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## **STOCK MARKET WEALTH AND THE REAL ECONOMY: A LOCAL LABOR MARKET APPROACH**

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Simsek

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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 0.75% two years after the shock.

JEL Classification: E44, E21, E32

Keywords: Stock Prices, consumption wealth effect, marginal propensity to consume, employment, wages, regional heterogeneity, Time-varying risk premium, nominal rigidities, monetary policy

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

Gabriel Chodorow-Reich<sup>†</sup>      Plamen T. Nenov<sup>‡</sup>      Alp Simsek<sup>§</sup>

February 12, 2020

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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 0.75% two years after the shock.

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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 to identify the causal effect of stock wealth changes on regional labor market outcomes. We then present a model that relates the regional outcomes to the household-level propensity to consume out of stock wealth as well as to the aggregate labor market effects of stock wealth changes. Our empirical estimates map into a household-level annual marginal consumption propensity 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.

To frame the regional analysis, 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, 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 employment in the nontradable sector and in total. Local wages increase (weakly) more in high wealth areas, which induces a (weak) fall in tradable employment.

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.

We combine our empirical results with the theoretical model to calibrate two key parameters: the strength of 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 partial equilibrium 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.<sup>1</sup> 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 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. Homothetic preferences and production across sectors underlies this theoretical result, and we provide evidence of such homotheticity 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

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<sup>1</sup>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.

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 0.75%.

The rest of the paper is organized as follows. After discussing the related literature, we start by presenting the empirical analysis. Section 2 describes the data sets and the construction of our main variables. Section 3 presents 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 partial equilibrium 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.<sup>2</sup>

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 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., 2018).<sup>3</sup>

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 incor-

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

<sup>3</sup>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. (2018) 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. (2018) for a discussion of the possible drivers of these differences.

porating several features important for a structural interpretation of the results, including endogenous changes in wealth, monetary policy, partial wage adjustment, 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 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. (2018) and formalized in Guren et al. (2020), 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 partial equilibrium spending effect.<sup>4</sup> 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 *nontradable* 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.

### 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.

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<sup>4</sup>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.

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 income by a price-dividend ratio to arrive at stock wealth held in taxable accounts.<sup>5</sup> 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.<sup>6</sup> Specifically, as we describe in more detail in Appendix A.1.2, we merge the Barber and Odean (2000) data set with CRSP stock

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<sup>5</sup>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.

<sup>6</sup>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.

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% 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.<sup>7</sup> 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,  $S_{a,t}$ .

Figure 1a shows the variation in this measure across U.S. counties in 1990. Figure 1b and Figure 1c show the variation in 1990 and 2015, respectively, after removing state-specific means. The within-state differences are persistent over time, with a within-state correlation between  $S_{a,1990}$  and  $S_{a,2015}$  of 0.81. Table A.4 reports summary statistics for  $S_{a,t}$  and other variables used in the analysis.

## 2.2 Stock Market Return

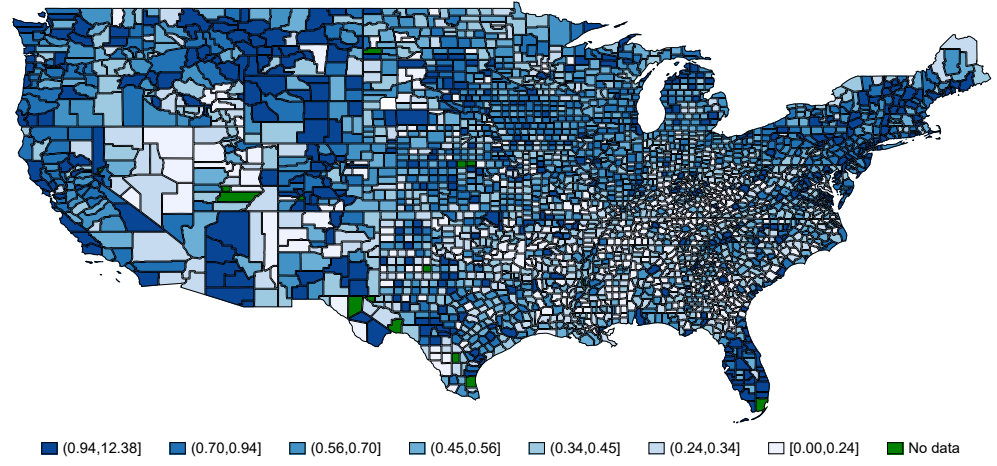
We write the stock market return in county  $a$  as  $R_{a,t-1,t}^* = \alpha_a + R_{t-1,t}^f + b_{a,t} \times (R_{t-1,t}^m - R_{t-1,t}^f) + e_{a,t-1,t}$ , where  $R_{t-1,t}^f$  is the risk-free rate in period  $t$ ,  $R_{t-1,t}^m$  is the market return,  $b_{a,t}$

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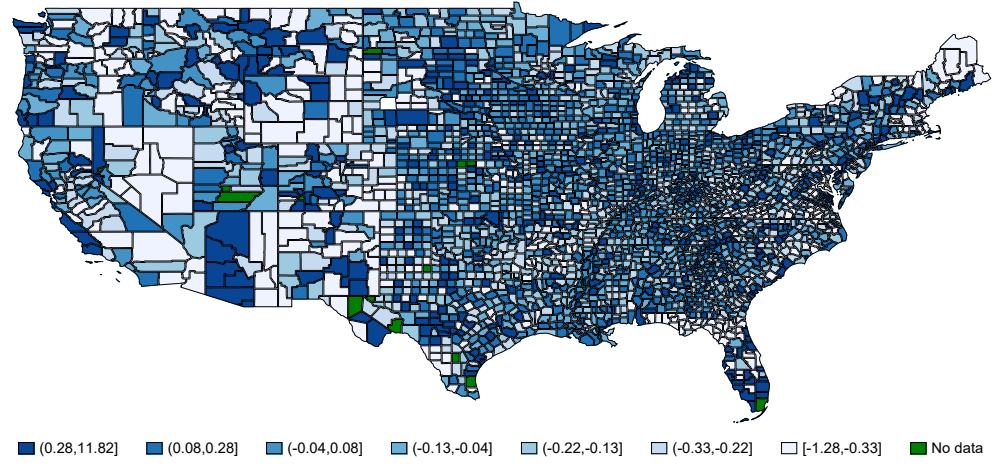
<sup>7</sup>This adjustment is appropriate if the marginal propensities to consume out of taxable and non-taxable stock wealth are the same. We revisit this assumption at the end of our analysis (see Footnote 44.)

Figure 1: Stock Market Wealth Relative to Labor Income Across U.S. Counties.

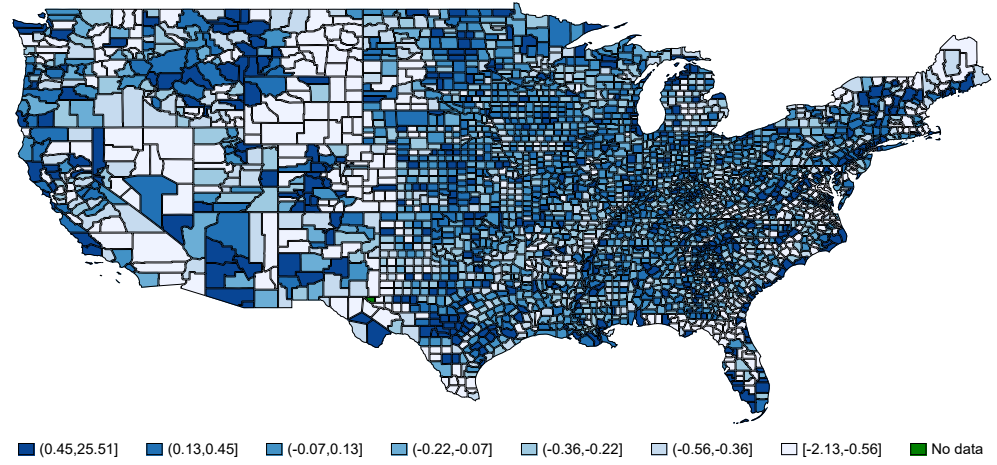
(a) 1990



(b) 1990, within state



(c) 2015, within state



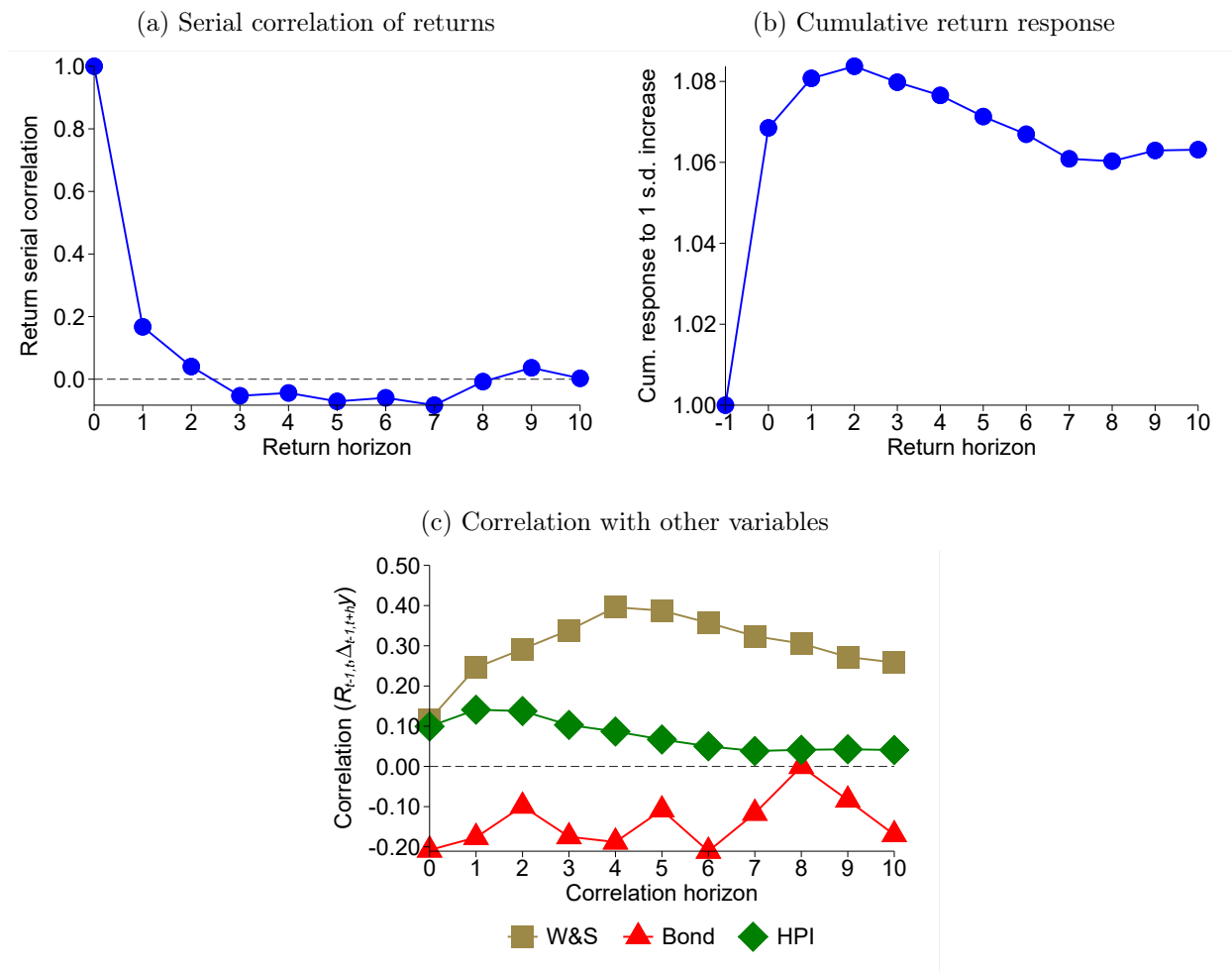
is a county-specific portfolio beta, and  $e_{a,t-1,t}$  is an idiosyncratic component of the return. We do not observe  $R_{a,t-1,t}^*$ . Instead, we define the variable  $R_{a,t-1,t}$  that enters into our main regressor as  $R_{a,t-1,t} = R_{t-1,t}^f + b_{a,t} \times (R_{t-1,t}^m - R_{t-1,t}^f)$ . To operationalize  $R_{a,t-1,t}$ , we equate the risk-free rate  $R_{t-1,t}^f$  with the interest rate on a 3-month Treasury bill, the market return  $R_{t-1,t}^m$  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 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  $\alpha_a$ , 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 this type of heterogeneity. 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.<sup>8</sup>

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<sup>8</sup>Formally, assume the true structural model is  $y_a = \beta(S_a R_a^*) + \epsilon_a$  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  $\epsilon_a$  is independent of the measured change in wealth  $S_a R_a$ . (We have dropped time subscripts and ignored the component  $\alpha_a$  to simplify notation and without loss of generality).

Figure 2: Attributes of Quarterly Stock Returns



Notes: Panel (a) reports the coefficients  $\beta_h$  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  $\prod_{h=0}^j (1 + \beta_h \sigma_R)$  at each quarterly horizon  $j$  shown on the lower axis, where  $\sigma_R$  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  $t+h$ .

Substituting, we have  $y_a = \beta (S_a R_a) + u_a$ , 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  $\beta$ , since  $Cov(S_a e_a, S_a R_a) = Cov(\epsilon_a, S_a R_a) = 0$  by the independence assumptions on  $e_a$  and  $\epsilon_a$ . 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  $\epsilon_a$ , 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.

Figure 2a shows the serial correlation in the quarterly return on the CRSP portfolio and Figure 2b 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 2a. 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 2b in what follows. Figure 2c shows the correlation of 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.<sup>9</sup>

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.<sup>10</sup> The re-

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<sup>9</sup>The NAICS version of the QCEW contains a number of transcription errors prior to 2001. We follow Chodorow-Reich and Wieland (Forthcoming, Appendix F) and hand-correct these errors before applying the seasonal adjustment procedure.

<sup>10</sup>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.



tail 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), 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:

$$\Delta_{a,t-1,t+h}y = \beta_h[S_{a,t-1}R_{a,t-1,t}] + \Gamma'_h X_{a,t-1} + \epsilon_{a,t-1,t+h}, \quad (1)$$

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,  $R_{a,t-1,t} = b_{a,t}R_{t-1,t}^m + (1 - b_{a,t})R_{t-1,t}^f$  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  $t - 1$ ,  $\beta_h$  and  $\Gamma_h$  are coefficients (with the latter possibly vector-valued), and  $\epsilon_{a,t-1,t+h}$  contains un-modeled determinants of the outcome variable.

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  $R_{t-1,t}^f$  is much less volatile than  $R_{t-1,t}^m$ , we can use the approximation  $S_{a,t-1}R_{a,t-1,t} \approx S_{a,t-1}b_{a,t}R_{t-1,t}^m$  in Eq. (1).<sup>11</sup> In that case, Eq. (1) has an approximate shift-share structure with a single national shifter given by the market return

<sup>11</sup>That is, for any (de-meaned) variable  $v_{a,t}$ ,  $E[S_{a,t-1}R_{a,t-1,t}v_{a,t}] = E[S_{a,t-1}b_{a,t}R_{t-1,t}^m v_{a,t}] + E[S_{a,t-1}(1 - b_{a,t})R_{t-1,t}^f v_{a,t}] \approx E[S_{a,t-1}b_{a,t}R_{t-1,t}^m v_{a,t}]$ , where the term  $E[S_{a,t-1}(1 - b_{a,t})R_{t-1,t}^f v_{a,t}]$  is negligible because  $1 - b_{a,t} \approx 0$  and  $Var(R_{t-1,t}^f) \ll Var(R_{t-1,t}^m)$ . In fact, our results below change imperceptibly whether or not we include the term  $S_{a,t-1}(1 - b_{a,t})R_{t-1,t}^f$ .

$R_{t-1,t}^m$ , and the identifying assumption for  $\text{plim}\hat{\beta}_h = \beta_h$  takes the form:

$$E [R_{t-1,t}^m \mu_t] = 0, \quad (2)$$

where  $\mu_t \equiv E [S_{a,t-1} b_{a,t} \epsilon_{a,t-1,t+h}]$  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  $\epsilon_{a,t-1,t+h}$ .<sup>12</sup> 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  $\mu_t$ . 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  $\beta_h$  also requires that other aggregate variables correlated with  $R_{t-1,t}^m$  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 the robustness analysis below.

### 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

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<sup>12</sup>To derive this condition, let  $\mathbf{Y}$  denote the  $AT \times 1$  vector of  $\Delta_{a,t-1,t+h} y$  stacked over  $A$  areas and  $T$  time periods,  $\mathbf{S}$  the  $AT \times T$  matrix containing the vector  $(b_{1,t} S_{1,t-1} \dots b_{A,t} S_{A,t-1})'$  in rows  $A(t-1) + 1$  to  $At$  of column  $t$  and zeros elsewhere,  $\mathbf{R}$  the  $T \times 1$  vector of stock market returns,  $\mathbf{X}$  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  $\mathbf{Y} = \beta_h \mathbf{S} \mathbf{R} + \mathbf{X} \boldsymbol{\Gamma}_h + \boldsymbol{\epsilon}$ . It follows that  $\text{plim}\hat{\beta}_h = \beta_h$  if  $0 = \lim_{A,T \rightarrow \infty} (\mathbf{S} \mathbf{R})' \boldsymbol{\epsilon} = \lim_{A,T \rightarrow \infty} \mathbf{R}' \mathbf{S}' \boldsymbol{\epsilon} = \lim_{A,T \rightarrow \infty} \sum_t R_{t-1,t} \sum_a b_{a,t} S_{a,t-1} \epsilon_{a,t-1,t+h} = E [R_{t-1,t} \mu_t]$ . Note that this identification condition presumes a homogenous treatment effect. We explore treatment heterogeneity explicitly in Section 4.4.

“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 quarters (to capture human capital and private business wealth).<sup>13</sup> Finally, we also include a Bartik (1991) shift-share measure of predicted employment growth at horizon  $h$  based only on industry composition,  $\Delta_{a,t-1,t+h}e^B$ .<sup>14</sup> 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.<sup>15</sup>

### 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 require-

<sup>13</sup>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  $\frac{E_t[H_t^\infty] - E_{t-1}[H_t^\infty]}{E_{t-1}[H_t^\infty]} \simeq \ln E_t[H_t^\infty] - \ln E_{t-1}[H_t^\infty]$ . Relative to this definition, our control (i) truncates the horizon at  $T = 11$  (truncating at longer horizons gives similar results); (ii) replaces  $E_t[H_t^{11}]$  with its perfect-forecast counterpart  $H_t^{11}$  (under rational expectations, this provides an unbiased measure of expected wealth); and (iii) replaces  $E_{t-1}[H_t^{11}]$  with income in the last period,  $A_{t-1}$ . Under the efficient market hypothesis, this last step does not matter because both  $E_{t-1}[H_t^\infty]$  and  $A_{t-1}$  are determined in period  $t - 1$  and therefore should be orthogonal to the stock return  $R_{t-1,t}^m$ .

<sup>14</sup>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  $i$ .

<sup>15</sup>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.

ment 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 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.<sup>16</sup> 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 2a.

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

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<sup>16</sup>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  $S_{a,t-1}^o R_{t-1,t}^o$  the change in some other type of wealth  $o$ , we can write  $S_{a,t-1}^o R_{t-1,t}^o = \gamma S_{a,t-1} R_{t-1,t}^o + S_{a,t-1}^{o,\perp} R_{t-1,t}^o$ , where  $\gamma S_{a,t-1}$  is the fitted value from a regression of  $S_{a,t-1}^o$  on  $S_{a,t-1}$  and so by construction  $S_{a,t-1}^{o,\perp}$  is orthogonal to  $S_{a,t-1}$ . Therefore, omitting the part  $S_{a,t-1}^{o,\perp} R_{t-1,t}^o$  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  $\gamma$ ). 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.

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 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 3 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 2b), these time paths should be interpreted as the dynamic responses to a permanent change in stock market wealth. Panel A of Figure 3 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 0.69 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.

Table 1: Baseline Results

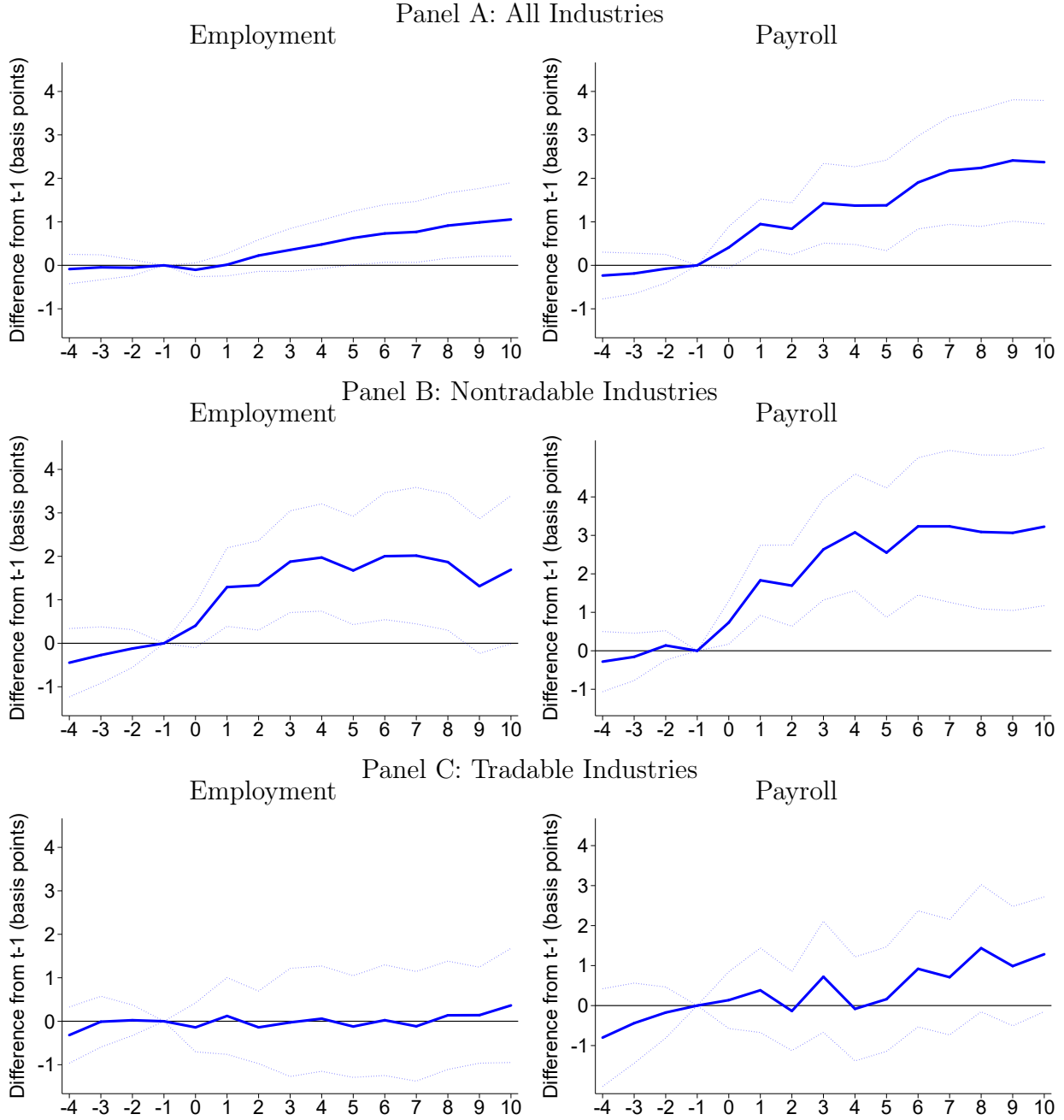
	All		Non-traded		Traded	
	Emp.	W&S	Emp.	W&S	Emp.	W&S
	(1)	(2)	(3)	(4)	(5)	(6)
Right hand side variables:						
$S_{a,t-1}R_{a,t-1,t}$	0.77* (0.36)	2.18** (0.63)	2.02* (0.80)	3.24** (1.01)	-0.11 (0.64)	0.71 (0.74)
Horizon $h$	Q7	Q7	Q7	Q7	Q7	Q7
Pop. weighted	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes
State $\times$ 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.

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.

