

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

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## Abstract

This paper uses a local labor market analysis to provide evidence on the stock market consumption wealth effect. Our empirical strategy exploits regional heterogeneity in stock market wealth to identify the causal effect of stock price changes on labor market outcomes. An increase in stock wealth increases county employment and payroll in nontradable industries, as well as in total, while having no effect on employment in tradable industries. We use these responses to calibrate a model with stock market shocks and consumption wealth effects in a heterogeneous geographic setting. Combining the data and model, we find that a one dollar increase in stock wealth increases household spending by around 2.8 cents per year. A 20% increase in stock valuations, unless countered by monetary policy, increases the aggregate labor bill by at least 0.85% and aggregate employment by at least 0.26% 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. According to this view, a decline in stock prices reduces the wealth of stock-owning households, causing a reduction in spending and thereby 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, a decline in expected TFP could also account for both a negative stock return and a subsequent decline in household spending and employment.

In this paper we use a local labor market analysis to address this empirical challenge and to provide quantitative evidence on the stock market consumption wealth effect. Our empirical strategy exploits regional heterogeneity in stock market wealth to identify the causal effect of stock price changes on labor market outcomes. To guide and interpret the empirical analysis, we present a model featuring regional heterogeneity in stock wealth. Overall, we find statistically strong evidence for the stock market wealth effect.

We start by presenting the theory. The model environment features a continuum of areas, a tradable and nontradable good, and two factors of production, capital and labor. Ownership of capital is heterogeneous across areas, mirroring the regional heterogeneity in stock wealth in the data. The price of capital is endogenous and can change due to changes in households' beliefs about the expected future productivity of capital (equivalently, due to changes in risk aversion or risk). Thus, stock prices can change without any change in the productivity of the economy in the short run, consistent with a large finance literature which finds that stock prices fluctuate considerably without meaningful changes in underlying earnings or dividends (Cochrane, 2011; Campbell, 2014).

In the model, changes in the price of capital impact local labor markets more in areas with greater ownership of capital. The main mechanism is a wealth effect: an increase in local stock wealth increases local spending on nontradable goods. Higher spending drives up the labor bill and employment in the nontradable sector. It also increases the total labor bill and—due to nominal wage rigidities—total employment. Local wages also weakly increase, which induces a (weak) fall in tradable employment. In sum, the model predicts that an increase in stock wealth in an area increases the labor bill and employment in nontradable industries and in total, while weakly reducing employment in tradable industries. Finally, the model guides our empirical analysis by showing that the coefficient from a regression of the log change in a labor market outcome on the change in local wealth normalized by the local labor bill has a direct structural interpretation.

To test these predictions, we use regional variation in stock market wealth to investigate how changes in local stock wealth driven by aggregate stock price changes affect local labor market outcomes. We measure county-level stock market wealth by capitalizing dividend income reported on tax returns. We merge these data with administrative employment and payroll data from the Quarterly Census of Employment and Wages (QCEW). We interact the local stock market wealth with the return on the S&P 500 index and normalize by local labor income to obtain our “stock market wealth shock” measure for each area and quarter. Our preferred specification also controls for county fixed effects, state-by-quarter fixed effects, and a Bartik employment shock based on 3-digit NAICS employment shares. Thus, our identifying assumption is that following a positive stock return, areas with high stock market wealth do not experience unusually rapid employment or payroll growth — relative to other counties in the same state and conditional on their industrial composition — for reasons other than the wealth effect on local spending.

We find that an increase in local stock wealth induced by a positive return on the S&P 500 index 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 0.69 basis points higher and the local payroll is 2.25 basis points higher. Because stock returns are close to i.i.d., these responses should be interpreted as the short-run effect of a permanent change in stock market wealth. Motivated by our model, we also investigate the effect on employment and the wage bill in the nontradable and tradable sectors following the sectoral classifications in Mian and Sufi (2014). Consistent with the theory, the employment response in industries classified as nontradable exceeds the overall response, while employment in industries classified as tradable does not increase. We also report a large response in the residential construction sector, again 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 which co-move with the stock market. 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. We further show the robustness of these findings along a number of dimensions, including: using a more parsimonious specification with only county and time fixed effects; including interactions of stock market wealth with other aggregate variables such as TFP growth, GDP growth, or the change in interest rates to allow wealthier counties to have different loadings on these variables; 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 weighting the regression or not. These exercises exploit the substantial variation in stock returns which occurs independent of other

macroeconomic variables. We also report a decomposition exercise along the lines of Andrews et al. (2017) and show that no single state or group of states drive the results. On the other hand, we find evidence of a larger response of the nontradable labor bill to stock market wealth changes in states with a lower average level of wealth.

We next combine our empirical results with the theoretical model to calibrate two key parameters: the strength of the direct stock wealth effect and the degree of wage flexibility. To calibrate the stock wealth effect, we provide a separation result from our model that decomposes the empirical coefficient on *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> 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 nontradable labor bill implies that in partial equilibrium a one dollar increase in stock-market wealth increases annual consumption expenditure by about 2.8 cents two years after the shock. For the degree of wage flexibility, we provide an upper bound by comparing the response of total employment with the response of the total labor bill. Specifically, our empirical responses suggest that 1 percent increase in employment is associated with at most a 2.26 percent increase in wages at a two year horizon. Wage adjustment would be even smaller if hours per worker (which we do not observe) also change in the same direction as employment.

Finally, we use the model to quantify the *aggregate* effects that stock price shocks would generate if monetary policy (or other demand-stabilization policies) does not respond to the shock. We first show that with homothetic preferences and production across sectors, a one dollar increase in stock market wealth has the same *proportional* effect on nontradable and total labor bill, up to an adjustment for the difference in the local and aggregate spending multipliers. We then consider a 20% positive shock to stock valuations — approximately the yearly standard deviation of stock returns. Using our empirical estimate for the nontradable labor bill, and applying a bounding argument for moving from local to aggregate effects similar to that in Chodorow-Reich (2019), this shock would increase the aggregate labor bill by at least 0.85% two years after the shock. Combining this effect with our estimated bound for wage flexibility, the shock would also increase aggregate employment by at least 0.26%. We conclude that stock market fluctuations can have sizable real effects.

The rest of the paper is organized as follows. We discuss related literature next. Section 2

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<sup>1</sup> In general, there may be an additional term reflecting the response of output in the traded sector when relative prices change across areas. This term disappears in our benchmark calibration which features Cobb-Douglas preferences across traded goods produced in different regions. We show in robustness that allowing for a non-unitary elasticity of substitution across regions does not meaningfully change our conclusions.

describes the theoretical framework. Section 3 describes the data sets and the construction of our main variables. Section 4 presents the baseline empirical specification and discusses conditions for causal inference. Section 5 contains the empirical results. 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. 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 precise information on household consumption as well as financial wealth. The recent literature has tried to address these challenges in various ways (see Poterba (2000) for a survey of the earlier literature).

One strand of the literature uses aggregate time series data (see e.g. Poterba and Samwick, 1995; Davis and Palumbo, 2001; Lettau et al., 2002; Lettau and Ludvigson, 2004; Carroll et al., 2011). While the evidence is mixed, we believe aggregate time series data is not ideal to capture the wealth effect. 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 (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. For example, 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. (2018) 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 (2.8 cents per dollar

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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.

per year) is close to the estimates from the recent literature. Also, consistent with Di Maggio et al. (2018), we find evidence for a heterogeneous response depending on the wealth level. An additional advantage of the regional approach is that it directly estimates the local *general equilibrium* effect. In particular, by examining the response of labor markets, 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 which 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 the time fixed effect, allowing us to isolate the consumption wealth channel.

Our theoretical framework builds upon the model in Mian and Sufi (2014) by incorporating several features important for the structural interpretation of the results, including endogenous changes in wealth, monetary policy, partial wage adjustment, and imperfectly substitutable tradable goods. The 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. We show how 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. (in progress), we illustrate how the estimated lo-

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<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.

cal general equilibrium effects can be combined with (external) estimates of the local income multiplier to obtain the partial equilibrium spending effect. Our decomposition differs from theirs in that it applies to the coefficient for the nontradable labor bill—a variable which 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.

Finally, our paper relates to a literature that studies the monetary policy response to asset price fluctuations. Rigobon and Sack (2003), Bjørnland and Leitemo (2009), and more recently Cieslak and Vissing-Jorgensen (2017) show that monetary policy responds to the stock market. Caballero and Simsek (2017) argue that the monetary policy response to asset price fluctuations mitigates demand recessions, and empirically support this view by comparing the severity of recessions following house price declines within and outside the Eurozone. Our paper complements their findings by showing that stock price declines (that are unrelated to short-run productivity) would reduce aggregate employment if monetary policy were to not respond.<sup>4</sup>

## 2 Theoretical Predictions

This section develops a stylized theoretical model to guide and interpret the empirical analysis. We present the main equations and results in the main text and relegate additional details to Appendix A. We use the model to illustrate the aggregate and cross-sectional effects of changes in stock wealth and to motivate our empirical specification. In Section 6 we show how the empirical results can be used to calibrate the model.

The model consists of a continuum of areas denoted by 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

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<sup>4</sup>The previous literature has been skeptical about whether such a response is welfare improving. Specifically, Bernanke et al. (1999; 2001) and Gilchrist and Leahy (2002) argue that for an inflation-targeting central bank there is little additional benefit to targeting asset prices generally and the stock market in particular beyond the informational content of asset prices for future inflation.

in period 1. Importantly, ownership of capital is heterogeneous across areas. We focus on understanding 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.

## 2.1 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 which can be transported costlessly across areas,  $C_{a,t}^T$ , and a nontradable good which must be consumed in the area in which it is produced,  $C_{a,t}^N$ . The household has intra-period preferences:

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

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

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

There are two technologies for producing the tradable consumption good  $Y_t^T$ :

$$Y_t^T = \left( \int_a F(K_{a,t}^T, L_{a,t}^T)^{\frac{\varepsilon-1}{\varepsilon}} da \right)^{\frac{\varepsilon}{\varepsilon-1}} + G_t(\tilde{K}_t^T).$$

The first technology combines tradable inputs produced in each area using local labor  $L_{a,t}^T$  and capital  $K_{a,t}^T$  and the Cobb-Douglas technology:

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

The elasticity of substitution  $\varepsilon > 0$  governs the effect of unit costs in an area on the aggregate expenditure on exports from that area.

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

$$G_t(\tilde{K}_t^T) = D_t^{1-\alpha} \tilde{K}_t^T.$$

The productivity parameter  $D_t$  determines the rental rate of capital (the exponent,  $1-\alpha$ , helps to simplify the expressions). We will obtain changes in stock prices by varying the future productivity in this technology,  $D_1$ .

