicity, capital is mobile across areas in all periods including period 0).

Importantly, each area is populated by two types of agents denoted by superscript $i = s$ ("stockholders") and $i = h$ ("hand-to-mouth") with population mass $1 - \theta$ and θ, respectively (where $\theta \in (0,1)$). Stockholders own (and trade) the capital, and also supply a fraction of the labor. They have a relatively low MPC that we estimate. Hand-to-mouth households hold no capital, and they supply the remaining fraction of labor. They have a much higher MPC equal to one. This heterogeneous MPC setup approximates the data better than a representative household model and enables us to calibrate the Keynesian multiplier. We also assume that the stockholders' labor supply is exogenous (or perfectly inelastic) but hand-to-mouth households' labor supply (in period 0) is endogenous (or somewhat elastic). This asymmetric labor supply assumption enables us to introduce some labor elasticity while abstracting away from the wealth effects on labor supply.

Our focus is to understand how fluctuations in the price of capital affects cross-sectional and aggregate outcomes in the short run. To this end, we will generate endogenous changes in the capital price in period 0 from exogenous permanent changes to the productivity of capital in period 1. We interpret these changes as capturing stock market fluctuations due to a "time-varying risk premium." We validate the risk premium interpretation in Section B.8, where we introduce uncertainty about capital productivity in period 1.

Goods and Production Technologies. For each period t, there is a composite tradable good that can be consumed everywhere. For each area a, there is also a corresponding nontradable good that can only be produced and consumed in area a. Labor and capital are perfectly mobile across the production technologies described below. We assume all production firms are competitive and not subject to nominal rigidities (we will assume nominal rigidities in the labor market).

The nontradable good in area a can be produced according to a standard Cobb-Douglas technology,

$$Y_{a,t}^N = \left(K_{a,t}^N/\alpha^N\right)^{\alpha^N} \left(L_{a,t}^N/\left(1-\alpha^N\right)\right)^{1-\alpha^N}. \tag{B.1}$$

Here, $L_{a,t}^N, K_{a,t}^N$ denote the quantity of labor and capital used by the nontradable sector in area a. The term $1 - \alpha^N$ captures the share of labor in the nontradable sector.

In each period, the tradable good can be produced as a composite of tradable inputs across areas, where each input is produced according to a standard Cobb-Douglas technology:

$$\begin{aligned} Y_t^T &= \left(\int_a \left(Y_{a,t}^T\right)^{\frac{\varepsilon-1}{\varepsilon}} da\right)^{\frac{\varepsilon}{\varepsilon-1}} && \text{(B.2)} \\ \text{where } Y_{a,t}^T &= \left(K_{a,t}^T/\alpha^T\right)^{\alpha^T} \left(L_{a,t}^T/\left(1-\alpha^T\right)\right)^{1-\alpha^T}. && \text{(B.3)} \end{aligned}$$

Here, $L_{a,t}^T, K_{a,t}^T$ denote the quantity of labor and capital used by the tradable sector in area a. The term $1 - \alpha^T$ captures the share of labor in the tradable sector. The parameter, $\varepsilon > 0$, captures the elasticity of substitution across tradable inputs. When $\varepsilon > 1$ (resp. $\varepsilon < 1$), tradable inputs are gross substitutes (resp. gross complements).

Starting from period 1 onward, the tradable good can also be produced with another technology that uses only capital. This technology is linear,

$$\tilde{Y}_t^T = D^{1-\alpha^T} \tilde{K}_t^T \text{ for } t \geq 1. \tag{B.4}$$

Here, $\tilde{K}_t^T$ denotes the capital employed in the capital-only technology, and $\tilde{Y}_t^T$ denotes the tradable good produced via this technology (we use the tilde notation to distinguish them from K_t^T and Y_t^T). The term, $D^{1-\alpha^T}$, captures the capital productivity in period 1. This technology ensures that the rental rate of capital in the long run (periods $t \geq 1$) is a function of the exogenous parameter, D (with our normalization, it will be proportional to D). This in turn helps to generate fluctuations in the price of capital (in period 0) that are unrelated to current or future labor productivity.

Nominal Factor Returns and Prices. We let $P_{a,t}^N$ denote the nominal price of the nontradable good in period t and area a. We let P_t^T denote the price of the composite tradable good, and $P_{a,t}^T$ denote the price of the tradable input produced in area a

Likewise, we let $W_{a,t}$ denote the nominal wage for labor in period t and area a. We let R_t denote the nominal rental rate of capital in period t. There is a single rental rate for capital since capital is mobile across areas by assumption. Starting from period 1 onward, there is also a single wage (since labor is also mobile across areas), that is, $W_{a,t} = W_t$ for $t \geq 1$.

Capital Supply. In each period t, aggregate capital supply is exogenous and normalized to one,

$$\overline{K}_t \equiv 1. \tag{B.5}$$

Since capital is mobile across areas in all periods, we don't need to specify its location.

There are two financial assets. First, there is a claim on capital that pays R_t units in each period t. We let Q_t denote its nominal *cum-dividend* price. Thus, $Q_t - R_t$ denotes the nominal ex-dividend price. Second, there is also a risk-free asset in zero net supply. We denote the nominal gross risk-free interest rate between periods t and $t+1$ with R_t^f.

Heterogeneous Ownership of Capital. Stockholders in different areas start with zero units of the risk-free asset but they can differ in their endowments of aggregate capital. Specifically, we let $1+x_{a,t}$ denote the share of aggregate capital held in area a in period t. For simplicity, capital wealth in an area is evenly distributed among stockholders: thus, each stockholder holds $(1+x_{a,t})\,/\,(1-\theta)$ units of aggregate capital. The initial shares across areas $\{1+x_{a,0}\}_a$, are exogenous and can be heterogeneous. The common-wealth benchmark corresponds to the special case with $x_{a,0} = 0$ for each a.

Households' Choice Between Nontradables and Tradables. Households of either type $i \in \{s, h\}$ consume the tradable good, $C_{a,t}^{i,T}$, and the nontradable good, $C_{a,t}^{i,N}$. We assume households' utility depends on these expenditures through a consumption aggregator given by:

$$C^i_{a,t} = \left(C^{i,N}_{a,t}/\eta\right)^{\eta} \left(C^{i,T}_{a,t}/\left(1-\eta\right)\right)^{1-\eta}.$$

Here, η denotes the share of nontradables in spending.

In view of this assumption, we can formulate households' optimization problem in two steps. Consider the expenditure minimization problem in period t given a target consumption level $C^i_{a,t}$,

$$\begin{aligned} &\min_{C^N_{a,t}, C^T_{a,t}} P^N_{a,t} C^N_{a,t} + P^T_{a,t} C^T_{a,t} \\ &\left(C^N_{a,t}/\eta\right)^{\eta} \left(C^T_{a,t}/\left(1-\eta\right)\right)^{1-\eta} \geq C^i_{a,t}. \end{aligned} \tag{B.6}$$

This problem is linearly homogeneous in $C^i_{a,t}$. Let $P_{a,t}$ (the unit cost or the ideal price index) denote the solution with $C^i_{a,t} = 1$. Then, given the price path, $\{P_{a,t}\}_{t=0}^{\infty}$, households first choose the path of their consumption (aggregator), $\left\{C^i_{a,t}\right\}_{t=0}^{\infty}$ (as we describe subsequently). Households then split their consumption $C^i_{a,t}$ between nontradables and tradables to solve problem $(B.6)$.

Throughout, we use $C^N_{a,t}, C^T_{a,t}$ to denote the total nontradable and tradable spending by the households in an area, that is,

$$\begin{aligned} C^N_{a,t} &= \left(1-\theta\right) C^{s,N}_{a,t} + \theta C^{h,N}_{a,t} \\ C^T_{a,t} &= \left(1-\theta\right) C^{s,T}_{a,t} + \theta C^{h,T}_{a,t}. \end{aligned} \tag{B.7}$$

Here, recall that $1-\theta$ and θ denote stockholders' and hand-to-mouth households' population share, respectively.

Stockholders' Labor Supply. In each period, stockholders' labor supply is still exogenous and the same across areas,

$$L^s_{a,t} = \overline{L} \text{ for each } a. \tag{B.8}$$

In contrast, hand-to-mouth households' labor is endogenous as we describe below.

Stockholders' Optimal Consumption-Saving and Portfolio Choice. Stockholders in area a have time separable log utility. They choose how much to consume and save and how to allocate savings across capital and the risk-free asset. We formulate their problem in period 0 as:

$$\begin{aligned} &\max_{\left\{C^s_{a,t}, S_{a,t} \geq 0, \frac{1+x_{a,t+1}}{1-\theta}\right\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \left(1-\rho\right)^t \log C^s_{a,t} \\ &P_{a,t} C^s_{a,t} + S_{a,t} = W_{a,t} \overline{L} + \frac{1+x_{a,t}}{1-\theta} Q_t + A^f_{a,t} \\ &S_{a,t} = \frac{A^f_{a,t+1}}{R^f_t} + \frac{1+x_{a,t+1}}{1-\theta} \left(Q_t - R_t\right) \end{aligned} \tag{B.9}$$

$$\text{with } A^f_{a,0} = 0 \text{ and } 1 + x_{a,0} \geq 0 \text{ given.}$$

Here, we use $1-\rho \in (0,1)$ to denote the one-period discount factor. The parameter $\rho \in (0,1)$ is inversely related to the discount factor and plays a central role in our analysis (as we will see, it will be equal to the marginal propensity to consume). We require savings (total asset holdings) $S_{a,t}$ to be nonnegative—this does not bind in equilibrium and helps to rule out Ponzi schemes.

The term, $\frac{1+x_{a,t+1}}{1-\theta}$ denotes the units of capital that the household purchases at the ex-dividend price, $\frac{1+x_{a,t+1}}{1-\theta}(Q_t - R_t)$. We normalize by $1-\theta$, so that $x_{a,t+1}$ denotes the total purchases in area a. Households invest the rest of their savings in the risk-free asset, $\frac{A^f_{a,t}}{R^f_t}$, which delivers $A^f_{a,t}$ units of cash in the next period. Areas start with the same cash positions for simplicity, $A^f_{a,0} = 0$ (which is zero to ensure market clearing), but heterogeneous capital positions, $\{1 + x_{a,0}\}_a$.

Hand-to-mouth Households' Labor Supply. Hand-to-mouth households are myopic (equivalently, they have time separable preferences with discount factor set equal to 0). Therefore, they spend their labor income in all periods

$$P_{a,t} C^h_{a,t} = W_{a,t} L^h_t. \tag{B.10}$$

Their labor supply is endogenous. For the purpose of endogenizing the labor supply, we work with a GHH functional form for the intra-period preferences between consumption and labor that eliminates the wealth effects on the labor supply. These effects seem counterfactual for business cycle analysis (Galí (2011)).

Specifically, recall that in each area there is a mass θ of hand-to-mouth households. Suppose each hand-to-mouth household corresponds to a "representative agent" that is subdivided into a continuum of worker types denoted by $\nu \in [0,1]$. These workers provide specialized labor services. A worker ν who specializes in providing a particular type of labor service has the utility function:

$$C^h_{a,t}(\nu) - \chi \frac{\left(L^h_{a,t}(\nu)\right)^{1+\varphi^h}}{1+\varphi^h}. \tag{B.11}$$

Since she is myopic, she is subject to the budget constraint:

$$P_{a,t} C^h_{a,t}(\nu) = W_{a,t}(\nu) L^h_{a,t}(\nu). \tag{B.12}$$

Here, $L^h_{a,t}(\nu)$ denotes her labor and $C^h_{a,t}(\nu)$ denotes her consumption.

In each area a, there is also an intermediate firm that produces the (hand-to-mouth) labor services in the area by combining specific labor inputs from each worker type according to the aggregator:

$$L^h_{a,t} = \left(\int_0^1 L^h_{a,t}(\nu)^{\frac{\varepsilon_w - 1}{\varepsilon_w}} d\nu \right)^{\frac{\varepsilon_w}{\varepsilon_w - 1}}.$$

This leads to the labor demand equation:

$$L^h_{a,t}(\nu) = \left(\frac{W_{a,t}(\nu)}{W_{a,t}}\right)^{-\varepsilon_w} L^h_{a,t} \tag{B.13}$$

$$\text{where } W_{a,t} = \left(\int_0^1 W_{a,t}(\nu)^{1-\varepsilon_w} d\nu\right)^{1/(1-\varepsilon_w)}. \tag{B.14}$$

Here, $L^h_{a,t}$ denotes the equilibrium labor provided by the representative hand-to-mouth household. (The total labor by all hand-to-mouth households is $\theta L^h_{a,t}$).

In period 0, a fraction of the workers in an area, λ_w, reset their wages to maximize the intra-period utility function in $(B.11)$ subject to the budget constraints in $(B.12)$ and the labor demand equation in $(B.13)$. The remaining fraction, $1-\lambda_w$, have preset wages given by $\overline{W}$—the nominal level targeted by monetary policy (as we describe subsequently).

The wage level in an area is determined according to the ideal price index $(B.14)$. This index also ensures:

$$\int_0^1 W_{a,t}(\nu) L^h_{a,t}(\nu) d\nu = W_{a,t} L^h_{a,t}.$$

Substituting this into Eq. $(B.12)$, we obtain the budget constraint for the representative hand-to-mouth household that we stated earlier [cf. $(B.10)$]:

$$P_{a,t} C^h_{a,t} \equiv \int_0^1 P_{a,t} C^h_{a,t}(\nu) d\nu = W_{a,t} L^h_{a,t}.$$

Here, we have defined $C^h_{a,t}$ as the consumption by the representative hand-to-mouth household.

Optimal Wage Setting and the Labor Supply. First consider the flexible workers that reset their wages in period 0. These workers optimally choose $\left(W^{flex}_{a,t}, L^{h,flex}_{a,t}\right)$ that satisfy:

$$W^{flex}_{a,t} \equiv P_{a,t} \frac{\varepsilon_w}{\varepsilon_w - 1} MRS_{a,t} \tag{B.15}$$

$$\text{where } MRS_{a,t} = \chi \left(L^{h,flex}_{a,t}\right)^{\varphi^h} \text{ and } L^{h,flex}_{a,t} = \left(\frac{W^{flex}_{a,t}}{W_{a,t}}\right)^{-\varepsilon_w} L^h_{a,t}.$$

In particular, workers set a real (inflation-adjusted) wage that is a constant markup over their marginal rate of substitution between labor and consumption (MRS). The functional form in $(B.11)$ ensures that the MRS depends on the level of labor supply but not on the level of consumption.

Note that $W^{flex}_{a,t}$ appears on both side of Eq. $(B.15)$. Solving for the fixed point, we further obtain:

$$\left(W^{flex}_{a,t}\right)^{1+\varphi^h \varepsilon_w} = \frac{\varepsilon_w}{\varepsilon_w - 1} \chi P_{a,t} W^{\varepsilon_w \varphi^h}_{a,t} \left(L^h_{a,t}\right)^{\varphi^h}. \tag{B.16}$$

Next consider the sticky workers. These workers have a preset wage level, $\overline{W}$. They provide the labor services demanded at this wage level (as long as their markup remains positive, which is the case in our analysis since we focus on log-linearized outcomes).

Next we use $(B.14)$ to obtain an expression for the aggregate wage level and the (hand-to-mouth) labor supply:

$$\begin{aligned} W_{a,t} &= \left(\lambda_w \left(W_{a,t}^{flex}\right)^{1-\varepsilon_w} + (1-\lambda_w)\,\overline{W}^{1-\varepsilon_w}\right)^{1/(1-\varepsilon_w)} \\ &= \left(\lambda_w \left(\frac{\varepsilon_w}{\varepsilon_w - 1}\chi W_{a,t}^{\varepsilon_w \varphi^h} P_{a,t}\left(L_{a,t}^h\right)^{\varphi^h}\right)^{(1-\varepsilon_w)/\left(1+\varphi^h\varepsilon_w\right)} + (1-\lambda_w)\,\overline{W}^{1-\varepsilon_w}\right)^{1/(1-\varepsilon_w)}. \end{aligned} \tag{B.17}$$

Here, the first line substitutes the wages of flexible and sticky workers. The second line substitutes the optimal wage for flexible workers from Eq. $(B.16)$. This expression illustrates that greater hand-to-mouth labor in an area, $L_{a,t}^h$, creates wage pressure. The amount of pressure depends positively on the fraction of flexible workers, λ_w, and negatively on the labor supply elasticity, $1/\varphi^h$, as well as on the elasticity of substitution across labor types, ε_w. An increase in the local price index, $P_{a,t}$, also creates wage pressure.

It is also instructive to consider the (hand-to-mouth) labor supply in two special cases. First, consider the "frictionless" case without nominal rigidities: that is, suppose wages are fully flexible, $\lambda_w = 1$. All workers set the same wage, which implies $W_{a,t}^{flex} = W_{a,t}$. Using this observation Eq. $(B.17)$ becomes:

$$\frac{W_{a,t}}{P_{a,t}} = \frac{\varepsilon_w}{\varepsilon_w - 1}\chi\left(L_{a,t}^h\right)^{\varphi^h}. \tag{B.18}$$

Hence, the frictionless hand-to-mouth labor supply in each area a is described by a neoclassical intra-temporal optimality condition. In particular, the real wage is a constant markup over the MRS between labor and consumption.

Next consider the case in which the nominal wage in the area is equal to the monetary policy target, $W_{a,t} = \overline{W}$. Substituting this expression into $(B.17)$, we obtain,

$$\frac{\overline{W}}{P_{a,t}} = \frac{\varepsilon_w}{\varepsilon_w - 1}\chi\left(L_{a,t}^h\right)^{\varphi^h}. \tag{B.19}$$

This is equivalent to $(B.18)$ (since $W_{a,t} = \overline{W}$). Hence, our model features a version of "the divine coincidence": stabilizing the nominal wage at the target $(\overline{W})$ is equivalent to stabilizing the labor supply at its frictionless level.