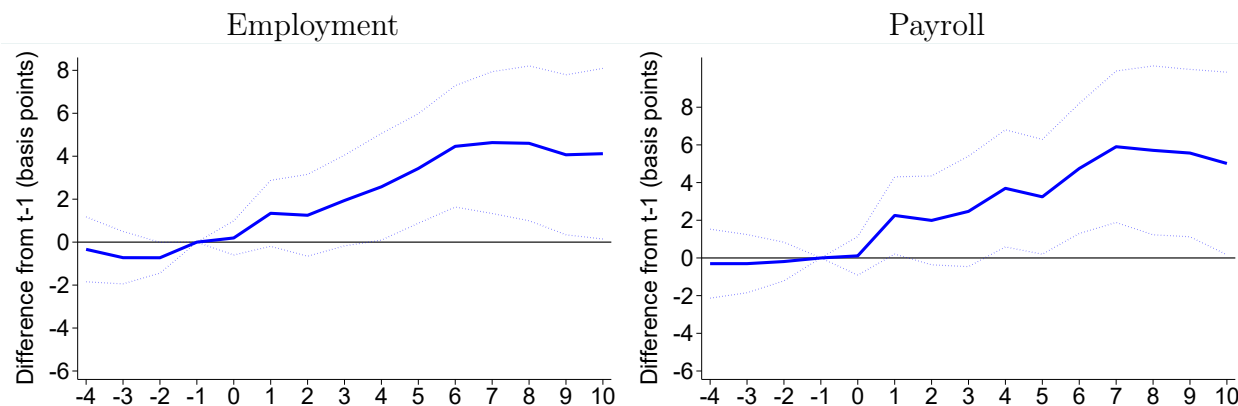
Figure 4 shows a large response of employment and payroll in the residential building construction sector (NAICS 2361). We show this sector separately because, while it also produces output consumed locally, the magnitude does not easily translate into our theoretical model since the sector produces 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 employ-

Figure 3: Baseline Results



Notes: The figure reports the coefficients  $\beta_h$  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.

Figure 4: Response of Residential Construction



Notes: The figure reports the coefficients  $\beta_h$  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.

ment 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.<sup>17</sup>

Figure 5 reports the response of population. The magnitude lies well below the response of total employment and the data cannot reject no population response at the horizon we examine.<sup>18</sup>

## 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.

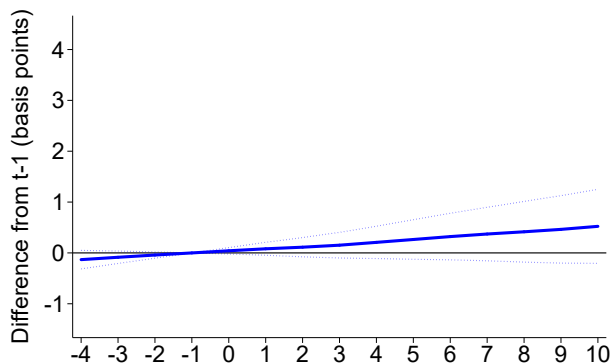
Table 2 shows robustness to subtracting or adding covariates to the baseline specification. Rows 2 expands the variation used to identify the response by removing the interactions of  $S_{a,t-1}$  with changes in aggregate labor income, non-corporate income, bond wealth, and house prices, and the Bartik 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 2c, while

<sup>17</sup>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.) 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.

<sup>18</sup>The population data by county come from the Census Bureau. The Census reports population as of July 1 of each year. We linearly interpolate these data to obtain a quarterly series.



Figure 5: Response of Population



Notes: The figure reports the coefficients  $\beta_h$  from estimating Eq. (1), for total county population 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.

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 these other aggregate factors.

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 (Güvener 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.<sup>19</sup> 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

<sup>19</sup>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.

Table 2: Robustness to Covariates

Dependent variable:	Total		Nontradable		Tradable	
	Emp.	Payroll	Emp.	Payroll	Emp.	Payroll
Specification:						
1. Baseline	0.77* (0.36)	2.18** (0.63)	2.02* (0.80)	3.23** (1.01)	-0.12 (0.64)	0.71 (0.74)
2. Only county & stateXquarter FE	1.04* (0.40)	2.82** (0.74)	1.21 (1.06)	2.92** (1.06)	0.02 (0.87)	1.55 (1.04)
3. Control high earners	0.58 (0.35)	1.64** (0.58)	1.90* (0.80)	2.83** (0.94)	-0.06 (0.65)	0.30 (0.70)
4. Aggregate TFP sensitivity	0.66* (0.31)	2.06** (0.62)	1.85* (0.76)	3.03** (0.95)	-0.09 (0.59)	0.75 (0.71)
5. Control local house prices	0.70+ (0.37)	2.15** (0.65)	1.50* (0.64)	2.82** (0.92)	-0.45 (0.62)	0.35 (0.70)
6. Control large firm share	0.70* (0.34)	2.05** (0.59)	1.93* (0.76)	3.09** (0.95)	-0.18 (0.61)	0.67 (0.70)
7. Control lagged outcomes	0.75* (0.36)	2.17** (0.63)	2.10* (0.80)	3.19** (0.99)	-0.19 (0.70)	0.75 (0.73)
8. CzoneXtime FE	1.09** (0.38)	2.24** (0.67)	2.41* (0.96)	3.68** (1.11)	-0.37 (0.64)	0.24 (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.

investment response by such firms. Row 7 includes lagged outcomes to control directly for any pre-trends.<sup>20</sup> 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

<sup>20</sup>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).

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 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 preferences for output of different industries are similar across locations, 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.<sup>21</sup>

The last row returns to the baseline specification but expands the geographic unit to a Core Based Statistical Area (CBSA).<sup>22</sup> The point estimates change little except in the

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<sup>21</sup>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.

<sup>22</sup>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 and excluded from the estimation. Because CBSA’s may contain counties from multiple states (e.g. the

Table 3: Other Robustness

Dependent variable:	Total		Nontradable		Tradable	
	Emp.	Payroll	Emp.	Payroll	Emp.	Payroll
Specification:						
1. Baseline	0.77* (0.36)	2.18** (0.63)	2.02* (0.80)	3.23** (1.01)	-0.12 (0.64)	0.71 (0.74)
2. Keep if $R_{t-1,t} \in [P5, P95]$	1.14* (0.46)	2.98** (0.93)	3.52** (1.01)	5.12** (1.25)	0.27 (0.97)	1.84 (1.23)
3. Trim top/bottom 1% of $S_{a,t}$	1.02* (0.51)	2.93** (0.91)	2.65* (1.15)	4.56** (1.40)	0.52 (1.06)	1.33 (1.11)
4. Drop S&P 500 HQs	0.30 (0.21)	0.69+ (0.39)	1.68* (0.66)	1.98** (0.68)	0.02 (0.82)	0.72 (0.88)
5. Drop Forbes Top Private HQs	0.40 (0.25)	0.89* (0.42)	1.88* (0.75)	2.66** (0.84)	0.29 (0.78)	0.75 (0.85)
6. Unweighted	0.47 (0.31)	0.84* (0.42)	2.98* (1.19)	2.86** (1.03)	0.11 (0.84)	0.56 (1.05)
7. Trim by population	0.82** (0.31)	1.84** (0.56)	2.15** (0.78)	3.04** (0.91)	0.51 (0.74)	1.52 (0.94)
8. Price component only	0.74* (0.36)	2.11** (0.62)	1.93* (0.78)	3.11** (0.99)	-0.15 (0.62)	0.65 (0.72)
9. IV with lagged wealth	0.76* (0.37)	1.91** (0.60)	1.60* (0.76)	2.61** (0.96)	-0.23 (0.58)	0.42 (0.72)
10. IV with fixed dividends/income	0.89** (0.12)	2.61** (0.18)	1.63** (0.21)	2.89** (0.25)	0.21 (0.42)	1.20* (0.51)
11. Concentration-based T/NT	0.77* (0.36)	2.18** (0.63)	2.13** (0.62)	4.26** (1.00)	-0.72 (0.98)	0.62 (1.61)
12. Across CBSAs	0.44 (0.47)	1.80+ (1.03)	2.56+ (1.53)	3.00+ (1.63)	0.68 (1.61)	1.95 (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.

tradable sectors 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.

### 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  $\Delta$  on the horizon  $h$ ),  $\pi_a$  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,  $\beta_s$  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  $s$ .<sup>23</sup> 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

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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.

<sup>23</sup>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  $\beta_s$  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	$\beta_s$ , 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

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.

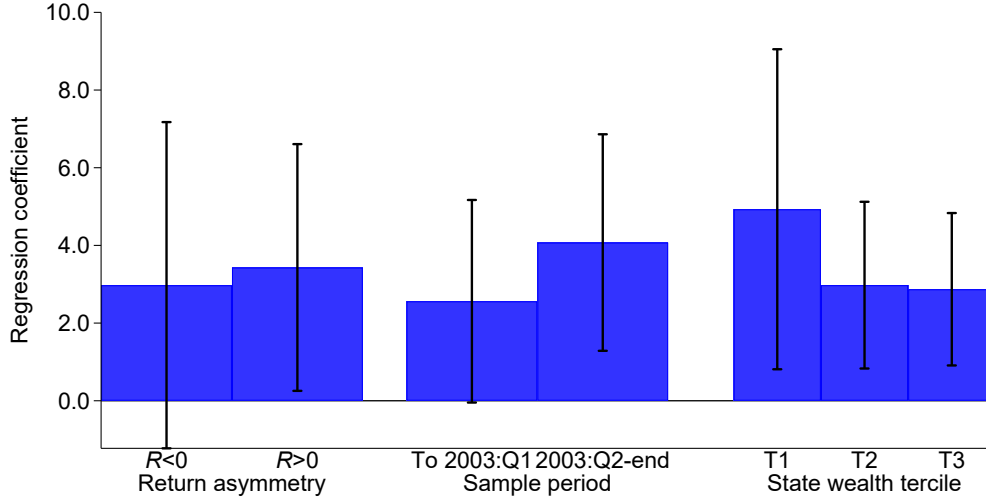
#### 4.4 Heterogeneity

This section reports heterogeneity of the response along the dimensions of whether the stock return is positive or negative, the sample period, and wealth level. For each dimension, we augment 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  $m$ . Figure 6 reports results for the coefficient on nontradable payroll, the variable most directly used in our theoretical analysis.

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.<sup>24</sup>

<sup>24</sup>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.

Figure 6: Heterogeneity



Notes: The figure reports the coefficients  $\beta_h^m$  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.

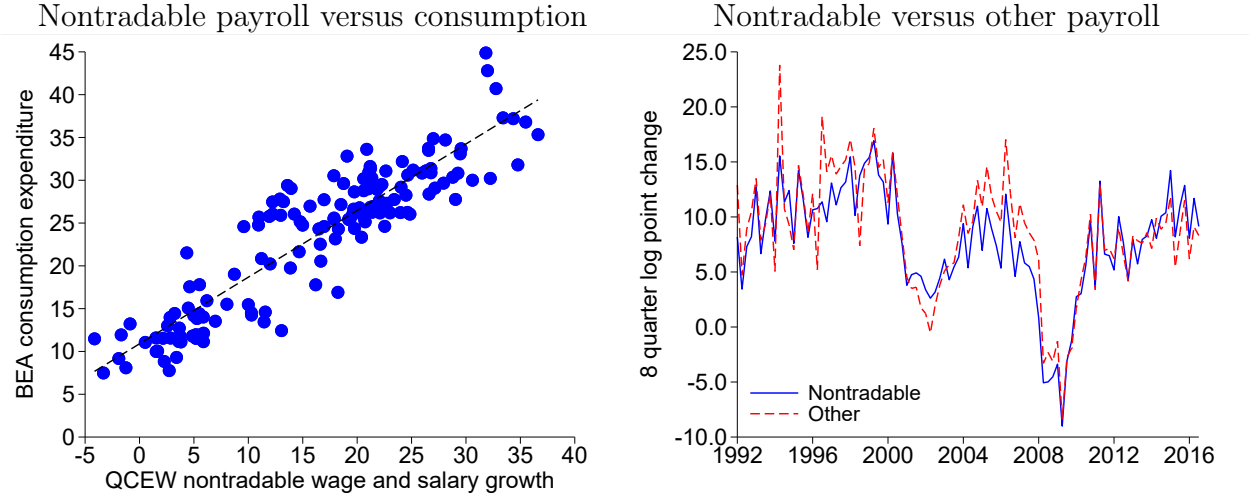
Finally, many theories of consumption predict higher MPCs for less wealthy households. In the context of stock market wealth, Di Maggio et al. (forthcoming) find a higher MPC in Sweden among households in the lower half of the wealth distribution. In our regional context, such heterogeneity could also 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.<sup>25</sup> This insensitivity may partly reflect that in practice stock wealth heterogeneity is substantially greater within than across counties, and our cross-county analysis already reflects the wealth-weighted MPC within a typical county.

## 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 marginal propensity to consume out of stock market wealth. Before turning to that analysis, we

<sup>25</sup>We split states by tercile of their time-averaged real (deflated by the price index for personal consumption 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 7: Nontradable Payroll, Consumption Expenditure, and Total 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.

present empirical evidence of the relationship between nontradable payroll and consumption expenditure, nontradable sectors and the rest of the economy, and direct evidence of a response of consumption expenditure.

We first show a tight relationship between nontradable payroll and consumption expenditure growth at the state level. The left panel of Figure 7 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 derives essentially entirely from 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 7 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. Intuitively, if the national economy is nearly



closed, then all sectors are nontradable nationally and will co-move if homotheticity holds.

Appendix A.5 provides further evidence of preference homotheticity across nontradable and other sectors by extending the Dynan and Maki (2001) analysis of securities-owning households in the Consumer Expenditure Survey. We estimate the effect of the stock market on these households' consumption, separately for their retail expenditure and other expenditure. Consistent with homotheticity, we find similar (cumulative) effects 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  $S_{a,t-1}^C$ , 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 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. There is a continuum of areas denoted by

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  $\Delta_{a,t-1,t+h}y = \beta_h[S_{a,t-1}^C R_{a,t-1,t}] + \Gamma'_h X_{a,t-1} + \epsilon_{a,t-1,t+h}$ , where  $y$  is total consumption expenditure in state  $a$ ,  $h = 2$  years,  $S_{a,t-1}^C$  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).

subscript  $a$  and two time periods denoted by subscripts 0 and 1. We interpret period 1 as the long-run, in which prices adjust and macroeconomic outcomes are determined solely by productivity. In contrast, period 0 is the short-run in which aggregate demand can matter. Hence, a period in the model may correspond to several years. There are two factors of production, labor and capital. Labor is specific to the area in period 0, which ensures that wages and employment in the short run are influenced by local demand. Capital is mobile across areas (in either period), which simplifies the analysis by ensuring that capital has a single price. The price of capital in period 0 is endogenous and can change due to fluctuations in its expected productivity in period 1. Importantly, capital ownership is heterogeneous across areas. We analyze how changes in the price of capital affect local labor market outcomes. We also separately model nontradable and tradable goods, which yields additional predictions and will play an important role in the calibration.

## 5.1 Environment and Equilibrium

In each period  $t \in \{0, 1\}$  and area  $a$ , a representative household divides its consumption  $C_{a,t}$  between a tradable good that can be transported costlessly across areas,  $C_{a,t}^T$ , and a nontradable good that must be consumed in the area where it is produced,  $C_{a,t}^N$ , according to the preferences:

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

Competitive firms produce the nontradable good using labor  $L_{a,t}^N$  and capital  $K_{a,t}^N$  and the Cobb-Douglas technology:

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

Here,  $1 - \alpha^N$  denotes the share of labor in the nontradable sector.

There are two technologies for producing the tradable consumption good. The first technology 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:

$$Y_t^T = \left( \int_a (Y_{a,t}^T)^{\frac{\varepsilon-1}{\varepsilon}} da \right)^{\frac{\varepsilon}{\varepsilon-1}}$$

where  $Y_{a,t}^T = (K_{a,t}^T/\alpha^T)^{\alpha^T} (L_{a,t}^T/(1 - \alpha^T))^{1-\alpha^T}$ .

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.

The second technology uses only capital  $\tilde{K}_t^T$ :

$$\tilde{Y}_t^T = D_t^{1-\alpha^T} \tilde{K}_t^T.$$

The productivity parameter  $D_t$  determines the rental rate of capital. 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 of this technology,  $D_1$ . The normalizing power  $1 - \alpha^T$  simplifies the expressions.

Areas are identical except for their initial capital wealth. The representative household in area  $a$  enters period 0 owning  $1 + x_{a,0}$  units of capital, where  $\int_a x_{a,0} da = 0$ . 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 households 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.

The representative household in each area separates its consumption and labor choices as follows. At the beginning of period 0, the household splits into a consumer and a continuum of workers.<sup>26</sup> The consumer makes a consumption-savings decision to maximize a time-separable log utility function subject to an intertemporal budget constraint:

$$\max_{C_{a,0}, C_{a,1}} \log C_{a,0} + \delta \log C_{a,1} \tag{3}$$

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<sup>26</sup>We choose to model consumption and labor decisions separately for two reasons. First, assuming workers choose labor according to Greenwood et al. (1988) (GHH) preferences allows us to ignore the wealth effects of labor supply. Second, we can endow consumers with standard time-separable preferences. In addition to simplifying the subsequent expressions, this setup accords with the fact that workers hold relatively little stock market wealth. At the same time, we sidestep some consequences of GHH preferences, such as leading to unplausibly large fiscal and monetary multipliers (Auclert and Rognlie, 2017).

$$\text{s.t.} \quad P_{a,0}C_{a,0} + \frac{P_{a,1}C_{a,1}}{R^f} = W_{a,0}L_{a,0} + (1 + x_{a,0})Q_0 + \frac{W_{a,1}L_{a,1}}{R^f}. \quad (4)$$

Here,  $P_{a,t}$  denotes the price level in period  $t$  in area  $a$ ,  $W_{a,t}$  the wage level,  $L_{a,t}$  labor supply, and  $R^f$  the risk-free rate. The elasticity of intertemporal substitution (EIS) of one simplifies the analysis and is empirically plausible (see Appendix B.9 for a discussion of how a more general EIS affects our analysis).

In period 1 (the long run) labor is exogenous,  $L_{a,1} = \bar{L}_1$ , for all  $a$ , and the nominal wage is constant,  $W_{a,1} = \bar{W}$ . We model period 0 labor supply to incorporate both some degree of wage stickiness and disutility of labor. Specifically, a worker of type  $\nu$  supplies specialized labor services  $L_{a,0}(\nu)$  subject to a constant elasticity labor demand curve—determined by the aggregate demand for labor in the area as well as the elasticity of substitution between specialized labor types.<sup>27</sup> A fraction of the labor types (the sticky workers) supply labor at the preset wage  $\bar{W}$  (the same wage as in the long-run). The remainder (the flexible workers) set a wage  $W_{a,0}(\nu)$  to maximize:

$$\log \left( C_{a,0} - \frac{\chi}{1 + \varphi} \int_0^1 L_{a,0}(\nu)^{1+\varphi} d\nu \right),$$

where  $\varphi$  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.

In Online Appendix B.1, we derive the optimal wage set by flexible workers and combine it with the wage of the sticky workers to obtain a labor supply curve (c.f. Eq. (B.17)). We linearize the resulting equation around a benchmark in which all areas have common wealth to derive the log-linear labor supply curve (c.f. Eq. (B.57)):

$$\log \frac{W_{a,0}}{\bar{W}} = \lambda \left( \log \frac{P_{a,0}}{P_0} + \varphi \log \frac{L_{a,0}}{\bar{L}_0} \right). \quad (5)$$

Here,  $P_0$  and  $\bar{L}_0$  denote the price level and labor that would obtain if all areas had the same wealth, and  $\lambda \in [0, 1]$  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 relationship between labor and the real wage.<sup>28</sup>

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<sup>27</sup>Formally, the worker faces the labor demand curve  $L_{a,0}(\nu) = \left( \frac{W_{a,0}(\nu)}{W_{a,0}} \right)^{-\varepsilon_w} L_{a,0}$ , where  $W_{a,0} = \left( \int_0^1 W_{a,0}(\nu)^{1-\varepsilon_w} d\nu \right)^{1/(1-\varepsilon_w)}$  and  $L_{a,0} = \left( \int_0^1 L_{a,0}(\nu)^{\frac{\varepsilon_w-1}{\varepsilon_w}} d\nu \right)^{\frac{\varepsilon_w}{\varepsilon_w-1}}$ . Here,  $L_{a,0}$  denotes the aggregate demand for labor in area  $a$  that obtains in equilibrium.

<sup>28</sup>Letting  $\lambda_w$  denote the fraction of flexible workers that reset wages in period 0,  $\lambda = \frac{\lambda_w}{1+(1-\lambda_w)\varphi\varepsilon_w}$ .

Finally, at the end of period 0 the household recombines and makes a portfolio decision to allocate savings between capital (stock wealth) and a risk-free asset. The risk-free asset is in zero net supply and generates a gross nominal return in period 1 denoted by  $R^f$ . The monetary policy sets  $R^f$  to keep labor supply equal to its frictionless level on average.<sup>29</sup> Specifically, it ensures  $\int_a L_{a,0} da = \bar{L}_0$ , where  $\bar{L}_0$  denotes the labor supply that would obtain if all areas had the same stock wealth and there were no wage rigidities. Appendix B.1 completes the description of the setup and defines the equilibrium.

## 5.2 Consumption Wealth Effect

In Appendix B.2, we characterize the equilibrium and establish the key mechanism behind our results: the consumption wealth effect. Specifically, in view of the preferences in (3), the time-zero consumption expenditure in area  $a$  satisfies:

$$P_{a,0}C_{a,0} = \frac{1}{1 + \delta} (H_{a,0} + (1 + x_{a,0}) Q_0). \quad (6)$$

Here,  $H_{a,0}$  denotes human capital wealth, the present discounted value of labor income. Hence, we have the standard result with log utility that consumption expenditure is a fraction of lifetime wealth.

We now solve for the endogenous variables, first in a benchmark case in which areas have common wealth and then by linearizing the equilibrium equations around that benchmark. We use the common wealth benchmark to illustrate the source of stock price fluctuations, and we use the log-linearized equilibrium to describe the empirical predictions regarding the cross-sectional effects of these fluctuations.

## 5.3 Common Wealth Benchmark and Stock Price Fluctuations

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  $a$ . We solve for the equilibrium in Appendix B.3. We make a parametric assumption on  $D_0$  to ensure that firms are indifferent to using the capital-only technology in period 0 (but they do use it in period 1).<sup>30</sup> In this case, the equilibrium is particularly simple. To state the result,

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<sup>29</sup>In practice, monetary policy affects the nominal interest rate by changing the money supply, in an environment where money provides liquidity services and the interest rate reflects the “price” of liquidity. 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).

<sup>30</sup>For simplicity, we assume the capital-only technology can be used to produce tradables but not nontradables. This provides a potential source of nonhomotheticity across sectors. The assumption on  $D_0$  ensures that production remains homothetic in period 0, which is important for some of our results.

we define the weighted average capital share across the nontradable and tradable sectors,

$$\bar{\alpha} = \eta\alpha^N + (1 - \eta)\alpha^T. \quad (7)$$

The equilibrium with common wealth is then given by:

$$\begin{aligned} W_0 &= \bar{W}, \quad L_0 = \bar{L}_0 \text{ where } \bar{L}_0 \text{ solves (B.38)}, \\ L_0^N/\bar{L}_0 &= \frac{1 - \alpha^N}{1 - \bar{\alpha}}\eta \text{ and } L_0^T/\bar{L}_0 = \frac{1 - \alpha^T}{1 - \bar{\alpha}}(1 - \eta). \\ R^f &= R^{f,*} = \frac{1}{\delta} \frac{\bar{L}_1 + D_1}{\bar{L}_0 + D_0}, \\ Q_0/\bar{W} &= D_0 + \frac{D_1}{R^f} = D_0 + \delta (\bar{L}_0 + D_0) \frac{D_1}{\bar{L}_1 + D_1}, \\ H_0/\bar{W} &= \bar{L}_0 + \frac{\bar{L}_1}{R^f} = \bar{L}_0 + \delta (\bar{L}_0 + D_0) \frac{\bar{L}_1}{\bar{L}_1 + D_1}. \end{aligned} \quad (8)$$

The first line shows that the nominal wage is equal to its long-run level and labor supply is given by its frictionless level (see the appendix for a characterization). The second 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 third line characterizes the interest rate that brings about this outcome (“rstar”).

The last two lines characterize the prices of physical and human capital. An increase in the *future* productivity of capital,  $D_1$ , increases the equilibrium price of capital  $Q_0$ . Monetary policy responds to this change by raising  $R^f$ ; however, the equilibrium price of capital increases even after incorporating the monetary policy response.<sup>31</sup>

We focus on the comparative statics of a change in the future productivity of capital from some  $D_1^{old}$  to  $D_1^{new}$ . By Eq. (8), the price of capital changes from  $Q_0^{old}$  to some  $Q_0^{new}$ , while leaving the aggregate labor market outcomes unchanged,  $L_0 = \bar{L}_0, W_0 = \bar{W}$ . We next investigate how this change affects *local* labor market outcomes when stock wealth is heterogeneously distributed across areas. In Appendix B.8, we generalize the model to incorporate uncertainty over  $D_1$  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.<sup>32</sup>

<sup>31</sup>Specifically, we have  $\frac{dQ_0}{dD_1} = \frac{\delta\bar{W}(\bar{L}_0+D_0)D_1}{(\bar{L}_1+D_1)^2} > 0$  and  $\frac{dR^f}{dD_1} = \frac{1}{\delta(\bar{L}_0+D_0)} > 0$ . We also have  $\frac{d(Q_0+H_0)}{dD_1} = 0$ : that is, the interest rate response stabilizes the *total* wealth,  $Q_0 + H_0$ . This ensures that aggregate spending and thus aggregate employment remains unchanged.