Areas are identical except for their initial capital wealth. Specifically, 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.<sup>5</sup>

The representative household in each area supplies labor in both periods. For simplicity, the frictionless labor supply is fixed within a period and denoted by  $\bar{L}_t$ . In period 1, equilibrium labor will coincide with the frictionless labor supply,  $L_{a,1} = \bar{L}_1$  for each  $a$ . In period 0, labor can differ from the frictionless benchmark due to nominal wage rigidities. We model wage rigidity with the following ‘‘Wage Phillips Curve’’ (see Galí (2011); Beraja et al. (2016) for microfounded models that lead to variants of this equation):

$$W_{a,0}/\bar{W} = (L_{a,0}/\bar{L}_0)^\kappa. \quad (1)$$

Here,  $\bar{W}$  is the nominal wage that would obtain in period 0 absent shocks (for simplicity, it is the same as the nominal wage in period 1). The parameter  $\kappa \geq 0$  governs the degree of wage flexibility. When  $\kappa \rightarrow \infty$ , nominal wages are completely flexible and labor is always equal to its frictionless level.<sup>6</sup> When  $\kappa = 0$ , nominal wages are completely fixed and labor can deviate from its frictionless level without affecting wage inflation.

In period 0, the representative household in each area  $a$  makes a consumption-savings decision to maximize a time-separable log utility function:

$$\log C_{a,0} + \delta \log C_{a,1}. \quad (2)$$

In particular, the elasticity of intertemporal substitution (EIS) is equal to one. This assumption simplifies the analysis. It is also empirically plausible, as it falls roughly in the middle of the wide range of estimates found in the literature (see Appendix A.9 for a discussion of how a more general EIS affects our analysis).

Households also make a portfolio decision to allocate their savings between capital (stock wealth) and a risk-free asset. The risk-free asset is in zero net supply and generates a gross

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<sup>5</sup>Since capital is mobile across regions, our model does not feature any home bias in stock ownership. Section 3.1 discusses how home bias may affect our empirical estimates.

<sup>6</sup>One difference from the standard RBC model is that we assume the frictionless labor supply is fixed. Endogenizing the labor supply would make it *more* difficult to match our empirical evidence, as we find that an increase in local stock wealth *increases* local employment. In the standard RBC model, a positive wealth shock increases leisure as well as consumption and therefore *reduces* employment (see, e.g., Barro and King (1984)). Jaimovich and Rebelo (2009) modify the basic RBC model in order to generate a positive comovement between wealth shocks and labor supply.

nominal return in period 1 denoted by  $R^f$ . The monetary policy sets the nominal return on the risk-free asset to  $R^f = R^{f,*}$ , where  $R^{f,*}$  is the level that ensures that aggregate employment in period 0 equals its frictionless level,  $\int_a L_{a,0} da = \bar{L}_0$ . Appendix A.1 completes the description of the setup and defines the equilibrium.

## 2.2 Consumption Wealth Effect

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

$$P_{a,0}C_{a,0} = \frac{1}{1+\delta} (H_{a,0} + (1+x_{a,0})Q_0). \quad (3)$$

Here,  $P_{a,0}$  is the period 0 price level in area  $a$ ,  $(1+x_{a,0})Q_0$  denotes the stock wealth in the area, and  $H_{a,0}$  denotes human capital wealth: that is, 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 case to illustrate the source of stock price fluctuations, and we use the log-linearized equilibrium to describe the regional effects of these fluctuations.

## 2.3 Stock Price Fluctuations With Common Wealth

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 A.3. We make a parametric assumption on  $D_0$  that ensures that firms are indifferent to using the capital-only technology in period 0 (but they use it in period 1).<sup>7</sup> In this case, the equilibrium is particularly simple and given by:

$$\begin{aligned} L_0 &= \bar{L}_0, W_0 = \bar{W} \text{ and } L_0^N = \eta\bar{L}_0, L_0^T = (1-\eta)\bar{L}_0, \\ R^f &= R^{f,*} = \frac{1}{\delta} \frac{\bar{L}_1 + D_1}{\bar{L}_0 + D_0}, \end{aligned} \quad (4)$$

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<sup>7</sup>For simplicity, we assume the capital-only technology can be used to produce tradables but not non-tradables. This provides one potential source of nonhomotheticity across sectors. The assumption on  $D_0$  ensures that production remains homothetic in period 0, which will be important for some of our results. It also simplifies the expressions, e.g., it implies the share of labor in period 0 is given by its share in the Cobb-Douglas technology,  $1-\alpha$ .

$$\begin{aligned}
Q_0/\bar{W} &= D_0 + \frac{D_1}{R^f} = D_0 + \delta (\bar{L}_0 + D_0) \frac{D_1}{\bar{L}_1 + D_1}, \\
H_0/\bar{W} &= \bar{L}_0 + \frac{\bar{L}_1}{R^f} = \bar{L}_0 + \delta (\bar{L}_0 + D_0) \frac{\bar{L}_1}{\bar{L}_1 + D_1}.
\end{aligned}$$

The first equation shows that labor and nominal wages are equal to the frictionless levels. Moreover, the share of labor employed in each sector is determined by the sectoral shares in household spending. The second equation characterizes the interest rate that brings about this outcome (“rstar”).

The last two equations characterize the prices of physical and human capital. An increase in the future productivity of capital,  $D_1$ , translates into an increase in the equilibrium price of capital  $Q_0$ . The monetary policy responds to this change by raising  $R^f$ ; however, the price of capital increases in equilibrium even after incorporating the monetary policy response.

We focus on the comparative statics of a change in the productivity of capital from some  $D_1^{old}$  to  $D_1^{new}$ . By Eq. (4), this changes the price of capital from  $Q_0^{old}$  to some  $Q_0^{new}$ , while leaving the aggregate labor market outcomes unchanged,  $L_0 = \bar{L}_0, W_0 = \bar{W}$ . In the rest of the analysis, we investigate how this change affects *local* labor market outcomes when stock wealth is heterogeneously distributed across areas. In Appendix A.8, we generalize the analysis to incorporate uncertainty over  $D_1$  and show that our analysis is robust to obtaining the fluctuations in  $Q_0$  from other sources such as changes in the level of uncertainty or changes in risk aversion.<sup>8</sup>

## 2.4 Empirical Predictions with Heterogeneous Wealth

We now derive predictions for the empirically-relevant case of a heterogeneous distribution of stock wealth and highlight 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  $w_{a,0} = \log(W_{a,0}/\bar{W})$  and  $l_{a,0} = \log(L_{a,0}/\bar{L}_0)$  denote the log-deviations of total nominal wages and total labor for each area. We likewise define  $l_{a,0}^N$  and  $l_{a,0}^T$  for the nontradable and tradable sectors. In Appendix A.4 we present closed-form solutions for  $w_{a,0}, l_{a,0}, l_{a,0}^N, l_{a,0}^T$  for a given level of  $D_1$ .

Our key predictions correspond to the comparative statics as  $D_1^{old}$  changes to  $D_1^{new}$ . Since the benchmark around which we log-linearize remains unchanged, the first-order effect on

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<sup>8</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 *quantitative* effects on local labor market outcomes as in our baseline model.

local labor market outcomes is characterized by changes in log-deviations. We solve for these changes as follows (see Appendix A.5):

$$\Delta(w_{a,0} + l_{a,0}) = \frac{1 + \kappa}{1 + \kappa\zeta} \mathcal{M} (1 - \alpha) \eta \frac{1}{1 + \delta} \frac{x_{a,0} \Delta Q_0}{\bar{W}L_0}, \quad (5)$$

$$\Delta l_{a,0} = \frac{1}{1 + \kappa} \Delta(w_{a,0} + l_{a,0}), \quad (6)$$

$$\Delta(w_{a,0} + l_{a,0}^N) = \mathcal{M} (1 - \alpha) \frac{1}{1 + \delta} \left[ \frac{x_{a,0} \Delta Q_0}{\bar{W}L_0} + (1 - \eta) \Delta(w_{a,0} + l_{a,0}^T) \right], \quad (7)$$

$$\Delta(w_{a,0} + l_{a,0}^T) = -(\varepsilon - 1) (1 - \alpha) \Delta w_{a,0}, \quad (8)$$

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

$$\text{and } \zeta = 1 + (\varepsilon - 1) (1 - \alpha) (1 - \eta) \mathcal{M}.$$

Here,  $\Delta y \equiv y^{new} - y^{old}$  denotes the change in the corresponding equilibrium variable. In particular,  $\Delta Q_0 = Q_0^{new} - Q_0^{old}$  denotes the change in the aggregate stock wealth in dollars. Thus,  $x_{a,0} \Delta Q_0$  denotes the change in stock wealth in an area relative to other areas. The equations describe how the (relative) stock wealth change normalized by the labor bill,  $\frac{x_{a,0} \Delta Q_0}{\bar{W}L_0}$ , affects the (relative) local labor market outcomes in the area.

These equations are intuitive. Eq. (5) 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. (3)), of which  $\eta/(1 + \delta)$  falls on nontradable goods produced locally. The increase in spending in turn leads to  $(1 - \alpha) \eta / (1 + \delta)$  more dollars of payments to local labor. 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 adjustment 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 affects the tradable labor bill and thus the total labor bill. This effect reduces (resp. increases) the labor bill when tradable inputs are gross substitutes,  $\varepsilon > 1$  (resp. gross complements,  $\varepsilon < 1$ ).

Eq. (6) is a rearrangement of the Wage Phillips Curve, Eq. (1), which relates changes in labor to changes in the wage bill according to the wage flexibility parameter,  $\kappa$ . In particular, the relative magnitude of the responses of employment and of the total labor bill to a change in stock wealth will discipline  $\kappa$  in our calibration exercise.

Eqs. (7) and (8) 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,  $\Delta(w_{a,0} + l_{a,0}^T) = 0$ ,

and the effect on the nontradable labor bill parallels the effect on the total labor bill. The coefficient multiplying the wealth change can be decomposed into three terms: the partial equilibrium marginal propensity to consume (MPC) out of stock market wealth  $1/(1 + \delta)$ , the labor share of income  $1 - \alpha$ , and the local multiplier  $\mathcal{M}$ . In Section 6 we use this simple decomposition to recover the partial equilibrium MPC given externally calibrated  $\alpha$  and  $\mathcal{M}$ . Notably, the expression does not require information on the share of nontradables in spending,  $\eta$ .

When  $\varepsilon \neq 1$ , the decomposition for the nontradable sector does not hold exactly. In this case, as illustrated by Eq. (8), the stock wealth shock can have an effect on the tradable labor bill if it has an effect on wages. As illustrated by Eq. (7), 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 are sufficiently sticky, then the tradable adjustment has a small impact on the analysis even when  $\varepsilon$  is somewhat different than 1.

## 2.5 Summary and Implications

According to Eqs. (5) to (8), an increase in *national* stock prices driven by, e.g., changes in risk aversion or expected *future* productivity, 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 A.4, we further derive the predictions that nontradable employment, total employment, and wages weakly increase, and tradable employment weakly falls.