Monetary Policy. We assume monetary policy sets the nominal interest rate R_t^f to stabilize the average nominal wage at the target level $\overline{W}$:

$$\int_a W_{a,t}\,da = \overline{W} \text{ for each } t. \tag{B.20}$$

In periods $t \geq 1$, nominal wages are equated across regions (since labor is mobile). Therefore, Eq. ($B.20$) implies $W_{a,t} = \overline{W}$ for each area, which in turn implies Eq. ($B.19$). For these periods, monetary policy replicates the frictionless labor supply.

In period 0, wages are not necessarily equated across areas. Thus, monetary policy cannot stabilize labor supply in every area. For this period, the policy rule in ($B.20$) can be thought of as stabilizing the labor supply "on average" at its frictionless level. When areas have common initial wealth (and therefore common initial wage, $W_{a,0} = \overline{W}$), monetary policy stabilizes the labor supply at its frictionless level also in period 0.

Market Clearing Conditions. First consider the nontradable good. Recall that we use $Y_{a,t}^N$ to denote nontradable production and $C_{a,t}^N$ to denote the total nontradable spending in an area [cf. ($B.1$) and ($B.7$)]. Thus, we have the market clearing condition,

$$Y_{a,t}^N = C_{a,t}^N \text{ for each } a, t. \tag{B.21}$$

Next consider the composite tradable good. We use Y_t^T to denote the tradable production with the standard CES technology in either period, and $\tilde{Y}_t^T$ to denote the production with the capital-only technology in periods $t \geq 1$ [cf. ($B.2$) and ($B.4$)]. We also use $C_{a,t}^T$ to denote the total tradable spending in an area [cf. ($B.22$)]. Thus, we have the market clearing conditions:

$$Y_0^T = \int C_{a,0}^T da. \tag{B.22}$$

$$Y_t^T + \tilde{Y}_t^T = \int_a C_{a,t}^T da \text{ for } t \geq 1. \tag{B.23}$$

There is a single market clearing condition for each period since the tradable good can be transported across areas costlessly.

Next consider the tradable good produced in area a. This market clearing condition is already embedded in our notation, since we use $Y_{a,t}^T$ to denote the tradable production in area a as well as the tradable input used in the CES production technology [cf. ($B.3$) and ($B.2$)].

Next consider factor market clearing conditions. In period 0, for labor we have:

$$L_{a,0} = (1-\theta)\,\overline{L} + \theta L_{a,0}^h = L_{a,0}^N + L_{a,0}^T \text{ for each } a. \tag{B.24}$$

Labor supply comes from stockholders, who supply exogenous labor, $L_{a,0}^s = \overline{L}$, and hand-to-mouth households, who supply endogenous labor, $L_{a,0}^h$. Labor demand comes from nontradable and tradable production firms in the area. For capital, we have

$$1 = \int_a \left(K_{a,0}^N + K_{a,0}^T\right) da. \tag{B.25}$$

Capital supply is exogenous and normalized to one. Capital demand comes from nontradable and tradable production firms in all areas. There is a single market clearing condition since capital is mobile across areas.

For future periods $t \geq 1$, both factors are mobile across areas. Therefore, we have the following analogous market clearing conditions,

$$\int_a \left((1-\theta)\,\overline{L} + \theta L_{a,t}^h \right) da \;=\; \int_a \left(L_{a,t}^N + L_{a,t}^T \right) da \tag{B.26}$$

$$1 \;=\; \int_a \left(K_{a,t}^N + K_{a,t}^T \right) da + \tilde{K}_t^T \text{ for each } t \geq 1. \tag{B.27}$$

Capital demand reflects that capital can also be used with the alternative linear technology, $\tilde{K}_t^T$.

Finally, the asset market clearing conditions can be written as,

$$\int_a x_{a,t} da = 0 \text{ and } \int_a A_{a,t}^f = 0. \tag{B.28}$$

This condition ensures that the holdings of capital across areas sum to its supply (one). The second condition says the holdings of the risk-free asset sum to its supply (zero). We can then define the equilibrium as follows.

Definition 1. *Given an initial distribution of ownership of capital, $\{x_{a,0}\}_a$ (that sum to zero across areas), and otherwise symmetric regions, an equilibrium is a collection of cross-sectional and aggregate allocations together with paths of (nominal) factor prices, $\{\{W_{a,t}\}_a, R_t\}_t$, goods prices, $\left\{\{P_{a,t}^N\}_a, P_t^T\right\}_t$, the asset price, $\{Q_t\}_t$, and the interest rate, $\left\{R_t^f\right\}_t$, such that:*

(i) Competitive firms maximize according to the production technologies described in $(B.1 - B.4)$.

(ii) Stockholders choose their consumption and portfolios optimally [cf. problem $(B.9)$]. All households split their consumption between nontradable and tradable goods to solve the expenditure minimization problem $(B.6)$.

(iii) Capital supply is exogenous and given by $(B.5)$. Labor supply of stockholders is also exogenous and given by $(B.8)$. Labor supply of hand-to-mouth households is endogenous and satisfy Eq. $(B.17)$.

(iv) Monetary policy stabilizes the average wage in each period at a particular level $\overline{W}$ [cf. $(B.20)$].

(v) Goods, factors, and asset markets clear [cf. Eqs. $(B.21 - B.28)$].

B.2 General Characterization of Equilibrium

We next provide a general characterization of equilibrium. In subsequent sections, we use this characterization to solve for the equilibrium under different specifications. Throughout, we assume the parameters satisfy:

$$D \;\geq\; \frac{\overline{\alpha}}{1-\overline{\alpha}}\overline{L} \tag{B.29}$$

$$\chi = \frac{\varepsilon_w - 1}{\varepsilon_w}\left(\frac{1-\overline{\alpha}}{\overline{\alpha}}\right)^{\overline{\alpha}} \frac{1}{\overline{L}^{\overline{\alpha}+\varphi^h}} \tag{B.30}$$

The first condition ensures that the capital-only production technology is actually used when it is available, $\tilde{K}_t \geq 0$ for $t \geq 1$. The second condition ensures that in period 0 the frictionless hand-to-mouth labor supply (and thus, the frictionless aggregate labor supply) is the same as the stockholders' exogenous labor supply, $\overline{L}$. This is a symmetry assumption that simplifies the notation but otherwise does not play an important role.

We start by establishing general properties on the supply and the demand side that apply in all periods. We then fully characterize the equilibrium in periods $t \geq 1$ (long run). Finally, we derive the equations that characterize the equilibrium in period 0 (short run).

B.2.1 General Properties

Supply Side. First consider households' choice between nontradable and tradable goods. Households solve $(B.6)$, which implies:

$$P_{a,t} \equiv \left(P_{a,t}^N\right)^{\eta}\left(P_t^T\right)^{1-\eta} \tag{B.31}$$

$$P_{a,t}^N C_{a,t}^{i,N} = \eta P_{a,t} C_{a,t}^i \text{ and } P_{a,t}^T C_{a,t}^{i,T} = (1-\eta) P_{a,t} C_{a,t}^i. \tag{B.32}$$

Here, recall that $P_{a,t}$ (the unit cost or the ideal price index) denotes the solution to the problem with $C_{a,t}^i = 1$. Aggregating across all households in an area, we further obtain

$$P_{a,t}^N C_{a,t}^N = \eta P_{a,t} C_{a,t} \text{ and } P_t^T C_{a,t}^T = (1-\eta) P_{a,t} C_{a,t}.$$

In view of the Cobb-Douglas aggregator, the shares of nontradables and tradables in household spending are constant.

Next consider optimization by firms that produce the nontradable good, which implies [cf. $(B.1)$]:

$$P_{a,t}^N = \left(W_{a,t}\right)^{1-\alpha^N} R_t^{\alpha^N} \tag{B.33}$$

$$w_{a,t} L_{a,t}^N = \left(1-\alpha^N\right) P_{a,t}^N Y_{a,t}^N \text{ and } R_t K_{a,t}^N = \alpha^N P_{a,t}^N Y_{a,t}^N. \tag{B.34}$$

Similarly, optimization by firms that produce the tradable input in an area implies [cf. $(B.3)$]:

$$P_{a,t}^T = \left(W_{a,t}\right)^{1-\alpha^T} R_t^{\alpha^T} \tag{B.35}$$

$$w_{a,t} L_{a,t}^T = \left(1-\alpha^T\right) P_{a,t}^T Y_{a,t}^T \text{ and } R_t K_{a,t}^T = \alpha^T P_{a,t}^T Y_{a,t}^T. \tag{B.36}$$

Here, we use $P_{a,t}^T$ to denote the price of the tradable input produced in an area. In view of Cobb-Douglas technologies, the shares of labor and capital in production of the nontradable good as well as the local tradable input are constant.

Next consider the firms that produce the composite tradable good with the CES production technology [cf. $(B.2)$]. These firms' optimization implies:

$$
\begin{aligned}
P_t^T &= \left(\int_a \left(P_{a,t}^T \right)^{1-\varepsilon} da \right)^{1/(1-\varepsilon)} && \text{(B.37)} \\
P_{a,t}^T Y_{a,t}^T &= \left(\frac{P_{a,t}^T}{P_t^T} \right)^{1-\varepsilon} P_t^T Y_t^T. && \text{(B.38)}
\end{aligned}
$$

The unit cost of the composite tradable good is determined by the ideal price index. The share of tradable inputs from an area depends on the price in that area relative to the unit cost, $\frac{P_{a,t}^T}{P_t^T}$, as well as the elasticity of substitution across tradables, ε.

Finally, consider the firms that produce the composite tradable good in periods $t \geq 1$ with the linear technology [cf. $(B.4)$]. These firms' optimization implies,

$$
P_t^T = R_t / D_t^{1-\alpha^T} \text{ as long as } \tilde{K}_t^T > 0 \text{ (for } t \geq 1\text{)}. \tag{B.39}
$$

As we will verify below, the parametric restriction in $(B.29)$ ensures $\tilde{K}_t^T > 0$.

Recall also that we have the labor supply equation $(B.17)$ for each area a.

Demand Side. We next turn to the demand side. First consider the nontradable sector. Combining the market clearing condition $(B.21)$ with the factor shares in $(B.32)$ and $(B.34)$, we solve for the factor bills as:

$$
\begin{aligned}
W_{a,t} L_{a,t}^N &= \left(1 - \alpha^N \right) \eta P_{a,t} C_{a,t} && \text{(B.40)} \\
R_t K_{a,t}^N &= \frac{\alpha^N}{1-\alpha^N} W_{a,t} L_{a,t}^N
\end{aligned}
$$

For the nontradable sector, the demand comes from the nontradable expenditure within the area. In view of the Cobb-Douglas technologies, this demand is split across factors in constant proportions.

Next consider the tradable sector. We combine the market clearing conditions $(B.22)$ and $(B.23)$ with the factor shares in $(B.32)$, $(B.36)$, and $(B.38)$ to solve:

$$
\begin{aligned}
W_{a,t} L_{a,t}^T &= \left(1 - \alpha^T \right) \left(\frac{P_{a,t}^T}{P_t^T} \right)^{1-\varepsilon} \left((1-\eta) \int_a P_{a,t} C_{a,t} da - \tilde{Y}_t^T \right) && \text{(B.41)} \\
\text{and } R_t K_{a,t}^T &= \frac{\alpha^T}{1-\alpha^T} w_{a,t} L_{a,t}^T \\
\text{where } \tilde{Y}_0^T &= 0 \text{ and } \tilde{Y}_t^T = D_t^{1-\alpha^T} \tilde{K}_t^T \text{ for } t \geq 1.
\end{aligned}
$$

For the tradable sector (that use standard technologies), the demand comes from the tradable expenditure *from all areas.* The demand also depends on the relative price in that area, $\frac{P_{a,t}^T}{P_t^T}$, as well as the elasticity of substitution across tradable inputs, ε. The expression, $\tilde{Y}_t^T$ denotes the production of the composite tradable good via the alternative capital-only technology, which is zero in period 0 but not in periods $t \geq 1$ (as the technology is only available in periods $t \geq 1$).

Stockholders' Optimality Conditions. Finally, we characterize stockholders' optimality conditions at any period t [cf. problem $(B.9)$]. First consider their portfolio choice. Since there is no risk in capital (for simplicity), problem $(B.9)$ implies that stockholders take a non-zero position on capital if and only if its price satisfies, $\frac{Q_{t+1}}{Q_t - R_t} = R_t^f$. This implies,

$$\begin{aligned} Q_t &= R_t + \frac{Q_{t+1}}{R_t^f} \\ &= \sum_{n \geq 0}^{\infty} \frac{R_{t+n}}{R_t^f .. R_{t+n-1}^f}. \end{aligned} \tag{B.42}$$

Here, the second line rolls the equation forward to write the stock price as the present discounted value of the rental rate. We assume the transversality condition, $\lim_{n\to\infty} \frac{R_{t+n}}{R_t^f .. R_{t+n-1}^f} = 0$, which will hold in the equilibria we will characterize. Given the capital price in $(B.55)$, stockholders are indifferent between saving in the risk-free asset and in capital.

Next consider stockholders' consumption choice. Given the capital price in $(B.55)$, we can aggregate stockholders' budget constraints from time t onward to obtain a lifetime budget constraint at time t:

$$\sum_{n \geq 0}^{\infty} \frac{P_{a,t+n} C_{a,t+n}^s}{R_t^f .. R_{t+n-1}^f} = \sum_{n \geq 0}^{\infty} \frac{W_{a,t+n} \overline{L}}{R_t^f .. R_{t+n-1}^f} + \frac{1 + x_{a,t}}{1 - \theta} Q_t + A_{a,t}^f. \tag{B.43}$$

As before, we assume the transversality condition, $\lim_{n\to\infty} \frac{W_{a,t+n} \overline{L}}{R_t^f .. R_{t+n-1}^f} = 0$. In addition, the optimality condition for safe savings $A_{a,t+1}^f$ implies the Euler equation,

$$\frac{1}{P_{a,t+n-1} C_{a,t+n-1}^s} = \frac{(1-\rho) R_{t+n-1}^f}{P_{a,t+n} C_{a,t+n}^s} \text{ for each } t \geq 0, n \geq 1. \tag{B.44}$$

Solving this backward, we obtain $\frac{P_{a,t+n} C_{a,t+n}^s}{R_t^f .. R_{t+n-1}^f} = (1-\rho)^n P_{a,t} C_{a,t}^s$. After substituting this into $(B.43)$ and calculating the sum, we obtain

$$P_{a,t} C_{a,t}^s = \rho \left(\sum_{n \geq 0}^{\infty} \frac{W_{a,t+n} \overline{L}}{R_t^f .. R_{t+n-1}^f} + \frac{1 + x_{a,t}}{1 - \theta} Q_t + A_{a,t}^f \right). \tag{B.45}$$

Hence, in each period t, stockholders spend a fraction of their lifetime wealth. Their lifetime wealth consists of the present discounted value of their labor income as well as their stock wealth and cash at the beginning of the period. The marginal propensity to spend out of wealth is given by ρ.

B.2.2 Long Run Equilibrium

We next characterize the equilibrium further in periods $t \geq 1$. For these periods, labor (as well as capital) is mobile across areas. In addition, production technologies remain constant over time. In view of these features, we conjecture an equilibrium in which the economy immediately reaches a steady state in period $t = 1$. Specifically, we prove the following.

Proposition 1. *Suppose conditions* $(B.29)$ *and* $(B.30)$ *hold. Starting from period* $t \geq 1$ *onward, there is a steady-state equilibrium in which the capital-only technology is (weakly) used,* $\tilde{K}_t^T \geq 0$*. In this equilibrium, nominal wages, rental rates, price indices, hand-to-mouth labor, and aggregate labor are constant across areas and over time:*

$$W_{a,t} = \overline{W} \text{ and } R_t = \overline{W}D \tag{B.46}$$

$$P_{a,t}^T = \overline{W}D^{\alpha^T}, P_{a,t}^N = \overline{W}D^{\alpha^N}, P_{a,t} = \overline{W}D^{\overline{\alpha}} \text{ where } \overline{\alpha} = \eta\alpha^N + (1-\eta)\alpha^T \tag{B.47}$$

$$L_{a,t}^h = L^{h,long} \leq \overline{L} \text{ where } D^{-\overline{\alpha}} = \frac{\varepsilon_w}{\varepsilon_w - 1}\chi\left(L^{h,long}\right)^{\varphi^h}. \tag{B.48}$$

The interest rate and the price of capital are constant over time:

$$R_t^f = \frac{1}{1-\rho} \tag{B.49}$$

$$Q_t = \frac{\overline{W}D}{\rho}. \tag{B.50}$$

Stockholders' capital and cash holdings and consumption are constant over time and determined by their capital and cash holdings in period 1*:*

$$x_{a,t} = x_{a,1}, A_{a,t}^f = A_{a,1}^f \tag{B.51}$$

$$P_{a,t}C_{a,t}^s = \rho\left(\frac{\overline{WL}}{\rho} + \frac{1+x_{a,1}}{1-\theta}\frac{\overline{W}D}{\rho} + A_{a,1}^f\right). \tag{B.52}$$

Proof. We first show factor and goods prices satisfy Eqs. $(B.46)$ and $(B.47)$. Since labor is mobile across areas, wages are equated across areas, $W_{a,t} \equiv W_t$. This proves $W_{a,t} = \overline{W}$ since monetary policy stabilizes the wage at the target level [cf. $(B.20)$]. Substituting this into the unit cost equations $(B.35)$ and $(B.37)$, we find $P_t^T = \overline{W}^{1-\alpha^T} R_t^{\alpha^T}$. Combining this with $(B.39)$, we establish $(B.46)$. Substituting Eq. $(B.46)$ into the remaining unit cost equations $(B.31)$ and $(B.33)$, we also establish $(B.47)$. Since the capital only technology is used (as we verify shortly), the rental rate is determined by the productivity of this technology, D. This provides a simple expression also for other prices.