<sup>32</sup>Specifically, we show that a reduction in households’ perceived uncertainty about  $D_1$  increases  $Q_0$  and  $R^{f,*}$ . After extending the analysis to more general Epstein-Zin preferences, we also establish that a decrease in households’ relative risk aversion parameter increases  $Q_0$  and  $R^{f,*}$  (see Proposition 3). Finally, we show that, conditional on generating the same increase in  $Q_0$ , the decline in risk or risk aversion has the same

## 5.4 Heterogeneous Wealth and Cross-Sectional Predictions

We now derive cross-sectional predictions for the empirically-relevant case of a heterogeneous distribution of stock wealth. We also highlight the properties of the coefficients that will inform our calibration exercise.

We first log-linearize the equations that characterize the equilibrium around the common wealth benchmark for a given  $D_1$ . Specifically, we let  $w_{a,0} = \log(W_{a,0}/\bar{W})$ ,  $p_{a,0} = \log(P_{a,0}/P_0)$  and  $l_{a,0} = \log(L_{a,0}/\bar{L}_0)$  denote the log-deviations of nominal wages, nominal prices, and total labor for each area. We define  $l_{a,0}^N$  and  $l_{a,0}^T$  similarly for the nontradable and tradable sectors. In Appendix B.4 we present closed-form solutions for  $p_{a,0}$ ,  $w_{a,0}$ ,  $l_{a,0}$ ,  $l_{a,0}^N$ ,  $l_{a,0}^T$  for a given level of  $D_1$ .

In particular, we express local prices in terms of local wages,

$$p_{a,0} = \eta (1 - \alpha^N) w_{a,0}. \quad (9)$$

Combining this with Eq. (5), we obtain a reduced-form labor supply equation:

$$w_{a,0} = \kappa l_{a,0}, \text{ where } \kappa = \frac{\lambda\varphi}{1 - \lambda\eta(1 - \alpha^N)}. \quad (10)$$

Here,  $\kappa$  is a composite wage adjustment parameter that combines the effect of inverse wage stickiness,  $\lambda$ , and the inverse labor supply elasticity,  $\varphi$ . The parameter also depends on the share of nontradables,  $\eta$ , and the share of labor in nontradables,  $1 - \alpha^N$ , because these parameters determine the extent to which a change in local nominal wages affects local prices and therefore local real wages.

Our key predictions correspond to the comparative statics as  $D_1^{old}$  changes to  $D_1^{new}$ . Since the benchmark we log-linearize around does not change, the first-order effect on local labor market outcomes is characterized by changes in log-deviations. We solve for these changes as follows (see Appendix B.5):

$$\Delta(w_{a,0} + l_{a,0}) = \frac{1 + \kappa}{1 + \kappa\zeta} \mathcal{M} (1 - \alpha^N) \eta \frac{1}{1 + \delta} \frac{x_{a,0} \Delta Q_0}{\bar{W} \bar{L}_0}, \quad (11)$$

$$\Delta l_{a,0} = \frac{1}{1 + \kappa} \Delta(w_{a,0} + l_{a,0}), \quad (12)$$

$$\Delta(w_{a,0} + l_{a,0}^N) = \mathcal{M} \frac{1}{1 + \delta} \left[ (1 - \bar{\alpha}) \frac{x_{a,0} \Delta Q_0}{\bar{W} \bar{L}_0} + (1 - \alpha^T) (1 - \eta) \Delta(w_{a,0} + l_{a,0}^T) \right], \quad (13)$$

$$\Delta(w_{a,0} + l_{a,0}^T) = -(\varepsilon - 1) (1 - \alpha^T) \Delta w_{a,0}, \quad (14)$$

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*quantitative* effects on local labor market outcomes as in our baseline model.

$$\text{where } \mathcal{M} = \frac{1}{1 - (1 - \alpha^N) \eta / (1 + \delta)}$$

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

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,  $\frac{x_0 \Delta Q_0}{WL_0}$ , affects the (relative) local labor market outcomes in the area.

These equations are intuitive. Eq. (11) 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  $1/(1 + \delta)$  dollars of additional total spending (cf. Eq. (6)), of which  $\eta/(1 + \delta)$  is spent on nontradable goods produced locally. The increase in spending, in turn, increases the local labor bill by  $(1 - \alpha^N) \eta / (1 + \delta)$  dollars. This direct effect gets amplified by the local Keynesian income multiplier, denoted by  $\mathcal{M}$ . 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. (12) is a rearrangement of the reduced-form labor supply equation in (10), which relates changes in labor to changes in the labor bill according to the wage adjustment parameter,  $\kappa$ . In particular, how much employment responds relative to the total labor bill (given a change in stock wealth) will discipline  $\kappa$  in our calibration exercise.

Eqs. (13) and (14) characterize the effects on the labor bill separately for the nontradable 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,  $\Delta (w_{a,0} + l_{a,0}^T) = 0$ . The coefficient multiplying the wealth change for the nontradable labor bill can be decomposed into three terms: the partial equilibrium MPC out of stock market wealth  $1/(1 + \delta)$ , the weighted average labor share of income  $1 - \bar{\alpha}$ , and the local multiplier  $\mathcal{M}$ . In Section 6 we use this decomposition to recover the partial equilibrium MPC given externally calibrated  $1 - \bar{\alpha}$  and  $\mathcal{M}$ . Notably, the expression does not require information on the share of nontradables in spending,  $\eta$ , or the share of labor in the nontradable sector,  $1 - \alpha^N$  (see Section 6 for the intuition).

When  $\varepsilon \neq 1$ , the decomposition for the nontradable sector does not hold exactly. In this case, as illustrated by Eq. (14), the stock wealth shock can affect the tradable labor bill if it has an effect on wages. As illustrated by Eq. (13), this affects local households' income



and, therefore, creates knock-on effects in the nontradable sector (captured by the additional term in brackets). However, if wages do not adjust much, then the tradable adjustment has a small impact on the analysis even when  $\varepsilon$  is somewhat different from 1.

## 5.5 Summary and Mapping into the Empirical Analysis

According to Eqs. (11) to (14), 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 employment, total employment, and wages weakly increase, and tradable employment 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  $S_{a,0} \equiv \frac{x_{a,0}Q_0}{WL_0}$  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:

$$S_{a,0}R_0 = \frac{x_{a,0}\Delta Q_0}{WL_0}. \quad (15)$$

This variable corresponds to our main regressor, the change in the stock wealth of the area normalized by the local labor bill. Eqs. (11) to (14) illustrate that the empirical coefficients using this regressor have a tight mapping into the key parameters of the model.<sup>33</sup> We next exploit this mapping and provide a structural interpretation of our empirical findings.<sup>34</sup>

## 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,  $\frac{1}{1+\delta}$ , and the degree of wage adjustment,  $\kappa$ . We only need two model equations to recover these parameters. Therefore,

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<sup>33</sup>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 heterogeneous risky portfolios and thus heterogeneous stock returns,  $R_{a,0}$ . Eqs. (11) to (14) would naturally generalize to a richer setting that features multiple risky assets and heterogeneous portfolios.

<sup>34</sup>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).

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 3, 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  $\varepsilon = 1$ . To facilitate interpretation, we rewrite Eq. (13) as:

$$\begin{aligned} \Delta(w_{a,0} + l_{a,0}^N) &= \mathcal{M}(1 - \bar{\alpha})\rho \times S_{a,0}R_0, \\ \text{where } \rho &= \frac{1}{\mathbb{T}} \frac{1}{1 + \delta} \text{ and } S_{a,0} = \frac{x_{a,0}Q_0}{\overline{WL}_0/\mathbb{T}}, R_0 = \frac{\Delta Q_0}{Q_0}. \end{aligned} \quad (16)$$

Here, we have introduced the change of variables  $\frac{1}{1+\delta} = \rho\mathbb{T}$ , where we interpret  $\rho$  as the stock market wealth effect *per year* and  $\mathbb{T}$  as the length of period 0 in years. Thus, the denominator of  $S_{a,0}$ ,  $\frac{\overline{WL}_0}{\mathbb{T}}$ , equals the labor bill *per year* as in the empirical implementation, and the empirical coefficient maps into the stock wealth effect *per year*. In particular, the empirical coefficient can be decomposed into the product of three terms:  $\rho$ , the partial equilibrium MPC out of stock market wealth, the weighted-average labor share of income  $1 - \bar{\alpha}$ , 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,  $1 - \bar{\alpha} = 2/3$ , and adjust other parameters to achieve a multiplier  $\mathcal{M} = 1.5$ , in line with empirical estimates (Nakamura and Steinsson, 2014; Chodorow-Reich, 2019).<sup>35</sup> We then calculate  $\rho$  by combining Eq. (16) with the empirical coefficient for the nontradable labor bill.

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

$$\mathcal{M}(1 - \bar{\alpha})\rho = \frac{\Delta(w_{a,0} + l_{a,0}^N)}{S_{a,0}R_0} = 3.23\%. \quad (17)$$

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<sup>35</sup>To see how we calibrate the multiplier, note that the change of variables in (16) creates one free parameter,  $\mathbb{T}$ . This parameter is not very meaningful since our model has stylized time periods (it has only two periods). The parameter affects the analysis mainly through its impact on the local multiplier, which is given by:

$$\mathcal{M} = \frac{1}{1 - (1 - \alpha^N)\eta/(1 + \delta)} = \frac{1}{1 - (1 - \alpha^N)\eta\rho\mathbb{T}}.$$

Therefore, we use  $\mathbb{T}$  to calibrate the local multiplier as  $\mathcal{M} = 1.5$  given all other parameters. We avoid a literal interpretation of  $\mathbb{T}$  and view it as a stand in for other features, such as borrowing constraints, which would affect  $\mathcal{M}$  in richer models (see Appendix B.6 for intuition about why  $\mathbb{T}$  affects  $\mathcal{M}$  in our model).

Substituting  $1 - \bar{\alpha} = 2/3$  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 four 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,  $\eta$ , or the labor share in the nontradable sector,  $1 - \alpha^N$ . To understand why, rewrite Eq. (16) as:

$$\frac{\Delta (W_{a,0}L_{a,0}^N/\mathbb{T})}{\overline{WL}_0^N/\mathbb{T}} = \mathcal{M}\rho (1 - \alpha^N) \eta (x_{a,0}\Delta Q_0) \quad \text{where} \quad \frac{\overline{WL}_0^N}{\overline{WL}_0} = \eta \frac{1 - \alpha^N}{1 - \bar{\alpha}}. \quad (18)$$

This expression illustrates that the effect of stock market wealth on the nontradable labor bill *in dollars*,  $\Delta (W_{a,0}L_{a,0}^N/\mathbb{T})$ , does depend on both  $\eta$  and  $1 - \alpha^N$ . However, with homothetic preferences and production across sectors, we have  $\frac{\overline{WL}_0^N}{\overline{WL}_0} = \eta \frac{1 - \alpha^N}{1 - \bar{\alpha}}$ : 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. (16) normalizes the stock wealth change with the total labor bill,  $\eta$  and  $1 - \alpha^N$  drop out of the equation. Intuitively, with homothetic preferences these sectors' *average* share of the labor bill proxies for their *marginal* share of changes in the labor bill. As a consequence, the decomposition in (16) is robust to the nontradable spending share as well as the sectoral differences in labor share.<sup>36</sup> Moreover, since the decomposition does not depend on  $\eta$ , we can use it as long as we observe the response in a subset of nontradable sectors.

Third, when  $\varepsilon \neq 1$ , Eq. (16) applies up to an adjustment (see Eq. (13)). 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

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<sup>36</sup> Eq. (18) suggests the decomposition is also robust to (certain types of) cross-county heterogeneity in labor shares. For instance, suppose that areas with high stock wealth ( $x_{a,0} > 0$ ) feature greater labor share in nontradables ( $1 - \alpha_a^N > 1 - \alpha^N$ )—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 ( $\overline{WL}_{a,0}^N > \overline{WL}_0^N$ ). As long as the average labor bill is proportional to the labor share,  $\frac{\overline{WL}_{a,0}^N}{\overline{WL}_0^N} = \eta \frac{1 - \alpha_a^N}{1 - \alpha_a^N}$ , Eq. (18) would still give the decomposition in (16).

analysis by much even if  $\varepsilon$  is somewhat different from 1. In practice, the value we obtain for  $\kappa$  (described next) implies that there is little loss of generality in ignoring this adjustment for empirically reasonable levels of  $\varepsilon$ , 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.<sup>37</sup>

Fourth, we can compare the  $\rho$  of 3.23 obtained from Eq. (17) to the  $\rho$  implied by the estimation using state-level consumption data. Following similar steps as in the derivation of Eq. (17), we obtain (see Eq. (B.67) in the appendix)

$$\Delta(p_{a,0} + c_{a,0}) = \mathcal{M}\rho \times S_{a,0}^C R_0. \quad (19)$$

Here,  $p_{a,0} + c_{a,0}$  denotes log nominal consumption expenditure and  $S_{a,0}^C = \frac{x_{a,0}Q_0}{P_0C_0}$  denotes the ratio of area  $a$ 's (relative) stock wealth to its consumption expenditure. Notably, the labor share does not enter into Eq. (19). Using  $\mathcal{M} = 1.5$  and the coefficient from Table 5, we obtain a nearly identical  $\rho$  of  $4.82/1.5 = 3.21$ .

## 6.2 Wage Adjustment

We use Eq. (12) to determine the wage adjustment parameter  $\kappa$ ,

$$\Delta l_{a,0} = \frac{1}{1 + \kappa} \Delta(w_{a,0} + l_{a,0}) . \quad (20)$$

Recall that  $\kappa$  is a composite parameter that combines inverse wage stickiness and inverse labor supply elasticity [cf. Eq. (10)]. 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:

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

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<sup>37</sup>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  $\rho$  also depends on the share of tradables,  $\eta$ . We allow this parameter to vary over a relatively large range,  $\eta \in [0.5, 0.8]$ , and show that the implied  $\rho$  remains within 5% of its baseline level. As expected, the greatest deviations from the baseline occur when  $\eta$  is low (that is, when the area is more open).

Combining these with Eq. (20), we obtain:

$$\kappa = 0.9. \tag{21}$$

Thus, a one percent change in labor is associated with a 0.9% change in wages at a horizon of two years.<sup>38</sup>

## 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 employment 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 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, since the aggregate spending multiplier is greater than the local multiplier, we can bound the aggregate effect from below. 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.

Our aggregation result for labor combines this finding with a third observation: since labor markets are local, the structural labor supply equation (5) remains unchanged as we switch from local to aggregate analysis (as emphasized by Beraja et al. (2016)). The reduced form labor supply equation in (10) changes slightly because shocks impact aggregate inflation and local inflation differently.

To establish these results formally, consider the model from Section 5, but assume that monetary policy keeps the nominal interest rate at a constant level,  $R^f = \bar{R}^f$ .<sup>39</sup> Appendix

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<sup>38</sup>We can also estimate  $\kappa$  from the response of tradable employment [cf. Eq. (B.66)]. Intuitively, tradable employment declines only insofar as local wages and prices rise, so the response of  $l^T$  provides information about  $\kappa$ . 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  $\kappa$ .

<sup>39</sup>As before, monetary policy stabilizes the long-run wage level at the constant level,  $\bar{W}$ .

B.7 extends our theoretical analysis to this case. The aggregate equilibrium with a fixed interest rate is described by the tuple,  $(Q_0, L_0, W_0, P_0)$ , that solves four equations provided in Appendix B.7. These equations illustrate that changes in the expected productivity of capital,  $D_1$ , affect not only the price of capital—as in the baseline model—but also aggregate income, employment, wages, and prices.

To characterize these effects further and to compare them with their local equilibrium counterparts, we log-linearize the equilibrium around the frictionless benchmark. Specifically, we let  $\bar{D}_1$  denote the level of capital productivity such that  $\bar{R}^f = R^{f,*}$  given  $\bar{D}_1$ . Considering the equilibrium variables as a function of  $D_1$ , and log-linearizing around  $D_1 = \bar{D}_1$ , we obtain the following equations for the aggregate labor bill and labor:

$$\Delta(w_0 + l_0) = \mathcal{M}^A (1 - \bar{\alpha}) \frac{1}{1 + \delta} \frac{\Delta Q_0^A}{\bar{W} \bar{L}_0}, \quad (22)$$

$$\Delta l_0 = \frac{1}{1 + \kappa^A} \Delta(w_0 + l_0), \quad (23)$$

$$\text{where } \mathcal{M}^A \equiv \frac{1}{1 - 1/(1 + \delta)} \frac{1 + \kappa^A}{1 - \bar{\alpha} + \kappa^A}$$

$$\text{and } \kappa^A \equiv \frac{\lambda \varphi}{1 - \lambda}.$$

Here,  $l_0 = \log(L_0/\bar{L}_0)$  and  $w_0 = \log(W_0/\bar{W})$  denote log deviations of aggregate employment and wages from the frictionless benchmark. The variable  $Q_0^A$  is the log-linear approximation to the exogenous part of stock wealth,  $\frac{\bar{W} D_1}{\bar{R}^f}$ .<sup>40</sup> As before,  $\Delta y \equiv y^{new} - y^{old}$  denotes the change in equilibrium variable  $y$  when expected future dividends change. Hence, Eqs. (22) and (23) describe the effect of a change in stock wealth on aggregate labor market outcomes. The parameter  $\mathcal{M}^A$  captures the aggregate multiplier. The parameter  $\kappa^A$  captures the degree of aggregate wage adjustment.

Eq. (22) shows that the effect on the aggregate labor bill closely parallels its local counterpart (Eq. (12)), with three differences. First, the direct spending effect is greater in the aggregate than at the local level,  $\frac{1 - \bar{\alpha}}{1 - \delta} > \frac{(1 - \alpha^N) \eta}{1 - \delta}$ . 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 greater than the local multiplier,  $\mathcal{M}^A > \mathcal{M}$ , because spending on tradables (as

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<sup>40</sup>The stock price satisfies  $Q_0 = W_0 D_0 + \frac{\bar{W} D_1}{\bar{R}^f}$ . In this setting, a one dollar increase in  $\frac{\bar{W} D_1}{\bar{R}^f}$  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 the rental rate of capital,  $W_0 D_0$ . 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.

well as the mobile factor, capital) diminish the local but not the aggregate multiplier.<sup>41</sup>

Likewise, Eq. (23) shows that the reduced-form labor supply equation closely parallels its local counterpart (cf. Eqs. (12) and (10)). In fact, since labor markets are local, the structural labor supply equation (5) that features prices and labor does not change as we switch from local to aggregate analysis. However, while the aggregate price level moves one-for-one with wages,  $p_0 = w_0$ , the price level for local consumption does not, since the prices of tradable goods and capital are determined nationally,  $p_{a,0} = w_{a,0}\eta(1 - \alpha^N)$  [cf. Eq. (9)]. Therefore, the real wage  $w - p$  responds locally but not in the aggregate. The real wage response generates a neoclassical local labor supply response, with strength determined by the magnitude of the Frish elasticity  $1/\varphi$ , that does not extend to the aggregate level. Rewriting the expressions for  $\kappa$  and  $\kappa^A$  to eliminate the wage stickiness parameter,  $\lambda$ , we obtain:

$$\frac{1}{\kappa} = \frac{1}{\varphi} (1 - \eta(1 - \alpha^N)) + \frac{1}{\kappa^A}. \quad (24)$$

This expression illustrates that the local labor response,  $\frac{1}{\kappa}$ , combines a neoclassical response to higher real wages,  $\frac{1}{\varphi}(1 - \eta(1 - \alpha^N))$ , that only occurs locally, and a term due to wage stickiness that extends to the aggregate,  $\frac{1}{\kappa^A}$ .

We now use our estimates for the local effects to quantify the aggregate effects on the labor market. We first use Eq. (22) to quantify the effect on the aggregate labor bill. Using the change of variables,  $\frac{1}{1+\delta} = \rho\mathbb{T}$ , we rewrite this equation as follows:

$$\begin{aligned} \Delta(w_0 + l_0) &= \mathcal{M}^A(1 - \bar{\alpha})\rho \times S_0^A R_0^A \\ \text{where } S_0^A &= \frac{Q_0^A}{\overline{W}L_0/\mathbb{T}} \text{ and } R_0^A = \frac{\Delta Q_0^A}{Q_0^A}. \end{aligned} \quad (25)$$

We define  $S^A$  as the ratio of aggregate stock wealth to the aggregate yearly labor bill, and  $R^A$  as the shock to stock valuations. Hence,  $S_0^A R_0^A$  is the aggregate analog of  $S_{a,0}R_0$  from the local analysis.

The coefficient in Eq. (25) is the same as its local counterpart in Eq. (16) 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

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<sup>41</sup>The aggregate spending multiplier is captured by the term  $\tilde{\mathcal{M}}^A \equiv \frac{1}{1-1/(1+\delta)}$ , which exceeds the local multiplier  $\mathcal{M} = \frac{1}{1-(1-\alpha^N)\eta/(1+\delta)}$ . In our setting, there is also a second multiplier effect in the aggregate, captured by the term  $\mathcal{F}^A \equiv \frac{1+\kappa^A}{1-\bar{\alpha}+\kappa^A} > 1$ . This effect emerges because demand-driven fluctuations in our model are absorbed by labor only. We refer to  $\mathcal{F}^A$  as *the factor-share multiplier*. The composite multiplier,  $\mathcal{M}^A = \mathcal{F}^A \tilde{\mathcal{M}}^A$ , combines the standard spending multiplier with the factor-share multiplier. Our model is too stylized to provide an exact mapping between the local and aggregate multipliers. The inequality  $\frac{\mathcal{M}^A}{\mathcal{M}} \geq 1$  is a robust feature of settings with constrained monetary policy (Chodorow-Reich, 2019).

bill (for quarter 7) with the inequality  $\frac{\mathcal{M}^A}{\mathcal{M}} \geq 1$  to bound the coefficient from below:

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

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 on the labor bill in *all* sectors. In particular, the proportional change of the labor bill in the nontradable sectors—which we estimate with our local labor market approach—is the same as the proportional change of the labor bill in the tradable sectors, which we cannot estimate directly due to demand slippage to other regions. Importantly, while clearly convenient for aggregation, the homotheticity assumption also has empirical grounding, as we demonstrated in Section 4.5.

We next quantify the effect on aggregate labor. Using Eqs. (21) and (24) and setting the Frisch elasticity  $\varphi^{-1}$  to 0.5 (Chetty et al., 2012), the nontradable labor share  $1 - \alpha^N$  to  $2/3$  (a conservative value), and the nontradable share  $\eta$  to 0.5 (a conservative value), yields  $\kappa^A = 1.3$ .<sup>42</sup> Then, Eqs. (23) and (25) imply:

$$\Delta l_0 = \frac{1}{1 + \kappa^A} \Delta (w_0 + l_0) = \frac{1}{1 + \kappa^A} \mathcal{M}^A (1 - \bar{\alpha}) \rho \times S_0^A R_0^A. \quad (26)$$

Substituting in the value of  $\kappa^A$  and the response of the labor bill, we obtain:

$$\frac{1}{1 + \kappa^A} \mathcal{M}^A (1 - \bar{\alpha}) \rho \geq \frac{3.23\%}{1 + 1.3} \frac{\mathcal{M}^A}{\mathcal{M}} \geq 1.4\%.$$

Therefore, a one dollar increase in stock valuations increases aggregate labor (total hours worked) by the equivalent of at least 1.4 cents (i.e. the labor bill for the additional hours worked is at least 1.4 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  $S^A = 2.67$ .<sup>43</sup> Substituting this value into

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<sup>42</sup>As we have emphasized, the nontradable share of consumption expenditure  $\eta$  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.

<sup>43</sup>This value coincides almost exactly with the corresponding ratio of 2.63 obtained using C-corporation



Eqs. (25) and (26), we obtain:

$$\begin{aligned}\Delta(w_0 + l_0) &= 3.23\% \frac{\mathcal{M}^A}{\mathcal{M}} \times 2.67 \times R_0^A \geq 8.6\% \times R_0^A, \\ \Delta l_0 &\geq 1.4\% \frac{\mathcal{M}^A}{\mathcal{M}} \times 2.67 \times R_0^A \geq 3.73\% \times R_0^A.\end{aligned}$$

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 0.75%, at a horizon of two years.<sup>44</sup>

## 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. We use 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 0.75% two years after the shock.

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 (Kuang, 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, Kermani and Majlesi

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equity wealth in the FAUS and total wages and salaries in NIPA. This value has increased to 2.89 in 2018.