The model also motivates the form of the regressions we analyze in subsequent sections. In particular, define  $S_{a,0} \equiv \frac{x_{a,0}Q_0}{WL_0}$  as the area'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:

$$S_{a,0}R_0 = \frac{x_{a,0}\Delta Q_0}{WL_0}. \quad (9)$$

Hence,  $S_{a,0}R_0$  captures the change in the stock wealth of the area normalized by the local labor bill. Eqs. (5) to (8) illustrate that regressions of log changes in local labor market outcomes on this variable yield coefficients tightly related to key parameters of the model, a mapping we exploit in Section 6. As emphasized by Dynan and Maki (2001), such “dollar-dollar” specifications arise naturally in consumption-wealth models.<sup>9</sup>

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<sup>9</sup>An alternative would be to estimate an elasticity and to convert back into a dollar-dollar coefficient using the sample average of the ratio of stock market wealth to labor income (or consumption). This alternative has the drawback that the relevant ratios vary substantially over time as the stock market booms and busts,

### 3 Data

In this section we explain how we measure the key objects introduced by the theory: 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.

#### 3.1 Stock Market Wealth and Stock Market Return

Motivated by Eq. (9), we define our main regressor  $S_{a,t-1}R_{t-1,t}$  as the product of stock market wealth in county  $a$  in period  $t - 1$  and the market return between  $t - 1$  and  $t$ , normalized by the period  $t - 1$  labor bill.

**Stock market wealth.** We construct local stock market wealth by capitalizing dividend income. 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. Appendix B.1 describes these data and our sample construction in greater detail. Dividend income (reported on line 9 of form 1040 prior to 2018) includes any distribution from a C-corporation. It excludes distributions from partnerships, S-corporations, or trusts.<sup>10</sup> We define stock market wealth in a county as dividend income multiplied by the price-dividend ratio of the S&P500 stock market index. This method is similar to Mian et al. (2013) and Saez and Zucman (2016), except we directly use the price-dividend ratio for the aggregate stock market index rather than allocating household equity from the Financial Accounts of the United States. We divide capitalized stock market wealth by SOI (annual) county labor income to arrive at our measure of local stock market wealth relative to labor income,  $S_{a,t}$ . Formally, denoting total reported dividend and labor income in year  $t$  for location  $a$  as  $D_{a,t}$  and  $W_{a,t}L_{a,t}$  and the price-dividend ratio on the S&P500 as  $Q_t/D_t$ , we construct

$$S_{a,t} = \frac{Q_t}{D_t} \frac{D_{a,t}}{W_{a,t}L_{a,t}}. \quad (10)$$

Figure 1a shows the variation in this measure across U.S. counties in 1990. Because of the regional differences, our baseline specification will exploit only within-state variation. Thus, 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-

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a problem noted in the very different context of fiscal multipliers by Ramey and Zubairy (2018).

<sup>10</sup>Some S-corporations may also pay out dividends if they were previously C-corporations.

state correlation between  $S_{a,1990}$  and  $S_{a,2015}$  of 0.81. Table B.3 reports summary statistics for  $S_{a,t}$  and other variables used in the analysis.

**Stock market return.** We equate the stock market return  $R_{t-1,t}$  with the total return on the S&P500.<sup>11</sup> Figure 2a shows the serial correlation in quarterly returns during our sample period and Figure 2b the cumulative return following a one standard deviation increase in the stock market. 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 change in other macroeconomic aggregate variables over the horizon  $t - 1$  to  $t + h$ . In our sample, the stock market return is positively correlated contemporaneously with utilization-adjusted TFP and with the change in the short-term interest rate and GDP growth over the next several quarters.<sup>12</sup> However, the correlation coefficients are all well below one, reflecting the substantial movement in stock prices independent of economic fundamentals (Shiller, 1981; Cochrane, 2011; Campbell, 2014).

**Measurement error.** Appendix B.2 discusses possible measurement error in the capitalization approach arising from heterogeneous stock portfolios across counties, non-taxable retirement wealth, and dividends paid by non-public C-corporations. In brief, we show that heterogeneous stock portfolios would likely *attenuate* our results. We also present evidence from the Financial Accounts of the United States and the Survey of Consumer Finances that retirement wealth is too small and evenly distributed, and that non-public C-corporations are too small, to meaningfully affect our results.

## 3.2 Outcome Variables

Our main outcome variables are county-level 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

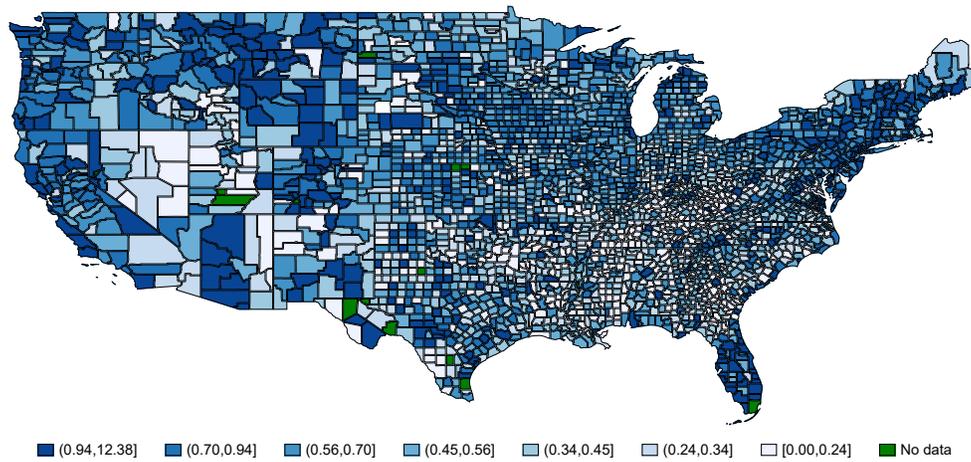
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<sup>11</sup>We obtain the S&P500 total return and dividend-price ratio from Robert Shiller’s website: [http://www.econ.yale.edu/~shiller/data/ie\\_data.xls](http://www.econ.yale.edu/~shiller/data/ie_data.xls).

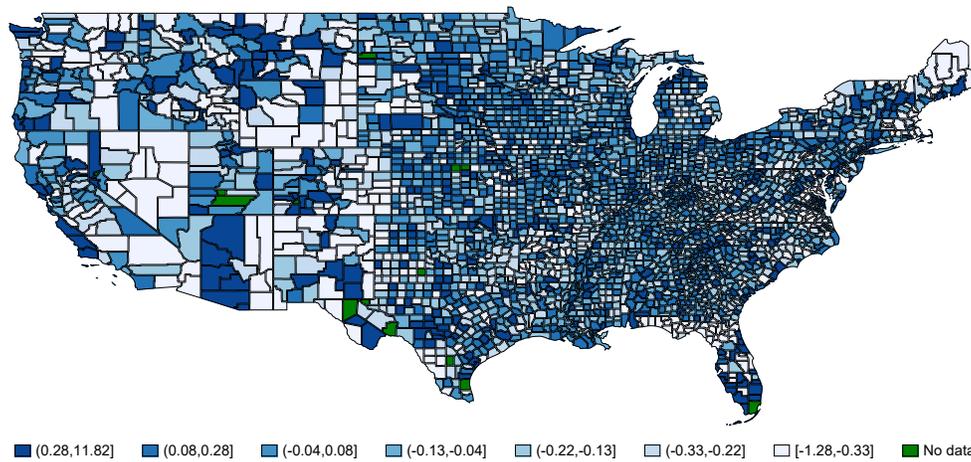
<sup>12</sup>We use the version of utilization-adjusted TFP constructed by John Fernald and available at <https://www.frbsf.org/economic-research/indicators-data/total-factor-productivity-tfp/>. Here and later, the interest rate refers to the 3 month Treasury bill constant maturity rate.

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

(a) 1990



(b) 1990, within state



(c) 2015, within state

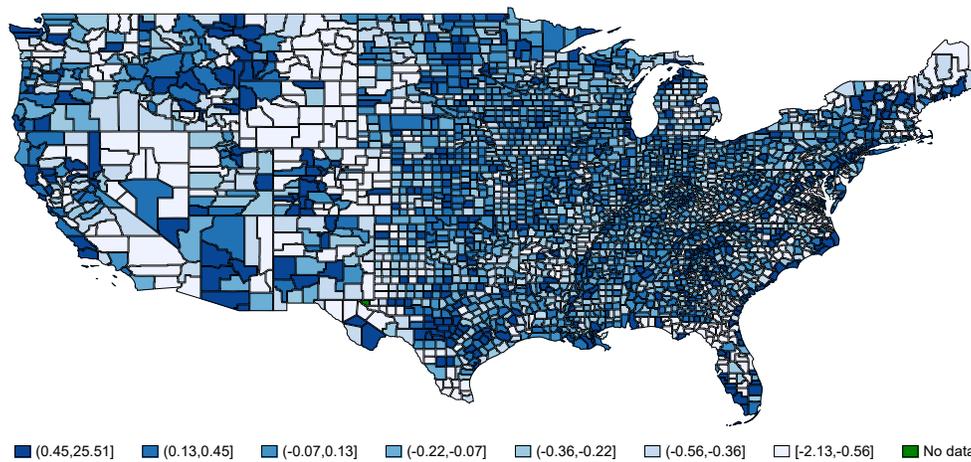
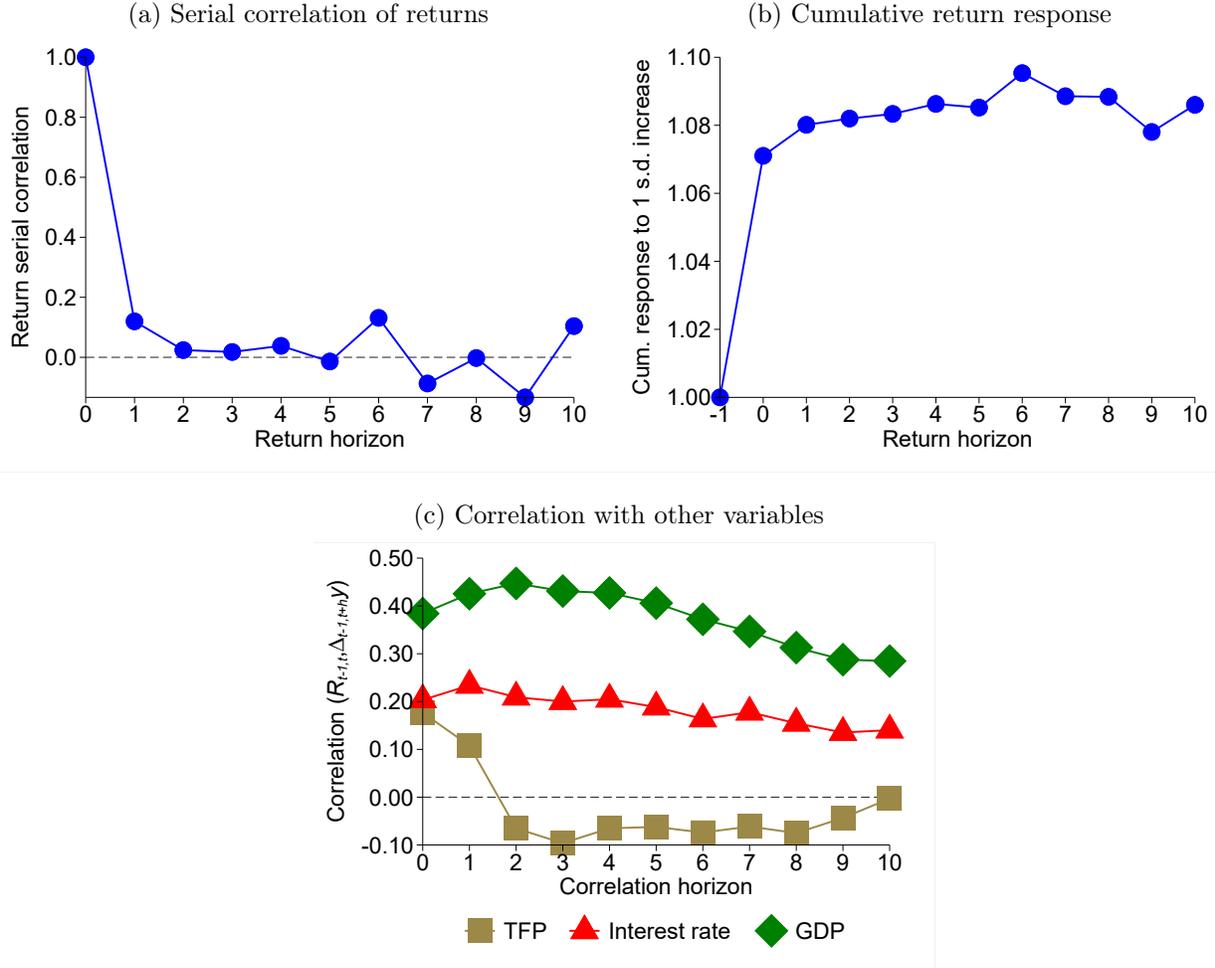