Substituting the expression for the price index P_t into the frictionless labor supply equation $(B.19)$, we also establish that hand-to-mouth labor is constant and given by $(B.48)$. Consider how the solution changes with D. First consider the lowest level of D allowed by condition $(B.29)$,

$D = \frac{\overline{\alpha}}{1-\overline{\alpha}}\overline{L}$. In this case the solution is given by $L^{h,long} = \overline{L}$ in view of condition $(B.30)$. Next note that increasing D decreases $L^{h,long}$. Intuitively, increasing the productivity of the capital-only technology draws capital from the standard technologies (as we verify shortly), which in turn lowers the labor supply. Therefore, the solution satisfies $L^{h,long} \leq \overline{L}$.

Next we verify that the capital-only technology is used in equilibrium, $\tilde{K}_t^T \geq 0$. To this end, we aggregate the factor demands used in the standard technologies across both sectors and across all areas to obtain [cf. Eqs. $(B.40)$ and $(B.41)$]:

$$\begin{aligned}
\overline{W}\left((1-\theta)\overline{L} + \theta L^{h,long}\right) &= \begin{bmatrix} \left(1-\alpha^N\right)\eta \int_a P_{a,t}C_{a,t}da \\ +\left(1-\alpha^T\right)\left((1-\eta)\int_a P_{a,t}C_{a,t}da - \tilde{Y}_t^T\right) \end{bmatrix} \\
&= (1-\overline{\alpha})\int_a P_{a,t}C_{a,t}da - \left(1-\alpha^T\right)\tilde{Y}_t^T \\
&\text{and} \\
R_t\left(1-\tilde{K}_t^T\right) &= \overline{\alpha}\int_a P_{a,t}C_{a,t}da - \alpha^T\tilde{Y}_t^T
\end{aligned}$$

Here, we have substituted the factor market clearing conditions $L_{a,t}^T + L_{a,t}^N = (1-\theta)\overline{L} + \theta L^{h,long}$ and $K_{a,t}^T + K_{a,t}^N + \tilde{K}_t^T = 1$ [cf. $(B.26)$ and $(B.27)$].

Combining these expressions, we solve for the capital bill used in the standard technologies:

$$R_t\left(1-\tilde{K}_t^T\right) = \frac{\overline{\alpha}}{1-\overline{\alpha}}\overline{W}\left((1-\theta)\overline{L} + \theta L^{h,long}\right) + \frac{\overline{\alpha}-\alpha^T}{1-\overline{\alpha}}\tilde{Y}_t.$$

After substituting $\tilde{Y}_t^T = R_t\tilde{K}_t^T$ and $R_t = \overline{W}D$, we find $\tilde{K}_t^T \equiv \tilde{K}^{T,long}(D)$ where:

$$D\left(1 - \frac{1-\alpha^T}{1-\overline{\alpha}}\tilde{K}^{T,long}(D)\right) = \frac{\overline{\alpha}}{1-\overline{\alpha}}\left((1-\theta)\overline{L} + \theta L^{h,long}(D)\right). \tag{B.53}$$

Since $L^{h,long}(D)$ is a decreasing function, $\tilde{K}^{T,long}(D)$ that solves $(B.53)$ is an increasing function of D. Moreover, when $D = \frac{\overline{\alpha}}{1-\overline{\alpha}}\overline{L}$, we have $L^{h,long}(D) = \overline{L}$, which implies $\tilde{K}^{T,long}(D) = 0$. This proves $\tilde{K}^{T,long}(D) \geq 0$ for each $D \geq \frac{\overline{\alpha}}{1-\overline{\alpha}}\overline{L}$ and establishes that the capital-only technology is used in equilibrium.

Finally, we verify that the constant interest rate path in $(B.49)$ corresponds to an equilibrium along with the asset price and allocations in $(B.50)$, $(B.51)$, and $(B.52)$.

Substituting $R_t^f = 1/(1-\rho)$ into $(B.42)$, and using $(B.46)$, we establish that the stock price satisfies $(B.50)$. Substituting this expression along with Eq. $(B.49)$ and the solution for the wage and the rental rate into Eq. $(B.45)$, we establish that stockholders' consumption satisfies

$$P_{a,t}C_{a,t}^s = \rho\left(\frac{\overline{WL}}{\rho} + \frac{1+x_{a,t}}{1-\theta}\frac{\overline{W}D}{\rho} + A_{a,t}^f\right). \tag{B.54}$$

Note also that stockholders are indifferent between saving in capital and the risk-free asset. In particular, $x_{a,t+1} = x_{a,t}$ is a solution as long as the implied cash holding is non-negative, $A_{a,t+1} \geq 0$. To verify this, consider the stockholders' budget constraint with the equilibrium wage and the rental rate [cf. $(B.9)$]:

$$P_{a,t}C^s_{a,t} + \frac{A^f_{a,t+1}}{R^f_t} + \frac{1 + x_{a,t+1}}{1-\theta}\left(Q_t - \overline{W}D\right) = \overline{WL} + \frac{1 + x_{a,t}}{1-\theta}Q_t + A^f_{a,t}.$$

Substituting $x_{a,t+1} = x_{a,t}$ along with Eq. $(B.54)$, we obtain $A_{a,t+1} = A_{a,t}$. By induction, we further obtain $x_{a,t+1} = x_{a,1}, A_{a,t+1} = A_{a,1}$. Since $A_{a,1} \geq 0$, this verifies $A_{a,t+1} \geq 0$ and establishes $(B.51)$. Substituting this into $(B.45)$, we establish that stockholders' consumption is constant over time and given by $(B.52)$.

Note also that this allocation satisfies the asset market clearing conditions [cf. $(B.28)$], which implies that it also satisfies the aggregate goods market clearing conditions. In fact, aggregating Eq. $(B.52)$ across all areas, it is easy to verify that stockholders in the aggregate spend their labor income and capital income. Hand-to-mouth households spend their labor income. Since asset and goods markets clear, the conjectured interest rate path $(B.49)$ corresponds to an equilibrium, which completes the proof. □

Therefore, the economy reaches a steady state immediately in period $t = 1$. This simplifies the analysis as it enables us to focus on the allocations in period $t = 0$, which we turn to subsequently. Note also that using Proposition 1 together with Eqs. $(B.40)$ and $(B.41)$ we could characterize the labor employed in nontradable and tradable sectors separately for periods $t \geq 1$. We skip this step since it will not play an important role for our analysis of the equilibrium in period 0.

B.2.3 Short Run Equilibrium

We next characterize the conditions that determine the equilibrium in period 0. In subsequent sections, we use these conditions to solve the equilibrium for different specifications of initial wealth across areas.

Asset Price in Period 0. Using Eqs. $(B.42)$ and $(B.50)$, we obtain

$$Q_0 = R_0 + \frac{Q_1}{R^f_0} = R_0 + \frac{1}{R^f_0}\frac{\overline{W}D}{\rho}. \tag{B.55}$$

Hence, the stock price in the first period depends on the future productivity in the capital only technology, D, the current interest rate, R^f_0, and the current rental rate, R_0.

We next claim the rental rate satisfies

$$R_0 = \frac{\overline{\alpha}}{1-\overline{\alpha}}\int_a W_{a,0}L_{a,0}da. \tag{B.56}$$

In view of the Cobb-Douglas technologies, the equilibrium rental rate of capital is proportional to the aggregate labor bill (and aggregate output). Combined with $(B.55)$, this describes the stock price in terms of the aggregate labor bill and the interest rate.

To prove the claim in $(B.56)$, we aggregate Eqs. $(B.40)$ and $(B.41)$ over the two sectors to obtain

$$\begin{aligned} W_{a,0}\left(L_{a,0}^{N}+L_{a,0}^{T}\right) &= \left(1-\alpha^{N}\right)\eta P_{a,0}C_{a,0}+\left(1-\alpha^{T}\right)\left(\frac{P_{a,0}^{T}}{P_{0}^{T}}\right)^{1-\varepsilon}(1-\eta)\int_{a}P_{a,0}C_{a,0}da \\ R_{0}\left(K_{a,0}^{T}+K_{a,0}^{N}\right) &= \alpha^{N}\eta P_{a,0}C_{a,0}+\alpha^{T}\left(\frac{P_{a,t}^{T}}{P_{t}^{T}}\right)^{1-\varepsilon}(1-\eta)\int_{a}P_{a,t}C_{a,t}da. \end{aligned}$$

Aggregating further across all areas and using the market clearing conditions $L_{a,0}^{N}+L_{a,0}^{T}=L_{a,0}$ and $K_{a,0}^{N}+K_{a,0}^{T}=1$ [cf. $(B.24)$ and $(B.25)$] along with $(B.37)$, we obtain:

$$\begin{aligned} \int_{a}W_{a,0}L_{a,0}da &= (1-\overline{\alpha})\int_{a}P_{a,0}C_{a,0}da \\ R_{0} &= \overline{\alpha}\int_{a}P_{a,0}C_{a,0}da. \end{aligned}$$

Here, recall that $\overline{\alpha}=\eta\alpha^{N}+(1-\eta)\,\alpha^{T}$ is the weighted-average capital share. Combining these expressions, we establish $(B.56)$.

Stockholders' Consumption in Period 0. It remains to characterize the households' consumption demand in period 0, which determines the labor demand and completes the characterization of equilibrium [cf. Eqs. $(B.40)$ and $(B.41)$]. Hand-to-mouth agents spend their income,

$$P_{a,t}C_{a,t}^{h}=W_{a,t}L_{a,t}^{h}. \tag{B.57}$$

Consider the stockholders. Note that their consumption is generally characterized by Eq. $(B.45)$. Using Proposition 1, and the assumption $A_{a,0}^{f}=0$, we can write this as

$$P_{a,0}C_{a,0}^{s}=\rho\left(W_{a,0}\overline{L}+\frac{1}{R_{0}^{f}}\frac{\overline{WL}}{\rho}+\frac{1+x_{a,0}}{1-\theta}Q_{0}\right). \tag{B.58}$$

Hence, stockholders spend a fraction of their lifetime wealth, which is determined by their current and future labor income as well as their stock wealth.

Aggregating Eqs. $(B.57)$ and $(B.58)$ with households' population shares, we characterize the aggregate household demand in an area [cf. (4)]:

$$P_{a,0}C_{a,0}=\theta W_{a,0}L_{a,0}^{h}+\rho\left((1-\theta)\left(W_{a,0}\overline{L}+\frac{1}{R_{0}^{f}}\frac{\overline{WL}}{\rho}\right)+(1+x_{a,0})\,Q_{0}\right). \tag{B.59}$$

Hence aggregate demand in the area is determined by spending by the hand-to-mouth households (that depends on local wages) and the spending by stockholders (that depends on local wealth).

Labor Demand in Period 0. Combining Eq. $(B.59)$ with $(B.40)$, and substituting $\theta L^h_{a,0} = L_{a,0} - (1-\theta)\,\overline{L}$ (by definition), we calculate the labor demand in the nontradable sector as:

$$W_{a,0}L^N_{a,0} = \left(1-\alpha^N\right)\eta \left(\begin{array}{c} W_{a,0}\left(L_{a,0} - (1-\theta)\,\overline{L}\right) + \\ \rho \left(\begin{array}{c} (1-\theta)\left(W_{a,0}\overline{L} + \frac{1}{R^f_0}\frac{\overline{WL}}{\rho}\right) \\ +\left(1+x_{a,0}\right)Q_0 \end{array} \right) \end{array} \right). \tag{B.60}$$

Likewise, we combine Eq. $(B.59)$ with $(B.41)$ to obtain the labor demand in the tradable sector as:

$$W_{a,0}L^T_{a,0} = \left(\frac{P^T_{a,0}}{P^T_0}\right)^{1-\varepsilon}\left(1-\alpha^T\right)(1-\eta) \left(\begin{array}{c} \int_a W_{a,0}\left(L_{a,0} - (1-\theta)\,\overline{L}\right)da + \\ \rho \left(\begin{array}{c} (1-\theta)\left(W_{a,0}\overline{L} + \frac{1}{R^f_0}\frac{\overline{WL}}{\rho}\right) \\ +\left(1+x_{a,0}\right)Q_0 \end{array} \right) \end{array} \right). \tag{B.61}$$

After summing Eqs. $(B.60)$ and $(B.61)$, and using the labor market clearing condition $L_{a,0} = L^T_{a,0} + L^N_{a,0}$ [cf. $(B.24)$], we solve for the total labor demand in an area as follows,

$$\begin{aligned} W_{a,0}L_{a,0} = {} & \left(1-\alpha^N\right)\eta \left(\begin{array}{c} W_{a,0}\left(L_{a,0} - (1-\theta)\,\overline{L}\right) + \\ \rho \left(\begin{array}{c} (1-\theta)\left(W_{a,0}\overline{L} + \frac{1}{R^f_0}\frac{\overline{WL}}{\rho}\right) \\ +\left(1+x_{a,0}\right)Q_0 \end{array} \right) \end{array} \right) \\ & + \left(\frac{P^T_{a,0}}{P^T_0}\right)^{1-\varepsilon}\left(1-\alpha^T\right)(1-\eta) \left(\begin{array}{c} \int_a W_{a,0}\left(L_{a,0} - (1-\theta)\,\overline{L}\right)da + \\ \rho \left(\begin{array}{c} (1-\theta)\left(W_{a,0}\overline{L} + \frac{1}{R^f_0}\frac{\overline{WL}}{\rho}\right) \\ +\left(1+x_{a,0}\right)Q_0 \end{array} \right) \end{array} \right) \end{aligned} \tag{B.62}$$

The first line illustrates the local labor demand due to local spending on the nontradable good. The second line illustrates the local labor demand due to aggregate spending on the tradable good. While this expression looks complicated, it will be simplified once we log-linearize around the common wealth allocation.

Given the unit costs and the aggregate variables, Eq. $(B.62)$ is a collection of $|I|$ equations in $2\,|I|$ local variables, $\{L_{a,0}, W_{a,0}\}_{a\in I}$. Recall also that we have Eq. $(B.17)$ that determines the local labor supply of hand-to-mouth households in each area. After substituting $\theta L^h_{a,0} = L_{a,0} - (1-\theta)\,\overline{L}$, we write this expression as:

$$W_{a,0} = \left(\begin{array}{c} \lambda_w \left(\frac{\varepsilon_w}{\varepsilon_w - 1}\chi W_{a,0}^{\varepsilon_w\varphi^h} P_{a,0}\left(\frac{L_{a,0}-(1-\theta)\overline{L}}{\theta}\right)^{\varphi^h}\right)^{(1-\varepsilon_w)/\left(1+\varphi^h\varepsilon_w\right)} \\ +\left(1-\lambda_w\right)\overline{W}^{1-\varepsilon_w} \end{array} \right)^{1/(1-\varepsilon_w)}. \tag{B.63}$$

This provides $|I|$ additional equations in $\{L_{a,0}, W_{a,0}\}_{a\in I}$. Thus, Eqs. $(B.62)$ and $(B.63)$ can be thought of as determining the equilibrium in labor markets in each area.

Recall also that we have characterized the aggregate variables earlier. In particular, the capital price is given $(B.55)$, which depends on the rental rate R_0 given by $(B.56)$ and the interest rate R_0^f. The interest rate is set by monetary policy to ensure the average nominal wage is equal to a target level, $\int_a W_{a,0} = \overline{W}$ [cf. $(B.20)$]. This completes the general characterization of equilibrium.

B.3 Benchmark Equilibrium with Common Stock Wealth

We next characterize the equilibrium in period 0 further in special cases of interest. In this section, we focus on a benchmark case in which areas have common wealth, $x_{a,0} = 0$ for each a, and provide a closed-form solution. In the next section, we log-linearize the equilibrium around this benchmark and provide a closed-form solution for the log-linearized equilibrium.