<sup>44</sup> 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 (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%.

(forthcoming), who argue that Swedish households respond to capital gains significantly less than they respond to dividend payouts.

Our *regional* analysis complements household-level studies of the stock wealth effect by providing direct evidence of stock market affecting labor market outcomes—a key concern for monetary policymakers. Our findings 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)). 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 (forthcoming) 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 of recent years—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 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, forthcoming). 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.<sup>1</sup> 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.<sup>2</sup>

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<sup>1</sup>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>.

<sup>2</sup>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.<sup>3</sup> 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.<sup>4</sup> 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

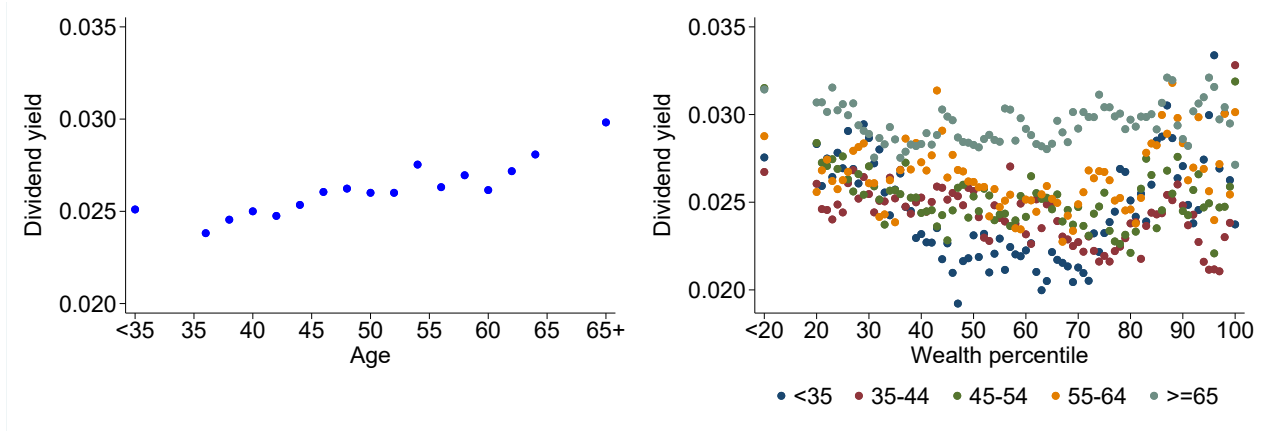
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change little if we do not exclude the 74 counties from the analysis. For example, the coefficient for total payroll at the 7 quarter horizon changes from 2.18 to 2.27 (s.e.=0.67), and the coefficient for nontradable payroll changes from 3.23 to 2.67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

<sup>3</sup>We are grateful to Marco Di Maggio, Amir Kermani, and Kaveh Majlesi for sharing their codes.

<sup>4</sup>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  $R^2$ s 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.<sup>5</sup>

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. 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.<sup>6</sup>

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 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

<sup>5</sup>The age bin coefficients shift uniformly up by 0.37 to 0.38, reflecting the incorporation of average wealth.

<sup>6</sup>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** (0.16)	2.21** (0.19)	2.28** (0.25)	2.51** (0.18)	2.45** (0.11)	2.83** (0.15)
Age 35-44	2.48** (0.11)	2.25** (0.16)	2.43** (0.18)	2.50** (0.14)	2.43** (0.08)	2.81** (0.12)
Age 45-54	2.65** (0.16)	2.27** (0.09)	2.51** (0.30)	2.50** (0.08)	2.49** (0.08)	2.86** (0.13)
Age 55-64	3.00** (0.11)	2.39** (0.14)	2.40** (0.20)	2.82** (0.10)	2.69** (0.08)	3.07** (0.13)
Age 65+	2.91** (0.12)	2.73** (0.12)	2.96** (0.17)	3.27** (0.11)	3.03** (0.07)	3.40** (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

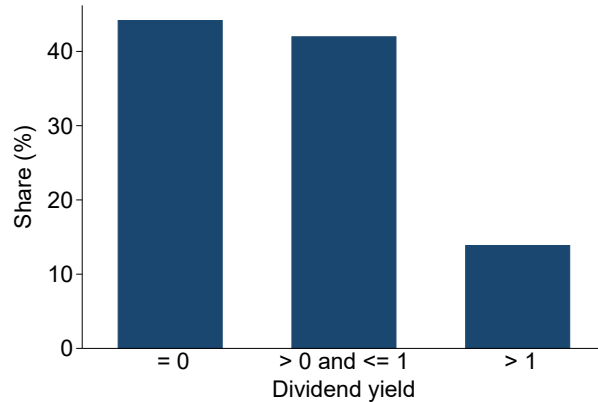
Notes: The table reports the coefficients from a regression of the account dividend yield on the variables indicated, at the account-month level. Standard errors in parentheses clustered by account. For readability, all coefficients multiplied by 100.

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.<sup>7</sup> 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 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

<sup>7</sup>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.

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.<sup>8</sup> 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.

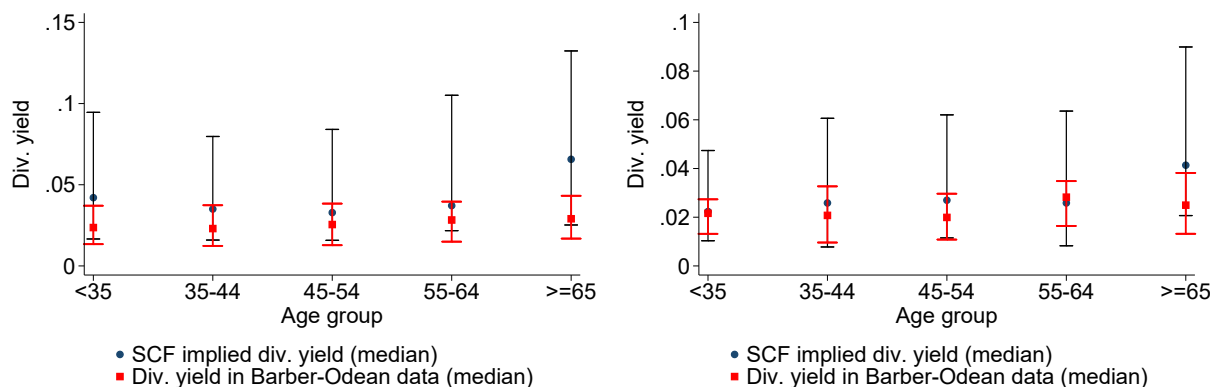
We begin by plotting in Figure A.4 the distribution of household holdings of corporate equity between taxable (directly held and non-IRA mutual fund) and non-taxable accounts using data from the Financial Accounts of the United States. Roughly 2/3 of corporate equity owned by households is held in taxable accounts.<sup>9</sup>

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

<sup>8</sup>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.

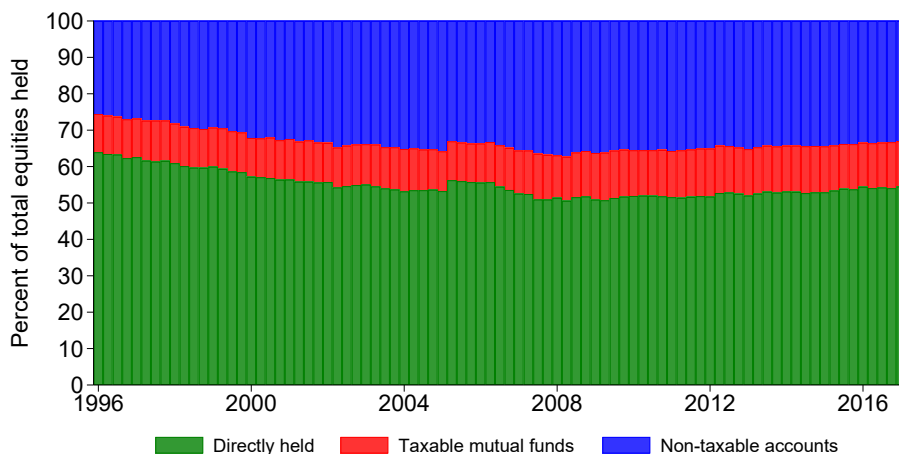
<sup>9</sup>Non-taxable retirement accounts here include only defined contribution accounts and exclude equity holdings of defined benefit plans. This definition accords with our empirical analysis since fluctuations in the market value of assets of defined benefit plans do not directly affect the future 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,  $\text{IRA mutual fund equity} = \text{IRA mutual funds at market value} \times \text{total equities held in mutual funds} / \text{total value of mutual funds}$  (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	$9.87 \times 10^8$
taxable stock wealth	65,428	1,001,526	0	$9.84 \times 10^8$

use the definition for stock-market wealth used in the Fed Bulletins.<sup>10</sup> 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 by domestic C-corporations.<sup>11</sup> This share never exceeds 7% of total equity, indicating that as a

<sup>10</sup>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".

<sup>11</sup>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



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

	(1)	(2)
Taxable stock wealth	1.09** (0.01)	1.08** (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.

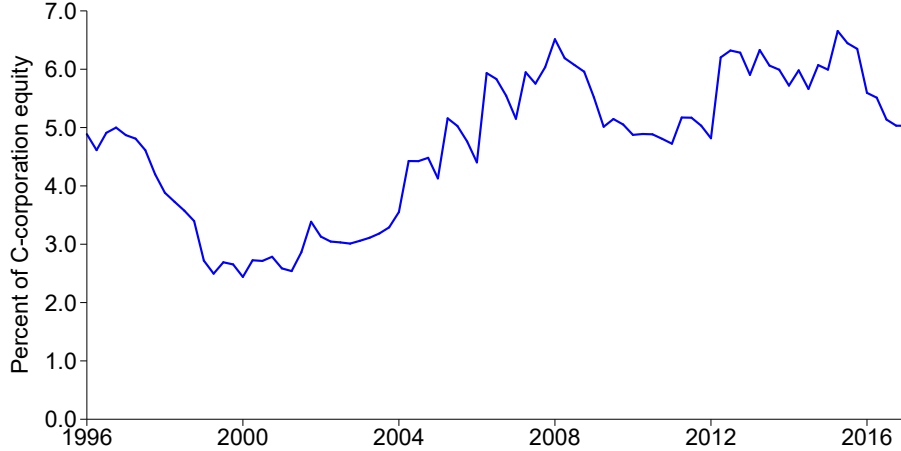
practical matter dividend income from non-public C-corporations is small. Moreover, as described in Appendix A.1 our baseline sample excludes a small number of counties with a substantial share of dividend income reported by late filers who disproportionately own closely-held corporations. Therefore, non-public C-corporation wealth does not appear to meaningfully affect our results.

### 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

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.

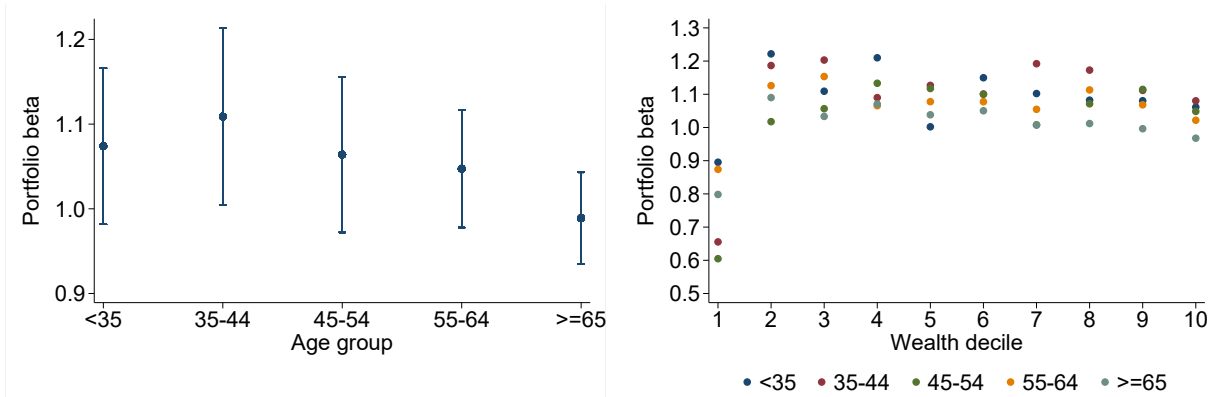
return characteristics across these same age groups. For example, it is well-known that stocks with higher dividend yields tend to be value stocks with a different return distribution than the stock market. Specifically, those stocks tend to have market betas below one. In that case the portfolio betas 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).<sup>12</sup> We then construct monthly returns for these portfolios by computing the weighted one-month return on the underlying CRSP assets.<sup>13</sup> 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 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.

<sup>12</sup>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.

<sup>13</sup>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.

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, 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

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.

of the resident population identifying themselves as white.<sup>14</sup> 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.

#### A.5 Responses by Category in the Consumer Expenditure Survey

This appendix describes our analysis of consumption responses by category 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

<sup>14</sup>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** (0.01)					0.09** (0.01)
Median age		0.10* (0.04)				-0.04* (0.02)
Retired (%)			0.12** (0.04)			0.31** (0.03)
Female (%)				0.19** (0.04)		-0.06* (0.03)
White (%)					-0.00 (0.00)	-0.02** (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.

of categories. While the survey does not ask directly about stock holdings, in the last interview it 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.<sup>15</sup>

The specification in Dynan and Maki (2001) is:

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

where  $\Delta \ln C_{i,t}$  is the log change in consumption expenditure by household  $i$  between the second and fifth CE interviews,<sup>16</sup>  $\Delta \ln W_{t-j}$  is the log change in the Wilshire 5000 between the recall periods

<sup>15</sup>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.

<sup>16</sup>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.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 <sup>+</sup>	-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 <sup>+</sup>	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 <sup>+</sup>	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 $\times$ 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.

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<sup>2</sup>, 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

Table A.7: Consumption Responses in the Consumer Expenditure Survey

	Non-durable goods and services		Retail and restaurants	
	<i>SH</i> (1)	Other (2)	<i>SH</i> (3)	Other (4)
Right hand side variables:				
Stock return	0.369** (0.133)	-0.015 (0.048)	0.198 (0.277)	-0.038 (0.100)
Lag 1	0.385* (0.151)	0.074 (0.053)	0.519+ (0.312)	0.121 (0.109)
Lag 2	0.252+ (0.134)	0.050 (0.047)	0.447 (0.278)	0.065 (0.097)
Lag 3	0.039 (0.103)	0.038 (0.037)	0.104 (0.220)	0.135+ (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<sup>2</sup>, 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.

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.

Table A.7 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 corre-

spondence to all purchases made at stores in the retail or restaurant sectors.<sup>17</sup> The cumulative consumption responses of purchases of goods from retail stores and at restaurants are very similar to the responses of total non-durable goods and services, albeit estimated with less precision.

Overall, these results provide support for our measure of local expenditure and of the homotheticity assumption we use to structural interpret our estimates. This conclusion holds even if one questions the causal identification of the Dynan and Maki (2001) framework, in which case one can interpret the relative responses across categories as reflective of general demand shocks rather than 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 of equilibrium. 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 valuations. 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 valuations (when monetary policy is passive) and compare the results with our earlier results on the cross-sectional effects. Finally, we consider two extensions of the baseline model. 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. In Section B.9, we extend the model to consider more general levels for the EIS parameter and discuss how it would affect our analysis.

### 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 are two periods  $t \in \{0, 1\}$ . We view period 1 as “the long run” over which wages are flexible and all factors are mobile across the areas. In the long run, outcomes will be determined by productivity. In contrast, period 0 corresponds to “the short run” over which wages are somewhat

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<sup>17</sup>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.



sticky and labor is not mobile. In this case, outcomes will be determined by aggregate demand. Hence, we interpret a period in the model as corresponding to several years.

Our focus is to understand how fluctuations in stock wealth affect cross-sectional and aggregate outcomes in the short run. To this end, we will generate endogenous changes in the price of capital in period 0 from exogenous changes to the productivity of capital in period 1. We interpret these changes as capturing stock price 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.** In every 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 (but labor is not mobile across areas in period 0 as we will describe later). We assume 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,

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

Here,  $L_{a,t}^N, K_{a,t}^N$  denotes the amount of area  $a$  labor and capital used to produce the nontradable good. The term  $1-\alpha^N$  captures the share of labor in the nontradable sector.

The tradable good can be produced in two ways. First, it can be produced as a composite of tradable inputs across areas, where each input is produced according to a standard Cobb-Douglas technology:

$$Y_t^T = \left( \int_a (Y_{a,t}^T)^{\frac{\varepsilon-1}{\varepsilon}} da \right)^{\frac{\varepsilon}{\varepsilon-1}} \quad (\text{B.2})$$

where  $Y_{a,t}^T = (K_{a,t}^T/\alpha^T)^{\alpha^T} (L_{a,t}^T/(1-\alpha^T))^{1-\alpha^T}$ .

Here,  $L_{a,t}^T, K_{a,t}^T$  denotes the amount of area  $a$  labor and capital used to produce the tradable good. 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).

Second, the tradable good can also be produced by another technology that uses only capital. This technology is linear,

$$\tilde{Y}_t^T = D_t^{1-\alpha^T} \tilde{K}_t^T. \quad (\text{B.3})$$

Here,  $\tilde{K}_t^T$  denotes the aggregate capital employed in the capital-only technology, and  $\tilde{Y}_t^T$  denotes the tradables produced via this technology (we use the tilde notation to distinguish them from  $K_t^T$  and  $Y_t^T$ ). The term,  $D_t^{1-\alpha^T}$ , captures the capital productivity in period  $t$ . The normalizing power

$1 - \alpha^T$  ensures that we obtain relatively simple expressions. As we will verify below, the rental rate (and thus, the price) of capital will depend on the productivity in the capital-only sector,  $D_t$ .

**Capital Supply.** In each period  $t$ , capital supply is exogenous,

$$K_t = \bar{K} \equiv 1 \text{ for each } t \in \{0, 1\}. \quad (\text{B.4})$$

To simplify the notation, we normalize the exogenous capital supply to one. Capital is perfectly mobile across areas in both periods (so its location is not important).

**Financial Assets.** There are two financial assets. First, there is a claim to capital (which we view as corresponding to the stock market). We let  $Q_0$  denote the nominal cum-dividend price of capital in period 0. Recall that the supply of capital is normalized to one and its nominal rental rate is denoted by  $R_t$ . Thus,  $Q_0 - R_0$  denotes the nominal ex-dividend price at the end of period 0.

Second, there is also a risk-free asset in zero net supply. We let  $R^f$  denote the nominal gross risk-free interest rate.

**Heterogeneous Ownership of Capital.** Households in different areas start with zero units of the risk-free asset but they can differ in their endowments of capital. Specifically, we let  $1 + x_{a,t}$  denote the share of aggregate capital held by investors in area  $a$  in period  $t$ . The initial shares,  $\{1 + x_{a,0}\}_a$ , are exogenous and can be heterogeneous. The common-wealth benchmark corresponds to the special case with  $x_{a,0} = 0$  for each  $a$ .

**Nominal Prices.** We let  $W_{a,t}$  and  $P_{a,t}^N$  denote, respectively, the nominal wage per unit of labor and the nominal price of the nontradable good in period  $t$  and area  $a$ . Likewise, we let  $R_t$  and  $P_t^T$  denote, respectively, the (nominal) rental rate of capital and the (nominal) price of the tradable good in period  $t$ .

Note that our assumption that labor is mobile across areas in period 1 implies that the nominal wage in period 1 is also the same across areas. We assume monetary policy stabilizes the nominal long-run wage at a constant level, that is:

$$W_{a,1} = \bar{W} \text{ for each } a. \quad (\text{B.5})$$

**Households' Optimization Decisions.** The representative household in each area separates its consumption and labor choices as follows. At the beginning of period 0, the household splits into a consumer and a continuum of workers. The consumer makes consumption-saving decisions and the workers choose labor supply. At the end of the period the household recombines and makes a portfolio decision to allocate savings between capital (stock wealth) and the risk-free asset.<sup>18</sup>

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<sup>18</sup>Without loss of generality, we allow the consumer to make the portfolio decision as well.

We choose to model consumption and labor decisions separately for two reasons. First, assuming workers choose labor according to Greenwood et al. (1988) (GHH) preferences allows us to ignore the wealth effects of labor supply. Second, we can endow consumers with standard time-separable preferences. In addition to simplifying the subsequent expressions, this setup accords with the fact that workers hold relatively little stock market wealth. At the same time, we sidestep some consequences of GHH preferences, such as leading to unplausibly large fiscal and monetary multipliers (Auclert and Rognlie, 2017)

**Consumption-Saving and Portfolio Choice Problem.** The household in area  $a$  divides its consumption  $C_{a,t}$  between the tradable good,  $C_{a,t}^T$ , and the nontradable good,  $C_{a,t}^N$ , according to the intra-period preferences:

$$C_{a,t} = (C_{a,t}^N/\eta)^\eta (C_{a,t}^T/(1-\eta))^{1-\eta}. \quad (\text{B.6})$$

With this normalization, the ideal price index is given by,

$$P_{a,t} \equiv (P_{a,t}^N)^\eta (P_{a,t}^T)^{1-\eta}. \quad (\text{B.7})$$

Households can be thought of as choosing the consumption aggregator  $C_{a,t}$  at these prices. They then distribute their spending optimally across the two sectors. The optimal expenditure on each sector satisfies,

$$P_{a,t}^N C_{a,t}^N = \eta P_{a,t} C_{a,t} \text{ and } P_{a,t}^T C_{a,t}^T = (1-\eta) P_{a,t} C_{a,t}. \quad (\text{B.8})$$

The household in area  $a$  chooses how much to consume and save and how to allocate savings across capital and the risk-free asset. The consumer's problem can then be written as,

$$\begin{aligned} \max_{C_{a,0,1+x_{a,1}}} \quad & \log C_{a,0} + \delta \log C_{a,1} & (\text{B.9}) \\ P_{a,0} C_{a,0} + S_{a,0} = & W_{a,0} L_{a,0} + (1+x_{a,0}) Q_0, \\ S_{a,0} = S_{a,0}^f + & (1+x_{a,1})(Q_0 - R_0) \\ P_{a,1} C_{a,1} = \overline{W} \overline{L}_1 + & (1+x_{a,1}) R_1 + S_{a,0}^f R^f. \end{aligned}$$

Here,  $1+x_{a,1}$  denotes the units of capital that the household purchases. This purchase costs  $(1+x_{a,1})(Q_0 - R_0)$  units of the consumption good in period 0. Households invest the rest of their savings,  $S_{a,0}^f = S_{a,0} - (1+x_{a,1})(Q_0 - R_0)$ , in the risk-free asset.

**Labor Supply Problem.** In period 1, the labor supply is exogenous (and constant across areas), that is:

$$L_{a,1} = \overline{L}_1 \text{ for each } a. \quad (\text{B.10})$$

In period 0, the labor supply is endogenous. For the purpose of endogenizing the labor supply,

we work with a GHH functional form for the intraperiod preferences between consumption and labor that eliminates the wealth effects on the labor supply. These effects seem counterfactual for business cycle analysis in general (Galí (2011)). In our context, they are likely to be insignificant also because stock wealth is a relatively small fraction of total household wealth (including human capital wealth).

Specifically, in each area the representative household consists of a continuum of workers denoted by  $\nu \in [0, 1]$ . The workers provide specialized labor services. They set their individual wages and labor supply to maximize the intra-period utility function:

$$\log \left( C_{a,0} - \chi \int_0^1 \frac{(L_{a,0}(\nu))^{1+\varphi}}{1+\varphi} d\nu \right). \quad (\text{B.11})$$

Here,  $C_{a,0}$  denotes the composite of nontradable and tradable goods as in the main model and  $L_{a,0}(\nu)$  denotes the labor supply by worker  $\nu$  who specializes in providing a particular type of labor service. The parameter,  $\varphi$ , captures the inverse Frisch elasticity of the labor supply; and the parameter,  $\chi$ , captures the disutility from labor. The intraperiod budget constraint is given by:

$$P_{a,0}C_{a,0} + S_{a,0} = \int_0^1 W_{a,0}(\nu) L_{a,0}(\nu) d\nu + (1 + x_{a,0}) Q_0. \quad (\text{B.12})$$

Here,  $P_{a,0}$  denotes the ideal price index over nontradable and tradable goods.

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

$$L_{a,0} = \left( \int_0^1 L_{a,0}(\nu)^{\frac{\varepsilon_w - 1}{\varepsilon_w}} d\nu \right)^{\frac{\varepsilon_w}{\varepsilon_w - 1}}.$$

This leads to the labor demand equation:

$$L_{a,0}(\nu) = \left( \frac{W_{a,0}(\nu)}{W_{a,0}} \right)^{-\varepsilon_w} L_{a,0} \quad (\text{B.13})$$

$$\text{where } W_{a,0} = \left( \int_0^1 W_{a,0}(\nu)^{1-\varepsilon_w} d\nu \right)^{1/(1-\varepsilon_w)}. \quad (\text{B.14})$$

Here,  $L_{a,0}$  denotes the aggregate equilibrium labor provided by the intermediate firm, which is the same as the labor supply in the main text.