Figure 2: Attributes of S&P500 Quarterly Return



Notes: Panel (a) reports the coefficients  $\beta_h$  from estimating the regression  $R_{t+h-1,t+h} = \alpha_h + \beta_h R_{t-1,t} + \epsilon_h$  at each quarterly horizon  $h$  shown on the lower axis, where  $R_{t+h-1,t+h}$  is the total return on the S&P 500 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 S&P 500 return. Panel (c) reports the correlation coefficients of  $R_{t-1,t}$  and  $\Delta_{t-1,t+h}y$  at each quarterly horizon  $h$  shown on the lower axis, where  $R_{t-1,t}$  is the total return on the S&P 500 in quarter  $t$  and  $\Delta_{t-1,t+h}y$  is the change in variable  $y$  between quarter  $t-1$  and  $t+h$ , for  $y \in \{\text{utilization-adjusted log TFP, 3 month Treasury bill rate, log real gdp}\}$ .

employment records. We use the NAICS-based version of the data which start in 1990 and seasonally adjust the published data by sequentially applying Henderson filters using the algorithm contained in the Census Bureau’s X-11 procedure.<sup>13</sup> 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>14</sup> This classification is conservative in the sense that it leaves a large amount of employment unclassified and our calibration 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.

## 4 Econometric Methodology

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

### 4.1 Framework

Our empirical implementation generalizes Eqs. (5) to (8) to allow for other differences across areas, other shocks, and higher frequency dynamics. We incorporate these elements by assuming the true data generating process takes the form:<sup>15</sup>

$$\Delta_{a,t-1,t+h}y = \beta_h[S_{a,t-1}R_{t-1,t}] + \Gamma'_h X_{a,t-1} + \epsilon_{a,t-1,t+h}, \quad (11)$$

where  $\Delta_{a,t-1,t+h}y = y_{a,t+h} - y_{a,t-1}$  is the log 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,  $R_{t-1,t}$  is the return on the aggregate stock market between  $t - 1$  and  $t$ ,  $X_{a,t-1}$  collects included covariates determined (from the perspective of a local area) as of

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<sup>13</sup>The NAICS version of the QCEW contains a number of transcription errors prior to 2001. We follow Chodorow-Reich and Wieland (2018, Appendix F) and hand-correct these errors before applying the seasonal adjustment procedure.

<sup>14</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.

<sup>15</sup>For example, with ex ante differences in labor income across areas, the denominator of  $S_{a,t-1}$  becomes lagged labor income. Other shocks enter into  $X_{a,t-1}$  if observed or  $\epsilon_{a,t-1,t+h}$  if unobserved.

time  $t - 1$ ,  $\beta_h$  and  $\Gamma_h$  are coefficients (with the latter possibly vector-valued), and  $\epsilon_{a,t-1,t+h}$  contains unmodeled 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. (11) as a Jordà (2005) local projection to be estimated by OLS. The identifying assumption for  $\text{plim}\hat{\beta}_h = \beta_h$  is:

$$E[R_{t-1,t}\mu_t] = 0, \quad (12)$$

where  $\mu_t \equiv E[S_{a,t-1}\epsilon_{a,t-1,t+h}]$  is a time  $t$  cross-area average of the product of stock wealth and the unobserved component.<sup>16</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.

This exposition illustrates the connection between our research design and the more general shift-share design studied in Goldsmith-Pinkham et al. (2018) and Borusyak et al. (2018). Eq. (11) has a shift-share structure with a single shifter  $R_{t-1,t}$  and area-specific loading  $S_{a,t-1}$ . The condition  $E[R_{t-1,t}\mu_t] = 0$  coincides with the exogeneity condition in Borusyak et al. (2018) in the case of a single national observed shock and multiple (asymptotically infinite) 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 index 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  $R_{t-1,t}$  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. In fact, we show in Table B.4 that  $S_{a,t}$  correlates with the share of a county's population with a college education and the median age, among other variables.

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<sup>16</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  $(S_{1,t-1} \dots S_{A,t-1})'$  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. (11) in matrix form as:

$$\mathbf{Y} = \beta_h \mathbf{S} \mathbf{R} + \mathbf{X} \Gamma_h + \boldsymbol{\epsilon}.$$

It follows that  $\text{plim}\hat{\beta}_h = \beta_h$  if

$$0 = \lim_{a,t \rightarrow \infty} (\mathbf{S} \mathbf{R})' \boldsymbol{\epsilon} = \lim_{a,t \rightarrow \infty} \mathbf{R}' \mathbf{S}' \boldsymbol{\epsilon} = \lim_{a,t \rightarrow \infty} \sum_t R_{t-1,t} \sum_a S_{a,t-1} \epsilon_{a,t-1,t+h} = E[R_{t-1,t}\mu_t].$$

Instead, as illustrated by Eq. (12), 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.

## 4.2 Baseline Specification

Our baseline specification implements Eq. (11) 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, eight lags of the “shock” variable  $\{S_{a,t-j-1}R_{t-j-1,t-j}\}_{j=1}^8$ , and a measure of predicted employment growth at horizon  $h$  based only on industry composition,  $\Delta_{a,t-1,t+h}e^B$ . Thus, the specification utilizes only within-state variation in stock market wealth and controls directly for the small correlation with lagged stock returns shown in Figure 2a through the lags of the shock variable. Following 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>17</sup> This variable controls for exposure to national industry shifts which may correlate with stock returns and absorbs residual variation in the main outcomes. 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. (2018) in the special case of a single national shifter.

## 4.3 Threats to Identification

Combining the criterion in Eq. (12) with our baseline specification, we can restate our identifying assumption as follows: following a positive stock return, areas with high stock market wealth relative to labor income do not experience unusually rapid employment or payroll

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<sup>17</sup>We do not “leave-one-out” in defining  $\Delta_{a,t-1,t+h}e^B$  because (i) with roughly 3000 counties the resulting bias is small; (ii) since we use  $\Delta_{a,t-1,t+h}e^B$  as a control any bias would *attenuate* our coefficient of interest; and (iii) as a practical matter, missing data due to disclosure limitations in the QCEW makes seasonal adjustment of county-by-industry data difficult. Such missing data has a minor effect on  $\Delta_{a,t-1,t+h}e^B$  because county-industry cells with suppressed data tend to have small employment shares. To further reduce the impact of suppressed data, we use the QCEW annual file (which has fewer suppressed cells than the quarterly file) to impute missing observations in the QCEW quarterly file.

growth — relative to their own mean and to other counties in the same state, and conditional on their industrial composition — for reasons other than the wealth effect on local consumption expenditure. As emphasized by Goldsmith-Pinkham et al. (2018), this requirement mirrors the parallel trends assumption in a continuous difference-in-difference design with multiple treatments. Two main threats to identification exist.

The first threat occurs because stock prices are forward-looking, so fluctuations in the stock market may reflect news about deeper economic forces such as productivity growth 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 makes immediate progress by requiring only the weaker condition that high and low stock wealth areas not load differently on other aggregate variables that co-move with the stock market. Moreover, while we motivated the normalization of stock wealth by labor income to facilitate the mapping between the empirical analysis and the model, this normalization means that we do not simply compare wealthy and poor areas but rather areas that differ in their ratio of stock market to human capital wealth.

The control variables further weaken the exogeneity condition. In the baseline specification, county fixed effects absorb general trends which may differ across high and low wealth areas (for example, due to population growth). State  $\times$  quarter fixed effects allow for loadings on other aggregate factors to vary by geographic state. Bartik employment growth allows for high wealth areas to concentrate in industries with higher stock market betas than those in low wealth areas or for certain industries to drive the stock market return and concentrate in high wealth areas, all without violating the identifying assumption. We show in robustness exercises that our results do not depend on these controls and are robust to finer controls such as commuting zone  $\times$  quarter fixed effects. Furthermore, we exploit the substantial variation in stock returns which occurs independent of other aggregate variables (see Figure 2c) to report specifications which control directly for the interaction of stock market wealth with other macroeconomic variables such as TFP growth, interest rate changes, and GDP growth.

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

an 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) in robustness exercises we control for the interaction of the stock market return with the share of payroll in a county at establishments belonging to large (500+ employee) firms, as these firms are more likely to have access to public capital markets.

## 5 Results

### 5.1 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 which mostly produce tradable goods.

Figure 3 reports the time paths of responses of quarterly employment and payroll to an increase in stock market wealth equivalent to 1% of annual labor income, formally, the coefficients  $\beta_h$  from estimating Eq. (11). 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 0.0069 log point (i.e. an approximately 0.69 basis point increase) and payroll by 0.0225 log point in quarter  $t + 7$ . The increases appear persistent, consistent with the near unit-root behavior of the shock itself.