Labor Market Equilibrium. First consider the labor supply. By symmetry, wages, price indices, and labor are the same across areas. We denote these allocations by dropping the area subscript W_0, P_0, L_0^h, L_0. Then, the monetary policy rule $(B.20)$ implies $W_0 = \overline{W}$. Hence, in this case monetary policy ensures labor supply is at its frictionless level also in period 0 [cf. Eq. $(B.19)$]:

$$\frac{\overline{W}}{P_0} = \frac{\varepsilon_w}{\varepsilon_w - 1}\chi\left(L_0^h\right)^{\varphi^h}. \tag{B.64}$$

Next consider the labor demand. Using Eq. $(B.56)$ the rental rate of capital is given by:

$$R_0 = \frac{\overline{\alpha}}{1-\overline{\alpha}}\overline{W}L_0. \tag{B.65}$$

When wages are the same across all areas, the unit cost is given by $P_0 = \overline{W}^{1-\overline{\alpha}}R_0^{\overline{\alpha}}$ [cf. Eqs. $(B.31)$, $(B.33)$, and $(B.37)$]. Combining this with Eq. $(B.65)$, we obtain,

$$P_0 = R_0^{\overline{\alpha}}\overline{W}^{1-\overline{\alpha}} = \left(\frac{\overline{\alpha}}{1-\overline{\alpha}}\right)^{\overline{\alpha}} L_0^{\overline{\alpha}}\overline{W} \text{ where } L_0 = (1-\theta)\overline{L} + \theta L_0^h. \tag{B.66}$$

After rearranging this expression, we obtain a labor demand equation

$$\frac{\overline{W}}{P_0} = \left(\frac{1-\overline{\alpha}}{\overline{\alpha}}\right)^{\overline{\alpha}}\left((1-\theta)\overline{L} + \theta L_0^h\right)^{-\overline{\alpha}}. \tag{B.67}$$

Eqs. $(B.64)$ and $(B.67)$ uniquely determines the hand-to-mouth labor. Condition $(B.30)$ ensures that the solution satisfies:

$$L_0^h = \overline{L}. \tag{B.68}$$

In sum, with common wealth, monetary policy ensures hand-to-mouth labor is at its frictionless level. In view of the normalizing condition $(B.30)$, this is the same as stockholders' labor supply. This ensures that the total labor is also at its frictionless level

$$L_0^T + L_0^N = L_0 = (1-\theta)\overline{L} + \theta L_0^h = \overline{L}. \tag{B.69}$$

Asset and Goods Market Equilibrium. Next consider the price of capital. Combining Eqs. $(B.65), (B.69)$ with Eq. $(B.55)$, we obtain:

$$Q_0 = \frac{\overline{\alpha}}{1-\overline{\alpha}}\overline{WL} + \frac{1}{R_0^f}\frac{\overline{W}D}{\rho}. \tag{B.70}$$

Next note that we can aggregate the labor demand Eq. $(B.62)$ to obtain:

$$\frac{\overline{WL}}{1-\overline{\alpha}} = \frac{\theta\overline{WL}+}{\rho\left((1-\theta)\left(\overline{WL} + \frac{1}{R_0^f}\frac{\overline{WL}}{\rho}\right) + \frac{\overline{\alpha}}{1-\overline{\alpha}}\overline{WL} + \frac{1}{R_0^f}\frac{\overline{W}D}{\rho}\right)}.$$

Rearranging terms, we obtain:

$$\begin{aligned}
\overline{Y}_0 \equiv \frac{\overline{LW}}{1-\overline{\alpha}} &= M^A\rho\left[\frac{1}{R_0^f}\left((1-\theta)\frac{\overline{WL}}{\rho} + \frac{\overline{W}D}{\rho}\right)\right] \\
\text{where } M^A &= \frac{1}{1-(1-\overline{\alpha})(\theta+\rho(1-\theta))-\rho\overline{\alpha}} \\
&= \frac{1}{(1-\rho)(1-(1-\overline{\alpha})\theta)}
\end{aligned} \tag{B.71}$$

Here, we have also defined the frictionless output $\overline{Y}_0$. The last line simplifies the multiplier. The expression says that the value of the stockholders' future claims (the bracketed term) should be at a particular level such that its direct spending effect, combined with the multiplier effects, are just enough to ensure output is equal to its frictionless level.

Using Eq. $(B.71)$, we characterize the equilibrium interest rate ("rstar"):

$$\begin{aligned}
R_0^f &= (1-\overline{\alpha})M^A\frac{(1-\theta)\overline{L}+D}{\overline{L}} \\
&= \frac{1}{1-\rho}\frac{1-\overline{\alpha}}{1-(1-\overline{\alpha})\theta}\frac{(1-\theta)\overline{L}+D}{\overline{L}}.
\end{aligned} \tag{B.72}$$

As expected, greater impatience (ρ) or greater future capital productivity (D) increases the equilibrium interest rate.

Using $(B.70)$ and $(B.72)$, we can also solve for the equilibrium price of capital as:

$$Q_0/\overline{W} = \frac{\overline{L}}{1-\overline{\alpha}}\left(\overline{\alpha} + \frac{1-\rho}{\rho}(1-(1-\overline{\alpha})\theta)\frac{D}{(1-\theta)\overline{L}+D}\right). \tag{B.73}$$

It is easy to check that (as long as $\theta < 1$) an increase in the future productivity of capital, D, also increases the equilibrium price of capital. The interest rate reacts to this change to ensure output is at its supply determined level. This mitigates the rise in the stock price somewhat but does not completely undo it, since some of the interest rate response is absorbed by stockholders' human capital wealth. (The last point is the difference from Caballero and Simsek (2020): here, "time-varying risk premium" translates into actual price movements because we have two different types of wealth and the "risk premium" varies only for one type of wealth.)

Next consider the determination of tradable and nontradable labor. Using $(B.60)$ and $(B.61)$, along with symmetry across areas, we obtain:

$$\frac{L_0^N}{L_0^T} = \frac{\left(1-\alpha^N\right)\eta}{\left(1-\alpha^T\right)\left(1-\eta\right)}.$$

Combining this with $L_0^N + L_0^T = \overline{L}$, we further solve:

$$\begin{aligned} L_0^N &= \frac{1-\alpha^N}{1-\overline{\alpha}}\eta\overline{L}, \\ L_0^T &= \frac{1-\alpha^T}{1-\overline{\alpha}}\left(1-\eta\right)\overline{L}. \end{aligned} \tag{B.74}$$

Hence, the labor employed in the nontradable and tradable sectors is determined by the share of the corresponding good in household spending, with an adjustment for the differences in the share of labor across the two sectors. The following result summarizes this discussion.

Proposition 2. *Suppose conditions* $(B.29)$ *and* $(B.30)$ *hold. Consider the equilibrium in period* 0 *when areas have common stock wealth,* $x_{a,0} = 0$ *for each* a. *All areas have identical allocations and prices. Nominal wages are given by* $W_0 = \overline{W}$. *Monetary policy ensures hand-to-mouth labor is at its frictionless level. This is equal to stockholders' labor,* $L_0^h = \overline{L}$, *which also implies* $L_0 = L_0^T + L_0^N = \overline{L}$ *[cf.* $(B.68 - B.69)$*]. The nominal interest rate is given by Eq.* $(B.72)$ *and the price of capital is given by Eq.* $(B.73)$. *The shares of labor employed in the nontradable and tradable sectors is given by Eq.* $(B.74)$. *An increase in the future productivity of capital* D *increases the interest rate and the price of capital but does not affect the labor market outcomes in period* 0.

B.4 Log-linearized Equilibrium with Heterogeneous Stock Wealth

We next consider the case with a more general distribution of stock wealth, $\{x_{a,0}\}_a$, that satisfies $\int_a x_{a,0}da = 0$. In this case, we log-linearize the equilibrium conditions around the common-wealth benchmark (for a fixed level of D), and we characterize the log-linearized equilibrium. To this end, we define the log-deviations of the local equilibrium variables around the common-wealth benchmark: $y = \log\left(Y/Y^b\right)$, where $Y \in \left\{L_{a,0}, L_{a,0}^N, L_{a,0}^T, W_{a,0}, P_{a,0}, P_{a,0}^T\right\}_a$. We also define the log-deviations of the endogenous aggregate variables: $y = \log\left(Y/Y^b\right)$, where $Y \in \left\{P_0^T, R_0, Q_0, R_0^f\right\}$. The following lemma simplifies the analysis (proof omitted).

Lemma 1. *Consider the log-linearized equilibrium conditions around the common-wealth benchmark. The solution to these equations satisfies* $\int_a l_{a,0} da = \int_a w_{a,0} da = 0$ *and* $p_0^T = r_0 = q_0 = r_0^f = 0$. *In particular, the log-linearized equilibrium outcomes for the aggregate variables are the same as their counterparts in the common-wealth benchmark.*

We next log-linearize the equilibrium conditions and characterize the log-linearized equilibrium outcomes for each area a. We start by Eqs. $(B.31)$, $(B.33)$, and $(B.37)$ that characterize the price indices in terms of nominal wages in an area. Log-linearizing Eqs. $(B.33)$ and $(B.37)$ we obtain,

$$\begin{aligned} p_{a,0}^N &= \left(1-\alpha^N\right) w_{a,0} \\ p_{a,0}^T &= \left(1-\alpha^T\right) w_{a,0}. \end{aligned} \tag{B.75}$$

Log-linearizing Eq. $(B.31)$, we further obtain,

$$p_{a,0} = \eta p_{a,0}^N = \eta \left(1-\alpha^N\right) w_{a,0}. \tag{B.76}$$

Next, we log-linearize the labor supply equation $(B.63)$ to obtain,

$$w_{a,0} = \frac{\lambda_w}{1+\varphi^h \varepsilon_w} \left(p_{a,0} + \varphi^h \varepsilon_w w_{a,0} + \varphi^h \frac{l_{a,0}}{\theta} \right).$$

After rearranging terms and simplifying, we obtain Eq. (7) from the main text:

$$\begin{aligned} & w_{a,0} = \lambda \left(p_{a,0} + \varphi l_{a,0}\right) \\ \text{where} \qquad & \lambda = \frac{\lambda_w}{1+\left(1-\lambda_w\right) \varphi^h \varepsilon_w} \text{ and } \varphi = \frac{\varphi^h}{\theta} \end{aligned} \tag{B.77}$$

Note that we derive the wage flexibility and labor inelasticity parameters, λ and φ, in terms of the more structural parameters, $\lambda_w, \varphi, \varepsilon_w, \varphi^h, \theta$. As expected, wage flexibility is greater when a greater fraction of members adjust wages (greater λ_w), labor supply is more inelastic (greater φ^h), labor types are less substitutable (smaller ε_w). To understand the parameter φ, note that stockholders always supply the frictionless labor and thus their labor elasticity is effectively zero, $1/\varphi^s = 0$. Therefore, the aggregate "weighted-average" labor elasticity reflects the hand-to-mouth households' elasticity and their population share, $1/\varphi = (1-\theta)/\varphi^s + \theta/\varphi^h = \theta/\varphi^h$.

Combining Eqs. $(B.76)$ and $(B.77)$, we obtain the reduced form labor supply equation:

$$w_{a,0} = \kappa l_{a,0}, \text{ where } \kappa = \frac{\lambda\varphi}{1-\lambda\eta\left(1-\alpha^N\right)}. \tag{B.78}$$

As expected, the wage adjustment parameter, κ, depends on the wage flexibility parameter, λ, and the inverse elasticity of the labor supply, φ. It also depends on the share of the nontradable sector and the share of labor in the nontradable sector, $\eta, 1-\alpha^N$. These parameters capture the extent to which a change in local wages translate into local inflation, which creates further wage pressure.

Next, we log-linearize the labor demand equation $(B.62)$ to obtain,

$$\begin{aligned}\left(w_{a,0}+l_{a,0}\right)\overline{WL} &= \left(1-\alpha^N\right)\eta\left[\theta\overline{WL}\left(w_{a,0}+\frac{l_{a,0}}{\theta}\right)+\rho\left(\begin{array}{c}\left(1-\theta\right)\overline{WL}w_{a,0}\\ +x_{a,0}Q_0\end{array}\right)\right] \\ &\quad -p^T_{a,0}\left(\varepsilon-1\right)\overline{W}L^T_0.\end{aligned} \tag{B.79}$$

Here, the first line captures the local expenditure on nontradable labor, which comes from both hand-to-mouth households and stockholders. Hand-to-mouth households' spending depends on the local wage, $w_{a,0}$, as well as the local aggregate labor $l_{a,0}$ (multiplied by $1/\theta$ to capture the implied local hand-to-mouth labor). Stockholders' spending depends on the local wage, $w_{a,0}$, as well as the local stock wealth, $x_{a,0}$. The second line captures the local expenditure on tradable labor that depends on the local price of nontradables, $p^T_{a,0}$, as well as the elasticity of substitution, $\varepsilon-1$. The term, $\overline{W}L^T_0=\left(1-\alpha^T\right)\left(1-\eta\right)\frac{\overline{WL}}{1-\overline{\alpha}}$, captures the expenditure on tradable labor in the commonwealth benchmark [cf. $(B.74)$].

After rearranging terms, and using Eq. $(B.78)$, we solve for the labor bill:

$$\begin{aligned}\left(w_{a,0}+l_{a,0}\right)\overline{WL} &= \mathcal{M}\left(\left(1-\alpha^N\right)\eta\rho x_{a,0}Q_0-p^T_{a,0}\left(\varepsilon-1\right)\overline{W}L^T_0\right), \\ \text{where } \mathcal{M} &= \frac{1}{1-\left(1-\alpha^N\right)\eta\left\{\frac{\theta\kappa+1}{\kappa+1}+\rho\frac{\kappa(1-\theta)}{\kappa+1}\right\}}.\end{aligned} \tag{B.80}$$

Here, we have used $w_{a,0}=\kappa l_{a,0}$ to write the wage and the labor in terms of the labor bill. We have also defined, $\mathcal{M}$, which captures the local Keynesian multiplier effects. The term in set brackets can be thought of as a weighted-average MPCs out of labor income between hand-to-mouth households (MPC given by 1) and stockholders (MPC given by ρ). The relative weights, $\frac{\theta\kappa+1}{\kappa+1}$ and $\frac{\kappa(1-\theta)}{\kappa+1}$, capture the extent to which additional labor income is split between hand-to-mouth households and stockholders. This depends not only on the population shares (θ) but also on the wage adjustment parameter (κ), because agents have different labor supply elasticities (a simplifying assumption).

Finally, using Eq. $(B.75)$ to substitute for the price of tradables in terms of local wages, $p^T_{a,0}=\left(1-\alpha^T\right)w_{a,0}$, and using Eq. $(B.78)$ once more, we obtain the following closed-form solution:

$$w_{a,0}+l_{a,0} = \frac{1+\kappa}{1+\kappa\zeta}\mathcal{M}\left(1-\alpha^N\right)\eta\rho\frac{x_{a,0}Q_0}{\overline{WL}} \tag{B.81}$$

$$l_{a,0} = \frac{1}{1+\kappa}\left(w_{a,0}+l_{a,0}\right) \tag{B.82}$$

$$w_{a,0} = \frac{\kappa}{1+\kappa}\left(w_{a,0}+l_{a,0}\right), \tag{B.83}$$

$$\text{where } \zeta = 1+\left(\varepsilon-1\right)\left(1-\alpha^T\right)\frac{L^T_0}{\overline{L}}\mathcal{M}$$

$$= \quad 1 + (\varepsilon - 1) \frac{\left(1 - \alpha^T\right)^2}{1 - \overline{\alpha}} (1 - \eta) \mathcal{M}.$$

Here, the last line defines the parameter, ζ, and the last line substitutes for L_0^T from $(B.74)$. Eq. $(B.81)$ illustrates that the local spending on nontradables affects the local labor bill. Eqs. $(B.82)$ and $(B.83)$ illustrate that this also affects labor and wages according to the wage adjustment parameter, κ.

The term, $\frac{1+\kappa}{1+\kappa\zeta}$, in Eq. $(B.81)$ captures the effect that works through exports. In particular, an increase in local spending increases local wages, which generates an adjustment of local exports. As expected, this adjustment is stronger when wages are more flexible (higher κ). The adjustment is also stronger when tradable inputs are more substitutable across regions (higher ε, which leads to higher ζ). In fact, when tradable inputs are gross substitutes ($\varepsilon > 1$, which leads to $\zeta > 1$), the export adjustment dampens the direct spending effect on the labor bill. When tradable inputs are gross complements ($\varepsilon < 1$, which leads to $\zeta < 1$), the export adjustment amplifies the direct spending effect.

Finally, consider the effect on local labor employed in nontradable and tradable sectors. First consider the tradable sector. Log-linearizing Eq. $(B.61)$, we obtain

$$\begin{aligned} w_{a,0} + l_{a,0}^T &= -(\varepsilon - 1) p_{a,0}^T \\ &= -(\varepsilon - 1) \left(1 - \alpha^T\right) w_{a,0} \\ &= -(\varepsilon - 1) \left(1 - \alpha^T\right) \frac{\kappa}{1 + \kappa\zeta} \mathcal{M} \left(1 - \alpha^N\right) \eta\rho \frac{x_{a,0} Q_0}{\overline{W}L}. \end{aligned} \tag{B.84}$$

Here, the third line uses Eqs. $(B.83)$ and $(B.81)$. These expressions illustrate that the export adjustment described above affects the tradable labor bill. While the effect of stock wealth on the tradable labor bill is ambiguous (as it depends on whether $\varepsilon > 1$ or $\varepsilon < 1$), we show that the effect on tradable labor is always (weakly) negative, $dl_{a,0}^T / dx_{a,0} \leq 0$. Intuitively, the increase in local wages always generate some substitution of labor away from the area. On the other hand, labor bill can increase or decrease depending on the strength of the income effect relative to this substitution effect.

Next consider the nontradable sector. Note that the total labor bill is the sum of nontradable and tradable labor bills:

$$(w_{a,0} + l_{a,0}) \overline{W}L = \left(w_{a,0} + l_{a,0}^N\right) \overline{W} L_0^N + \left(w_{a,0} + l_{a,0}^T\right) \overline{W} L_0^T.$$

Substituting this into $(B.80)$ we obtain

$$\begin{aligned} \left(w_{a,0} + l_{a,0}^N\right) \overline{W} L_0^N &= \mathcal{M} \left[\left(1 - \alpha^N\right) \eta\rho x_{a,0} Q_0 - (\varepsilon - 1) p_{a,0}^T \overline{W} L_0^T\right] + (\varepsilon - 1) p_{a,0}^T \overline{W} L_0^T \\ &= \mathcal{M} \left(1 - \alpha^N\right) \eta\rho x_{a,0} Q_0 - (\mathcal{M} - 1)(\varepsilon - 1) p_{a,0}^T \overline{W} L_0^T \end{aligned}$$

After substituting $w_{a,0} + l^T_{a,0} = -(\varepsilon - 1)\, p^T_{a,0}$ from $(B.84)$, normalizing by $\overline{WL}$, using Eq. $(B.74)$, we further obtain:

$$w_{a,0} + l^N_{a,0} = \mathcal{M}\left(1 - \overline{\alpha}\right)\rho \frac{x_{a,0} Q_0}{\overline{WL}} + (\mathcal{M} - 1) \frac{1 - \alpha^T}{1 - \alpha^N} \frac{1 - \eta}{\eta} \left(w_{a,0} + l^T_{a,0}\right). \tag{B.85}$$

This expression illustrates that greater stock wealth affects the nontradable labor bill due to a direct and an indirect effect. The direct effect is positive as it is driven by the impact of greater local wealth on local spending. There is also an indirect effect due to the impact of the stock wealth on the tradable labor bill—the multiplier effects of which accrue to the nontradable labor bill. The indirect effect has an ambiguous sign because stock wealth can decrease or increase the tradable labor bill depending on ε. Nonetheless, we show that the direct effect always dominates. Specifically, regardless of ε, we have $d\left(w_{a,0} + l^N_{a,0}\right)/dx_{a,0} > 0, dl^N_{a,0}/dx_{a,0} > 0$: that is, greater stock wealth increases the nontradable labor bill as well as nontradable labor. The following result summarizes this discussion.