In period 0, a fraction of the workers in an area,  $\lambda_w$ , reset their wages to maximize the intra-period utility function in (B.11) subject to the labor demand equation in (B.13) and the budget constraints in (B.12). The remaining fraction,  $1 - \lambda_w$ , have preset wages given by  $\bar{W}$  (which is the same as the long-run wage level for simplicity).

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

also ensures:

$$\int_0^1 W_{a,0}(\nu) L_{a,0}(\nu) d\nu = W_{a,0} L_{a,0}.$$

Substituting this into Eq. (B.12), we obtain the budget constraint in problem (B.9) stated earlier.

**Optimal Wage Setting and the Wage Phillips Curve.** First consider the flexible workers that reset their wages in period 0. These workers optimally choose  $(W_{a,0}^{flex}, L_{a,0}^{flex})$  that satisfy:

$$W_{a,0}^{flex} \equiv P_{a,0} \frac{\varepsilon_w}{\varepsilon_w - 1} MRS_{a,0} \quad (B.15)$$

$$\text{where } MRS_{a,0} = \chi \left( L_{a,0}^{flex} \right)^\varphi \text{ and } L_{a,0}^{flex} = \left( \frac{W_{a,0}^{flex}}{W_{a,0}} \right)^{-\varepsilon_w} L_{a,0}$$

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  $W_{a,0}^{flex}$  appears on both side of Eq. (B.15). Solving for the fixed point, we further obtain:

$$\left( W_{a,0}^{flex} \right)^{1+\varphi\varepsilon_w} = \frac{\varepsilon_w}{\varepsilon_w - 1} \chi P_{a,0} W_{a,0}^{\varepsilon_w\varphi} L_{a,0}^\varphi. \quad (B.16)$$

Next consider the sticky workers. These workers have preset wages,  $\bar{W}$ , and they provide the labor services demanded at these wages.

Next we use (B.14) to obtain an expression for the aggregate wage level:

$$\begin{aligned} W_{a,0} &= \left( \lambda_w \left( W_{a,0}^{flex} \right)^{1-\varepsilon_w} + (1 - \lambda_w) \bar{W}^{1-\varepsilon_w} \right)^{1/(1-\varepsilon_w)} \\ &= \left( \lambda_w \left( \frac{\varepsilon_w}{\varepsilon_w - 1} \chi W_{a,0}^{\varepsilon_w\varphi} P_{a,0} L_{a,0}^\varphi \right)^{(1-\varepsilon_w)/(1+\varphi\varepsilon_w)} + (1 - \lambda_w) \bar{W}^{1-\varepsilon_w} \right)^{1/(1-\varepsilon_w)}. \end{aligned} \quad (B.17)$$

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). As we show in Section B.4 below, log-linearizing Eq. (B.17) leads to Eq. (5) in the main text. Eq. (B.17) illustrates that greater employment in an area,  $L_{a,0}$ , creates wage pressure. The amount of pressure depends positively on the fraction of flexible workers,  $\lambda_w$ , and negatively on the labor supply elasticity,  $1/\varphi$ , as well as on the elasticity of substitution across labor types,  $\varepsilon_w$ . An increase in the local price index,  $P_{a,0}$ , also creates wage pressure.

It is also instructive to consider the special case in which wages are fully flexible,  $\lambda_w = 1$ . In this case, all workers set the same wage, which implies  $W_{a,0}^{flex} = W_{a,0}$ . Using this observation Eq.

(B.17) becomes:

$$\frac{W_{a,0}}{P_{a,0}} = \frac{\varepsilon_w}{\varepsilon_w - 1} \chi L_{a,0}^\varphi. \quad (\text{B.18})$$

Hence, the frictionless labor supply in each area  $a$  is described by a neoclassical intratemporal optimality condition. In particular, real wage is a constant markup over the MRS between labor and consumption.

**Market Clearing Conditions.** The market clearing condition for nontradable goods and the tradable good can be written as, respectively,

$$Y_{a,t}^N = C_{a,t}^N \quad (\text{B.19})$$

$$Y_t^T + \tilde{Y}_t^T = \int_a C_{a,1}^T da. \quad (\text{B.20})$$

Here,  $Y_{a,t}^N, Y_t^T, \tilde{Y}_t^T$  are given by Eqs. (B.1 – B.3).

Labor and capital market clearing conditions for period 0 can be written as,

$$L_{a,0} = L_{a,0}^N + L_{a,0}^T \text{ for each } a \quad (\text{B.21})$$

$$\bar{K} = 1 = \int_a \left( K_{a,0}^N + K_{a,0}^T + \tilde{K}_{a,0} \right) da. \quad (\text{B.22})$$

The analogous conditions for period 1 can be written as,

$$\bar{L}_1 = \int_a \left( L_{a,1}^N + L_{a,1}^T \right) da \quad (\text{B.23})$$

$$\bar{K} = 1 = \int_a \left( K_{a,1}^N + K_{a,1}^T + \tilde{K}_{a,1} \right) da. \quad (\text{B.24})$$

Note that there is a single market clearing condition for capital because capital is mobile in either period. Likewise, there is a single market clearing condition for labor in period 1. In contrast, there is a separate market clearing condition in each area for labor in period 0.

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

$$\int_a x_{a,1} da = 0. \quad (\text{B.25})$$

**Monetary Policy and Equilibrium.** To close the model, it remains to specify how the monetary policy sets the nominal interest rate,  $R^f$ . For most of the analysis, we assume that the monetary policy sets  $R^f$  to ensure aggregate employment is “on average” equal to frictionless employment.

Specifically, we define  $\bar{L}_0$  as the frictionless labor supply that would obtain when all areas have

common wealth. It is the solution to the frictionless labor supply equation [cf. (B.18)]:

$$\frac{W_0}{P_0} = \frac{\varepsilon_w}{\varepsilon_w - 1} \chi \bar{L}_0^\varphi, \quad (\text{B.26})$$

where  $W_0 = W_{0,a}$  and  $P_0 = P_{0,a}$  denote the common wage and price level across areas. Below, we characterize  $P_0$  in terms of  $W_0$  and the remaining parameters and provide a closed form solution for  $\bar{L}_0$ . We assume monetary policy sets  $R^f$  to ensure:

$$\int_a L_{a,0} da = \bar{L}_0. \quad (\text{B.27})$$

We can then define the equilibrium as follows.

**Definition 1.** *Given a distribution of ownership of capital,  $\{x_{a,0}\}_a$  (that sum to zero across areas), an equilibrium is a collection of cross-sectional and aggregate allocations together with (nominal) factor prices,  $(\{W_{a,t}\}_a, R_t)$ , goods prices,  $(\{P_{a,t}^N\}_a, P_t^T)$ , the asset price,  $Q_0$ , and the interest rate,  $R^f$ , such that:*

- (i) *Competitive firms maximize according to the production technologies described in (B.1 – B.3).*
- (ii) *Households choose their consumption and portfolios optimally [cf. problem (B.9)].*
- (ii) *Capital supply is exogenous in both periods and given by (B.4). Labor supply and nominal wages in period 1 are exogenous and given by Eqs. (B.10) and (B.5). Labor supply and nominal wages in period 0 are endogenous and satisfy Eq. (B.17).*
- (iv) *Monetary policy sets the interest rate  $R^f$  to ensure Eq. (B.27) with  $\bar{L}_0$  that solves Eq. (B.26).*
- (v) *Goods, factors, and asset markets clear [cf. Eqs. (B.19 – B.25)].*

## B.2 General Characterization of Equilibrium

We next provide a general characterization of equilibrium. We start by establishing the properties on the supply side that apply in both periods. We then use these properties to characterize the equilibrium in period 1. We then establish properties on the demand side and characterize the equilibrium in period 0. Throughout, we focus on an equilibrium in which the capital-only technology is used in equilibrium,  $\tilde{K}_t \geq 0$ . Later in the appendix, we will ensure this by making appropriate parametric assumptions on  $D_t$ .

**Supply Side.** The price of nontradable good in an area is equal to the unit production cost [cf. (B.1)]

$$P_{a,t}^N = (W_{a,t})^{1-\alpha^N} R_t^{\alpha^N}. \quad (\text{B.28})$$

Likewise, the price of the composite tradable good is equal to its unit production cost according to both the standard and the linear technology [cf. (B.2) and (B.3)]

$$P_t^T = \left( \int_a (P_{a,t}^T)^{1-\varepsilon} da \right)^{1/(1-\varepsilon)} = R_t/D_t^{1-\alpha^T}, \quad (\text{B.29})$$

$$\text{where } P_{a,t}^T = (W_{a,t})^{1-\alpha^T} R_t^{\alpha^T}. \quad (\text{B.30})$$

Here, we define  $P_{a,t}^T$  as the unit cost of producing the tradable input in area  $a$ .

Using Eq. (B.29), we also obtain an expression for the rental rate in terms of wages and the parameter  $D_t$ ,

$$R_t^{1-\alpha^T} = D_t^{1-\alpha^T} \left( \int_a W_{a,t}^{(1-\alpha^T)(1-\varepsilon)} da \right)^{1/(1-\varepsilon)}. \quad (\text{B.31})$$

Hence, the rental rate of capital is determined by the productivity of the linear technology together with wages in each area (that determine the price of the tradable good). This also implies that, given the wages in each area, we can uniquely calculate all other prices. The following lemma formalizes these results, and characterizes the prices when wages are equated across areas.

**Lemma 1.** *Given a collection of strictly positive nominal wages,  $\{W_{a,t}\}_a$  and capital productivity,  $D_t$ , Eq. (B.31) uniquely determines the rental rate of capital,  $R_t$ . Eqs. (B.28 – B.30) determine the remaining prices,  $P_{a,t}^N, P_{a,t}^T, P_t^T$ , and Eq. (B.7) determines the price of the final good in terms of these prices,  $P_{a,t} = (P_{a,t}^N)^\eta (P_t^T)^{1-\eta}$ . If  $W_{a,t} \equiv W_t$  for each  $a$ , then*

$$\begin{aligned} R_t &= D_t W_t \\ P_{a,t}^N &= D_t^{\alpha^N} W_t \\ P_t^T &= P_{a,t}^T = D_t^{\alpha^T} W_t \\ P_{a,t} &= D_t^{\bar{\alpha}} W_t. \end{aligned}$$

Here, recall that  $\bar{\alpha} = \eta\alpha^N + (1-\eta)\alpha^T$  denotes the weighted-average share of capital across the two sectors [cf. (7)].

We next characterize the demand for labor in the nontradable and tradable sectors. Note that the Cobb-Douglas production function in (B.1) implies,

$$\begin{aligned} W_{a,t} L_{a,t}^N &= (1-\alpha^N) P_{a,t}^N Y_{a,t}^N, \\ \text{where } P_{a,t}^N Y_{a,t}^N &= P_{a,t}^N C_{a,t}^N. \end{aligned} \quad (\text{B.32})$$

Here, the second line substitutes the market clearing condition (B.19). Hence, the demand for nontradable labor in an area is determined by the demand for nontradable goods in the area.

Likewise, the Cobb-Douglas production function in (B.2) implies,

$$W_{a,t} L_{a,t}^T = (1-\alpha^T) P_{a,t}^T Y_{a,t}^T.$$



That is, the demand for tradable labor in an area is determined by the demand for tradable inputs from the area. To characterize this further, note that the CES production function in (B.2) implies,

$$P_{a,t}^T Y_{a,t}^T = \left( \frac{P_{a,t}^T}{P_t^T} \right)^{1-\varepsilon} P_t^T Y_t^T.$$

So the demand for tradable inputs in an area depends on the demand for the tradable good in the aggregate (that uses the standard technology) as well as the local unit cost. Combining these expressions, and using Eq. (B.20), we further obtain,

$$W_{a,t} L_{a,t}^T = (1 - \alpha^T) \left( \frac{P_{a,t}^T}{P_t^T} \right)^{1-\varepsilon} P_t^T Y_t^T, \quad (\text{B.33})$$

where  $P_t^T Y_t^T = \int_a P_t^T C_{a,t}^T da - P_t^T \tilde{Y}_t^T$  and  $P_t^T \tilde{Y}_t^T = R_t \tilde{K}_t^T$ .

Here, the second line captures that the demand for tradables that uses the standard technology is determined by the total demand for tradables net of the production via the capital-only technology. The following lemma summarizes this discussion. It also characterizes Eq. (B.33) further by solving for the amount of production in the tradable sector via the capital-only technology,  $P_t^T \tilde{Y}_t^T = R_t \tilde{K}_t^T$ .

**Lemma 2.** *The demand for nontradable labor is given by Eq. (B.32). The demand for tradable labor is given by Eq. (B.33). In equilibrium, the amount of capital employed in the capital-only technology satisfies,*

$$R_t \tilde{K}_t^T = \frac{1 - \bar{\alpha}}{1 - \alpha^T} R_t - \frac{\bar{\alpha}}{1 - \alpha^T} \int_a W_{a,t} L_{a,t} da. \quad (\text{B.34})$$

Therefore, Eq. (B.33) can be further solved as,

$$W_{a,t} L_{a,t}^T = \left( \frac{P_{a,t}^T}{P_t^T} \right)^{1-\varepsilon} \left[ (1 - \alpha^T) \int_a P_t^T C_{a,t}^T da - (1 - \bar{\alpha}) R_t + \bar{\alpha} \int_a W_{a,t} L_{a,t} da \right]. \quad (\text{B.35})$$

**Proof.** To establish Eq. (B.35), note that the analogue of Eqs. (B.32) and (B.33) also apply for capital. In particular, after aggregating across areas, we have,

$$\begin{aligned} R_t \int_a K_{a,t}^N da &= \alpha^N \int_a P_{a,t}^N C_{a,t}^N da \\ R_t \int_a K_{a,t}^T da &= \alpha^T \left( \int_a P_t^T C_{a,t}^T da - R_t \tilde{K}_t^T \right). \end{aligned}$$

Here, the second line uses  $P_t^T = \left( \int_a (P_{a,t}^T)^{1-\varepsilon} da \right)^{1/(1-\varepsilon)}$ . Adding these equations, and using the market clearing condition for capital in (B.22) and (B.24), we obtain,

$$R_t (1 - \tilde{K}_t^T) = \alpha^N \int_a P_{a,t}^N C_{a,t}^N da + \alpha^T \left( \int_a P_t^T C_{a,t}^T da - R_t \tilde{K}_t^T \right).$$

Using Eq. (B.8), we can express the right hand side in terms of aggregate consumption expenditure,

$$R_t \left(1 - \tilde{K}_t^T\right) = \bar{\alpha} \int_a P_{a,t} C_{a,t} da - \alpha^T R_t \tilde{K}_t^T, \quad (\text{B.36})$$

where recall that  $\bar{\alpha} = \alpha^N \eta + \alpha^T (1 - \eta)$  [cf. (7)].

Next note that, in equilibrium, aggregate consumption expenditure is equal to aggregate income,

$$\int_a P_{a,t} C_{a,t} da = \int_a W_{a,t} L_{a,t} da + R_t.$$

Substituting this into Eq. (B.36), we solve for the production of tradables via capital-only technology as,

$$R_t \tilde{K}_t^T = \frac{1 - \bar{\alpha}}{1 - \alpha^T} R_t - \frac{\bar{\alpha}}{1 - \alpha^T} \int_a W_{a,t} L_{a,t} da.$$

This establishes Eq. (B.34). Substituting this expression into Eq. (B.33), we obtain Eq. (B.35), completing the proof.  $\square$

**Equilibrium in Period 1 (Long Run).** Our analysis so far enables us to characterize the equilibrium in period 1. Since labor is mobile across areas, the wages are equated across areas,  $W_{a,1} \equiv \bar{W}$  for each  $a$ . Then, using Lemma 1, we obtain,

$$R_1 = D_1 \bar{W}. \quad (\text{B.37})$$

Thus, the nominal rental rate of capital is determined by the productivity of capital,  $D_1$ , together with the the long-run nominal wage level,  $\bar{W}$ .

We can also explicitly solve for the aggregate consumption in nontradables and tradables, as well as the allocation of factors to these sectors. We skip these steps since they are not necessary for our analysis.

**Average Labor Supply in Period 0 (Short Run).** We can also utilize the analysis so far to solve Eq. (B.26). Recall that this equation corresponds to the frictionless labor supply when all areas have common stock wealth. It describes the average labor supply  $\bar{L}_0$  that monetary policy targets with an arbitrary distribution of stock wealth [cf. (B.38)].

When areas have common wealth, wages are equated across areas,  $W_{a,0} = W_0$  for each  $a$ . Using Lemma 1, we also obtain  $P_0 = D_0^\alpha W_0$ . Substituting these expressions into (B.26), we obtain:

$$\frac{W_0}{P_0} = \frac{1}{D_0^\alpha} = \frac{\varepsilon_w}{\varepsilon_w - 1} \chi \bar{L}_0^\varphi. \quad (\text{B.38})$$

Note that, given the other parameters, there is a unique solution to Eq. (B.38) that describes the frictionless labor supply  $\bar{L}_0$ . We next turn to the demand side and characterize the rest of the equilibrium in period 0.

**Asset Prices in Period 0 (Short Run).** Next consider households' portfolio decision in period 0. Since there is no risk in capital (for simplicity), problem (B.9) implies households take a non-zero position on capital if and only if its price satisfies,

$$\begin{aligned} Q_0 &= R_0 + \frac{R_1}{R^f} \\ &= R_0 + \frac{D_1 \overline{W}}{R^f}. \end{aligned} \tag{B.39}$$

Here, the second line substitutes for the future rental rate of capital from Eq. (B.37). Hence, a standard asset pricing condition applies to capital. In particular, households' stock wealth depends on (among other things) the productivity of capital and the interest rate,  $R^f$ .

**Demand Side in Period 0 (Short Run).** We next consider the households' consumption-savings decision in period 0. We define the households' human capital wealth in an area as,

$$H_{a,0} = W_{a,0} L_{a,0} + \frac{\overline{W} L_1}{R^f}. \tag{B.40}$$

We can then rewrite the households' budget constraints in (B.9) as a lifetime budget constraint,

$$P_{a,0} C_{a,0} + P_{a,1} C_{a,1} = H_{a,0} + (1 + x_{a,0}) Q_0.$$

Combining this with log utility, we obtain the optimality condition,

$$P_{a,0} C_{a,0} = \frac{1}{1 + \delta} (H_{a,0} + (1 + x_{a,0}) Q_0). \tag{B.41}$$

That is, households spend a constant fraction of their lifetime wealth, where the latter is a combination of their human capital and stock wealth. Combining this with Eq. (B.8), we further obtain,

$$P_{a,0}^N C_{a,0}^N = \frac{\eta}{1 + \delta} (H_{a,0} + (1 + x_{a,0}) Q_0), \tag{B.42}$$

$$P_0^T C_{a,0}^T = \frac{1 - \eta}{1 + \delta} (H_{a,0} + (1 + x_{a,0}) Q_0). \tag{B.43}$$

We next combine Eq. (B.42) with Eq. (B.32) from Lemma 2 to obtain,

$$W_{a,0} L_{a,0}^N = \frac{(1 - \alpha^N) \eta}{1 + \delta} (H_{a,0} + (1 + x_{a,0}) Q_0). \tag{B.44}$$

Thus, nontradable labor demand is determined by the local nontradable demand, which is equal to local wealth multiplied by the share of wealth spent ( $1/(1 + \delta)$ ) multiplied by the share of nontradables ( $\eta$ ) multiplied by the share of labor in the nontradable sector ( $1 - \alpha^N$ ).

Likewise, we combine Eq. (B.43) with Eq. (B.35) from Lemma 2 to obtain,

$$W_{a,0}L_{a,0}^T = \left(\frac{P_{a,0}^T}{P_0^T}\right)^{1-\varepsilon} \left\{ \frac{(1-\alpha^T)(1-\eta)}{1+\delta} (H_0 + Q_0) - (1-\bar{\alpha})R_0 + \bar{\alpha} \int_a W_{a,0}L_{a,0} da \right\}. \quad (\text{B.45})$$

Here, we define the aggregate human capital wealth as,  $H_0 = \int_a H_{a,0} da$ . Hence, tradable labor demand is determined by aggregate demand for the tradable good, which depends on the aggregate wealth and similar coefficients as above.

After summing Eqs. (B.44) and (B.45), we obtain an expression for the total labor demand in an area as follows,

$$\begin{aligned} W_{a,0}L_{a,0} &= \frac{(1-\alpha^N)\eta}{1+\delta} (H_{a,0} + (1+x_{a,0})Q_0) \\ &+ \left(\frac{P_{a,0}^T}{P_0^T}\right)^{1-\varepsilon} \left\{ \frac{(1-\alpha^T)(1-\eta)}{1+\delta} (H_0 + Q_0) - (1-\bar{\alpha})R_0 + \bar{\alpha} \int_a W_{a,0}L_{a,0} da \right\}. \end{aligned} \quad (\text{B.46})$$

After substituting  $H_{a,0}$  from Eq. (B.40), we can also write the labor demand equation as follows,

$$\begin{aligned} W_{a,0}L_{a,0} &= \frac{(1-\alpha^N)\eta}{1+\delta} \left( W_{a,0}L_{a,0} + \frac{\overline{WL}_1}{R^f} + (1+x_{a,0})Q_0 \right) \\ &+ \left(\frac{P_{a,0}^T}{P_0^T}\right)^{1-\varepsilon} \left\{ \frac{(1-\alpha^T)(1-\eta)}{1+\delta} \left( \int_a W_{a,0}L_{a,0} da + \frac{\overline{WL}_1}{R^f} + Q_0 \right) - (1-\bar{\alpha})R_0 + \bar{\alpha} \int_a W_{a,0}L_{a,0} da \right\}. \end{aligned} \quad (\text{B.47})$$

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.

Next recall from Lemma 1 that the prices,  $P_{a,0}^T, P_0^T, R_0$  are implicit functions of wages,  $\{W_{a,0}\}_a$ . Therefore, Eq. (B.47) is a collection of  $|I|$  equations in  $2|I| + 1$  unknowns,  $\{L_{a,0}, W_{a,0}\}_{a \in I}$  and  $R^f$ . Recall also that we have Eq. (B.17) that relates wages to the labor and the price level in each area. This provides  $|I|$  additional equations in  $\{L_{a,0}, W_{a,0}\}_{a \in I}$ . The monetary policy rule in (B.38) provides the remaining equation, where  $\bar{L}_0$  is given by Eq. (B.38). The equilibrium is characterized as the solution to these  $2|I| + 1$  equations.

### B.3 Benchmark Equilibrium with Common Stock Wealth

We next characterize the equilibrium 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. Throughout, we assume the productivity in the capital-only technology satisfies:

**Assumption D.**  $D_0 = \frac{\bar{\alpha}}{1-\bar{\alpha}}\bar{L}_0$  and  $D_1 \geq \frac{\bar{\alpha}}{1-\bar{\alpha}}\bar{L}_1$ .

To understand the role of this assumption, note that the common-wealth benchmark features identical wages across areas as well as identical and frictionless employment (in either period),  $W_{a,t} = W_t$  and  $L_{a,t} = \bar{L}_t$ . Using this observation, together with Lemmas 1 and 2, we obtain  $D_t \tilde{K}_t^T = \frac{1-\bar{\alpha}}{1-\alpha^T} D_t - \frac{\bar{\alpha}}{1-\alpha^T} L_t$ . Therefore, the inequality  $D_t \geq \frac{\bar{\alpha}}{1-\alpha} \bar{L}_t$  ensures that firms use the capital-only technology in equilibrium,  $\tilde{K}_t^T \geq 0$ . In period 0, we assume that the inequality holds as equality, which implies that firms are indifferent to use this technology and, moreover,  $\tilde{K}_0^T = 0$ . Thus, Assumption D ensures that the production in period 0 is homothetic across sectors despite the presence of the capital-only technology in the tradable sector—this homotheticity will be important for some of our results. This assumption also simplifies the expressions, e.g., it ensures that the share of labor is equal to its sector-weighted average share in the Cobb-Douglas technologies,  $1 - \bar{\alpha}$ .

Recall also that  $\bar{L}_0$  is endogenous and corresponds to the solution to Eq. (B.38). Given the other parameters, there is a unique level of  $D_0, \bar{L}_0$  that satisfy Assumption D along with this equation.

To characterize the equilibrium in period 0 further, note that the areas are symmetric. Therefore, we drop the area subscript and denote the allocations with,  $W_0, P_0, L_0, R_0, H_0$ .