Panels B and C examine the responses in industries classified as producing nontradable or tradable output, respectively. Employment in industries classified as producing nontradable goods and services rises by more than the total effect. In contrast, the employment response in industries classified as producing tradables is flat following a positive stock market return. The difference between the tradable and nontradable employment coefficients is significant at the 5% level. The rise in employment in nontradable industries and flat response in tradable industries accords with the predictions of the theoretical model. It also militates against a

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:						
$S_{a,t-1}R_{t-1,t}$	0.69*	2.25**	1.60*	2.83**	0.03	2.18**
	(0.35)	(0.62)	(0.71)	(0.83)	(0.55)	(0.68)
Bartik predicted employment	0.86**	1.46**	0.57**	0.81**	1.66**	2.13**
	(0.08)	(0.14)	(0.10)	(0.10)	(0.19)	(0.24)
Horizon $h$	Q7	Q7	Q7	Q7	Q7	Q7
Population weighted	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes
State×time FE	Yes	Yes	Yes	Yes	Yes	Yes
Shock lags	Yes	Yes	Yes	Yes	Yes	Yes
$R^2$	0.65	0.63	0.38	0.48	0.35	0.35
Counties	3,064	3,064	3,058	3,058	3,038	3,038
Periods	93	93	93	93	93	93
Observations	282,837	282,837	280,206	280,206	269,675	269,675

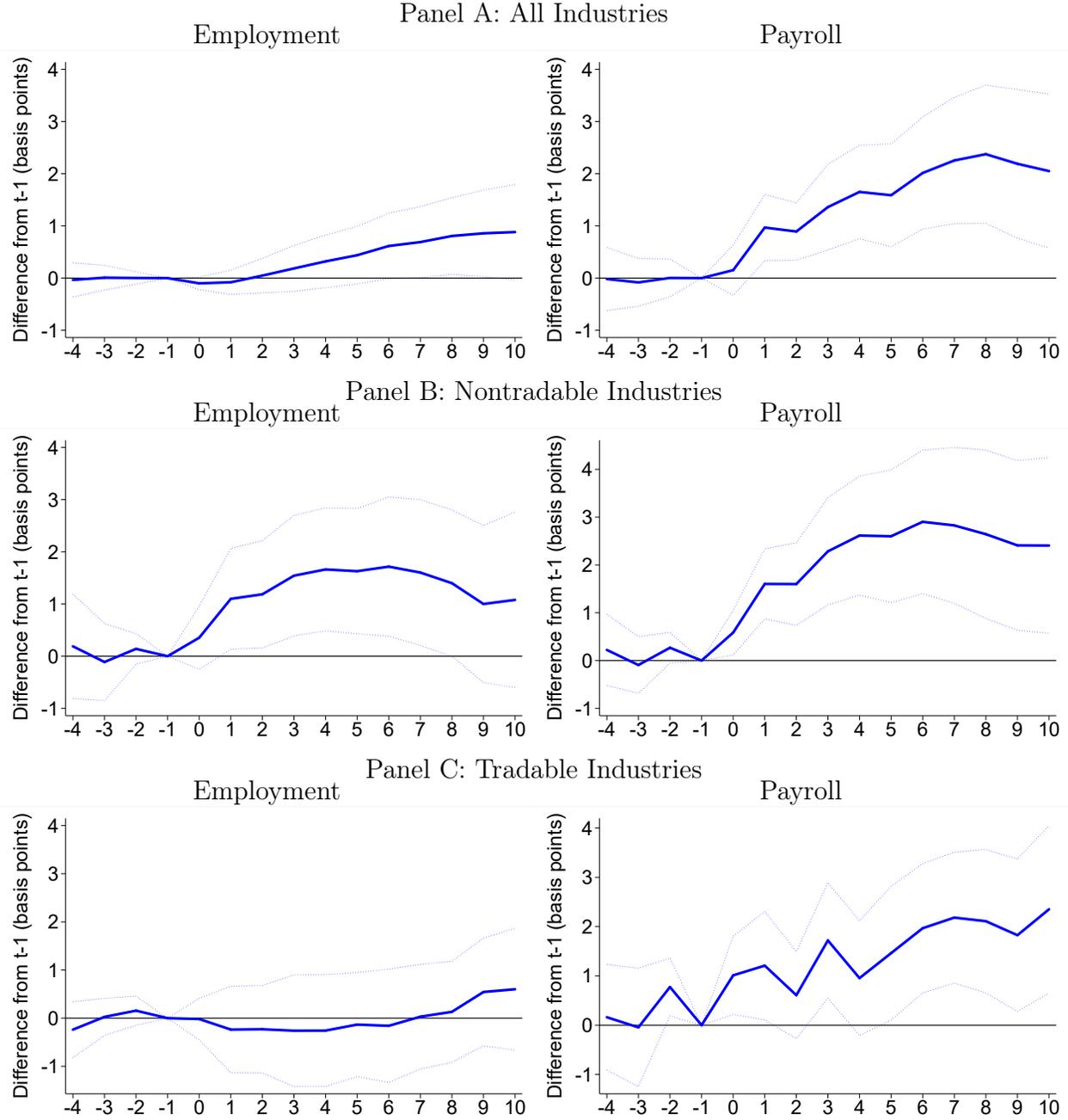
Notes: The table reports coefficients and standard errors from estimating Eq. (11) for  $h = 7$ . Columns (1) and (2) include all covered employment and payroll; columns (3) and (4) include employment and payroll in NAICS 44-45 (retail trade) and 72 (accommodation and food services); columns (5) and (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.

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).<sup>18</sup> We show this sector separately because, while it also produces output consumed locally, the magnitude does not easily translate into our theoretic-

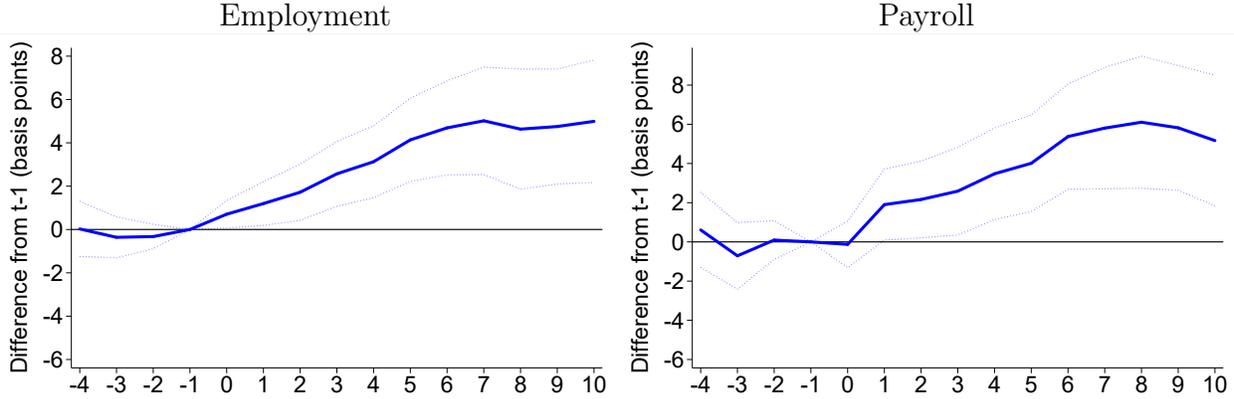
<sup>18</sup>Figure B.3 reports smaller but statistically significant positive responses in specialty trade contractors (NAICS 238), a category that includes a number of sectors (electrical contractors, plumbers, etc.) involved in the construction of residential buildings. The figure also shows positive but delayed responses in non-residential building construction (NAICS 2362), possibly reflecting non-residential building construction firms engaging in some residential construction to meet the higher local demand. In contrast, there is a flat response in heavy and civil engineering construction (NAICS 237). In unreported results, we also find a large and statistically significant response of new building permits using the Census Bureau residential building permits survey.

Figure 3: Baseline Results



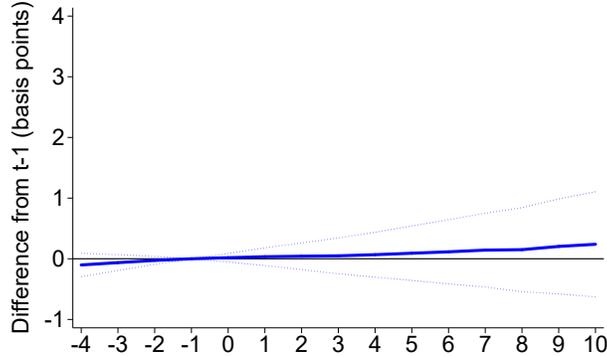
Notes: The figure reports the coefficients  $\beta_h$  from estimating Eq. (11) for quarterly employment (left panel) and wages (right panel) at each quarterly horizon  $h$  shown on the lower axis. Panel A includes all covered employment and payroll; Panel B includes employment and payroll in NAICS 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. (11) for residential building construction (NAICS 2361) employment and payroll at each quarterly horizon  $h$  shown on the lower axis. The shock occurs in period 0 and is an increase in stock market wealth equivalent to 1% of annual labor income. The dashed lines show the 95% confidence interval bands.

Figure 5: Response of Population



Notes: The figure reports the coefficients  $\beta_h$  from estimating Eq. (11) 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.

cal model since the sector produces a capital good (housing) that provides a service flow over many years. Thus, a desire by local residents to increase their consumption of housing services following a positive wealth shock will result in a front-loaded response of employment in the construction sector. Nonetheless, the large response provides additional evidence of a local demand channel at work.

Figure 5 reports the (non-)response of population to an increase in wealth.<sup>19</sup> Population inflows do not explain the increase in employment when stock market wealth rises.

<sup>19</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.

Table 2: Robustness to Covariates

Dependent variable:	Total emp.	Total payroll	Nontradable emp.	Nontradable payroll
Specification:				
Baseline	0.69* (0.35)	2.25** (0.62)	1.60* (0.71)	2.83** (0.83)
Only county & state×quarter FE	1.07** (0.38)	2.91** (0.69)	1.56+ (0.81)	3.05** (0.92)
Only county & quarter FE	1.10* (0.48)	2.78** (0.85)	1.43+ (0.84)	2.84** (1.03)
TFP sensitivity	0.62+ (0.33)	2.23** (0.60)	1.21* (0.59)	2.52** (0.74)
Interest rate sensitivity	0.70* (0.34)	1.67** (0.54)	0.97+ (0.57)	1.90** (0.61)
GDP sensitivity	0.71+ (0.38)	1.65** (0.60)	1.81* (0.78)	2.47** (0.84)
Control house prices	0.60+ (0.34)	2.18** (0.62)	1.13* (0.52)	2.41** (0.73)
Control large firm share	0.62+ (0.33)	2.13** (0.58)	1.52* (0.66)	2.69** (0.77)
Control lagged outcomes	0.69* (0.34)	2.23** (0.60)	1.63* (0.72)	2.75** (0.82)
CzoneXtime FE	0.65 (0.46)	2.07** (0.67)	1.83+ (1.00)	2.94** (1.04)

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.