Proposition 3. *Consider the model with Assumption D when areas have an arbitrary distribution of stock wealth, $\{x_{a,0}\}_a$, that satisfies $\int_a x_{a,0} da = 0$. In the log-linearized equilibrium, local labor and wages in a given area,$(l_{a,0}, w_{a,0})$, are characterized as the solution to Eqs. $(B.78)$ and $(B.80)$. The solution is given by Eqs. $(B.82)$ and $(B.83)$. Local labor bill in nontradables and tradable sectors are given by Eqs. $(B.84)$ and $(B.85)$. In particular, local labor and wages satisfy the following comparative statics with respect to stock wealth:*

$$dl_{a,0}/dx_{a,0} > 0, dw_{a,0}/dx_{a,0} \geq 0 \text{ and } d\left(l_{a,0} + w_{a,0}\right)/dx_{a,0} > 0.$$

Moreover, regardless of ε, the labor bill in the nontradable sector and the labor in each sector satisfy the following comparative statics:

$$d\left(l^N_{a,0} + w_{a,0}\right)/dx_{a,0} > 0, dl^N_{a,0}/dx_{a,0} > 0 \text{ and } dl^T_{a,0}/dx_{a,0} \leq 0.$$

Proof. Most of the proof is presented earlier. It remains to establish the comparative statics for the tradable labor, the nontradable labor and the nontradable labor bill.

First consider the tradable labor. Note that the first line of the expression in $(B.84)$ implies

$$l^T_{a,0} = -\left(1 + (\varepsilon - 1)\left(1 - \alpha^T\right)\right) w_{a,0}. \tag{B.86}$$

Since $(\varepsilon - 1)\left(1 - \alpha^T\right) > -1$ (because $\varepsilon > 0$) and $dw_{a,0}/dx_{a,0} \geq 0$ (cf. Eq. $(B.83)$), this implies the comparative statics for the tradable labor, $dl^T_{a,0}/dx_{a,0} \leq 0$.

Next consider the nontradable labor. Note that $L_{a,0} = L^T_{a,0} + L^N_{a,0}$. Log-linearizing this expression, we obtain,

$$l^N_{a,0} L^N_{a,0} = l_{a,0} \overline{L} - l^T_{a,0} L^T_{a,0}.$$

Differentiating this expression with respect to $x_{a,0}$ and using $dl_{a,0}/dx_{a,0} > 0$ and $dl^T_{a,0}/dx_{a,0} \leq 0$, we obtain the comparative statics for the nontradable labor, $dl^N_{a,0}/dx_{a,0} > 0$. Combining this with $dw_{a,0}/dx_{a,0} \geq 0$, we further obtain the comparative statics for the nontradable labor bill, $d\left(l^N_{a,0} + w_{a,0}\right)/dx_{a,0} > 0$. $\square$

B.5 Comparative Statics of Local Labor Market Outcomes

We next combine our results to investigate the impact of a change in aggregate stock wealth (over time) on local labor market outcomes. Specifically, consider the comparative statics of an increase in the future capital productivity from some D^{old} to $D^{new} > D^{old}$.

First consider the effect on the common-wealth benchmark. By Proposition 2, the equilibrium price of capital increases from Q_0^{old} to $Q_0^{new} > Q_0^{old}$. The labor market outcomes remain unchanged: in particular, $L_0 = \overline{L}, W_0 = \overline{W}, L_0^N/L_0 = \frac{1-\alpha^N}{1-\overline{\alpha}}\eta$ and $L_0^T/L_0 = \frac{1-\alpha^T}{1-\overline{\alpha}}(1-\eta)$.

Next consider the effect when areas have heterogeneous wealth. We use the notation $\Delta X = X^{new} - X^{old}$ for the comparative statics on variable X. Consider the effect on labor market outcomes, for instance, the (log of the) local labor bill $\log(W_{a,0}L_{a,0})$. Note that we have:

$$\log(W_{a,0}L_{a,0}) \simeq \log\left(\overline{WL}\right) + w_{a,0} + l_{a,0}.$$

Here, $w_{a,0}, l_{a,0}$ are characterized by Proposition 3 as linear functions of capital ownership, $x_{a,0}$; and the approximation holds up to first-order terms in capital ownership, $\{x_{a,0}\}_a$. Note also that the change of D does not affect $\log\left(\overline{WL}\right)$. Therefore, the comparative statics in this case can be written as,

$$\begin{aligned}\Delta \log(W_{a,0}L_{a,0}) &\simeq \Delta(w_{a,0} + l_{a,0}) \\ &= \left(w_{a,0}^{new} + l_{a,0}^{new}\right) - \left(w_{a,0}^{old} + l_{a,0}^{old}\right).\end{aligned}$$

Here, the approximation holds up to first-order terms in $\{x_{a,0}\}_a$. Put differently, up to a first order, the change of D affects the (log of the) local labor bill through its effect on the log-linearized equilibrium variables.

Recall that the log-linearized equilibrium is characterized by Proposition 3. In particular, considering Eq. $(B.81)$ for D^{old} and D^{new}, we obtain:

$$\begin{aligned}w_{a,0}^{old} + l_{a,0}^{old} &= \frac{1+\kappa}{1+\kappa\zeta}\mathcal{M}\left(1-\alpha^N\right)\eta\rho\frac{x_{a,0}Q_0^{old}}{\overline{WL}_0}, \\ w_{a,0}^{new} + l_{a,0}^{new} &= \frac{1+\kappa}{1+\kappa\zeta}\mathcal{M}\left(1-\alpha^N\right)\eta\rho\frac{x_{a,0}Q_0^{new}}{\overline{WL}_0}.\end{aligned}$$

These equations illustrate that the change of D affects the log-linearized equilibrium only through its effect on the price of capital, Q_0. Taking their difference, we obtain Eq. (10) in the main text that describes $\Delta(w_{a,0} + l_{a,0})$.

Applying the same argument to Eqs. $(B.82)$, $(B.85)$, $(B.84)$, we also obtain Eqs. (11), (12), (13) in the main text that describe, respectively, $\Delta l_{a,0}, \Delta\left(w_{a,0}+l_{a,0}^{N}\right), \Delta\left(w_{a,0}+l_{a,0}^{T}\right)$. These equations illustrate that an increase in local stock wealth due to a change in aggregate stock wealth has the same impact on local labor market outcomes as an increase of stock wealth in the cross section that we characterized earlier.

Comparative Statics of Local Consumption. We next derive the comparative statics of local consumption that we use in Section 6 (see Eq. (18)). For simplicity, we focus on the case $\varepsilon = 1$. Using $(B.62)$, we have

$$P_{a,0}C_{a,0} = \frac{W_{a,0}L_{a,0}^{N}}{\left(1-\alpha^{N}\right)\eta}.$$

Log-linearizing this expression around the common-wealth benchmark, we obtain

$$\begin{aligned}
\left(p_{a,0}+c_{a,0}\right)P_{0}C_{0} &= \left(w_{a,0}+l_{a,0}^{N}\right)\frac{\overline{W}L_{0}^{N}}{\left(1-\alpha^{N}\right)\eta} \\
&= \mathcal{M}\rho x_{a,0}Q_{0}
\end{aligned}$$

Here, the second line uses Eqs. $(B.85)$ and $(B.74)$, and observes that $w_{a,0}+l_{a,0}^{T}=0$ when $\varepsilon=1$. After rearranging terms, and considering the change from D^{old} to $D^{new}>D^{old}$, we obtain

$$\Delta\left(p_{a,0}+c_{a,0}\right) = \mathcal{M}\rho\frac{x_{a,0}\Delta Q_{0}}{P_{0}C_{0}}. \tag{B.87}$$

After an appropriate change of variables, this equation gives Eq. (18) in the main text.

B.6 Details of the Calibration Exercise

This appendix provides the details of the calibration exercise in Section 6. We start by summarizing the solution for the local labor market outcomes that we derived earlier. In particular, we write Eqs. $(B.81-B.85)$ as follows:

$$\begin{aligned}
\frac{\Delta\left(w_{a,0}+l_{a,0}\right)}{SR} &= \frac{1+\kappa}{1+\kappa\zeta}\mathcal{M}\left(1-\alpha^{N}\right)\eta\rho, \\
\frac{\Delta l_{a,0}}{SR} &= \frac{1}{1+\kappa}\frac{\Delta\left(w_{a,0}+l_{a,0}\right)}{SR} \qquad\qquad \text{(B.88)} \\
\frac{\Delta w_{a,0}}{SR} &= \frac{\kappa}{1+\kappa}\frac{\Delta\left(w_{a,0}+l_{a,0}\right)}{SR} \\
\frac{\Delta\left(w_{a,0}+l_{a,0}^{T}\right)}{SR} &= -\left(\varepsilon-1\right)\left(1-\alpha^{T}\right)\frac{\Delta w_{a,0}}{SR} \\
\frac{\Delta\left(w_{a,0}+l_{a,0}^{N}\right)}{SR} &= \mathcal{M}\rho\left(1-\overline{\alpha}\right)-\left(\mathcal{M}-1\right)\frac{\left(1-\alpha^{T}\right)^{2}}{1-\alpha^{N}}\frac{1-\eta}{\eta}\left(\varepsilon-1\right)\frac{\Delta w_{a,0}}{SR} \qquad \text{(B.89)} \\
\text{where } S &= \frac{x_{a,0}Q_{a,0}}{\overline{W}L_{0}}, R = \frac{\Delta Q_{0}}{Q_{0}}
\end{aligned}$$

$$\text{and } \mathcal{M} = \frac{1}{1-(1-\alpha^N)\,\eta\left\{\frac{\theta\kappa+1}{\kappa+1}+\rho\frac{(1-\theta)\kappa}{\kappa+1}\right\}}$$
$$\text{and } \zeta = 1+(\varepsilon-1)\frac{\left(1-\alpha^T\right)^2}{1-\overline{\alpha}}(1-\eta)\,\mathcal{M}.$$

Our calibration relies on two model equations that determine the key parameters κ and ρ. Specifically, we calibrate κ by using Eq. (B.88), which replicates Eq. (19) from the main text. We calibrate ρ by using Eq. (B.89) which generalizes Eq. (15) from the main text. For reasons we describe in the main text, we do not use the response of the tradable sector for calibration purposes (see Footnote 36).

Note that combining Eq. (B.88) with the empirical coefficients for employment and the total labor bill from Table 1 (for quarter 7), we obtain:

$$0.77\% \leq \frac{1}{1+\kappa}2.18\%$$

As we discuss in the main text, while the model makes predictions for total labor supply including changes in hours per worker, in the data we only observe employment. A long literature dating to Okun (1962) finds an elasticity of total hours to employment of 1.5. Applying this adjustment and using the coefficients for total employment and the total labor bill from Table 1 yields:

$$\frac{\Delta l_{a,0}}{S_{a,0}R_0} = 1.5 \times 0.77\%$$
$$\frac{\Delta\left(w_{a,0}+l_{a,0}\right)}{S_{a,0}R_0} = 2.18\%.$$

Combining these with Eq. (19), we obtain:

$$\kappa = 0.9. \tag{B.90}$$

Thus, a one percent change in labor is associated with a 0.9% change in wages at a horizon of two years.

That leaves us with Eq. (B.89) to determine the stock wealth effect parameter, ρ. In the main text, we focus on a baseline calibration that assumes unit elasticity for tradables, $\varepsilon = 1$, which leads to a particularly straightforward analysis. In this appendix, we first provide the details of the baseline calibration. We then show that this calibration is robust to considering a wider range for the tradable elasticity parameter, $\varepsilon \in [0.5, 1.5]$.

Throughout, we set the labor share parameters in the two sectors so that the weighted-average share of labor is equal to the standard empirical estimates [cf. (6)]:

$$1-\overline{\alpha} = \frac{2}{3}.$$

To keep the calibration simple, we set the same labor share for the two sectors:

$$1-\alpha^L = 1-\alpha^N = \frac{2}{3}.$$

Eq. (B.89) (when $\varepsilon = 1$) shows that our analysis is robust to allowing for heterogeneous labor share across the two sectors.

B.6.1 Details of the Baseline Calibration

Setting $\varepsilon = 1$, Eq. (B.89) reduces to Eq. (15) in the main text,

$$\frac{\Delta\left(w_{a,0} + l_{a,0}^N\right)}{SR} = \mathcal{M}\left(1-\overline{\alpha}\right)\rho.$$

Combining this expression with the empirical coefficient for the nontradable labor bill from Table 1 (for quarter 7), we obtain:

$$\mathcal{M}\left(1-\overline{\alpha}\right)\rho = 3.23\% \text{ with } 1-\overline{\alpha} = \frac{2}{3}. \tag{B.91}$$

We also require the local income multiplier to be consistent with empirical estimates from the literature, that is:

$$\mathcal{M} = \frac{1}{1-\left(1-\alpha^N\right)\eta\left\{\frac{\kappa\theta+1}{\kappa+1} + \rho\frac{\kappa(1-\theta)}{\kappa+1}\right\}} = 1.5 \tag{B.92}$$

After substituting $1-\alpha^N = 2/3$, and rearranging terms, we obtain:

$$\eta\left\{\frac{\kappa\theta+1}{1+\kappa} + \rho\frac{\left(1-\theta\right)\kappa}{1+\kappa}\right\} = 0.5. \tag{B.93}$$

Note also that we already have $\kappa = 0.9$. Hence, for a given ρ, the calibration of the multiplier provides a restriction in terms of the share of nontradables, η, and the fraction of hand-to-mouth households, θ. For instance, when $\eta = 0.5$, we require $\theta = 1$. In this case, we need the weighted-average MPC (the term inside the set brackets) to be one, which happens only if the hand-to-mouth population share is equal to one. More generally, increasing η decreases the implied θ.

Given Eq. (B.92), Eq. (B.91) determines the stock wealth effect parameter independently of the other parameters:

$$\rho = 3.23\%.$$

The parameter, η, is difficult to calibrate precisely because there is no good measure of the trade bill at the county level. We allow for a wide range of possibilities:

$$\eta \in \left[\underline{\eta}, \overline{\eta}\right], \text{ where } \underline{\eta} = 0.5 \text{ and } \underline{\eta} = 0.8. \tag{B.94}$$

For each η, we obtain the implied θ from Eq. $(B.93)$, which falls into the range:

$$\theta(\eta) \in \left[\underline{\theta}, \overline{\theta}\right], \text{ where } \underline{\theta} = \theta(\overline{\eta}) = 0.18 \text{ and } \overline{\theta} = \theta(\underline{\eta}) = 1. \tag{B.95}$$

B.6.2 Robustness of the Baseline Calibration

Next consider the case with general ε. In this case, Eq. $(B.89)$ is more complicated and given by:

$$\frac{\Delta\left(w_{a,0} + l_{a,0}^N\right)}{SR} = \mathcal{M}\rho\left(1 - \overline{\alpha}\right) - \left(\mathcal{M} - 1\right)\left(\varepsilon - 1\right)\frac{\left(1 - \alpha^T\right)^2}{1 - \alpha^N}\frac{1 - \eta}{\eta}\frac{\Delta w_{a,0}}{SR}.$$

In particular, the nontradable labor bill also depends on the effect on local wages. The intuition is that the change in local wages affects the tradable labor bill, which generates spillover effects on the local spending and the local nontradable labor bill. Consistent with this intuition, the magnitude of this effect depends on the elasticity ε and the multiplier $\mathcal{M}$ as well as the parameters, α^T, α^N, η.