Substituting common wages, prices, and labor into Eq. (B.17) and using Eq. (B.26), we further obtain  $W_0 = W_0^{flex} = \bar{W}$ . Intuitively, since monetary policy targets the frictionless labor supply, the flexible-wage members of the household set the same wage level as the sticky-wage members. Therefore, the equilibrium wage level is the same as the sticky wage level,  $\bar{W}$  (which we take as equal to the long-run wage level). Using Lemma 1, we also obtain,  $R_0 = D_0 \bar{W}$  and  $P_0 = D_0^\alpha \bar{W}$ .

Substituting these observations into the labor demand Eq. (B.46), we obtain,

$$\bar{W} \bar{L}_0 = \frac{1-\bar{\alpha}}{1+\delta} (H_0 + Q_0) - (1-\bar{\alpha}) D_0 \bar{W} + \bar{\alpha} \bar{W} \bar{L}_0.$$

After rearranging terms, we obtain,

$$\bar{W} \bar{L}_0 = \frac{1}{1+\delta} (H_0 + Q_0) - D_0 \bar{W}.$$

Rearranging further, we obtain,

$$(H_0 + Q_0) / \bar{W} = (1 + \delta) (\bar{L}_0 + D_0). \quad (\text{B.48})$$

This expression says that the aggregate wealth (in real terms) must be a constant multiple of the supply-determined output level.

Next note that, after substituting the wages and the rental rate into Eqs. (B.40) and (B.39), human capital and stock wealth are given by, respectively,

$$H_0 / \bar{W} = \bar{L}_0 + \frac{\bar{L}_1}{R^{f,*}}, \quad (\text{B.49})$$

$$Q_0 / \bar{W} = D_0 + \frac{D_1}{R^{f,*}}. \quad (\text{B.50})$$

Combining the last three expressions, we can solve for “rstar” as,

$$R^{f,*} = \frac{1}{\delta} \frac{\bar{L}_1 + D_1}{\bar{L}_0 + D_0}. \quad (\text{B.51})$$

Intuitively, monetary policy adjusts the interest rate (“rstar”) so that aggregate wealth is at an appropriate level to ensure the implied amount of spending clears the goods market at the supply-determined output level. As expected, greater impatience (low  $\delta$ ) or greater expected growth of capital income (high  $D_1$  relative to  $D_0$ ) or expected growth of labor income (high  $\bar{L}_1$  relative to  $\bar{L}_0$ ) translates into a greater interest rate in equilibrium. We can also solve for the equilibrium levels of human capital and stock wealth as,

$$H_0/\bar{W} = \bar{L}_0 + \delta (\bar{L}_0 + D_0) \frac{\bar{L}_1}{\bar{L}_1 + D_1} \quad (\text{B.52})$$

$$Q_0/\bar{W} = D_0 + \delta (\bar{L}_0 + D_0) \frac{D_1}{\bar{L}_1 + D_1} \quad (\text{B.53})$$

These expressions are intuitive. For instance, an increase in  $D_1$  increases stock prices as well as the risk-free rate, and it leaves total wealth unchanged. Intuitively, an increase in  $D_1$  exerts upward pressure on aggregate wealth and increases aggregate demand. The interest rate increases to ensure output is at its supply determined level. This mitigates the rise in the stock price somewhat but it does not completely undo it, since some of the interest rate response is absorbed by human capital wealth. (The last point is the difference from Caballero and Simsek (forthcoming): 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 employment. Substituting  $W_{a,0} = \bar{W}$  and  $x_{a,0} = 0$  into Eqs. (B.44) and (B.45), we solve for aggregate nontradable and tradable employment as, respectively,

$$L_0^N = \frac{(1 - \alpha^N) \eta}{1 + \delta} (H_0 + Q_0) / \bar{W}$$

$$L_0^T = \frac{(1 - \alpha^T) (1 - \eta)}{1 + \delta} (H_0 + Q_0) / \bar{W} - (1 - \bar{\alpha}) D_0 + \bar{\alpha} \bar{L}_0.$$

Combining this with Eq. (B.48), we further obtain,

$$L_0^N = (1 - \alpha^N) \eta (\bar{L}_0 + D_0)$$

$$L_0^T = (1 - \alpha^T) (1 - \eta) (\bar{L}_0 + D_0) - (1 - \bar{\alpha}) D_0 + \bar{\alpha} \bar{L}_0$$

Finally, substituting  $D_0 = \frac{\bar{\alpha}}{1 - \bar{\alpha}} \bar{L}_0$  from Assumption D, we can further simplify these expressions as

follows,

$$\begin{aligned} L_0^N &= \frac{1 - \alpha^N}{1 - \bar{\alpha}} \eta \bar{L}_0, \\ L_0^T &= \frac{1 - \alpha^T}{1 - \bar{\alpha}} (1 - \eta) \bar{L}_0. \end{aligned} \tag{B.54}$$

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.

**Proposition 1.** *Consider the model with Assumption D when areas have common stock wealth,  $x_{a,0} = 0$  for each  $a$ . In equilibrium, all areas have identical allocations and prices. In period 0, labor is equal to its frictionless level,  $L_0 = \bar{L}_0$ , that solves Eq. (B.38), and nominal wages and prices are given by  $W_0 = \bar{W}$  and  $P_0 = D_0^\alpha \bar{W}$ . The nominal interest rate is given by Eq. (B.51); human capital and stock wealth are given by Eqs. (B.52) and (B.53); the shares of labor employed in the nontradable and tradable sectors is given by Eq. (B.54). In particular, an increase in  $D_1$  decreases increases the interest rate and the price of capital but do 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  $D_1$ ), 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:  $y = \log(Y/Y^b)$ , where  $Y \in \{L_{a,0}, L_{a,0}^N, L_{a,0}^T, W_{a,0}, P_{a,0}, P_{a,0}^T, H_{a,0}\}_a$ . We also define the log-deviations of the endogenous aggregate variables:  $y = \log(Y/Y^b)$ , where  $Y \in \{P_t^T, R_t, Q_t, R^f\}$ . The following lemma simplifies the analysis (proof omitted).

**Lemma 3.** *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  $p_t^T = r_t = q_0 = r^f = 0$ . 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.28), (B.30) and (B.7) that characterize the other prices in terms of nominal wages in an area. Log-linearizing Eqs. (B.28) and (B.30) we obtain,

$$\begin{aligned} p_{a,0}^N &= (1 - \alpha^N) w_{a,0} \\ p_{a,0}^T &= (1 - \alpha^T) w_{a,0}. \end{aligned} \tag{B.55}$$

Log-linearizing Eq. (B.7), we further obtain:

$$p_{a,0} = \eta p_{a,0}^N = \eta (1 - \alpha^N) w_{a,0}. \quad (\text{B.56})$$

Next, we log-linearize the labor supply equation (B.17) to obtain:

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

After rearranging terms and simplifying, we obtain Eq. (5) from the main text:

$$w_{a,0} = \lambda (p_{a,0} + \varphi l_{a,0}), \text{ where } \lambda = \frac{\lambda_w}{1 + (1 - \lambda_w) \varphi \varepsilon_w}. \quad (\text{B.57})$$

Note that we derive the wage flexibility parameter,  $\lambda$ , in terms of the more structural parameters,  $\lambda_w, \varphi, \varepsilon_w$ . As expected, wage flexibility is greater when a greater fraction of members adjust wages (greater  $\lambda_w$ ), labor supply is more inelastic (greater  $\varphi$ ), labor types are less substitutable (smaller  $\varepsilon_w$ ).

Note also that, combining Eqs. (B.56) and (B.57), we obtain the simplified labor supply equation:

$$w_{a,0} = \kappa l_{a,0}, \text{ where } \kappa = \frac{\lambda \varphi}{1 - \lambda \eta (1 - \alpha^N)}. \quad (\text{B.58})$$

As expected, the wage adjustment parameter,  $\kappa$ , depends on the wage flexibility parameter,  $\lambda$ , and the inverse elasticity of the labor supply,  $\varphi$ . It also depends on the share of 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.47) to obtain,

$$\begin{aligned} (w_{a,0} + l_{a,0}) \overline{WL}_0 &= \frac{(1 - \alpha^N) \eta}{1 + \delta} ((w_{a,0} + l_{a,0}) \overline{WL}_0 + x_{a,0} Q_0) \\ &\quad - (\varepsilon - 1) (1 - \alpha^T) w_{a,0} \overline{WL}_0^T. \end{aligned} \quad (\text{B.59})$$

Here, the second line substitutes  $p_{a,0}^T = (1 - \alpha^T) w_{a,0}$  from Eq. (B.55). It also observes that the term in the set brackets in (B.47) is common across areas and is equal to  $\overline{WL}_0^T$  at the commonwealth benchmark (the aggregate expenditure on tradable labor).

After rearranging terms, we further obtain the simplified labor demand equation:

$$\begin{aligned} (w_{a,0} + l_{a,0}) \overline{WL}_0 &= \mathcal{M} \left( \frac{(1 - \alpha^N) \eta}{1 + \delta} x_{a,0} Q_0 - (\varepsilon - 1) (1 - \alpha^T) w_{a,0} \overline{WL}_0^T \right), \\ \text{where } \mathcal{M} &= \frac{1}{1 - (1 - \alpha^N) \eta / (1 + \delta)} \end{aligned} \quad (\text{B.60})$$

Here, we defined the parameter,  $\mathcal{M}$ , which captures the local Keynesian multiplier effects.



For each area  $a$ , Eqs. (B.60) and (B.58) represent 2 equations in 2 unknowns,  $(w_{a,0}, l_{a,0})$ . Hence, these equations characterize the local labor market outcomes in the log-linearized equilibrium.

Solving these equations, we also obtain the following closed-form characterization,

$$w_{a,0} + l_{a,0} = \frac{1 + \kappa}{1 + \kappa\zeta} \mathcal{M} \frac{(1 - \alpha^N) \eta x_{a,0} Q_0}{1 + \delta} \frac{1}{\overline{W} \overline{L}_0} \quad (\text{B.61})$$

$$l_{a,0} = \frac{1}{1 + \kappa} (w_{a,0} + l_{a,0}) \quad (\text{B.62})$$

$$w_{a,0} = \frac{\kappa}{1 + \kappa} (w_{a,0} + l_{a,0}), \quad (\text{B.63})$$

$$\begin{aligned} \text{where } \zeta &= 1 + (\varepsilon - 1) (1 - \alpha^T) \frac{L_0^T}{\overline{L}_0} \mathcal{M} \\ &= 1 + (\varepsilon - 1) \frac{(1 - \alpha^T)^2}{1 - \bar{\alpha}} (1 - \eta) \mathcal{M}. \end{aligned}$$

Here, the last line defines the parameter,  $\zeta$ , and the last line substitutes  $\frac{L_0^T}{\overline{L}_0} = 1 - \eta$  [cf. Eq. (B.54)]. Eq. (B.61) illustrates that the local spending on nontradables affects the local labor bill. Eqs. (B.62) and (B.63) illustrate that this also affects employment and wages according to the wage flexibility parameter,  $\kappa$ .

The term,  $\frac{1+\kappa}{1+\kappa\zeta}$ , in Eq. (B.61) 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  $\kappa$ ). The adjustment is also stronger when tradable inputs are more substitutable across regions (higher  $\varepsilon$ , which leads to higher  $\zeta$ ). 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.45) and following the same steps that we use in deriving the second line in (B.59), we obtain

$$\begin{aligned} w_{a,0} + l_{a,0}^T &= -(\varepsilon - 1) (1 - \alpha^T) w_{a,0} \\ &= -(\varepsilon - 1) (1 - \alpha^T) \frac{\kappa}{1 + \kappa\zeta} \mathcal{M} \frac{(1 - \alpha^N) \eta x_{a,0} Q_0}{1 + \delta} \frac{1}{\overline{W} \overline{L}_0}. \end{aligned} \quad (\text{B.64})$$

Here, the second line uses Eqs. (B.63) and (B.61). 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 employment 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. Log-linearizing Eq. (B.47) (after substituting for  $H_{a,0}$  from Eq. (B.40)), and simplifying the expression as before, we obtain an expression for the labor bill in the nontradable sector,

$$\begin{aligned}
w_{a,0} + l_{a,0}^N &= \frac{1}{\overline{WL}_0^N} \frac{(1 - \alpha^N) \eta}{1 + \delta} ((w_{a,0} + l_{a,0}) \overline{WL}_0 + x_{a,0} Q_0) \\
&= \frac{1}{\overline{WL}_0^N} \frac{(1 - \alpha^N) \eta}{1 + \delta} \left( (w_{a,0} + l_{a,0}^N) \overline{WL}_0^N + (w_{a,0} + l_{a,0}^T) \overline{WL}_0^T + x_{a,0} Q_0 \right) \\
&= \frac{1}{\overline{WL}_0^N} \mathcal{M} \frac{(1 - \alpha^N) \eta}{1 + \delta} \left( (w_{a,0} + l_{a,0}^T) \overline{WL}_0^T + x_{a,0} Q_0 \right) \\
&= \frac{1}{\frac{1 - \alpha^N}{1 - \bar{\alpha}} \eta \overline{WL}_0} \mathcal{M} \frac{(1 - \alpha^N) \eta}{1 + \delta} \left( (w_{a,0} + l_{a,0}^T) \frac{1 - \alpha^T}{1 - \bar{\alpha}} (1 - \eta) \overline{WL}_0 + x_{a,0} Q_0 \right) \\
&= \mathcal{M} \frac{1}{1 + \delta} \left( (1 - \bar{\alpha}) \frac{x_{a,0} Q_0}{\overline{WL}_0} + (1 - \alpha^T) (1 - \eta) (w_{a,0} + l_{a,0}^T) \right) \tag{B.65}
\end{aligned}$$

Here, the second line separates the expression for the total labor bill into the labor bill for nontradable and tradable sectors. The third line accounts for the multiplier effects through the nontradable labor bill. The fourth line uses Eq. (B.54) to substitute for  $\overline{L}_0^N / \overline{L}_0$  and  $\overline{L}_0^T / \overline{L}_0$ . The last line simplifies and rearranges terms.

Eq. (B.65) 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 (which in turn affects local labor income). The indirect effect has an ambiguous sign because stock wealth can decrease or increase the tradable labor bill depending on  $\varepsilon$  (cf. Eq. (B.64)). Nonetheless, we show that the direct effect always dominates. Specifically, regardless of  $\varepsilon$ , we have  $d(w_{a,0} + l_{a,0}^N) / dx_{a,0} > 0$ ,  $dl_{a,0}^N / dx_{a,0} > 0$ : that is, greater stock wealth increases the nontradable labor bill as well as nontradable employment. The following result summarizes this discussion.

**Proposition 2.** *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.60) and (B.58). The solution is given by Eqs. (B.62) and (B.63). Local labor bill in nontradables and tradable sectors are given by Eqs. (B.64) and (B.65). In particular, local employment and wages satisfy the following comparative statics with respect to stock wealth:*

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

Moreover, regardless of  $\varepsilon$ , employment and the labor bill in nontradable and tradable sectors satisfy

the following comparative statics:

$$d(l_{a,0}^N + w_{a,0})/dx_{a,0} > 0, dl_{a,0}^N/dx_{a,0} > 0 \text{ and } dl_{a,0}^T/dx_{a,0} \leq 0.$$

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

First consider the tradable employment. Note that the first line of the expression in (B.64) implies

$$l_{a,0}^T = -(1 + (\varepsilon - 1)(1 - \alpha^T)) w_{a,0}. \quad (\text{B.66})$$

Since  $(\varepsilon - 1)(1 - \alpha^T) > -1$  (because  $\varepsilon > 0$ ) and  $dw_{a,0}/dx_{a,0} \geq 0$  (cf. Eq. (B.63)), this implies the comparative statics for the tradable employment,  $dl_{a,0}^T/dx_{a,0} \leq 0$ .

Next consider the nontradable employment. Note that  $L_{a,0} = L_{a,0}^T + L_{a,0}^N$ . Log-linearizing this expression, we obtain,

$$l_{a,0}^N L_{a,0}^N = l_{a,0} \bar{L}_0 - l_{a,0}^T L_{a,0}^T.$$

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

## 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 capital productivity from some  $D_1^{old}$  to  $D_1^{new} > D_1^{old}$ .

First consider the effect on the common-wealth benchmark. By Proposition 1, the equilibrium price of capital increases from  $Q_1^{old}$  to  $Q_1^{new} > Q_1^{old}$ . The labor market outcomes remain unchanged: in particular,  $L_0 = \bar{L}_0$ ,  $W_0 = \bar{W}$ ,  $L_0^N/\bar{L}_0 = \frac{1-\alpha^N}{1-\alpha} \eta$  and  $L_0^T/\bar{L}_0 = \frac{1-\alpha^T}{1-\alpha} (1 - \eta)$ .

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:

$$\log(W_{a,0} L_{a,0}) \simeq \log(\bar{W} \bar{L}_0) + w_{a,0} + l_{a,0}.$$

Here,  $w_{a,0}, l_{a,0}$  are characterized by Proposition 2 as linear functions of capital ownership,  $x_{a,0}$ ; and the approximation holds up to second-order terms in capital ownership,  $\{x_{a,0}\}_a$ . Note also that the change of  $D_1$  does not affect  $\log(\bar{W} \bar{L}_0)$ . Therefore, the comparative statics in this case can be

written as,

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

where the approximation holds up to second-order terms in  $\{x_{a,0}\}_a$ . Put differently, up to second-order terms, the change of  $D_1$  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 2. In particular, considering Eq. (B.61) for  $D_1^{old}$  and  $D_1^{new}$ , we obtain:

$$\begin{aligned}w_{a,0}^{old} + l_{a,0}^{old} &= \frac{1 + \kappa}{1 + \kappa \zeta} \mathcal{M} \frac{(1 - \alpha^N) \eta x_{a,0} Q_0^{old}}{1 + \delta} \frac{1}{\overline{W} L_0}, \\ w_{a,0}^{new} + l_{a,0}^{new} &= \frac{1 + \kappa}{1 + \kappa \zeta} \mathcal{M} \frac{(1 - \alpha^N) \eta x_{a,0} Q_0^{new}}{1 + \delta} \frac{1}{\overline{W} L_0}.\end{aligned}$$

These equations illustrate that the change of  $D_1$  affects the log-linearized equilibrium only through its effect on the price of capital,  $Q_0$ . Taking their difference, we obtain Eq. (11) in the main text that describes  $\Delta (w_{a,0} + l_{a,0})$ .

Applying the same argument to Eqs. (B.62), (B.65), (B.64), we also obtain Eqs. (12), (13), (14) in the main text that describe, respectively,  $\Delta l_{a,0}$ ,  $\Delta (w_{a,0} + l_{a,0}^N)$ ,  $\Delta (w_{a,0} + l_{a,0}^T)$ . 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. (19)). For simplicity, we focus on the case  $\varepsilon = 1$ . Combining Eqs. (B.8) and (B.47), we obtain

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

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

$$\begin{aligned}(p_{a,0} + c_{a,0}) P_0 C_0 &= (w_{a,0} + l_{a,0}^N) \frac{\overline{W} L_0^N}{(1 - \alpha^N) \eta} \\ &= \mathcal{M} \frac{1}{1 + \delta} x_{a,0} Q_0\end{aligned}$$

Here, the second line uses the third line of Eq. (B.65) and observes that  $w_{a,0} + l_{a,0}^T = 0$  when  $\varepsilon = 1$ . After rearranging terms, and considering the change from  $D_1^{old}$  to  $D_1^{new} > D_1^{old}$ , we obtain

$$\Delta(p_{a,0} + c_{a,0}) = \mathcal{M} \frac{1}{1 + \delta} \frac{x_{a,0} \Delta Q_0}{P_0 C_0}. \quad (\text{B.67})$$

After an appropriate change of variables, this equation gives Eq. (19) 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 use the change of variables,  $\frac{1}{1+\delta} = \rho \mathbb{T}$  and write the differenced versions of Eqs. (B.61 – B.65) as follows:

$$\begin{aligned} \frac{\Delta(w_{a,0} + l_{a,0})}{SR} &= \frac{1 + \kappa}{1 + \kappa \zeta} \mathcal{M} (1 - \alpha^N) \eta \rho, \\ \frac{\Delta l_{a,0}}{SR} &= \frac{1}{1 + \kappa} \frac{\Delta(w_{a,0} + l_{a,0})}{SR} \\ \frac{\Delta w_{a,0}}{SR} &= \frac{\kappa}{1 + \kappa} \frac{\Delta(w_{a,0} + l_{a,0})}{SR} \end{aligned} \quad (\text{B.68})$$

$$\begin{aligned} \frac{\Delta(w_{a,0} + l_{a,0}^T)}{SR} &= -(\varepsilon - 1) (1 - \alpha^T) \frac{\Delta w_{a,0}}{SR} \\ \frac{\Delta(w_{a,0} + l_{a,0}^N)}{SR} &= \mathcal{M} \rho (1 - \bar{\alpha}) \left( 1 - (\varepsilon - 1) \frac{(1 - \alpha^T)^2}{1 - \bar{\alpha}} (1 - \eta) \mathbb{T} \frac{\Delta w_{a,0}}{SR} \right) \end{aligned} \quad (\text{B.69})$$

$$\text{where } S = \frac{x_{a,0} Q_{a,0}}{\overline{WL}_0 / \mathbb{T}}, R = \frac{\Delta Q_0}{Q_0}$$

$$\text{and } \mathcal{M} = \frac{1}{1 - (1 - \alpha^N) \eta \rho \mathbb{T}}$$

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

Our calibration relies on two model equations that determine the key parameters  $\kappa$  and  $\rho$ . Specifically, we calibrate  $\kappa$  by using Eq. (B.68), which replicates Eq. (20) from the main text. We calibrate  $\rho$  by using Eq. (B.69) which generalizes Eq. (16) 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 38).

Note that combining Eq. (B.68) 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:

$$\frac{\Delta l_{a,0}}{S_{a,0}R_0} = 1.5 \times 0.77\%$$

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

Combining these with Eq. (20), we obtain:

$$\kappa = 0.9. \tag{B.70}$$

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.69) to determine the stock wealth effect parameter,  $\rho$ . 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. (7)]:

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

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.69) (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  $\varepsilon = 1$  in Eq. (B.69) reduces to Eq. (16) in the main text,

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

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

$$\mathcal{M} (1 - \bar{\alpha}) \rho = 3.23\%. \tag{B.71}$$

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

$$\mathcal{M} = \frac{1}{1 - (1 - \alpha^N) \rho \eta \mathbb{T}} = 1.5 \quad (\text{B.72})$$

With these assumptions, as we discussed in the main text, Eq. (B.71) determines the stock wealth effect parameter independently of the other parameters such as  $\kappa, \eta, \mathbb{T}$ . In particular, we have:

$$\rho = 3.23\%.$$

Combining this with Eq. (B.72) to match the multiplier, we also obtain:

$$\eta \mathbb{T} = 15.48.$$

Hence, our calibration of the multiplier determines the product of  $\eta$  and  $\mathbb{T}$ .

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

$$\eta \in [\underline{\eta}, \bar{\eta}], \text{ where } \underline{\eta} = 0.5 \text{ and } \bar{\eta} = 0.8. \quad (\text{B.73})$$

Then, our calibration of the multiplier implies:

$$\mathbb{T} = \mathbb{T}(\eta) \equiv \frac{15.48}{\eta}, \text{ where } \mathbb{T}(\bar{\eta}) = 19.35 \text{ and } \mathbb{T}(\underline{\eta}) = 30.96.$$

In particular, for every choice of  $\eta$ , there exists a horizon parameter  $\mathbb{T}$  that supports the calibration of the multiplier in our model. Since our model is stylized in the time dimension (it has only two periods), we do not interpret  $\mathbb{T}$  literally but view it as a modeling device to calibrate the multiplier  $\mathcal{M}$ . In particular, we view the implied high levels of  $\mathbb{T}$  as capturing reasons outside our model (such as borrowing constraints) that would increase the income multiplier in practice.<sup>19</sup>

### B.6.2 Robustness of the Baseline Calibration

Next consider the case with general  $\varepsilon$ . In this case, Eq. (B.69) is more complicated and given by:

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

In particular, the nontradable labor bill in this case also depends on the effect on local wages. The intuition is that the change in local wages affects the tradable labor bill, which affects local

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<sup>19</sup>The dependence of  $\mathcal{M}$  on  $\mathbb{T}$  in our model can be understood by considering the intertemporal Keynesian cross (see Auclert et al. (2018) for an exposition). When output is determined by aggregate demand, an increase in future spending increases not only future income but also current income through a wealth effect. In our environment, increasing  $\mathbb{T}$  increases the time-length of period 0 over which output is determined by aggregate demand. This leads to stronger multiplier effects.

households' income. This in turn affects local households' spending and the nontradable labor bill. Consistent with this intuition, the magnitude of this effect depends on the parameters  $\varepsilon, \alpha^T, \eta$ .<sup>20</sup>

Recall also that we have Eq. (B.68) that describes the change in wages as a function of the change in the total labor bill:

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

Substituting this expression into Eq. (B.69), 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 Eq. (B.71):

$$\mathcal{M}(1 - \bar{\alpha}) \rho \left( 1 - (\varepsilon - 1) \frac{(1 - \alpha^T)^2}{1 - \bar{\alpha}} (1 - \eta) \mathbb{T} \frac{\kappa}{1 + \kappa} 2.18\% \right) = 3.23\%. \quad (\text{B.74})$$

As this expression illustrates, the stock wealth effect parameter in this case is not determined independently of the remaining parameters,  $\kappa, \eta, \mathbb{T}$ . We have already established that  $\kappa = 0.9$  [cf. Eq. (B.70)]. We also assume  $1 - \bar{\alpha} = 1 - \alpha^T = 2/3$ . We also assume  $\eta$  lies in the range (B.73) that we described earlier. Recall also that we choose  $\mathbb{T}$  to ensure Eq. (B.72) given all other parameters. Hence, for any fixed  $\varepsilon$ , Eq. (B.74) describes  $\rho$  as a function of  $\eta$ , where  $\eta$  is required to lie in the range (B.73).