## 5.2 Robustness

Tables 2 and 3 report results from a number of robustness exercises for total and nontradable employment and payroll for the horizon  $h = 7$ . 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 and 3 expand the variation used to identify the response by removing the Bartik control and using quarter rather than state-by-quarter fixed effects. The coefficients on total

employment and payroll rise slightly in the specification without the Bartik employment control. A possible interpretation is that high wealth areas have higher nontradable employment shares and nontradable employment grows nationally when the stock market rises due to the consumption wealth effect, in which case including Bartik employment in the baseline specification over-controls for the effect of industry composition.

Rows 4 to 6 add interactions of wealth  $S_{a,t-1}$  and changes between  $t-1$  and  $t+h$  in aggregate log utilization-adjusted TFP, the short-term interest rate, and log GDP, respectively, to the baseline specification. In general, condition (12) states that  $R_{t-1,t}$  must be conditionally exogenous; controlling for interactions of other aggregate variables with  $S_{a,t-1}$  amounts to using only the variation in  $R_{t-1,t}$  which is orthogonal to these other variables. In our application, these interactions address directly the possibility that the period  $t$  stock return forecasts changes in other aggregate variables that might have differential effects in high and low wealth areas. Interacting with TFP addresses the concern that a positive stock market return forecasts future TFP growth, as in theories of news-driven business cycles (Beaudry and Portier, 2006), which could have a more pronounced impact on firms or workers in high wealth areas. Interacting with changes in interest rates addresses the concern that high and low stock wealth areas may also differ in their fixed income wealth.<sup>20</sup> The GDP interaction allows for any differential cyclicalities of high and low wealth areas and could *over-control* if, unlike in our model, aggregate GDP itself responds to the stock price change through a consumption wealth effect. We find small changes in the coefficients in each of these specifications. The insensitivity reflects a combination of two forces: (i) the loadings on these other variables do not vary too much with wealth, and (ii) as illustrated in Figure 2c, while stock prices are not strictly exogenous, much of the volatility in the stock market and hence the variation in our main regressor occurs for reasons unrelated to economic fundamentals.

Rows 7-10 add local controls to the baseline specification. Row 7 controls for contemporaneous and 12 lags of local house prices to ensure our results do not confound comovement of housing wealth with stock market wealth.<sup>21</sup> Row 8 controls for the share of payroll in a county at establishments belonging to large (500+ employee) firms interacted with the stock market return.<sup>22</sup> Large firms are more likely to have publicly traded equity and thus

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<sup>20</sup>Different fixed income wealth matters here only insofar as changes in the value of fixed income—due primarily to changes in interest rates—correlate with our main regressor. Therefore, interacting changes in the interest rate with stock wealth directly amounts to allowing for an arbitrary correlation between the levels of stock wealth and fixed income wealth.

<sup>21</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.

<sup>22</sup>Data on payroll by firm size come from the Census Bureau’s Quarterly Work Force Indicators. Because

experience a direct reduction in their cost of capital when the stock market rises; the stability of coefficients indicates that our results do not reflect an investment response by such firms. Row 9 includes lagged outcomes to control directly for any pre-trends.<sup>23</sup> Row 10 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 qualitatively similar responses in the first half (1990-2003) and second half (2004-2017) of the sample. Row 4 trims the top and bottom 1% of  $S_{a,t}$  per quarter. The point estimates uniformly rise without these very high and low wealth counties. Row 5 reports point estimates close to the baseline if we do not exclude counties with a large share of dividend income from late filers (filing in the last 3 months of a reporting year). Row 6 excludes counties in which at least one S&P 500 constituent firm (current or historical since 1962) has had its headquarters while row 7 excludes counties in which a firm on the Forbes list of the largest private companies have their headquarters. Row 8 excludes the quarters with the 5% largest and smallest stock returns with little effect on the results. Row 9 reports similar responses in unweighted regressions which exclude very small counties (fewer than 20,000 residents) while row 10 shows that the results are not driven by the largest 1% of counties. Row 11 shows that using employment and payroll from the Census Bureau’s Quarterly Work Force Indicators yields coefficients of similar magnitude but larger standard errors.

The last three rows alter the shock variable. Row 12 uses only the price component of the S&P 500 return with similar results. Row 13 uses the within-county mean ratio of dividend income to labor income in  $S_{a,t-1}$  so that variation in this variable reflects only variation in the aggregate dividend-price ratio. Because the dividend-labor income ratio changes little over time, fixing this ratio has little effect on the results. Finally, while our baseline specification normalizes dividend wealth by labor income, the last row shows we obtain similar results using dividend wealth per tax return instead.

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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 large share on a full set of county fixed effects.

<sup>23</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).

Table 3: Other Robustness

Dependent variable:	Total emp.	Total payroll	Nontradable emp.	Nontradable payroll
Specification:				
Baseline	0.69* (0.35)	2.25** (0.62)	1.60* (0.71)	2.83** (0.83)
1990-2003	0.25 (0.33)	2.08** (0.61)	2.27* (1.00)	2.70* (1.13)
2004-2017	1.55* (0.65)	2.73* (1.33)	1.60* (0.73)	3.52* (1.38)
Trim top/bottom 1% of $S_{a,t}$	1.02+ (0.56)	3.33** (0.92)	2.56* (1.27)	4.57** (1.33)
Keep late filers	0.65* (0.31)	2.24** (0.68)	1.52* (0.62)	2.58** (0.81)
Drop S&P 500 HQs	0.38 (0.28)	1.05* (0.51)	1.62* (0.80)	2.14** (0.72)
Drop Forbes Top Private HQs	0.33 (0.23)	1.05* (0.48)	1.76* (0.87)	2.61** (0.87)
Keep if $R_{t-1,t} \in [P5, P95]$	0.72 (0.45)	2.08* (0.81)	2.21* (1.00)	3.36** (1.12)
Unweighted, population > 20,000	0.61+ (0.34)	1.51** (0.53)	2.34* (1.13)	2.94** (0.88)
Trim by population	0.74* (0.33)	2.14** (0.66)	1.90* (0.83)	2.96** (0.89)
QWI	0.96* (0.48)	2.30** (0.72)	1.02* (0.43)	2.29** (0.75)
Price component only	0.68+ (0.35)	2.25** (0.62)	1.60* (0.71)	2.83** (0.83)
Time-invariant dividends	0.77* (0.34)	2.54** (0.64)	1.57* (0.74)	2.73** (0.89)
Wealth per return	1.23** (0.38)	3.32** (0.93)	1.77** (0.66)	3.49** (0.95)

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.

### 5.3 Decomposing Variation

In this section we provide evidence on which 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:

$$\begin{aligned}\beta &= \left( \sum_a \sum_t \pi_a \tilde{z}_{a,t}^2 \right)^{-1} \sum_a \sum_t \pi_a \tilde{z}_{a,t} \Delta_{a,t} \tilde{y} \\ &= \sum_s w_s \beta_s, \\ \text{where: } \beta_s &\equiv \left( \sum_{a \in s} \sum_t \pi_a \tilde{z}_{a,t}^2 \right)^{-1} \sum_{a \in s} \sum_t \pi_a \tilde{z}_{a,t} \Delta_{a,t} \tilde{y}, \\ w_s &\equiv \left( \sum_{a'} \sum_t \pi_{a'} \tilde{z}_{a',t}^2 \right)^{-1} \left( \sum_{a \in s} \sum_t \pi_a \tilde{z}_{a,t}^2 \right).\end{aligned}$$

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>24</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, the four states with the largest populations — California, Texas, New York, and Florida — rank among the five states with the highest weights. More surprisingly, Florida, with 6% of the 2010 population, has a weight in the regression above 40%. This high share reflects the large variation across Florida counties in stock market wealth. On the other hand, Florida does *not* drive the finding of a positive regression coefficient, as the Florida-only nontradable wage 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 (and 45 of 50 states overall) have  $\beta_s > 0$ . Thus, no one or two states drive the overall result.

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<sup>24</sup>We could have done this decomposition for the baseline specification after partialing out the Bartik 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 the Bartik term would differ across states.

Table 4: Ten States with Largest Weight

State	Population share	Weight	$\beta_s$ , nontradable wage bill
Florida	0.061	0.423	0.616
California	0.121	0.074	5.487
Texas	0.081	0.040	7.476
Virginia	0.026	0.034	3.583
New York	0.063	0.031	3.054
Georgia	0.031	0.025	1.158
Pennsylvania	0.041	0.025	0.179
Washington	0.022	0.023	6.729
Ohio	0.037	0.023	1.816
North Carolina	0.031	0.023	5.470

## 5.4 Heterogeneity

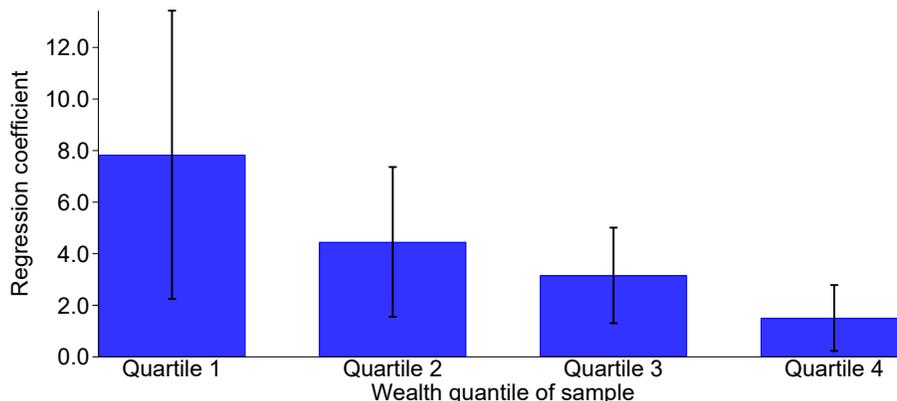
This section reports heterogeneity of the response by per capita wealth. Many theories of consumption predict higher MPCs for less wealthy households. In the context of stock market wealth, Di Maggio et al. (2018) find a higher MPC in Sweden among households in the lower half of the wealth distribution.

We start by taking a time average within each state of real (deflated by the price index for personal consumption expenditure) dividends per person and then sort states along this dimension into four quartiles of per capita wealth. We then estimate the baseline specification separately for each quartile of states.<sup>25</sup> Figure 6 reports the results, focusing on the wage bill response in nontradable industries. As shown in the following section, this coefficient relates most directly to the household-level MPC out of stock wealth.