Recall also that we have Eq. $(B.88)$ that describes the change in wages as a function of the change in the total labor bill:

$$\frac{\Delta w_{a,0}}{SR} = \frac{\kappa}{1 + \kappa}\frac{\Delta\left(w_{a,0} + l_{a,0}\right)}{SR}.$$

Substituting this expression into Eq. $(B.89)$, and using the empirical coefficients for the nontradable and the total labor bill from Table 1 (for quarter 7), we obtain the following generalization of $(B.91)$:

$$\mathcal{M}\rho\left(1 - \overline{\alpha}\right) = 3.23\% + \left(\mathcal{M} - 1\right)\left(\varepsilon - 1\right)\frac{\left(1 - \alpha^T\right)^2}{1 - \alpha^N}\frac{1 - \eta}{\eta}\frac{\kappa}{1 + \kappa}2.18\%. \tag{B.96}$$

Thus, the stock wealth effect parameter in this case is not determined independently of the remaining parameters. We have already calibrated $\kappa = 0.9$ and $\mathcal{M}$ =1.5 [cf. Eq. $(B.90)$ and $(B.92)$] as well as $1 - \overline{\alpha} = 1 - \alpha^T = 1 - \alpha^N = 2/3$. After substituting these, we obtain:

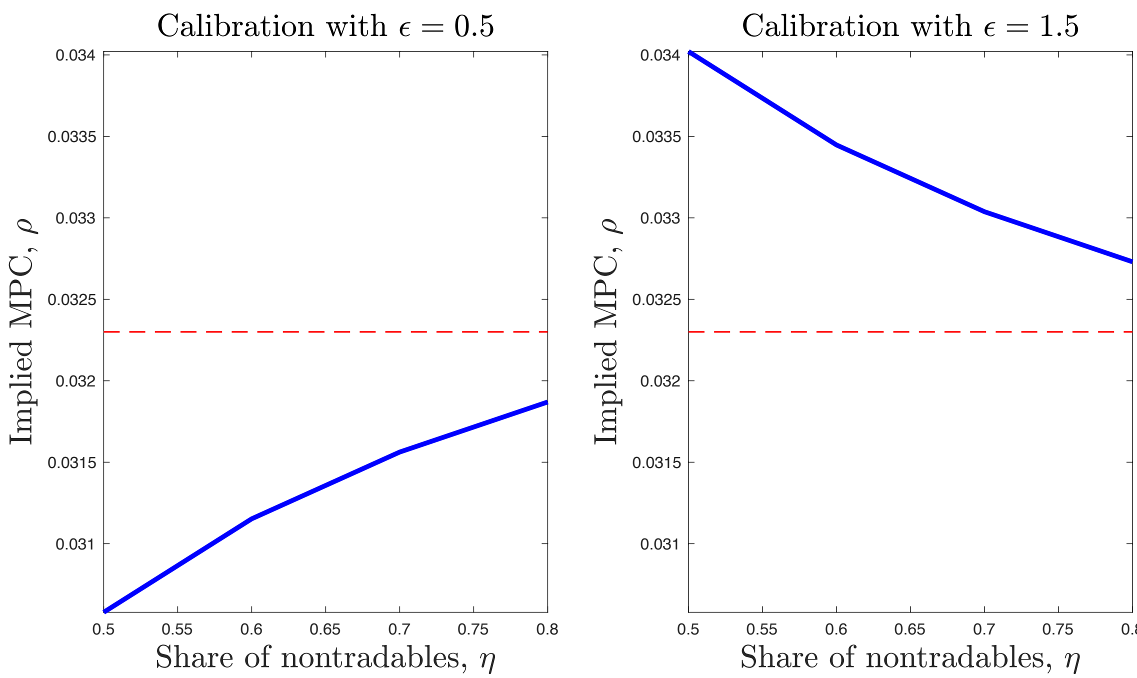
$$\rho = 3.23\% + \frac{1}{3}\left(\varepsilon - 1\right)\frac{1 - \eta}{\eta}\frac{0.9}{1.9}2.18\%.$$

For any fixed ε, Eq. $(B.96)$ describes ρ as a function of η, where η is required to lie in the range $(B.94)$. Substituting this (as well as κ) into $(B.93)$, we also obtain θ as a function of η.

Figure B.1 illustrates the possible values of ρ for $\varepsilon = 0.5$ (the left panel) and $\varepsilon = 1.5$ (the right panel). As the figure illustrates the implied values for ρ remain close to their corresponding levels from the baseline calibration with $\varepsilon = 1$. As expected, the largest deviations from the benchmark obtain when the share of nontradables is small—as trade has the largest impact on households' incomes in this case. However, ρ lies within 5% of its corresponding level from the baseline calibration even if we set $\eta = 0.5$.

The intuition for robustness can be understood as follows. As we described earlier, the additional effects emerge from the adjustment of the tradable labor bill due to a change in local wages. As long as wages do not change by much, the effect has a negligible effect on our baseline calibration.

Figure B.1:



Notes: Notes: The left panel (resp. the right panel) illustrates the implied ρ as a function of η given $\varepsilon = 0.5$ (resp. $\varepsilon = 1.5$), as we vary η over the range in $(B.94)$. The red dashed lines illustrate the implied ρ for the baseline calibration with $\varepsilon = 1$.

As it turns out, the value of κ that we find is such that the deviations from the benchmark are relatively small. Put differently, our analysis suggests that wages in an area do not change by much in response to stock wealth changes. Consequently, the tradable labor bill of the area also does not change by much either even if ε is somewhat different than 1.

B.7 Aggregation When Monetary Policy is Passive

So far, we assumed the monetary policy changes the interest rate to neutralize the impact of stock wealth changes on aggregate labor. In this appendix, we characterize the equilibrium under the alternative assumption that monetary policy leaves the interest rate unchanged in response to stock price fluctuations. In Section 7 of the main text, we use this characterization together with our calibration to describe how stock price fluctuations would affect aggregate labor market outcomes if they were not countered by monetary policy.

Specifically, consider some $\overline{D}$ and let $\overline{R}_0^f$ denote the "frictionless" interest rate that we characterized earlier corresponding to this level of productivity [$(B.72)$]:

$$\overline{R}_0^f = \frac{1}{1-\rho} \frac{1-\overline{\alpha}}{1-(1-\overline{\alpha})\,\theta} \frac{(1-\theta)\,\overline{L}+\overline{D}}{\overline{L}}. \tag{B.97}$$

Suppose the expected productivity D changes and is not necessarily equal to $\overline{D}$. In period 0, monetary policy leaves the interest rate unchanged at $\overline{R}_0^f$. Starting period $t \geq 1$ onward, monetary policy follows the same rule as before $(B.20)$. The model is otherwise the same as in Section B.1. Our goal is to understand how the change in expected D affects the aggregate equilibrium allocations in period 0 when the interest rate does not respond. For simplicity, we focus on the common-wealth benchmark, $x_{a,0} = 0$ (more generally, the results apply for the aggregate outcomes up to log linearization).

Most of our earlier analysis applies also in this case. In particular, Proposition 1 still applies and characterizes the equilibrium starting periods $t \geq 1$.

The differences concern the aggregate allocations in period 0. The analysis proceeds similar to Section B.3. Wages are the same across regions, W_a, but not necessarily equal to $\overline{W}$. Therefore, Eq. $(B.64)$ does not necessarily apply. Instead, we aggregate the labor supply Eq. $(B.63)$ to obtain

$$W_0^{1-\varepsilon_w} = \lambda_w \left(\frac{\varepsilon_w}{\varepsilon_w - 1} \chi W_0^{\varepsilon_w \varphi^h} P_0 \left(\frac{L_0 - (1-\theta)\overline{L}_0}{\theta} \right)^{\varphi^h} \right)^{(1-\varepsilon_w)/\left(1+\varphi^h \varepsilon_w\right)} + (1-\lambda_w)\,\overline{W}^{1-\varepsilon_w}. \quad \text{(B.98)}$$

We also have the following analogues of Eqs. $(B.65)$ and $(B.66)$:

$$\begin{aligned} R_0 &= \frac{\overline{\alpha}}{1-\overline{\alpha}} W_0 L_0 \\ P_0 &= R_0^{\overline{\alpha}} W_0^{1-\overline{\alpha}} = \left(\frac{\overline{\alpha}}{1-\overline{\alpha}} \right)^{\overline{\alpha}} L_0^{\overline{\alpha}} W_0. \end{aligned} \quad \text{(B.99)}$$

This implies the price of capital is now given by:

$$Q_0 = \frac{\overline{\alpha}}{1-\overline{\alpha}} W_0 L_0 + \frac{1}{\overline{R}_0^f} \frac{\overline{W} D}{\rho}. \quad \text{(B.100)}$$

Finally, we also aggregate Eq. $(B.62)$ to obtain the labor demand equation:

$$W_0 L_0 = (1-\overline{\alpha}) \left(\begin{array}{c} W_0 \left(L_0 - (1-\theta)\overline{L} \right) + \\ \rho \left((1-\theta) \left(W_0 \overline{L} + \frac{1}{\overline{R}_0^f} \frac{\overline{WL}}{\rho} \right) + Q_0 \right) \end{array} \right). \quad \text{(B.101)}$$

The equilibrium is characterized by Eqs. $(B.98 - B.101)$ in four variables, (W_0, L_0, P_0, Q_0). When $D = \overline{D}$, these equations are satisfied with $L_0 = \overline{L}$ and $W_0 = \overline{W}$ and corresponding $\overline{Q}_0, \overline{P}_0$ [cf. $(B.97)$]. To characterize the equilibrium further, we next log-linearize the equations around the allocations corresponding to $D = \overline{D}$.

Log-linearized Aggregate Equilibrium. We start with the supply side. Log-linearizing Eq. $(B.99)$, we obtain:

$$p_0 = \overline{\alpha} l_0 + w_0. \quad \text{(B.102)}$$

Log-linearizing the labor supply equation (B.98), we obtain the aggregate analogue of (7) from the main text:

$$w_0 = \lambda \left(p_0 + \varphi l_0\right) \tag{B.103}$$
$$\text{where} \qquad \lambda = \frac{\lambda_w}{1 + \left(1 - \lambda_w\right) \varphi^h \varepsilon_w} \text{ and } \varphi = \frac{\varphi^h}{\theta}.$$

Combining the last two equations, we further obtain:

$$w_0 = \kappa^A l_0, \text{ where } \kappa^A \equiv \frac{\lambda \left(\varphi + \overline{\alpha}\right)}{1 - \lambda} > \kappa = \frac{\lambda \varphi}{1 - \lambda \eta \left(1 - \alpha^N\right)}. \tag{B.104}$$

Here, κ^A denotes the *aggregate* wage adjustment parameter, and κ denotes the local wage adjustment as before [cf. (B.78)]. We discuss the comparison between κ^A and κ subsequently.

We next turn to the demand side. Log-linearizing Eq. (B.100), we obtain,

$$q_0 \overline{Q}_0 = \left(w_0 + l_0\right) \frac{\overline{\alpha}}{1 - \overline{\alpha}} \overline{WL} + d \frac{1}{\overline{R}_0^f} \frac{\overline{WD}}{\rho}. \tag{B.105}$$

Log-linearizing the labor demand Eq. (B.101), we obtain,

$$\begin{aligned} \left(w_0 + l_0\right) \overline{WL} &= \left(1 - \overline{\alpha}\right) \left(w_0 + \frac{l_0}{\theta}\right) \theta \overline{WL} + \rho \left(w_0 \left(1 - \theta\right) \overline{WL} + q_0 \overline{Q}_0\right) \\ &= \left(w_0 + \frac{l_0}{\theta}\right) \theta \overline{WL} + \rho \left(\begin{array}{c} w_0 \left(1 - \theta\right) \overline{WL} \\ + \left(w_0 + l_0\right) \frac{\overline{\alpha}}{1 - \overline{\alpha}} \overline{WL} + d \frac{1}{\overline{R}_0^f} \frac{\overline{WD}}{\rho} \end{array} \right). \end{aligned}$$

Here, the second line substitutes Eq. (B.105).

After rearranging terms to account for the multiplier effects, and using Eq. (B.103) to simplify the expression, we obtain the effect on the aggregate labor bill:

$$\left(w_0 + l_0\right) \overline{WL} = \left(1 - \overline{\alpha}\right) \mathcal{M}^A \rho Q^A \tag{B.106}$$
$$\text{where } Q^A = d \frac{1}{\overline{R}_0^f} \frac{\overline{WD}}{\rho} \tag{B.107}$$
$$\text{and } \mathcal{M}^A = \frac{1}{1 - \left(1 - \overline{\alpha}\right) \left\{ \frac{\theta \kappa^A + 1}{\kappa^A + 1} + \rho \frac{(1 - \theta) \kappa^A}{\kappa^A + 1} \right\} - \overline{\alpha} \rho}$$

Here, Q^A denotes the exogenous part of the stock wealth—the valuation of future payoffs excluding current payoffs (that respond endogenously). This is multiplied by ρ to obtain total spending. This spending is then amplified by the *aggregate* multiplier, $\mathcal{M}^A$, which is different than the local multiplier, $\mathcal{M}$. We discuss the comparison of $\mathcal{M}^A$ and $\mathcal{M}$ subsequently. The amplified spending is then multiplied by the effective labor share, $1 - \overline{\alpha}$, to obtain the aggregate labor bill.

Combining Eq. (B.107) with Eq. (B.104), we also obtain the separate effects on aggregate labor and wages:

$$
\begin{aligned}
l_0\overline{WL} &= \frac{1}{\kappa^A+1}\left(1-\overline{\alpha}\right)\rho Q^A && \text{(B.108)}\\
w_0\overline{WL} &= \frac{\kappa^A}{\kappa^A+1}\mathcal{M}^A\left(1-\overline{\alpha}\right)\rho Q^A && \text{(B.109)}
\end{aligned}
$$

Substituting Eq. $(B.107)$ into Eq. $(B.105)$, we obtain the actual stock price (that incorporates the endogenous change in R_0):

$$q_0\overline{Q}_0 = \left(\overline{\alpha}\mathcal{M}^A\rho + 1\right)Q^A. \tag{B.110}$$

Recall also that Eq. $(B.102)$ provides the solution for aggregate price index $p_0 = \alpha l_0 + w_0$.

Finally, considering Eqs. $(B.107)$ and $(B.108)$ for two different levels of future dividends, d^{old} and d^{new}, and taking the difference, we obtain Eqs. (21) and (22) in the main text.

Comparison with the Log-linearized Local Equilibrium. It is instructive to compare the log-linearized aggregate equilibrium with its counterpart we characterized earlier.

First consider the labor supply equations $(B.103)$ and $(B.104)$. Note that Eq. $(B.103)$ is the same as its local counterpart, Eq. $(B.77)$. Hence, controlling for prices as well as labor, the aggregate labor supply curve is the same as the local one. However, Eq. $(B.104)$ is different than its local counterpart, Eq. $(B.78)$. This is because the impact of aggregate nominal wages on the aggregate price index is greater than the impact of local wages on the local price index: specifically, we have $p_0 = \overline{\alpha}l_0 + w_0$ as opposed to $p_{0,a} = w_{0,a}\eta\left(1-\alpha^N\right)$ [cf. Eqs. $(B.102)$ and $(B.76)$]. The real wage $w-p$ increases locally whereas it decreases in the aggregate. Therefore, there is a positive neoclassical labor supply response locally whereas a negative one in the aggregate, with strength of both determined by the magnitude of the Frisch elasticity $1/\phi$.

To characterize these differences further, we rewrite the expressions for κ and κ^A to eliminate the wage stickiness parameter, λ, which gives:

$$\frac{1}{\kappa^A} = \frac{1}{1+\overline{\alpha}/\varphi}\left\{\frac{1}{\kappa} - \frac{1}{\varphi}\left(1-\eta\left(1-\alpha^N\right)\right)\right\}. \tag{B.111}$$

This expression calculates the aggregate labor response $1/\kappa^A$ in two steps. The term in set brackets starts with the local response but "cleanses" it from the local neoclassical effect to isolate the effect due to wage stickiness that extends to the aggregate. The term outside the set brackets adjusts the aggregate wage stickiness effect further for the aggregate neoclassical effect.

Next consider the aggregate labor bill equation $(B.107)$. Recall that its local counterpart is given by [cf. Eqs. $(B.82)$ and $(B.83)$]:

$$\frac{\left(l_{a,0}+w_{a,0}\right)\overline{WL}}{x_{a,0}Q_0} = \mathcal{M}\frac{1+\kappa}{1+\kappa\zeta}\left(1-\alpha^N\right)\eta\rho. \tag{B.112}$$

Hence, the aggregate effect differs from the local effect for three reasons. First, the direct spending effect is greater in the aggregate than at the local level, $(1-\overline{\alpha})\rho > \eta\left(1-\alpha^N\right)\rho$. Here, the inequality follows since $1-\overline{\alpha} = \eta\left(1-\alpha^N\right) + (1-\eta)\left(1-\alpha^T\right)$. Intuitively, spending on tradables increases the labor bill in the aggregate but not locally. Second, the aggregate labor bill does not feature the export adjustment term, $\frac{1+\kappa}{1+\kappa\zeta}$, because this adjustment is across areas.

Third, the aggregate multiplier is different and typically greater than the local multiplier. To see this, note we can the local and the aggregate multipliers as:

$$\begin{aligned} \mathcal{M}^A &= \frac{1}{1-m^A}, m^A = (1-\overline{\alpha})\left\{\frac{\theta\kappa^A+1}{\kappa^A+1} + \rho\frac{(1-\theta)\,\kappa^A}{\kappa^A+1}\right\} + \overline{\alpha}\rho \\ \mathcal{M} &= \frac{1}{1-m}, m = \eta\left(1-\alpha^N\right)\left\{\frac{\theta\kappa+1}{\kappa+1} + \rho\frac{(1-\theta)\,\kappa}{\kappa+1}\right\}. \end{aligned} \tag{B.113}$$

Here, m^A (resp. m) denote the additional spending induced by a dollar of income at the aggregate (resp. local) level. At the aggregate level, a dollar of income is split between labor and capital (according to their shares) and both components induce additional aggregate spending. At the local level, there are two differences. First, while the dollar is still split between labor and capital, the latter does not induce local spending—because capital is not held locally. Second, a fraction $1-\eta$ of the spending through labor income spills to other areas—because it is used to purchase tradables.

In view of these differences, if the additional (demand-induced) labor income were distributed symmetrically across households in the aggregate and in the local area, then the aggregate multiplier would always exceed the local multiplier. Formally, if the terms inside the set brackets were the same (which happens if $\kappa^A = \kappa$), then we would have $m^A > m$ since $1-\overline{\alpha} > \eta\left(1-\alpha^N\right)$ and $\overline{\alpha} > 0$. In our model, this comparison is slightly complicated by the fact that the aggregate and local wage flexibility terms are different, $\kappa^A \neq \kappa$, which changes the extent to which additional labor income accrues to wages compared to labor. This in turn affects the distribution of this income across stockholders and hand-to-mouth agents (that have heterogeneous MPCs), because these agents have heterogeneous labor supply elasticities (a simplifying assumption). As we will illustrate shortly, for our calibration these distributional effects are small and the slippage effects we described earlier dominate and imply that the aggregate multiplier is greater, $m^A > m$ and $\mathcal{M}^A > \mathcal{M}$.

Finally, going back to (B.112), note that as long as $\varepsilon \geq 1$ (and $\mathcal{M}^A > \mathcal{M}$), the aggregate effect is greater than the local effect. In this case, $\zeta \geq 1$ and thus the export adjustment also dampens the local effect relative to the aggregate effect. When $\varepsilon < 1$, the export adjustment tends to make the local effect greater than the aggregate effect. However, all other effects (the direct spending effect as well as the multiplier effect) tend to make the aggregate effect greater than the local effect.