Figure B.1 illustrates the possible values of  $\rho$  for  $\varepsilon = 0.5$  (the left panel) and  $\varepsilon = 1.5$  (the right panel). As the figure illustrates the implied values for  $\rho$  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,  $\rho$  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. As it turns out, the value of  $\kappa$  that we find given our calibration 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  $\varepsilon$  is somewhat different than 1.

## B.7 Aggregation When Monetary Policy is Passive

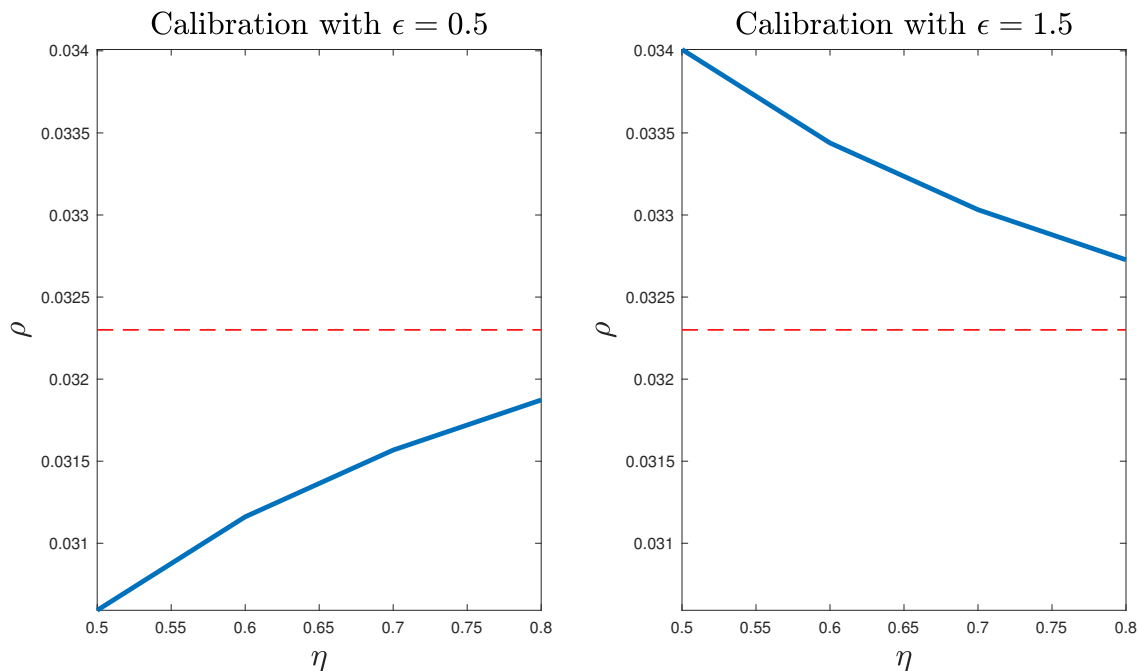
So far, we assumed the monetary policy changes the interest rate to neutralize the impact of stock wealth changes on aggregate employment. In this appendix, we characterize the equilibrium under

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<sup>20</sup>Less obviously, the magnitude also depends on the horizon parameter,  $\mathbb{T}$ . This parameter enters the equation for the same reason it enters the equation for the multiplier,  $\mathcal{M}$  (see Footnote 19). As before, the dependence of the equation on  $\mathbb{T}$  can be thought of as capturing reasons outside our model (such as households' borrowing constraints) that would amplify the spending effect of any change in households' incomes due to trade considerations.



Figure B.1:



Notes: Notes: The left panel (resp. the right panel) illustrates the implied  $\rho$  as a function of  $\eta$  given  $\epsilon = 0.5$  (resp.  $\epsilon = 1.5$ ), as we vary  $\eta$  over the range in (B.73). The red dashed lines illustrate the implied  $\rho$  for the baseline calibration with  $\epsilon = 1$ .

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.

The model is the same as in Section B.1 with the only difference that the monetary policy keeps the nominal interest rate at a constant level,  $R^f = \bar{R}^f$ . In particular, we continue to assume monetary policy stabilizes the long-run nominal wage at the constant level,  $\bar{W}$ . For simplicity, we also focus attention on the common-wealth benchmark,  $x_{a,0} = 0$ . Consequently, the areas have symmetric allocations that we denote by dropping the subscript  $a$ .

First note that the rental rate of capital is given by  $R_0 = D_0 W_0$  [cf. Lemma 1]. Consequently, the analogues of Eqs. (B.49) and (B.50) also apply in this setting. In particular, human capital wealth is given by,

$$H_0 = W_0 L_0 + \frac{\bar{W} \bar{L}_1}{\bar{R}^f} \quad (\text{B.75})$$

and the stock wealth is given by,

$$Q_0 = W_0 D_0 + \frac{\bar{W} \bar{D}_1}{\bar{R}^f}. \quad (\text{B.76})$$

Next note that the labor demand Eq. (B.46) applies also in this case. Using  $x_{a,0} = 0$  along with the definition of  $\bar{\alpha}$  [cf. (7)], we obtain

$$W_0 L_0 = \frac{1 - \bar{\alpha}}{1 + \delta} (H_0 + Q_0) - (1 - \bar{\alpha}) R_0 + \bar{\alpha} W_0 L_0.$$

Using  $R_0 = W_0 D_0$  and the expressions for  $H_0$  from Eq. (B.75), we further obtain,

$$W_0 L_0 = \frac{1 - \bar{\alpha}}{1 + \delta} \left( W_0 L_0 + \frac{\bar{W} \bar{L}_1}{\bar{R}^f} + Q_0 \right) - (1 - \bar{\alpha}) W_0 D_0 + \bar{\alpha} W_0 L_0.$$

Simplifying further, we obtain,

$$W_0 L_0 + W_0 D_0 = \frac{1}{1 + \delta} \left( W_0 L_0 + \frac{\bar{W} \bar{L}_1}{\bar{R}^f} + Q_0 \right). \quad (\text{B.77})$$

This equation says that the total amount of spending in the aggregate (on capital and labor) depends on the lifetime wealth multiplied by the propensity to spend out of wealth.

Next note that the labor supply equation (B.17) applies also in this case. Since areas have common wealth, we can rewrite this equation as:

$$W_0^{1 - \varepsilon_w} = \lambda_w \left( \frac{\varepsilon_w}{\varepsilon_w - 1} \chi P_0 W_0^{\varepsilon_w \varphi} L_0^\varphi \right)^{(1 - \varepsilon_w)/(1 + \varphi \varepsilon_w)} + (1 - \lambda_w) \bar{W}^{1 - \varepsilon_w}. \quad (\text{B.78})$$

Using Lemma 1, we also have:

$$P_0 = W_0 D_0^{\bar{\alpha}}. \quad (\text{B.79})$$

The equilibrium is characterized by Eqs. (B.76), (B.77), (B.78), (B.79) in four variables,  $(Q_0, W_0, L_0, P_0)$ .

Next note that there exists a level of  $D_1$ , denoted by  $\bar{D}_1$ , that ensures these equations are satisfied with  $L_0 = \bar{L}_0$  and  $W_0 = \bar{W}$ , along with  $\bar{Q}_0 \equiv \bar{W} D_0 + \frac{\bar{W} \bar{D}_1}{\bar{R}^f}$ . To simplify the expressions further, we next log-linearize the equations around the equilibrium with  $D_1 = \bar{D}_1$ .

**Log-linearized Aggregate Equilibrium.** Log-linearizing the stock pricing Eq. (B.76), we obtain,

$$q_0 \bar{Q}_0 = w_0 \bar{W} D_0 + d_1 \frac{\bar{W} \bar{D}_1}{\bar{R}^f}. \quad (\text{B.80})$$

Log-linearizing the labor demand Eq. (B.77), we obtain,

$$(w_0 + l_0) \bar{W} \bar{L}_0 + w_0 \bar{W} D_0 = \frac{1}{1 + \delta} ((w_0 + l_0) \bar{W} \bar{L}_0 + q_0 \bar{Q}_0).$$

After substituting Eq. (B.80), and rearranging terms to account for the multiplier effects, we further obtain,

$$(w_0 + l_0) \bar{W} \bar{L}_0 + w_0 \bar{W} D_0 = \tilde{\mathcal{M}}^A \frac{1}{1 + \delta} d_1 \frac{\bar{W} \bar{D}_1}{\bar{R}^f}, \quad (\text{B.81})$$

$$\text{where } \tilde{\mathcal{M}}^A = \frac{1}{1 - 1/(1 + \delta)}.$$

Log-linearizing the labor supply equation (B.78), we obtain:

$$w_0 = \lambda(p_0 + \varphi l_0), \text{ where } \lambda = \frac{\lambda_w}{1 + (1 - \lambda_w)\varphi\varepsilon_w}. \quad (\text{B.82})$$

Log-linearizing Eq. (B.79), we obtain:

$$p_0 = w_0. \quad (\text{B.83})$$

Combining the last two equations, we further obtain:

$$w_0 = \kappa^A l_0, \text{ where } \kappa^A \equiv \frac{\lambda\varphi}{1 - \lambda} > \kappa = \frac{\lambda\varphi}{1 - \lambda\eta(1 - \alpha^N)}. \quad (\text{B.84})$$

The log-linearized equilibrium is characterized by Eqs. (B.80), (B.81), (B.84) in three variables  $(q_0, w_0, l_0)$ . Given these variables, we also characterize the price level as  $p_0 = w_0$  [cf. (B.83)]. The equations for  $(q_0, w_0, l_0)$  can also be solved in closed form. We conjecture a linear solution:

$$\begin{aligned} q_0 \bar{Q}_0 &= A_Q Q^A \\ w_0 \bar{W} \bar{L}_0 &= A_W Q^A \\ l_0 \bar{W} \bar{L}_0 &= A_L Q^A, \\ \text{where } Q^A &= \frac{\bar{W} \bar{D}_1 d_1}{\bar{R}^f} \end{aligned} \quad (\text{B.85})$$

Here,  $Q^A$  denotes the log-linear approximation to the exogenous component of stock wealth  $(\frac{\bar{W} \bar{D}_1}{\bar{R}^f})$ . Hence, the coefficients  $A_Q, A_W, A_L$  describe the effect of a one dollar increase in the exogenous component of stock wealth on endogenous equilibrium outcomes.

To solve for these coefficients, we substitute the linear functional form in (B.85) into Eqs. (B.80), (B.81), (B.84). We also use Assumption D to substitute  $D_0 = \frac{\bar{\alpha}}{1 - \bar{\alpha}} \bar{L}_0$  and simplify the expressions, to obtain the system of equations,

$$\begin{aligned} A_Q &= \frac{\bar{\alpha}}{1 - \bar{\alpha}} A_W + 1 \\ A_W &= \kappa^A A_L \\ A_W + A_L + \frac{\bar{\alpha}}{1 - \bar{\alpha}} A_W &= \tilde{\mathcal{M}}^A \frac{1}{1 + \delta}. \end{aligned}$$

Using these equations, we obtain the closed-form solution for the effect on the aggregate labor bill,

$$\begin{aligned} A_W + A_L &= \mathcal{M}^A \frac{1 - \bar{\alpha}}{1 + \delta}, \\ \text{where } \mathcal{M}^A &= \mathcal{F}^A \tilde{\mathcal{M}}^A \text{ and } \mathcal{F}^A = \frac{1 + \kappa^A}{1 - \bar{\alpha} + \kappa^A} \end{aligned} \quad (\text{B.86})$$

The effect on the aggregate employment and wages are given by

$$A_L = \frac{1}{1 + \kappa^A} (A_W + A_L), \quad (\text{B.87})$$

$$A_W = \frac{\kappa^A}{1 + \kappa^A} (A_W + A_L). \quad (\text{B.88})$$

Substituting the solutions in (B.86 – B.88) into Eqs. (B.85), we obtain

$$w_0 + l_0 = \mathcal{M}^A \frac{1 - \bar{\alpha}}{1 + \delta} \frac{Q_0^A}{\bar{W}L_0}$$

$$l_0 = \frac{1}{1 + \kappa^A} (w_0 + l_0).$$

Considering the equation for two different levels of future dividends,  $d_1^{old}$  and  $d_1^{new}$ , and taking the difference, we obtain Eqs. (22) and (23) in the main text.

**Comparison with the Log-linearized Local Equilibrium.** It is instructive to compare the log-linearized labor supply equations (B.82) and (B.84) with their counterparts in the local analysis. Note that Eq. (B.82) is the same as its local counterpart, Eq. (B.57). Hence, controlling for prices as well as labor, the aggregate labor supply curve is the same as the local one. However, Eq. (B.84) is different than its local counterpart, Eq. (B.58). This is because the impact of aggregate nominal wages on the aggregate price level is greater than the impact of local wages on the local price level: specifically, we have  $p_0 = w_0$  as opposed to  $p_{0,a} = w_{0,a}\eta(1 - \alpha^N)$  [cf. Eqs. (B.83) and (B.56)]. Therefore, the real wage  $w - p$  responds locally but not in the aggregate. The real wage response generates a neoclassical local labor supply response, with strength determined by the magnitude of the Frish elasticity  $1/\phi$ , that does not extend to the aggregate level. Rewriting the expressions for  $\kappa$  and  $\kappa^A$  to eliminate the wage stickiness parameter,  $\lambda$ , we obtain:

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

This expression illustrates that the local labor response,  $\frac{1}{\kappa}$ , combines a neoclassical response to higher real wages,  $\frac{1}{\varphi} (1 - \eta(1 - \alpha^N))$ , that only occurs locally, and a term due to wage stickiness that extends to the aggregate,  $\frac{1}{\kappa^A}$ .

It is also instructive to consider the intuition for the labor bill characterized in (B.86). Note that  $1/(1 + \delta)$  describes the effect of stock wealth on total spending. Multiplying this with  $1 - \bar{\alpha}$  gives the direct effect on the aggregate labor bill. This direct effect is amplified by two types of multipliers. First, there is a standard aggregate spending multiplier captured by,  $\tilde{\mathcal{M}}^A = \frac{1}{1 - 1/(1 + \delta)} > 1$ . Second, there is also a second multiplier, which we refer to as the *factor-share multiplier*, denoted by  $\mathcal{F}^A = \frac{1 + \kappa^A}{1 - \bar{\alpha} + \kappa^A} > 1$ . The multiplier we use in the main text,  $\mathcal{M}^A = \mathcal{F}^A \tilde{\mathcal{M}}^A$ , is a composite of the two multipliers. The factor-share multiplier is somewhat specific to our model. In particular, it emerges from the assumption that labor is somewhat flexible but capital is not. These features

(combined with the production technologies we work with) implies that labor absorbs a greater fraction of demand-driven fluctuations in aggregate spending compared to capital. Consistent with this intuition, the factor-share multiplier is decreasing in the degree of wage flexibility,  $\kappa^A$ , and it approaches one in the limit with perfectly flexible wages,  $\kappa^A \rightarrow \infty$ .

Finally, we compare the aggregate effect in (B.86) with its local counterpart characterized earlier. Specifically, recall that Eqs. (B.62) and (B.63) imply the effect of stock wealth on the *local* labor bill is given by,

$$\frac{(l_{a,0} + w_{a,0}) \overline{WL}_0}{x_{a,0} Q_0} = \mathcal{M} \frac{1 + \kappa}{1 + \kappa \zeta} \frac{(1 - \alpha^N) \eta}{1 + \delta}. \quad (\text{B.89})$$

Comparing this expression with Eq. (B.86) illustrates that 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,  $\frac{1 - \bar{\alpha}}{1 + \delta} > \frac{\eta(1 - \alpha^N)}{1 + \delta}$ . Here, the inequality follows since  $1 - \bar{\alpha} = \eta(1 - \alpha^N) + (1 - \eta)(1 - \alpha^T)$ . 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 multiplier is greater in the aggregate than at the local level,  $\mathcal{M}^A > \mathcal{M}$ . In particular, the standard spending multiplier is greater at the aggregate level,  $\tilde{\mathcal{M}}^A > \mathcal{M}$ , because spending on tradables (as well as the mobile factor, capital) generates a multiplier effect in the aggregate but not locally. The factor-share multiplier increases the aggregate multiplier further,  $\mathcal{F}^A > 1$ .

Note also that, as long as  $\varepsilon \geq 1$ , 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 (captured by  $\eta < 1$  and  $\mathcal{M}^A > \mathcal{M}$ ) tend to make the aggregate effect greater than the local effect.

## 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, an aggregate state  $s \in S$  is realized at the beginning of period 1 with probability  $\pi(s)$  (with  $\sum_{s \in S} \pi(s) = 1$ ). States determine the productivity of the capital-only technology. We adopt the normalization,

$$D_1(s) = s, \quad (\text{B.90})$$

so that the state is equal to the productivity of capital, and we assume that  $S$  is a finite subset of  $\mathbb{R}_+$ . The baseline model is the special case in which  $S$  has a single element. We denote the equilibrium allocations in period 1 as functions of  $s$ , e.g.,  $C_{a,1}(s)$  denotes the consumption in area  $a$  and period 1 conditional on the aggregate state  $s$ .

Second, to analyze the effect of risk aversion, we also consider Epstein-Zin preferences that are more general than time-separable log utility. Specifically, we replace the preferences in (3) with,

$$\begin{aligned} & \log C_{a,0} + \delta \log U_{a,1}, & (B.91) \\ \text{where } U_{a,1} &= \left( E \left[ C_{a,1}(s)^{1-\gamma} \right] \right)^{1/(1-\gamma)}. \end{aligned}$$

Here,  $U_{a,1}$  captures the household's (and particularly, the consumer's) certainty-equivalent consumption. The parameter  $\gamma$  captures her risk aversion. The baseline model is the special case with  $\gamma = 1$ . Note that we still assume the elasticity of intertemporal substitution is equal to one. The consumer chooses  $C_{a,0}, S_{a,0}, 1 + x_{a,1}$  to maximize (B.91) subject to the budget constraints:

$$\begin{aligned} P_{a,0}C_{a,0} + S_{a,0} &= W_{a,0}L_{a,0} + (1 + x_{a,0})Q_0 & (B.92) \\ S_{a,0} &= S_{a,0}^f + (1 + x_{a,1})(Q_0 - R_0) \\ P_{a,1}(s)C_{a,1}(s) &= \bar{W}L_{a,1}(s) + (1 + x_{a,1})R_1(s) + S_{a,0}^f R^f. \end{aligned}$$

In period 0, the budget constraint is the same as before. In period 1, there is a separate budget constraint for each state. The rest of the equilibrium is unchanged.

**General Characterization of Equilibrium with Uncertainty.** Most of our analysis from the baseline case applies also in this case. First consider the equilibrium in period 1. As before, we have  $W_{a,1}(s) \equiv \bar{W}$  and  $L_{a,1}(s) = \bar{L}_1$  for each  $a$  and  $s$ . Using Lemma 1, we also obtain the following analogue of Eq. (B.37)

$$R_1(s) = D_1(s)\bar{W}. \quad (B.93)$$

Note also that aggregating the budget constraint across all areas, we obtain the aggregate budget constraint:

$$\int_a P_{a,1}(s)C_{a,1}(s) da = R_1(s) + \bar{W}\bar{L}_1.$$

By Lemma 1, the price of the consumption good is the same across areas,

$$P_{a,1}(s) = P_1(s) \equiv D_1(s)^{\bar{\alpha}}\bar{W}.$$

After substituting this expression and using (B.93), the aggregate budget constraint implies,

$$\int_a C_{a,1}(s) da = \frac{D_1(s) + \bar{L}_1}{(D_1(s))^{\bar{\alpha}}}. \quad (B.94)$$

In the common-wealth benchmark, the areas are identical so Eq. (B.94) provides a closed-form solution for consumption.

Next consider the equilibrium in period 0. The following lemma characterizes the consumers' optimal consumption and portfolio choice. To state the result let  $H_{a,0} = W_{a,0}L_{a,0} + \frac{\overline{WL}_1}{R^f}$  denote the human capital wealth in area  $a$  as in the baseline model.

**Lemma 4.** *The optimal consumption for area  $a$  satisfies,*

$$P_{a,0}C_{a,0} = \frac{1}{1 + \delta} [H_{a,0} + (1 + x_{a,0}) Q_0]. \quad (\text{B.95})$$

*Optimal portfolios in area  $a$  are such that the risk-free interest rate satisfies,*

$$1/R^f = E [M_{a,1}(s)] \quad (\text{B.96})$$

*and the price of capital satisfies,*

$$Q_0 = R_0 + E [M_{a,1}(s) R_1(s)], \quad (\text{B.97})$$

*where  $M_{a,1}(s)$  denotes the (nominal) stochastic discount factor for area  $a$  and is given by*

$$M_{a,1}(s) = \delta \frac{P_{a,0}C_{a,0}}{P_{a,1}(s)C_{a,1}(s)} \frac{C_{a,1}(s)^{1-\gamma}}{E [C_{a,1}(s)^{1-\gamma}]}. \quad (\text{B.98})$$

Eq. (B.41) illustrates that the consumption wealth effect remains unchanged in this case [cf. Eq. (B.41)]. This is because we use Epstein-Zin preferences with an intertemporal elasticity of substitution equal to one. Eqs. (B.96) and (B.97) 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.98) characterizes the SDF. When  $\gamma = 1$ , the SDF has a familiar form corresponding to time-separable log utility. We relegate the proof of Lemma 4 to the end of this section.

Since the optimal consumption Eq. (B.95) 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  $a$ . We generalize Assumption D as follows.

**Assumption D<sup>U</sup>.**  $D_0 = \frac{\bar{\alpha}}{1-\bar{\alpha}}\bar{L}_0$  and  $D_1(s) \geq \frac{\bar{\alpha}}{1-\bar{\alpha}}\bar{L}_1$  for each  $s \in S$ .

As before, this assumption ensures that  $\tilde{K}_0^T = 0$  and  $\tilde{K}_1^T(s) \geq 0$  for each  $s$ .

Note also that we still have  $L_{a,0} = \bar{L}_0$  where  $\bar{L}_0$  corresponds to the solution to (B.38).

Next note that, since areas are identical, we have  $C_{a,1}(s) = C_1(s)$ . We also have  $W_{a,1}(s) = \bar{W}$ . By Lemma 1, this implies,

$$P_{a,1}(s) = (D_1(s))^{\bar{\alpha}} \bar{W}. \quad (\text{B.99})$$

Combining these observations with Eq. (B.94), we obtain a closed-form solution for consumption,

$$C_1(s) = \frac{D_1(s) + \bar{L}_1}{(D_1(s))^{\bar{\alpha}}}. \quad (\text{B.100})$$

Next note that we also have  $W_{a,0} = \bar{W}$ , and

$$P_{a,0} = D_0^{\bar{\alpha}} \bar{W}. \quad (\text{B.101})$$

Therefore, the analogous equation also applies in period 0,

$$C_0 = \frac{D_0 + \bar{L}_0}{D_0^{\bar{\alpha}}}. \quad (\text{B.102})$$

Substituting this into Eq. (B.95), and using (B.101), we obtain,

$$(D_0 + \bar{L}_0) \bar{W} = \frac{1}{1 + \delta} [H_{a,0} + Q_0].$$

After rearranging the expression, we find that Eq. (B.48) also applies in this setting:

$$(H_0 + Q_0) / \bar{W} = (1 + \delta) (\bar{L}_0 + D_0). \quad (\text{B.103})$$

As before, the sum of capital and human capital wealth must be equal to a multiple of the frictionless output level. This is necessary so that the implied wealth effect is sufficiently large to clear the goods market.