The figure shows a response of the nontradable labor bill which declines monotonically with the average level of wealth among states in the sample. Among the least wealthy states, the point estimate equals 7.84, while for the wealthiest states the point estimate is 1.51. In all four subsamples these point estimates remain statistically significant at the 5% level. The data reject equality of the response in the wealthiest quartile with the responses in the two least wealthy quartiles at the 5% level (not shown in the figure). Thus, consistent with Di

<sup>25</sup>The quartiles are: Alabama, Arkansas, Idaho, Indiana, Kentucky, Louisiana, Mississippi, New Mexico, North Dakota, Oklahoma, Tennessee, Utah, West Virginia (quartile 1); Alaska, Georgia, Hawaii, Iowa, Michigan, Nebraska, North Carolina, Ohio, Oregon, South Carolina, South Dakota, Texas, Wisconsin (quartile 2); Arizona, California, Colorado, Kansas, Maine, Minnesota, Missouri, Montana, New York, Pennsylvania, Rhode Island, Virginia, Wyoming (quartile 3); Connecticut, Delaware, Florida, Illinois, Maryland, Massachusetts, Nevada, New Hampshire, New Jersey, Vermont, Washington (quartile 4).

Figure 6: Heterogeneity by Wealth



Notes: The figure reports the coefficients  $\beta_h$  from estimating Eq. (11) for the nontradable wage bill at horizon  $h = 7$ , separately for states in each quartile of the per capita wealth distribution. The whiskers show the 95% confidence intervals.

Maggio et al. (2018), we find evidence of a stock wealth effect on consumption that declines with wealth.

## 6 Calibration

In this section, we use our empirical results from Section 5 to calibrate two key parameters from the theoretical model in Section 2: the strength of the direct stock wealth effect,  $\frac{1}{1+\delta}$ , and the degree of wage flexibility,  $\kappa$ . We require only two model equations to determine these parameters. Therefore, our calibration also applies in richer models in which 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 (e.g. consumer habit or delayed recognition of the stock wealth changes). By quarter 7 adjustment is complete and the effect remains 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. (7) as follows:

$$\begin{aligned} \Delta(w_{a,0} + l_{a,0}^N) &= \mathcal{M}(1 - \alpha)\rho \times S_{a,0}R_0, \\ \text{where } \rho &= \frac{1}{T} \frac{1}{1 + \delta} \text{ and } S_{a,0} = \frac{x_{a,0}Q_0}{\overline{WL}_0/T}, R_0 = \frac{\Delta Q_0}{Q_0}. \end{aligned} \tag{13}$$

Here, we have introduced the change of variables  $\frac{1}{1+\delta} = \rho T$ , where we interpret  $\rho$  as the stock market wealth effect *per year* and  $T$  as the length of period 0 in years. Thus, the denominator of  $S_{a,0}$ ,  $\frac{\overline{WL}_0}{T}$ , equals the labor bill *per year* as in the empirical implementation, and the empirical coefficient can be mapped into the stock wealth effect *per year*. In particular, the empirical coefficient can be decomposed into three terms: the partial equilibrium MPC out of stock market wealth  $\rho$ , the labor share of income  $1 - \alpha$ , and the local Keynesian multiplier (equivalent to the multiplier on local government spending)  $\mathcal{M}$ . We set the labor share to a value standard in the literature,  $1 - \alpha = 2/3$ , 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>26</sup> We then obtain  $\rho$  by combining Eq. (13) with the empirical coefficient for the nontradable labor bill.

Using the coefficient for the nontradable labor bill from Table 1, and combining with Eq. (13), we obtain:

$$\mathcal{M}(1 - \alpha)\rho = \frac{\Delta(w_{a,0} + l_{a,0}^N)}{S_{a,0}R_0} = 2.83\%. \quad (14)$$

Substituting  $1 - \alpha = 2/3$  and  $\mathcal{M} = 1.5$ , we further obtain:

$$\rho = 2.83\%.$$

Hence, our estimates suggest that a one dollar increase in stock wealth increases household spending by about 2.83 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 from the recent literature that uses detailed household-level data from other countries (Di Maggio et al., 2018).

We make two remarks on this approach. First, it has the advantage of not requiring parameterization of the share of nontradables in spending,  $\eta$ . To understand why, it is

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<sup>26</sup> To see how we calibrate the multiplier, note that the change of variables in (13) creates one free parameter,  $T$ . This parameter is not very meaningful since our model is stylized in the time dimension (it has only two periods). The parameter affects the analysis mainly through its impact on the local multiplier, which is given by:

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

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

instructive to rewrite Eq. (13) as:

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

This expression illustrates that the effect on the nontradable labor bill *in dollars*,  $\Delta (W_{a,0}L_{a,0}^N/T)$ , does depend on the share of nontradables in spending,  $\eta$ . However, with homothetic preferences and production across sectors, the nontradable labor bill as a fraction of the total labor bill is equal to the share of nontradables in spending,  $\frac{\overline{WL}_0^N}{\overline{WL}_0} = \eta$ . Therefore, since Eq. (13) normalizes the stock wealth change with the total labor bill,  $\eta$  drops out of the equation. Intuitively, with homothetic preferences these sectors' share in total spending (measured by their share of the labor bill) proxies for their share in marginal spending. Thus, the decomposition in (13) requires only some fully nontradable sectors.<sup>27</sup>

Second, when  $\varepsilon \neq 1$ , Eq. (13) applies up to an adjustment (see Eq. (7)). 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 sticky, then the tradable adjustment does not change the analysis by much even if  $\varepsilon$  is somewhat different from 1. In practice, the upper bound we obtain for  $\kappa$  (described next) implies sufficiently sticky wages that there is little loss of generality in ignoring this adjustment for empirically reasonable levels of  $\varepsilon$ . Therefore, we adopt  $\varepsilon = 1$  as our baseline calibration in the main text and relegate the discussion of the more general case to the appendix.<sup>28</sup>

## 6.2 Wage Rigidity

To determine the wage flexibility parameter  $\kappa$ , we use Eq. (6),

$$\Delta l_{a,0} = \frac{1}{1 + \kappa} \Delta (w_{a,0} + l_{a,0}) . \quad (15)$$

---

<sup>27</sup>In particular, under the homotheticity assumption this approach remains valid even if the labor bill responds in other sectors not included in our definition of nontradables. In fact, as we discuss in Section 5, we also find strong effects in the residential construction sector. We do not use this sector for calibration because it likely reflects an accelerator-type mechanism on local housing investment that has no counterpart in our model.

<sup>28</sup>Specifically, in Appendix A.6.2 we consider the alternative calibrations  $\varepsilon = 0.5$  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 10% 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).

This equation results from the Wage Phillips Curve and arises in many models. The parameter  $\kappa$  should be interpreted as the wage flexibility parameter over the estimation horizon. One caveat is that the concepts of labor adjustment in the model and the data are different. The model makes predictions for total labor including changes in hours per worker. In the data we observe only the number of workers. We assume that hours per worker change in the same direction as the number of workers. Under this assumption, combining the corresponding empirical coefficients with Eq. (15) provides a lower bound on  $\frac{1}{1+\kappa}$ , or equivalently, an upper bound on the wage flexibility parameter,  $\kappa$ .

Using the coefficients for total employment and the total labor bill from Table 1, we obtain:

$$\begin{aligned} \frac{\Delta l_{a,0}}{S_{a,0}R_0} &\geq 0.69\% \\ \frac{\Delta(w_{a,0} + l_{a,0})}{S_{a,0}R_0} &= 2.25\%. \end{aligned}$$

Combining these with Eq. (15), we obtain:

$$\kappa \leq 2.26. \tag{16}$$

In particular, for an equivalent shock, the labor bill increases by about 2.25%, whereas employment increases by about 0.69%. This suggests that a one percent change in employment generates at most a 2.26% change in wages at a horizon of two years. The wage flexibility parameter could be even smaller if hours per worker also increase. In particular, we cannot rule out the limiting case that wages are perfectly sticky,  $\kappa \simeq 0$ , but we can rule out the other limiting case in which wages are perfectly flexible,  $\kappa \rightarrow \infty$ , as that case would feature zero effect on employment.

Our model offers another route to obtaining  $\kappa$  using the response of tradable employment [cf. Eq. (A.59)]. Intuitively, tradable employment declines only insofar as local wages rise, making the response of  $l^T$  informative for  $\kappa$ . We do not 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 the low value of  $\kappa$  obtained using Eq. (15).

## 7 Aggregation

We next use our empirical results and calibration to describe the effect of stock market wealth 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.

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 local and aggregate spending multipliers. Second, since the aggregate spending multiplier is greater than the local multiplier, we can bound the aggregate effect from below. Therefore, our direct empirical estimate of the effect on the local nontradable labor bill becomes a lower bound of the effect on the aggregate total labor bill.

Our aggregation result for employment combines this finding with a third observation: since labor markets are local, the Wage Phillips Curve Eq. (15) remains unchanged as we switch from local to aggregate analysis (as emphasized by Beraja et al. (2016)). Therefore, we can use our estimated upper bound for the wage flexibility parameter from Section 6 to provide a lower bound on the aggregate employment response.

To establish these results formally, consider the model from Section 2 with the only difference that monetary policy keeps the nominal interest rate at a constant level,  $R^f = \bar{R}^f$ . Appendix A.7 extends our theoretical analysis to this case. The aggregate equilibrium with a fixed interest rate is described by the triple,  $(Q_0, L_0, W_0)$ , that solves the following three equations:

$$\begin{aligned} Q_0 &= W_0 D_0 + \frac{\bar{W} D_1}{\bar{R}^f} & (17) \\ W_0 L_0 + W_0 D_0 &= \frac{1}{1 + \delta} \left( W_0 L_0 + \frac{\bar{W} L_1}{\bar{R}^f} + Q_0 \right) \\ W_0 / \bar{W} &= (L_0 / \bar{L}_0)^\kappa. \end{aligned}$$

Here, the first equation describes the equilibrium asset price. The rental rate of capital in period 0 is endogenous and given by  $R_0 = W_0 D_0$ . The second equation says that aggregate income is determined by aggregate wealth (human capital plus stock wealth) and the propensity to spend out of wealth. The last equation is the Wage Phillips Curve. This char-

acterization illustrates 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, wages, and employment.

To characterize these effects further (and to compare with their local equilibrium counterparts) we log-linearize the aggregate equilibrium around the frictionless benchmark. Specifically, 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 employment:

$$\Delta(w_0 + l_0) = \mathcal{M}^A (1 - \alpha) \frac{1}{1 + \delta} \frac{\Delta Q_0^A}{\bar{W}\bar{L}_0}, \quad (18)$$

$$\Delta l_0 = \frac{1}{1 + \kappa} \Delta(w_0 + l_0), \quad (19)$$

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

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,  $\frac{\bar{W}D_1}{R^f}$ .<sup>29</sup> As before,  $\Delta y \equiv y^{new} - y^{old}$  denotes the change in equilibrium variable  $y$  when expected future dividends change. Hence, Eqs. (18) and (19) describe the effect of a change in stock wealth on aggregate labor market outcomes. The parameter  $\mathcal{M}^A$  captures the aggregate multiplier effects.