Details and Robustness of the Aggregate Calibration. We next provide the details of the aggregate calibration exercise in Section 6. Most of the analysis is presented in the main text. Here, we show that our calibration of the aggregate wage adjustment coefficient, κ^A, is robust [cf.

$(B.111)$]. We then verify that with our calibration the aggregate multiplier is greater than the local multiplier, $\mathcal{M}^A > \mathcal{M}$.

First consider the wage adjustment coefficient. Recall from Section B.6 that we take $1 - \overline{\alpha} = 1 - \alpha^N = \frac{2}{3}$. As we describe in Section 6, we also use $\varphi^{-1} = 0.5$ for the (effective) Frisch elasticity. Combining these observations with Eq. $(B.111)$, and our estimate $\kappa = 0.9$, we obtain the aggregate wage adjustment coefficient as a function of the share of nontradables, $\kappa^A(\eta)$. Recall that we consider a wide range of parameters for the share of nontradables, $\eta \in [\underline{\eta}, \overline{\eta}]$, where $\underline{\eta} = 0.5$ and $\underline{\eta} = 0.8$ [cf. $(B.94)$]. Calculating the wage adjustment coefficient over this range, we obtain

$$\kappa^A(\eta) \in \left[\underline{\kappa}^A, \overline{\kappa}^A\right], \text{ where } \underline{\kappa}^A = \kappa^A(\overline{\eta}) = 1.32 \text{ and } \overline{\kappa}^A = \kappa^A\left(\underline{\eta}\right) = 1.5. \tag{B.114}$$

A higher κ^A implies a smaller labor response to a change in labor bill, $1/\left(1 + \kappa^A\right)$ [cf. (21)]. Hence, the calibration we use in the main text, $\eta = \underline{\eta} = 0.5$ and $\kappa^A = \overline{\kappa}^A = 1.5$, implies the smallest aggregate labor response (a conservative calibration). Eq. $(B.114)$ illustrates further that this calibration is robust. With other choices for η, the implied κ^A (as well as the implied labor adjustment, $1/\left(1 + \kappa^A\right)$) remains within 10% of our baseline calibration.

Next consider the aggregate multiplier. Recall from Section 6 that our baseline calibration implies $\rho = 3.23\%$. Recall also that, for each choice of η in $(B.94)$, we set the share of hand-to-mouth agents $\theta(\eta)$ that ensure the local multiplier is given by, $\mathcal{M}$ =1.5. Substituting these observations together with the implied $\kappa^A(\eta)$ from $(B.114)$ into $(B.113)$, we calculate the aggregate multiplier as a function of the share of nontradables, $\mathcal{M}^A(\eta)$.

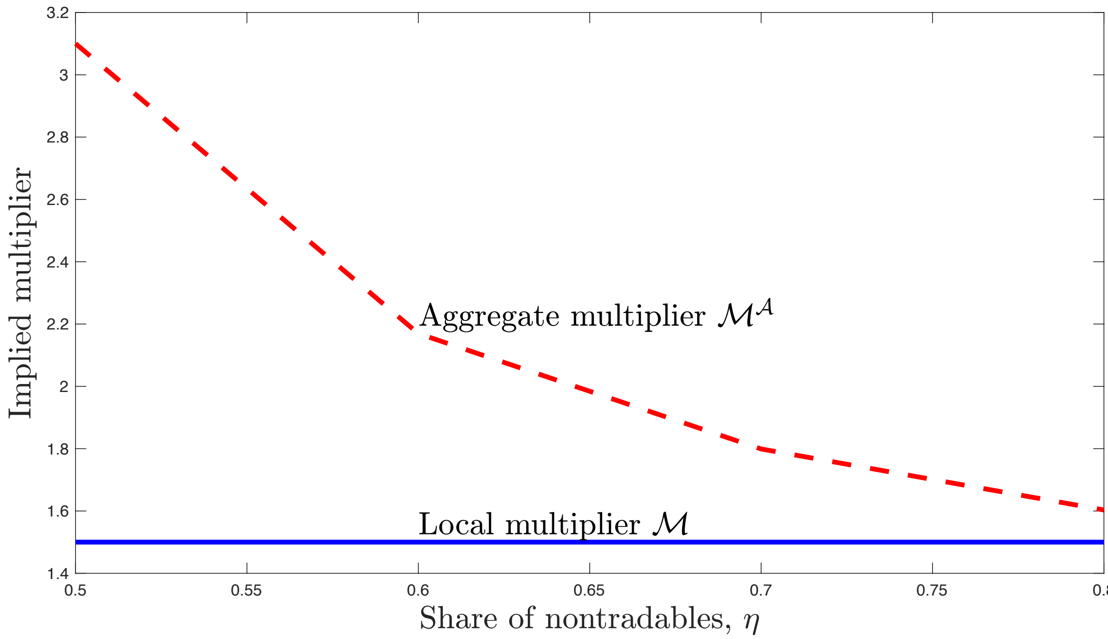
Figure B.2 plots the possible values of the aggregate multiplier together with the local multiplier (which is 1.5 by assumption). As expected, the difference between the two multipliers is smallest when the share of nontradables is largest. Nonetheless, the implied aggregate multiplier exceeds the local multiplier for each level of η that we consider. This verifies that our calibration the aggregate multiplier is greater than the local multiplier, $\mathcal{M}^A > \mathcal{M}$.

B.8 Extending the Model to Incorporate Uncertainty

In this appendix, we generalize the baseline model to introduce uncertainty about capital productivity in period 1. We show that changes in households' risk aversion or perceived risk generate the same qualitative effects on the price of capital (as well as on "rstar") as in our baseline model. Moreover, conditional on a fixed amount of change in the price of capital, the model with uncertainty features the same *quantitative* effects on local labor market outcomes. Therefore, this exercise illustrates that our baseline analysis is robust to generating stock price fluctuations from alternative channels than the change in expected stock payoffs that we consider in our baseline analysis.

The model is the same as in Section B.1 with two differences. First, there is uncertainty about the productivity of the future capital-only technology. Formally, we let $\mathcal{D} \subset [\frac{\overline{\alpha}}{1-\overline{\alpha}}\overline{L}, \infty)$ denote a finite set of productivities. This domain ensures condition $(B.29)$ holds for each $D \subset \mathcal{D}$. Let $\pi(D)$

Figure B.2:



Notes: Notes: The solid line illustrates the implied aggregate multiplier $\mathcal{M}^{A}$ as a function of η, as we vary η over the range in $(B.94)$. The dashed line illustrates the local multiplier that we calibrate as, $\mathcal{M} = 1.5$.

(with $\sum_{\mathcal{D}} \pi(D) = 1$) denote a probability distribution over $\mathcal{D}$. The productivity parameter D is uncertain in period 0 and it is realized in the beginning of period 1 with probability $\pi(D)$. Starting period 1 onward, there is no further uncertainty. The baseline model is the special case in which $\mathcal{D}$ has a single element. We denote the equilibrium allocations for periods $t \geq 1$ as a function of D, e.g., $C^s_{a,t}(D)$.

Second, to analyze the effect of risk aversion, we allow stockholders to have Epstein-Zin preferences that are more general than time-separable log utility. Specifically, we continue to assume the elasticity of intertemporal substitution is equal to one but allow for more general risk aversion.

Formally, we replace stockholders' preferences in (3) with the recursive utility defined by:

$$V_{a,t} = \left(C^s_{a,0}\right)^{\rho} U^{1-\rho}_{a,t+1} \text{ where } U_{a,t+1} = \left(E\left[V^{1-\gamma}_{a,t+1}\right]\right)^{1/(1-\gamma)}. \tag{B.115}$$

Here, $U^s_{a,t+1}$ captures a certainty-equivalent measure of the next period's continuation utility. The parameter, γ, captures relative risk aversion. The baseline model is the special case with $\gamma = 1$. The rest of the model is unchanged.

General Characterization of Equilibrium with Uncertainty. For periods $t \geq 1$, since there is no remaining uncertainty, our earlier analysis still applies. In particular, the utility function in $(B.115)$ becomes the same as in the baseline analysis. To see this, note that $U_{a,t+n} = V_{a,t+n}$ for each $t+n \geq t \geq 1$. Substituting this into $(B.115)$, taking logs, and iterating forward, we obtain:

$$\log V_{a,t} = \rho \sum_{n=0}^{\infty} (1-\rho)^n \log C^s_{a,t+n} \text{ for } t \geq 1.$$

This is equivalent to time separable log utility that we use in our baseline analysis [cf. (3)].

Therefore, Proposition 2 still applies and characterizes the equilibrium for periods $t \geq 1$. In particular, consumption is constant over time, $C^s_{a,t} = C^s_{a,1}(D)$ for each $t \geq 1$. Using this observation, we calculate,

$$V_{a,t} = C^s_{a,1}(D) \text{ for } t \geq 1. \tag{B.116}$$

Hence, for periods $t \geq 1$, the continuation utility is equal to consumption in period 1. Using Proposition 2, we also have an explicit characterization of this consumption:

$$P_{a,1}(D)\, C^s_{a,1}(D) = \rho\left(\frac{\overline{WL}}{\rho} + \frac{1+x_{a,1}}{1-\theta} Q_1(D) + A^f_{a,1}\right) \tag{B.117}$$

$$\text{where } P_1(D) = \overline{W} D^{\overline{\alpha}} \text{ and } Q_1(D) = \frac{\overline{W} D}{\rho} \tag{B.118}$$

For period 0, since there is uncertainty, stockholders' utility is different than before. Using Eqs. $(B.115), (B.116)$, and $(B.117)$, we write the stockholders' problem as [cf. problem $(B.9)$]:

$$\max_{C^s_{a,0}, \frac{1+x_{a,1}}{1-\theta}} \rho \log C^s_{a,0} + (1-\rho)\log U_{a,1} \tag{B.119}$$

$$\text{where } U_{a,1} = \left(E\left[C^s_{a,1}(D)^{1-\gamma}\right]\right)^{1/(1-\gamma)}$$

$$\text{s.t. } P_{a,0} C^s_{a,0} + \frac{A^f_{a,1}}{R^f_0} + \frac{1+x_{a,1}}{1-\theta}(Q_0 - R_0) = W_{a,0}\overline{L} + \frac{1+x_{a,0}}{1-\theta} Q_0$$

$$\text{and } P_1(D)\, C^s_{a,1}(D) = \rho\left(\frac{\overline{WL}}{\rho} + \frac{1+x_{a,1}}{1-\theta} Q_1(D) + A^f_{a,1}\right)$$

The following lemma characterizes the solution to this problem.

Lemma 2. *Consider stockholders in area a. Their optimal consumption in period 0 satisfies:*

$$P_{a,0} C^s_{a,0} = \rho\left(W_{a,0}\overline{L} + \frac{1}{R^f_0}\frac{\overline{WL}}{\rho} + \frac{1+x_{a,0}}{1-\theta} Q_0\right). \tag{B.120}$$

Their optimal portfolios are such that the risk-free interest rate satisfies,

$$\frac{1}{R^f_0} = E\left[M_{a,1}(D)\right] \tag{B.121}$$

and the price of capital satisfies,

$$Q_0 = R_0 + E\left[M_{a,1}(D)\, Q_1(D)\right] \;\; \text{with } Q_1(D) = \frac{\overline{W}D}{\rho}, \tag{B.122}$$

where $M_{a,1}(D)$ *denotes* the nominal stochastic discount factor (SDF) *for area a (per unit time) and is given by*

$$M_{a,1}(D) = (1-\rho)\,\frac{P_{a,0}C^s_{a,0}}{P_1(D)\,C^s_{a,1}(D)}\,\frac{C^s_{a,1}(D)^{1-\gamma}}{E\left[C^s_{a,1}(D)^{1-\gamma}\right]}. \tag{B.123}$$

Eq. $(B.120)$ illustrates that the consumption wealth effect remains unchanged in this case [cf. Eq. $(B.59)$]. This is because we use Epstein-Zin preferences with an intertemporal elasticity of substitution equal to one. Eqs. $(B.121)$ and $(B.122)$ illustrate that standard asset pricing conditions apply in this setting. Specifically, the risk-free asset as well as capital are priced according to a stochastic discount factor (SDF) that might be specific to the area. Eq. $(B.123)$ characterizes the SDF. When $\gamma = 1$, the SDF has a familiar form corresponding to time-separable log utility. We relegate the proof of Lemma B.119 to the end of this section.

Since the optimal consumption Eq. $(B.120)$ remains unchanged (and the remaining features of the model are also unchanged), the rest of the general characterization in Section B.2 also applies in this case.

We next characterize the equilibrium further in the common-wealth benchmark.

Common-wealth Benchmark with Uncertainty. Consider the benchmark case with $x_{a,0} = 0$ for each a. Most of the analysis from Section B.3 also applies in this case. In particular, wages and labor are at their frictionless levels $W_0 = \overline{W}, L_0 = L^h_0 = \overline{L}$. The rental rate, R_0, and the unit cost are given Eqs. $(B.65)$ and $(B.66)$.

The main difference concerns the pricing of stocks, which now reflects risk. To calculate the stochastic discount factor, note that $A^f_{a,1} = x_{a,1} = 0$ since areas are symmetric. Therefore, using Eqs. $(B.117)$ and $(B.118)$ stockholders' consumption in period 1 is given by,

$$\begin{aligned} P_1(D)\,C^s_1(D) &= \overline{WL} + \frac{\overline{W}D}{1-\theta} \\ \text{and } C^s_1(D) &= \frac{\overline{L} + \frac{D}{1-\theta}}{D^{\overline{\alpha}}}. \end{aligned} \tag{B.124}$$

Likewise, substituting $x_{a,0} = x_{a,1} = A^f_{a,1} = 0$ into the stockholders' budget constraint in $(B.119)$, we obtain stockholders' current expenditure:

$$P_0 C^s_0 = W_0 \overline{L} + \frac{R_0}{1-\theta}.$$

Since stockholders' aggregate savings is zero, their aggregate spending is equal to the sum of their labor and capital income. Combining this with $W_0 = \overline{W}$ and $R_0 = \frac{\overline{\alpha}}{1-\overline{\alpha}}\overline{WL}$ [cf. $(B.65)$], we also calculate stockholders' spending in period 0 in terms of the parameters

$$P_0 C_0^s = \overline{WL}\left(1 + \frac{\overline{\alpha}}{1-\overline{\alpha}}\frac{1}{1-\theta}\right). \tag{B.125}$$

Combining Eqs. $(B.124)$ and $(B.125)$ with $(B.123)$, we also calculate the stochastic discount factor as

$$\begin{aligned} M_1(D) &= (1-\rho)\frac{P_0 C_0^s}{P_1(D)\, C_1^s(D)}\frac{C_1^s(D)^{1-\gamma}}{E\left[C_1^s(D)^{1-\gamma}\right]} \\ &= (1-\rho)\frac{\overline{L}\left(1+\frac{\overline{\alpha}}{1-\overline{\alpha}}\frac{1}{1-\theta}\right)}{\overline{L}+\frac{D}{1-\theta}}\frac{\left(\frac{\overline{L}+\frac{D}{1-\theta}}{D^{\overline{\alpha}}}\right)^{1-\gamma}}{E\left[\left(\frac{\overline{L}+\frac{D}{1-\theta}}{D^{\overline{\alpha}}}\right)^{1-\gamma}\right]} \end{aligned} \tag{B.126}$$

Thus, in view of Lemma B.119, we obtain closed-form solutions for the interest rate and the price of capital:

$$\frac{1}{R_0^f} = E\left[M_1(D)\right] \tag{B.127}$$

$$Q_0/\overline{W} = \frac{\overline{\alpha}}{1-\overline{\alpha}}\overline{L} + E\left[M_1(D)\frac{D}{\rho}\right]. \tag{B.128}$$

When there is a single state, it is easy to check that Eqs. $(B.127)$ and $(B.128)$ give the same expression as in our baseline analysis [cf. $(B.72)$ and $(B.73)$]. Hence, these expressions generalize our baseline analysis to the case with uncertainty.

Here, we have arrived at these equations using a different method than in Section B.3. As before, we could also aggregate the labor demand and solve for the multiplier to obtain the following analogue of $(B.71)$:

$$\begin{aligned} \frac{\overline{LW}}{1-\overline{\alpha}} &= M^A \rho\left[\frac{1}{R_0^f}(1-\theta)\frac{\overline{WL}}{\rho} + E\left[M_1(D)\frac{\overline{W}D}{\rho}\right]\right] \\ \text{where } M^A &= \frac{1}{(1-\rho)\left(1-(1-\overline{\alpha})\theta\right)} \end{aligned}$$

As before, stockholders' future wealth should be at a particular level such that its direct spending effect, combined with the multiplier effects, are just enough to ensure output is equal to its frictionless level. Specifically, the term inside the set brackets is equal to a constant given by:

$$(1-\theta)\frac{1}{R_0^f}\frac{\overline{L}}{\rho} + E\left[M_1(D)\frac{D}{\rho}\right] = \frac{(1-\rho)\left(1-(1-\overline{\alpha})\theta\right)}{(1-\overline{\alpha})\rho}\overline{L}. \tag{B.129}$$

After substituting $\frac{1}{R_0^f} = E\left[M_1(D)\right]$ and the SDF from $(B.126)$, it can be checked that this equation indeed holds.

Recall that, in the baseline model without uncertainty, we generate fluctuations in Q_0 as well as R_0^f from changes in D. We next show that this aspect of the model also generalizes. In particular, after summarizing the above discussion, the following proposition establishes that changes in risk or risk aversion generate the same effects on asset prices as changes in future productivity in the baseline model.