Next note that, after substituting Eqs. (B.100) and (B.102) for consumption and Eqs. (B.99) and (B.101) for goods prices, we obtain a closed-form solution for the stochastic discount factor in (B.98),

$$M_1(s) = \delta \frac{D_0 + \bar{L}_0}{D_1(s) + \bar{L}_1} \frac{\left( \frac{D_1(s) + \bar{L}_1}{(D_1(s))^{\bar{\alpha}}} \right)^{1-\gamma}}{E \left[ \left( \frac{D_1(s) + \bar{L}_1}{(D_1(s))^{\bar{\alpha}}} \right)^{1-\gamma} \right]}. \quad (\text{B.104})$$

Combining this expression with Eqs. (B.96) and (B.97), we also obtain closed-form solutions for  $R^{f,*}$  (“rstar”) and  $Q_0$ :

$$1/R^{f,*} = E[M_1(s)] \quad (\text{B.105})$$

$$Q_0/\bar{W} = D_0 + E[M_1(s) D_1(s)]. \quad (\text{B.106})$$

Here, the second line substitutes  $R_0 = D_0 \bar{W}$  and  $R_1(s) = D_1(s) \bar{W}$ . We can also calculate the



human capital wealth as,

$$H_0/\bar{W} = \bar{L}_0 + \frac{\bar{L}_1}{R^f} = \bar{L}_0 + \bar{L}_1 E[M_1(s)]. \quad (\text{B.107})$$

Note also that, when  $\gamma = 1$ , we have time-separable log utility and Eq. (B.104) reduces to the more familiar form,  $M_1(s) = \frac{D_0 + \bar{L}_0}{D_1(s) + \bar{L}_1}$ . Using this expression, note that, when there is a single state, Eqs. (B.105) (B.106), and (B.107) become identical to their counterparts in the earlier analysis [cf. Eqs. (B.51), (B.53), and (B.52)].

Since the aggregate wealth  $H_0 + Q_0$  remains unchanged [cf. (B.103)], the rest of the characterization in Section B.3 remains unchanged. In particular, labor shares in nontradable and tradable sectors are given by  $L_0^N/\bar{L}_0 = \frac{1-\alpha^N}{1-\alpha} \eta$  and  $L_0^T/\bar{L}_0 = \frac{1-\alpha^T}{1-\alpha} (1-\eta)$  [cf. Eq. (B.54)].

Recall that, in the baseline model without uncertainty, we generate fluctuations in  $Q_0$  as well as  $R_f^*$  from changes in  $D_1$ . 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. To state the result, recall that we normalize  $D_1(s) = s$  so that the probability distribution for states,  $\pi(s)$ , is the same as the distribution for capital productivity.

**Proposition 3.** *Consider the model with uncertainty with Assumption  $D^U$  and the normalization in (B.90). 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, labor is at its frictionless level,  $L_0 = \bar{L}_0$ , and nominal wages are at their expected level,  $W_0 = \bar{W}$ ; the stochastic discount factor is given by Eq. (B.104); the nominal interest rate is given by Eq. (B.105); the human capital and stock wealth are given by Eqs. (B.107) and (B.106); the shares of labor employed in the nontradable and tradable sectors are given by Eq. (B.54).*

*Consider any one of the following changes:*

(i) *Suppose  $\gamma = 1$  and the probability distribution,  $(\pi^{\text{old}}(s))_{s \in S}$ , changes such that  $(\pi^{\text{new}}(s))_{s \in S}$  first-order stochastically dominates  $(\pi^{\text{old}}(s))_{s \in S}$ .*

(ii) *Suppose  $\gamma = 1$  and the probability distribution,  $(\pi^{\text{old}}(s))_{s \in S}$ , changes such that  $(\pi^{\text{old}}(s))_{s \in S}$  is a mean-preserving spread of  $(\pi^{\text{new}}(s))_{s \in S}$ .*

(iii) *Suppose  $(\pi(s))_s$  remains unchanged but risk-aversion decreases,  $\gamma^{\text{new}} < \gamma^{\text{old}}$ .*

*These changes increase  $Q_0$  and reduce  $R_f^*$  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 households perceive greater capital productivity in the first-order stochastic dominance sense. The second part shows that a similar result obtains if households' 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  $\gamma$ , and shows that a similar result obtains also if households' belief distribution remains unchanged but their risk aversion declines. We relegate the proof of Proposition 3 to the end of this section.

**Comparative Statics of Local Labor Market Outcomes with Uncertainty.** Recall that since the optimal consumption Eq. (B.95) remains unchanged, all equilibrium conditions for period 0 derived in Section B.2 continue to apply conditional on  $Q_0$  and  $R^f$ . 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 3 affect these conditions only through their effect on  $Q_0$ . It follows that, conditional on generating the same change in the price of capital,  $\Delta Q_0$ , the model with uncertainty features the same *quantitative* effects on local labor market outcomes as in our baseline model. Combining this result with the comparative static results in Proposition 3, 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 4.** To analyze the households' problem, we consider the change of variables,

$$\tilde{S}_{a,0} = S_{a,0} + \frac{\overline{WL}_1}{R^f}.$$

Note that  $L_{a,1}(s) \equiv \overline{L}_1$ . Hence,  $\tilde{S}_{a,0}$  can be thought of as the households' "effective savings" that incorporates the present discounted value of her lifetime wealth. We also consider the change of variables

$$\omega_{a,1} \equiv \frac{(1 + x_{a,1})(Q_0 - R_0)}{\tilde{S}_{a,0}}.$$

Here,  $\omega_{a,1}$  captures the fraction of households' 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 households' problem can be equivalently written as,

$$\begin{aligned} \max_{\tilde{S}_{a,0}, \omega_{a,1}} \quad & \log C_{a,0} + \delta \log U_{a,1}, & (B.108) \\ \text{where } U_{a,1} = & \left( E \left[ C_{a,1}(s)^{1-\gamma} \right] \right)^{1/(1-\gamma)} \\ P_{a,0} C_{a,0} + \tilde{S}_{a,0} = & W_{a,0} L_{a,0} + \frac{\overline{WL}_1}{R^f} + (1 + x_{a,0}) Q_0 \\ P_{a,1}(s) C_{a,1}(s) = & \tilde{S}_{a,0} \left( R^f + \omega_{a,1} \left( \frac{R_1(s)}{Q_0 - R_0} - R^f \right) \right) \end{aligned}$$

Here,  $\frac{R_1(s)}{Q_0 - R_0}$  denotes the gross return on capital. When  $\omega_{a,1} = 0$ , the household does not invest in capital so her portfolio return is the gross risk-free rate,  $R^f$ . When  $\omega_{a,1} = 1$ , the household invests

all of her savings in capital so her portfolio return is the gross return to capital,  $\frac{R_1(s)}{Q_0 - R_0}$ .

Next consider the optimality condition for  $\tilde{S}_{a,0}$  in problem (B.108). This gives:

$$\begin{aligned}
\frac{1}{P_{a,0}C_{a,0}} &= \delta E \left[ \frac{U_{a,1}^\gamma C_{a,1}(s)^{-\gamma}}{U_{a,1}} \frac{1}{P_{a,1}(s)} \left( R^f + \omega_{a,1} \left( \frac{R_1(s)}{Q_0 - R_0} - R^f \right) \right) \right] \\
&= \delta E \left[ U_{a,1}^{\gamma-1} C_{a,1}(s)^{-\gamma} \frac{C_{a,1}(s)}{\tilde{S}_{a,0}} \right] \\
&= \delta E \left[ U_{a,1}^{\gamma-1} U_{a,1}^{1-\gamma} \frac{1}{\tilde{S}_{a,0}} \right] \\
&= \delta \frac{1}{\tilde{S}_{a,0}}.
\end{aligned}$$

Here, the second line uses the budget constraint in period 1 to substitute for the return in terms of  $C_{a,1}(s)$ ; the third line uses  $U_{a,1}^{1-\gamma} = E \left[ C_{a,1}(s)^{1-\gamma} \right]$  (from the definition of the certainty-equivalent return), and the last line simplifies the expression. Combining the resulting expression with the budget constraint in period 1, we obtain,

$$P_{a,0}C_{a,0} = \frac{1}{1+\delta} \left[ W_{a,0}L_{a,0} + \frac{\overline{WL}_1}{R^f} + (1+x_{a,0})Q_0 \right].$$

This establishes (B.95).

Next, to establish the asset pricing condition for the risk-free asset, consider the optimality condition for  $S_{a,0}^f$  in the original version of the problem (as this corresponds to saving in the risk-free asset). This gives:

$$\frac{1}{P_{a,0}C_{a,0}} = E \left[ \frac{\delta}{P_{a,1}(s) C_{a,1}(s)^\gamma E \left[ C_{a,1}(s)^{1-\gamma} \right]} R^f \right]. \quad (\text{B.109})$$

Rearranging terms and substituting  $M_{a,1}(s)$  from Eq. (B.98), we obtain Eq. (B.96). Finally, to establish the asset pricing condition for capital, consider the optimality condition for  $\omega_{a,1}$  in problem (B.108). This gives:

$$E \left[ \frac{C_{a,1}(s)^{-\gamma}}{P_{a,1}(s)} \left( \frac{R_1(s)}{Q_0 - R_0} - R^f \right) \right] = 0.$$

Rearranging terms, we obtain,

$$\begin{aligned}
Q_0 &= R_0 + \frac{1}{R^f E \left[ \frac{1}{P_{a,1}(s) C_{a,1}(s)^\gamma} \right]} E \left[ \frac{1}{P_{a,1}(s) C_{a,1}(s)^\gamma} R_1(s) \right] \\
&= R_0 + \delta E \left[ \frac{P_{a,0}C_{a,0}}{P_{a,1}(s) C_{a,1}(s)^\gamma E \left[ C_{a,1}(s)^{1-\gamma} \right]} R_1(s) \right]
\end{aligned}$$

$$= R_0 + E[M_1(s)R_1(s)].$$

Here, the second line uses Eq. (B.109) to simplify the expression and the last line substitutes for  $M_1(s)$  from Eq. (B.98). This establishes (B.97) and completes the proof of the lemma.  $\square$

**Proof of Proposition 3.** It remains to establish the comparative statics exercises. Recall that the aggregate wealth and human capital wealth satisfy [cf. Eqs. (B.48) and (B.107)],

$$\begin{aligned} (H_0 + Q_0)/\bar{W} &= (1 + \delta)(\bar{L}_0 + D_0) \\ H_0/\bar{W} &= \bar{L}_0 + \frac{\bar{L}_1}{R^{f,*}}. \end{aligned}$$

Note that the probability distribution,  $(\pi(s))_{s \in S}$ , or the risk aversion,  $\gamma$ , affect these equations only through their effect on  $Q_0$  and  $R^f$ . These equations imply that if  $Q_0$  increases in equilibrium, then  $R^{f,*}$  must also increase. Specifically, the first equation implies that if  $Q_0$  increases then  $H_0$  decreases. The second equation implies that if  $H_0$  decreases then  $R^{f,*}$  increases. 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  $\gamma = 1$  and  $D_1(s) = s$  into Eqs. (B.106) and (B.104), we obtain the following expression for the price of capital:

$$\begin{aligned} Q_0 &= D_0 + \delta(D_0 + \bar{L}_0)E[f(s)], \tag{B.110} \\ \text{where } f(s) &= \frac{s}{s + \bar{L}_1}. \end{aligned}$$

Here, the second line defines the function  $f : \mathbb{R}_+ \rightarrow \mathbb{R}_+$ . Note that this function is strictly increasing and strictly concave: that is,  $f'(s) > 0$  and  $f''(s) < 0$  for  $s > 0$ . Combining this observation with Eq. (B.110) proves the desired comparative statics. To establish (i), note that  $E^{new}[f(s)] \geq E^{old}[f(s)]$  because  $f(s)$  is increasing in  $s$ , and  $\pi^{new}(s)$  first-order stochastically dominates  $\pi^{old}(s)$ . To establish (ii), note that  $E^{new}[f(s)] \geq E^{old}[f(s)]$  because  $f(s)$  is increasing and concave in  $s$ , and  $\pi^{new}(s)$  second-order stochastically dominates  $\pi^{old}(s)$  (which in turn follows because  $\pi^{old}(s)$  is a mean-preserving spread of  $\pi^{new}(s)$ ).

Finally, consider the comparative statics exercise in part (iii). In this case, Eqs. (B.106) and (B.104) imply,

$$\begin{aligned} Q_0 &= D_0 + \delta(D_0 + \bar{L}_0) \frac{E[f(s)g(s)^{1-\gamma}]}{E[g(s)^{1-\gamma}]}, \tag{B.111} \\ \text{where } g(s) &= \frac{s + \bar{L}_1}{s^\alpha}. \end{aligned}$$

Here, the second line defines the function  $g : \mathbb{R}_+ \rightarrow \mathbb{R}_+$ . We first claim that this function is

increasing in  $s$  over the relevant range. To see this, note that,

$$g'(s) = s^{-\bar{\alpha}-1} ((1 - \bar{\alpha})s - \bar{\alpha}\bar{L}_1).$$

Assumption D<sup>U</sup> implies that  $s \geq \frac{\bar{\alpha}}{1-\bar{\alpha}}\bar{L}_1$ , which in turn implies  $g'(s) \geq 0$ . Therefore,  $g(s)$  is increasing in  $s$  over the range implied by Assumption D<sup>U</sup>.

Next note that Eq. (B.111) can be rewritten as

$$Q_0 = D_0 + \delta (D_0 + \bar{L}_0) E^* [f(s)],$$

where  $E^*[\cdot]$  denotes the expectations under the endogenous probability distribution  $\{\pi_s^*\}_{s \in S}$ , defined by,

$$\pi_s^* = \frac{\pi_s g(s)^{1-\gamma}}{\sum_{\tilde{s} \in S} \pi_{\tilde{s}} g(\tilde{s})^{1-\gamma}} \text{ for each } s \in S. \quad (\text{B.112})$$

Hence, using our result from part (i), it suffices to show that  $\pi_s^{*,new}$  (which corresponds to  $\gamma^{new} < \gamma^{old}$ ) first-order stochastically dominates  $\pi_s^{*,old}$ .

To establish the last claim, define the cumulative distribution function corresponding to the endogenous probability distribution,

$$\Pi_s^*(\gamma) = \sum_{\tilde{s} \leq s} \pi_{\tilde{s}}^* = \frac{\sum_{\tilde{s} \leq s} \pi_{\tilde{s}} g(\tilde{s})^{1-\gamma}}{\sum_{\tilde{s} \in S} \pi_{\tilde{s}} g(\tilde{s})^{1-\gamma}} \text{ for each } s \in S. \quad (\text{B.113})$$

We made the dependence of the distribution function on  $\gamma$  explicit. To prove the claim, it suffices to show that  $\frac{d\Pi_s^*(\gamma)}{d\gamma} \geq 0$  for each  $s \in S$  (so that a decrease in  $\gamma$  decreases  $\Pi_s^*(\gamma)$  for each  $s$  and thus increases the distribution in the first-order stochastic dominance order). We have:

$$\begin{aligned} \frac{d\Pi_s^*(\gamma)}{d\gamma} &= \frac{\sum_{\tilde{s} \leq s} \pi_{\tilde{s}} g(\tilde{s})^{1-\gamma}}{\sum_{\tilde{s} \in S} \pi_{\tilde{s}} g(\tilde{s})^{1-\gamma}} \left( -\frac{\sum_{\tilde{s} \leq s} \pi_{\tilde{s}} g(\tilde{s})^{1-\gamma} \log g(\tilde{s})}{\sum_{\tilde{s} \leq s} \pi_{\tilde{s}} g(\tilde{s})^{1-\gamma}} + \frac{\sum_{\tilde{s} \in S} \pi_{\tilde{s}} g(\tilde{s})^{1-\gamma} \log g(\tilde{s})}{\sum_{\tilde{s} \in S} \pi_{\tilde{s}} g(\tilde{s})^{1-\gamma}} \right) \\ &= \frac{\sum_{\tilde{s} \leq s} \pi_{\tilde{s}} g(\tilde{s})^{1-\gamma}}{\sum_{\tilde{s} \in S} \pi_{\tilde{s}} g(\tilde{s})^{1-\gamma}} \left( -\sum_{\tilde{s} \leq s} \frac{\pi_{\tilde{s}}^*}{\Pi_s^*(\gamma)} \log g(\tilde{s}) + \sum_{\tilde{s} \in S} \pi_{\tilde{s}}^* \log g(\tilde{s}) \right) \\ &= \frac{\sum_{\tilde{s} \leq s} \pi_{\tilde{s}} g(\tilde{s})^{1-\gamma}}{\sum_{\tilde{s} \in S} \pi_{\tilde{s}} g(\tilde{s})^{1-\gamma}} (-E^* [\log g(\tilde{s}) \mid \tilde{s} \leq s] + E^* [\log g(\tilde{s})]). \end{aligned}$$

Here, the second line substitutes the definition of the endogenous distribution and its cumulative distribution from Eqs. (B.112) and (B.113). The last line substitutes the unconditional and conditional expectations. It follows that  $\frac{d\Pi_s^*(\gamma)}{d\gamma} \geq 0$  for some  $s \in S$  if and only if the unconditional expectation exceeds the conditional expectation,  $E^* [\log g(\tilde{s})] \geq E^* [\log g(\tilde{s}) \mid \tilde{s} \leq s]$ . This is true because  $\log g(s)$  is increasing in  $s$  (since  $g(s)$  is increasing), which implies that the conditional expectation is increasing in  $s$ . This proves the claim and completes the proof of part (iii).  $\square$

## B.9 Extending the Model for More General EIS

We next generalize the model to consider more general levels of EIS. For simplicity, suppose all areas except for one have time-separable log utility (3) as in the baseline model. The remaining area, denoted by  $a$ , has the following more general utility function,

$$u(C_{a,0}) + \delta u(C_{a,1}) \text{ where } u(C) = \frac{\varepsilon}{\varepsilon - 1} \left( C^{\frac{\varepsilon-1}{\varepsilon}} - 1 \right). \quad (\text{B.114})$$

We characterize the equilibrium in area  $a$  and illustrate how it depends on the EIS parameter,  $\varepsilon$ . To simplify the analysis, we assume all other areas have equal wealth,  $x_{\tilde{a},0} = 0$  for each  $\tilde{a} \neq a$ . Since area  $a$  has zero mass, this ensures that the aggregate allocations and prices, as well as the allocations and prices in each area  $\tilde{a} \neq a$ , are described by the common-wealth benchmark characterized in Section B.7.

To characterize the equilibrium in area  $a$ , first note that (after substituting the equilibrium price for  $Q_0$ ) households' budget constraints can be combined into a lifetime budget constraint,

$$P_{a,0}C_{a,0} + \frac{P_{a,1}C_{a,1}}{R^f} = H_{a,0} + (1 + x_{a,0})Q_0.$$

Households in area  $a$  maximize (B.114) subject to this constraint. The optimality condition gives the Euler equation,

$$\begin{aligned} P_{a,1}C_{a,1} &= \delta^\varepsilon R^f \left( R^{fr} \right)^{\varepsilon-1} P_{a,0}C_{a,0} \\ \text{where } R_a^{fr} &= R^f \frac{P_{a,0}}{P_{a,1}} \end{aligned} \quad (\text{B.115})$$

Here,  $R_a^{fr}$  denotes the real interest rate in area  $a$ . Substituting this into the budget constraint, we obtain the following analogue of Eq. (6),

$$P_{a,0}C_{a,0} = \frac{1}{1 + \delta^\varepsilon \left( R_a^{fr} \right)^{\varepsilon-1}} \left( H_{a,0} + (1 + x_{a,0})Q_0 \right), \quad (\text{B.116})$$

This expression illustrates that a similar relationship between wealth and consumption exists once we replace the exogenous parameter,  $\delta$ , with its counterpart,  $\delta^\varepsilon \left( R_a^{fr} \right)^{\varepsilon-1}$ . When  $\varepsilon = 1$ , the wealth-effect coefficient,  $\frac{1}{1 + \delta^\varepsilon \left( R_a^{fr} \right)^{\varepsilon-1}}$ , does not depend on the real interest rate. In this case, which we analyze in the main text, the income and substitution effects are exactly balanced so that we have a pure wealth effect. When  $\varepsilon > 1$ , the wealth-effect coefficient is decreasing in the interest rate. In this case, there is a net substitution effect so that greater interest rate increases savings and reduces consumption. Conversely, when  $\varepsilon < 1$ , the wealth-effect coefficient is increasing in the interest rate due to a net-income effect.

To characterize the rest of the equilibrium, note that much of the analysis in Section B.2 applies

also in this case. In particular, after using  $x_{\tilde{a},0} = 0$  for each  $\tilde{a}$ , the labor demand equation in area  $a$  is given by the following analogue of Eq. (B.47):

$$W_{a,0}L_{a,0} = \frac{(1 - \alpha^N)\eta}{1 + \delta^\varepsilon (R_a^{fr})^{\varepsilon-1}} \left( W_{a,0}L_{a,0} + \frac{\overline{WL}_1}{R^f} + (1 + x_{a,0})Q_0 \right) + \left( \frac{P_{a,0}^T}{P_0^T} \right)^{1-\varepsilon} \overline{WL}_0^T$$

Here, recall that  $R_a^{fr}$  is given by Eq. (B.115) where  $P_{a,t} = (P_{a,t}^N)^\eta (P_{a,t}^T)^{1-\eta}$  and  $P_{a,t}^N, P_{a,t}^T$  as well as  $P_{a,t}$  are characterized by Lemma 1. Using  $x_{\tilde{a},0} = 0$ , we also have,

$$P_{a,t} = \left( \frac{W_{a,0}}{\overline{W}} \right)^{\eta(1-\alpha^N)} D_t^{\overline{\alpha}} \overline{W} \text{ and } \frac{P_{a,0}^T}{P_0^T} = \left( \frac{W_{a,0}}{\overline{W}} \right)^{1-\alpha^T}.$$

After substituting these expressions, we simplify the labor demand equation as follows,

$$W_{a,0}L_{a,0} = \frac{(1 - \alpha^N)\eta}{1 + \delta^\varepsilon (R_a^{fr})^{\varepsilon-1}} \left( W_{a,0}L_{a,0} + \frac{\overline{WL}_1}{R^f} + (1 + x_{a,0})Q_0 \right) + \left( \frac{W_{a,0}}{\overline{W}} \right)^{(1-\alpha^T)(1-\varepsilon)} \overline{WL}_0^T,$$

where  $R_a^{fr} = R^f \frac{D_0^{\overline{\alpha}}}{D_1^{\overline{\alpha}}} \left( \frac{W_{a,0}}{\overline{W}} \right)^{\eta(1-\alpha^N)}$ .

The equilibrium in area  $a$  is characterized by solving this equation together with the labor supply equation (B.17).

To make progress, consider the special case in which wages are perfectly sticky,  $\lambda_w = 0$  (which also leads to  $\lambda = 0$ ). In this case,  $W_{a,0} = \overline{W}$  and the labor demand equation can be further simplified as,

$$\overline{W}L_{a,0} = \frac{(1 - \alpha^N)\eta}{1 + \delta^\varepsilon (R^{fr})^{\varepsilon-1}} \left( \overline{W}L_{a,0} + \frac{\overline{WL}_1}{R^f} + (1 + x_{a,0})Q_0 \right) + \overline{WL}_0^T, \quad (\text{B.117})$$

where  $R^{fr} = R^f \frac{D_0^{\overline{\alpha}}}{D_1^{\overline{\alpha}}}$ .

Here,  $R^{fr}$  denotes the aggregate real interest rate. This expression illustrates that the labor market equilibrium in area  $a$  is characterized in similar fashion to the equilibrium in other areas. The main difference concerns the wealth-effect coefficient,  $\frac{(1-\alpha^N)\eta}{1+\delta^\varepsilon(R^{fr})^{\varepsilon-1}}$ . The new coefficient illustrates that the level of the real interest rate affects the labor bill.

Next note that the aggregate equilibrium is unchanged and characterized as in Appendix B.7. In particular, the nominal interest rate is characterized by,

$$R^f = \frac{1}{\delta} \frac{\overline{L}_1 + D_1}{\overline{L}_0 + D_0}.$$

Thus, the real interest rate is characterized by,

$$R^{fr} = \frac{1}{\delta} \frac{\bar{L}_1 + D_1}{\bar{L}_0 + D_0} \frac{D_0^{\bar{\alpha}}}{D_1^{\bar{\alpha}}}.$$

Note that, we have:

$$\frac{dR^{fr}}{dD_1} = \frac{1}{\delta} \frac{D_0^{\bar{\alpha}}}{\bar{L}_0 + D_0} D_1^{-\bar{\alpha}-1} (-\bar{\alpha}\bar{L}_1 + (1 - \bar{\alpha}) D_1) \geq 0,$$

where the inequality follows from Assumption D. Therefore, an increase in  $D_1$  increases not only the nominal interest rate but also the real interest rate. Combining this observation with Eq. (B.117) illustrates that a shock to  $D_1$  that changes the price of capital has two effects on the labor markets in area  $a$  with high stock wealth,  $x_{a,0}$ . First, it creates a wealth effect as in the earlier analysis. Second, since it increases  $R^{fr}$ , it also creates a net substitution or income effect depending on whether  $\varepsilon > 1$  or  $\varepsilon < 1$ .