Proposition 4. *Consider the model with uncertainty described earlier where D takes values in the finite set $\mathcal{D} \subset [\frac{\overline{\alpha}}{1-\overline{\alpha}}\overline{L}, \infty)$ according to the probability distribution function $(\pi(D))_{\mathcal{D}}$. Suppose areas have common stock wealth, $x_{a,0} = 0$ for each a. In equilibrium, all areas have identical allocations and prices. In period 0, nominal wages and labor are at their frictionless levels, $W_0 = \overline{W}, L_0 = \overline{L}$; the stochastic discount factor is given by Eq. $(B.126)$; the nominal interest rate is given by Eq. $(B.127)$; the price of capital is given by Eq. $(B.128)$; the shares of labor employed in the nontradable and tradable sectors are given by Eq. $(B.74)$.*

Consider any one of the following changes:

(i) Suppose $\gamma = 1$ and the probability distribution, $\left(\pi^{old}(D)\right)_{\mathcal{D}}$, changes such that $(\pi^{new}(D))_{\mathcal{D}}$ first-order stochastically dominates $\left(\pi^{old}(D)\right)_{\mathcal{D}}$.

(ii) Suppose $\gamma = 1$ and the probability distribution, $\left(\pi^{old}(D)\right)_{\mathcal{D}}$, changes such that $\left(\pi^{old}(D)\right)_{\mathcal{D}}$ is a mean-preserving spread of $(\pi^{new}(D))_{\mathcal{D}}$.

(iii) Suppose $\left(\pi^{old}(D)\right)_{\mathcal{D}}$ remains unchanged but risk-aversion decreases, $\gamma^{new} < \gamma^{old}$.

These changes increase Q_0 and reduce R_0^f in equilibrium but do not affect the labor market outcomes in period 0.

The first part is a generalization of the comparative statics exercise that we consider in the baseline model. It shows that the price of capital increases also if agents perceive greater capital productivity in the first-order stochastic dominance sense. The second part shows that a similar result obtains if agents' expected belief for capital productivity remains unchanged but they perceive less risk in capital productivity. For analytical tractability, these two parts focus on the case, $\gamma = 1$, which corresponds to time-separable log utility as in the baseline model. The last part considers the case with general γ, and shows that a similar result obtains also if agents' belief distribution remains unchanged but their risk aversion declines. We relegate the proof of Proposition 4 to the end of this section.

Comparative Statics of Local Labor Market Outcomes with Uncertainty. Recall that since the optimal consumption Eq. $(B.120)$ remains unchanged, all equilibrium conditions for period 0 derived in Section B.2.3 continue to apply conditional on Q_0 and R_0^f. Therefore, the log-linearized equilibrium conditions derived in Section B.4 also continue to apply conditional on Q_0. Moreover, as we show in Section B.5, the comparative statics in Proposition 4 affect these conditions only through their effect on Q_0. It follows that, conditional on generating the same change in the price of capital, ΔQ_0, the model with uncertainty features the same *quantitative* effects on local labor market outcomes as in our our baseline model. Combining this result with the comparative static results in Proposition 4, we conclude that our baseline analysis is robust to generating stock price fluctuations from alternative sources such as changes in households' risk aversion or perceived risk about stock payoffs.

Proof of Lemma 2. To simplify the problem, consider the change of variables,

$$\tilde{S}_{a,0} = \frac{A^f_{a,1} + \overline{WL}/\rho}{R^f_0} + \frac{1+x_{a,1}}{1-\theta}\left(Q_0 - R_0\right).$$

Here, $\tilde{S}_{a,0}$ can be thought of as the stockholder's "effective savings" that incorporates the present discounted value of her lifetime wealth in subsequent periods, $\frac{1}{R^f_0}\frac{\overline{WL}}{\rho}$. We also define

$$\omega_{a,1} \equiv \frac{1+x_{a,1}}{1-\theta}\frac{Q_0 - R_0}{\tilde{S}_{a,0}}.$$

Here, $\omega_{a,1}$ captures the fraction of the stockholder's effective savings that she invests in capital (recall that $Q_0 - R_0$ denotes the ex-dividend price of capital). The remaining fraction, $1 - \omega_{a,1}$, is invested in the risk-free asset. After substituting this notation into the budget constraints, the stockholder's problem can be equivalently written as,

$$\begin{aligned}
&\max_{\tilde{S}_{a,0},\omega_{a,1}} \ \rho \log C^s_{a,0} + (1-\rho)\log U_{a,1} \qquad \text{(B.130)}\\
&\text{where } U_{a,1} = \left(E\left[C^s_{a,1}\left(D\right)^{1-\gamma}\right]\right)^{1/(1-\gamma)}\\
&\text{s.t. } P_{a,0}C^s_{a,0} + \tilde{S}_{a,0} = W_{a,0}\overline{L} + \frac{\overline{WL}}{\rho} + \frac{1+x_{a,0}}{1-\theta}Q_0\\
&P_1\left(D\right)C^s_{a,1}\left(D\right) = \rho\tilde{S}_{a,0}\left(R^f_0 + \omega_{a,1}\left(\frac{Q_1\left(D\right)}{Q_0 - R_0} - R^f_0\right)\right).
\end{aligned}$$

Here, $\frac{Q_1(D)}{Q_0-R_0}$ denotes the gross return on capital. When $\omega_{a,1} = 0$, the stockholder does not invest in capital so her portfolio return is the gross risk-free rate, R^f_0. When $\omega_{a,1} = 1$, the stockholder invests all of her savings in capital so her portfolio return is the gross return to capital, $\frac{Q_1(D)}{Q_0-R_0}$.

Next consider the optimality condition for $\tilde{S}_{a,0}$ in problem $(B.119)$. This gives:

$$\frac{\rho}{P_{a,0}C^s_{a,0}} = (1-\rho)\frac{U^\gamma_{a,1}}{U_{a,1}}E\left[C^s_{a,1}\left(D\right)^{-\gamma}\frac{1}{P_1\left(D\right)}\rho\left(R^f_0 + \omega_{a,1}\left(\frac{Q_1\left(D\right)}{Q_0 - R_0} - R^f_0\right)\right)\right].$$

Using the budget constraint in period 1 to substitute for the return in terms of $C^s_{a,1}(D)$ and simplifying, we further obtain:

$$\frac{\rho}{P_{a,0}C^s_{a,0}} = (1-\rho)\,U^{\gamma-1}_{a,1}E\left[C^s_{a,1}\left(D\right)^{-\gamma}\frac{C^s_{a,1}\left(D\right)}{\tilde{S}_{a,0}}\right]$$

$$
\begin{aligned}
&= (1-\rho) U_{a,1}^{\gamma-1} U_{a,1}^{1-\gamma} \frac{1}{\tilde{S}_{a,0}} \\
&= (1-\rho) \frac{1}{\tilde{S}_{a,0}}.
\end{aligned}
$$

Here, the second line uses $U_{a,1}^{1-\gamma} = E\left[C_{a,1}^{s}(D)^{1-\gamma}\right]$ (from the definition of the certainty-equivalent utility). The last line simplifies the expression. Combining the resulting expression with the budget constraint in period 0, we obtain,

$$
P_{a,0} C_{a,0}^{s} = \rho \left(W_{a,0} \overline{L} + \frac{\overline{WL}}{\rho} + \frac{1 + x_{a,0}}{1-\theta} Q_0 \right).
$$

This establishes $(B.120)$.

Next, to establish the asset pricing condition for the risk-free asset, consider the optimality condition for $A_{a,1}^{f}$ in the original problem $(B.119)$ (as this corresponds to saving in the risk-free asset). This gives:

$$
\begin{aligned}
\frac{\rho}{P_{a,0} C_{a,0}^{s}} &= (1-\rho) U_{a,1}^{\gamma-1} E\left[\frac{1}{P_1(D) C_{a,1}^{s}(D)^{\gamma}} \rho R_0^{f}\right] \\
&= (1-\rho) \frac{1}{E\left[C_{a,1}^{s}(D)^{1-\gamma}\right]} E\left[\frac{1}{P_1(D) C_{a,1}^{s}(D)^{\gamma}} \rho R_0^{f}\right] \qquad \text{(B.131)}
\end{aligned}
$$

Here, the second line substitutes $U_{a,1}^{1-\gamma} = E\left[C_{a,1}^{s}(D)^{1-\gamma}\right]$. Rearranging terms and substituting $M_{a,1}(D)$ from Eq. $(B.123)$, we obtain Eq. $(B.121)$.

Finally, to establish the asset pricing condition for capital, consider the optimality condition for $\omega_{a,1}$ in problem $(B.130)$. This gives:

$$
E\left[\frac{C_{a,1}^{s}(D)^{-\gamma}}{P_{a,1}(D)} \rho \left(\frac{Q_1(D)}{Q_0 - R_0} - R_0^{f}\right)\right] = 0.
$$

Rearranging terms, we obtain,

$$
\begin{aligned}
Q_0 &= R_0 + \frac{1}{R_0^{f}} \frac{1}{E\left[\frac{1}{P_{a,1}(D) C_{a,1}^{s}(D)^{\gamma}}\right]} E\left[\frac{1}{P_{a,1}(D) C_{a,1}^{s}(D)^{\gamma}} Q_1(D)\right] \\
&= R_0 + (1-\rho) \frac{1}{E\left[C_{a,1}^{s}(D)^{1-\gamma}\right]} E\left[\frac{P_{a,0} C_{a,0}^{s}}{P_1(D) C_{a,1}^{s}(D)^{\gamma}} Q_1(D)\right] \\
&= R_0 + E\left[M_{a,1}(D) Q_1(D)\right].
\end{aligned}
$$

Here, the second line uses Eq. $(B.131)$ to substitute for $1/R_0^{f}$ and the last line substitutes for $M_{a,1}(D)$ from Eq. $(B.123)$. This establishes $(B.122)$. Note that we also have $Q_1(D) = \frac{\overline{W}D}{\rho}$ from

$(B.118)$. This completes the proof of the lemma. $\square$

Proof of Proposition 4. It remains to establish the comparative statics exercises. Recall that stockholders' future wealth satisfies $(B.129)$. Using $(B.128)$ and $R_0 = \frac{\overline{\alpha}}{1-\overline{\alpha}}\overline{L}$ we can rewrite this as:

$$(1-\theta)\frac{1}{R_0^f}\frac{\overline{L}}{\rho} + Q_0/\overline{W} - \frac{\overline{\alpha}}{1-\overline{\alpha}}\overline{L} = \frac{(1-\rho)(1-(1-\overline{\alpha})\theta)}{(1-\overline{\alpha})\rho}\overline{L}.$$

Note that the probability distribution, $(\pi(D))_{\mathcal{D}}$, or the risk aversion, γ, affect this equation only through their effect on Q_0 and R_0^f. The equation then implies that if these changes increase Q_0 then they must also increase R_0^f. Therefore, it suffices to establish the comparative statics exercises for the price of capital, Q_0.

First consider the comparative statics exercises in parts (i) and (ii). After substituting $\gamma = 1$ into Eqs. $(B.128)$ and $(B.126)$, we obtain the following expression for the price of capital:

$$\begin{aligned} Q_0/\left(\overline{WL}\right) &= \frac{\overline{\alpha}}{1-\overline{\alpha}} + \frac{1-\rho}{\rho}\left(1-\theta+\frac{\overline{\alpha}}{1-\overline{\alpha}}\right)E\left[f(D)\right] \\ \text{where } f(D) &= \frac{D}{\overline{L}(1-\theta)+D} \end{aligned} \tag{B.132}$$

Here, the second line defines the function $f : \mathbb{R}_+ \to \mathbb{R}_+$. Note that this function is strictly increasing and strictly concave: that is, $f'(D) > 0$ and $f''(D) < 0$ for $D > 0$. Combining this observation with Eq. $(B.132)$ proves the desired comparative statics. To establish (i), note that $E^{new}[f(D)] \geq E^{old}[f(D)]$ because $f(D)$ is increasing in D, and $\pi^{new}(D)$ first-order stochastically dominates $\pi^{old}(D)$. To establish (ii), note that $E^{new}[f(D)] \geq E^{old}[f(D)]$ because $f(D)$ is increasing and concave in D, and $\pi^{new}(D)$ second-order stochastically dominates $\pi^{old}(D)$ (which in turn follows because $\pi^{old}(D)$ is a mean-preserving spread of $\pi^{new}(D)$).

Finally, consider the comparative statics exercise in part (iii). In this case, Eqs. $(B.128)$ and $(B.126)$ imply,

$$\begin{aligned} Q_0/\left(\overline{WL}\right) &= \frac{\overline{\alpha}}{1-\overline{\alpha}} + \frac{1-\rho}{\rho}\left(1-\theta+\frac{\overline{\alpha}}{1-\overline{\alpha}}\right)\frac{E\left[f(D)\,g(D)^{1-\gamma}\right]}{E\left[g(D)^{1-\gamma}\right]}, \\ \text{where } g(D) &= \frac{\overline{L}(1-\theta)+D}{D^{\overline{\alpha}}}. \end{aligned} \tag{B.133}$$

Here, the second line defines the function $g : \mathbb{R}_+ \to \mathbb{R}_+$. We first claim that this function is increasing in D over the relevant range. To see this, note that,

$$g'(D) = D^{-\overline{\alpha}-1}(1-\overline{\alpha})\left(D-(1-\theta)\frac{\overline{\alpha}}{1-\overline{\alpha}}\overline{L}\right).$$

This is strictly positive since $D \geq \frac{\overline{\alpha}}{1-\overline{\alpha}}\overline{L}$ [cf. condition $(B.29)$]. Therefore, $g(D)$ is increasing in D over the relevant range.

Next note that Eq. $(B.133)$ can be rewritten as

$$Q_0/\left(\overline{WL}\right)=\frac{\overline{\alpha}}{1-\overline{\alpha}}+\frac{1-\rho}{\rho}\left(1-\theta+\frac{\overline{\alpha}}{1-\overline{\alpha}}\right)E^*\left[f\left(D\right)\right],$$

where $E^*[\cdot]$ denotes the expectations under the endogenous probability distribution $(\pi^*(D))_{\mathcal{D}}$, defined by,

$$\pi^*(D)=\frac{\pi(D)\,g(D)^{1-\gamma}}{\sum_{\tilde{D}\in\mathcal{D}}\pi\left(\tilde{D}\right)g\left(\tilde{D}\right)^{1-\gamma}}\text{ for each }D\in\mathcal{D}.\tag{B.134}$$

Hence, using our result from part (i), it suffices to show that $\pi^{*,new}(D)$ (which corresponds to $\gamma^{new}<\gamma^{old}$) first-order stochastically dominates $\pi^{*,old}(D)$.

To establish the last claim, define the cumulative distribution function corresponding to the endogenous probability distribution,

$$\Pi^*(D,\gamma)=\sum_{\tilde{D}\leq D}\pi^*\left(\tilde{D}\right)=\frac{\sum_{\tilde{D}\leq D,\tilde{D}\in\mathcal{D}}\pi\left(\tilde{D}\right)g\left(\tilde{D}\right)^{1-\gamma}}{\sum_{\tilde{D}\in\mathcal{D}}\pi\left(\tilde{D}\right)g\left(\tilde{D}\right)^{1-\gamma}}\text{ for each }D\in\mathcal{D}.\tag{B.135}$$

We made the dependence of the distribution function on γ explicit. To prove the claim, it suffices to show that $\frac{\partial\Pi^*(D,\gamma)}{\partial\gamma}\geq 0$ for each $D\in\mathcal{D}$ (so that a decrease in γ decreases $\Pi^*(D,\gamma)$ for each D and thus increases the distribution in the first-order stochastic dominance order). We have:

$$\begin{aligned}
&\frac{\partial\Pi^*(D,\gamma)}{\partial\gamma}\Bigg/\left(\frac{\sum_{\tilde{D}\leq D}\pi\left(\tilde{D}\right)g\left(\tilde{D}\right)^{1-\gamma}}{\sum\pi\left(\tilde{D}\right)g\left(\tilde{D}\right)^{1-\gamma}}\right)\\
=&\;-\frac{\sum_{\tilde{D}\leq D}\pi\left(\tilde{D}\right)g\left(\tilde{D}\right)^{1-\gamma}\log g\left(\tilde{D}\right)}{\sum_{\tilde{D}\leq D}\pi\left(\tilde{D}\right)g\left(\tilde{D}\right)^{1-\gamma}}+\frac{\sum\pi\left(\tilde{D}\right)g\left(\tilde{D}\right)^{1-\gamma}\log g\left(\tilde{D}\right)}{\sum\pi\left(\tilde{D}\right)g\left(\tilde{D}\right)^{1-\gamma}}\\
=&\;-\sum_{\tilde{D}\leq D}\frac{\pi^*\left(\tilde{D}\right)}{\Pi^*(D,\gamma)}\log g\left(\tilde{D}\right)+\sum\pi^*\left(\tilde{D}\right)\log g\left(\tilde{D}\right)\\
=&\;-E^*\left[\log g\left(\tilde{D}\right)\quad|\tilde{D}\leq D\right]+E^*\left[\log g\left(\tilde{D}\right)\right].
\end{aligned}$$

Here, the second line substitutes the definition of the endogenous distribution and its cumulative distribution from Eqs. $(B.134)$ and $(B.135)$. The last line substitutes the unconditional and conditional expectations. It follows that $\frac{\partial\Pi^*(D,\gamma)}{\partial\gamma}\geq 0$ for some $D\in\mathcal{D}$ if and only if the unconditional expectation exceeds the conditional expectation, $E^*\left[\log g\left(\tilde{D}\right)\right]\geq E^*\left[\log g\left(\tilde{D}\right)|\quad\tilde{D}\leq D\right]$. This is true because $\log g(D)$ is increasing in D (since $g(D)$ is increasing). This proves the claim and completes the proof of part (iii). $\square$