Eq. (18) shows that the effect on the aggregate labor bill closely parallels its local counterpart (Eq. (6)), with three differences. First, the direct spending effect is greater in the aggregate than at the local level,  $\frac{1-\alpha}{1-\delta} > \frac{1-\alpha}{1-\delta}\eta$ . Intuitively, spending on goods which are tradable from the perspective of a local area are nontradable in the aggregate and therefore increase the aggregate labor bill. 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 well as the mobile factor, capital) diminish the local but not the aggregate multiplier.<sup>30</sup>

<sup>29</sup> In this setting, a one dollar increase in  $\frac{\bar{W}D_1}{R^f}$  increases the equilibrium stock price,  $Q_0$ , by more than one dollar. This is because the increase in aggregate demand and output also increases the rental rate of capital in period 0 [cf. Eq. (17)]. 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 shock.

<sup>30</sup> The aggregate spending multiplier is captured by the term  $\tilde{\mathcal{M}}^A \equiv \frac{1}{1 - 1/(1 + \beta)}$ , which exceeds the local multiplier  $\mathcal{M} = \frac{1}{1 - (1 - \alpha)\eta/(1 + \beta)}$ . In our setting, there is also a second multiplier effect in the aggregate, captured by the term  $\mathcal{F}^A \equiv \frac{1 + \kappa}{1 - \alpha + \kappa} > 1$ . 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.

To quantify the aggregate effects on the labor market using our estimates for the local effects, we again use the change of variables,  $\frac{1}{1+\delta} = \rho T$ , to rewrite Eq. (18) as follows:

$$\begin{aligned} \Delta(w_0 + l_0) &= \mathcal{M}^A (1 - \alpha) \rho \times S_0^A R_0^A \\ \text{where } S_0^A &= \frac{Q_0^A}{\overline{WL}_0/T} \text{ and } R_0^A = \frac{\Delta Q_0^A}{Q_0^A} \end{aligned} \quad (20)$$

We have also defined  $S^A$  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. (20) is the same as its local counterpart in Eq. (13) for the *local nontradable* labor bill, up to an adjustment for the differences in the local and aggregate spending multipliers. Hence, we can combine our estimate for the local nontradable labor bill (for quarter 7) with the inequality  $\frac{\mathcal{M}^A}{\mathcal{M}} \geq 1$  to bound the coefficient from below:<sup>31</sup>

$$\mathcal{M}^A (1 - \alpha) \rho = 2.83\% \frac{\mathcal{M}^A}{\mathcal{M}} \geq 2.83\%.$$

Therefore, if not countered by monetary policy, a one dollar increase in stock valuations increases the aggregate labor bill per year by at least 2.83 cents. Why is the effect on the *local nontradable* labor bill informative 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 — that we estimate using our local labor market approach — is the same as the proportional change of the labor bill in the tradable sectors that we cannot estimate directly due to demand slippage to other regions.

We next use Eq. (19) to quantify the effect on aggregate employment. This equation shows that the Wage Phillips Curve remains unchanged as we switch from local to aggregate analysis. Thus, we can combine the implied effect on the aggregate labor bill with our estimated lower bound for  $\frac{1}{1+\kappa}$  (or upper bound for  $\kappa$ ) to provide a lower bound for the effect on aggregate employment. In particular, Eq. (18) implies:

$$\Delta l_0 = \frac{1}{1 + \kappa} \Delta(w_0 + l_0) = \frac{1}{1 + \kappa} \mathcal{M}^A (1 - \alpha) \rho \times S_0^A R_0^A. \quad (21)$$

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<sup>31</sup> We believe 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).

Combining this expression with the inequality in (16) and our estimate for the aggregate labor bill, we bound the corresponding coefficient as:

$$\frac{1}{1 + \kappa} \mathcal{M}^A (1 - \alpha) \rho \geq \frac{2.83\%}{1 + 2.26} \frac{\mathcal{M}^A}{\mathcal{M}} \geq 0.87\%.$$

Therefore, a one dollar increase in stock valuations would increase aggregate employment by the equivalent of at least 0.87 cents (i.e. the labor bill for the number of new jobs created would be at least 0.87 cents) if monetary policy did not respond.

We can use these estimates together with the ratio of aggregate stock wealth to the aggregate yearly labor bill,  $S_0^A$ , to obtain the effect of a particular stock return on aggregate employment and the labor bill. Using data from 2015 (weighting counties by their income), we obtain  $S^A = 1.50$ . Substituting this value into Eqs. (20) and (21), we obtain:

$$\begin{aligned} \Delta(w_0 + l_0) &= 4.25\% \frac{\mathcal{M}^A}{\mathcal{M}} \times R_0^A \geq 4.25\% \times R_0^A, \\ \Delta l_0 &\geq 1.30\% \frac{\mathcal{M}^A}{\mathcal{M}} \times R_0^A \geq 1.30\% \times R_0^A. \end{aligned}$$

Therefore, if not countered by monetary policy, a 20% stock return — approximately the yearly standard deviation of the return on the S&P 500 — would increase the aggregate labor bill by at least 0.85%, and aggregate employment by at least 0.26% at a horizon of two years. Hence, our model suggests that stock market fluctuations have important real effects when monetary policy does not or cannot react.

## 8 Conclusion

In this paper, 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. A theoretical model can replicate these empirical patterns. We use the model to convert our estimated local general equilibrium effect into a partial equilibrium MPC out of stock market wealth of around 2.8 cents per year. Using the model, we also calculate the aggregate general equilibrium effects of the stock wealth consumption channel on the labor market: we find that a 20% change in stock valuations, unless countered by monetary policy, affects the aggregate labor bill by at least 0.85% and aggregate employment by at least 0.26% two years after the shock. In particular, consistent with what many policymakers in the U.S. seem to

believe (Cieslak and Vissing-Jorgensen, 2017), substantial stock price declines would reduce aggregate employment considerably if monetary policy did not respond to the shock.

An important practical question 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.

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, the response of total labor input is likely to be greater than our estimates under the mild assumption that hours per worker (which we do not observe) move in the same direction as employment. Second, 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. Third, other channels, such as the response of investment, also create a positive relationship between stock prices and aggregate demand (see Caballero and Simsek, 2017). 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 on stock wealth affecting 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 Model Details

In this appendix, we present the full model. In Section A.1, we describe the environment and define the equilibrium. For completeness, we repeat the key equations shown in the main text. In Section A.2, we provide a general characterization of equilibrium. In Section A.3, we provide a closed form solution for a benchmark case in which areas have the same stock wealth. In Section A.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 A.5, we use our results to characterize the cross-sectional effects of shocks to stock valuations. In Section A.6, we establish the robustness of the benchmark calibration of the model that we present in the main text. In Section A.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 A.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 A.9, we extend the model to consider more general levels for the EIS parameter and discuss how it would affect our analysis.

#### A.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 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 A.8, where we introduce uncertainty about capital productivity in period 1.

**Goods and Production Technologies.** In every period  $t$ , there is a 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).

In every area, there is a standard neoclassical production technology,  $F(K_t, L_t)$ , that can be used to produce either the nontradable good or the local input for the composite tradable good. For simplicity, we assume the standard production technology is Cobb-Douglas,<sup>1</sup>

$$F(K_t, L_t) = (K_t/\alpha)^\alpha (L_t/(1-\alpha))^{1-\alpha}. \quad (\text{A.1})$$

There is also a capital-only technology that can be used to produce the tradable good. This technology is linear,

$$G_t(K_t) = D_t^{1-\alpha} K_t. \quad (\text{A.2})$$

Here,  $D_t^{1-\alpha}$ , captures the capital productivity in period  $t$ . The normalizing power  $1-\alpha$  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,  $D_t$ .

More specifically, the nontradable good in area  $a$  can be produced according to the standard technology,

$$Y_{a,t}^N = F(K_{a,t}^N, L_{a,t}^N) = (K_{a,t}^N/\alpha)^\alpha (L_{a,t}^N/(1-\alpha))^{1-\alpha}. \quad (\text{A.3})$$

Here,  $L_{a,t}^N$  (resp.  $K_{a,t}^N$ ) denotes the area  $a$  labor (resp. aggregate capital) employed in the nontradable sector in area  $a$ .

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 the standard technology:

$$Y_t^T = \left( \int_a (Y_{a,t}^T)^{\frac{\varepsilon-1}{\varepsilon}} da \right)^{\frac{\varepsilon}{\varepsilon-1}} \quad (\text{A.4})$$

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

Here,  $L_{a,t}^T$  (resp.  $K_{a,t}^T$ ) denotes the area  $a$  labor (resp. aggregate capital) employed in the tradable sector in area  $a$ . The parameter,  $\varepsilon > 0$ , captures the elasticity of substitution across tradable inputs.

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<sup>1</sup>This formulation sets the expected labor productivity growth to zero. At the expense of additional notation, we could introduce a productivity parameter,  $A_t$ , and make it grow between periods 0 and 1.

When  $\varepsilon > 1$  (resp.  $\varepsilon < 1$ ), tradable inputs are gross substitutes (resp. gross complements).

Second, the tradable good can also be produced by the capital-only technology,

$$\tilde{Y}_t^T = G_t \left( \tilde{K}_t^T \right) = D_t^{1-\alpha} \tilde{K}_t. \quad (\text{A.5})$$

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  $Y_t^T$ ).

Combining Eqs. (A.4) and (A.5), we can also write the overall production of the tradable good as,

$$Y_t^T = Y_t^T + \tilde{Y}_t^T = \left( \int_a F(K_{a,t}^T, L_{a,t}^T)^{\frac{\varepsilon-1}{\varepsilon}} da \right)^{\frac{\varepsilon}{\varepsilon-1}} + G_t \left( \tilde{K}_t^T \right).$$

**Factor Supplies.** In each period  $t$ , capital supply is exogenous,

$$K_t = \bar{K} \equiv 1 \text{ for each } t \in \{0, 1\}. \quad (\text{A.6})$$

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).

In each period  $t$  and area  $a$ , the frictionless labor supply is also exogenous (and constant across areas), denoted by  $\bar{L}_t$ . The actual labor supply is denoted by  $L_{a,t}$ . In period 1, the actual labor supply is equal to the frictionless level,

$$L_{a,1} = \bar{L}_1 \text{ for each } a. \quad (\text{A.7})$$

In period 1, labor is also perfectly mobile across areas. These features will ensure that labor income in period 1 will be determined by labor productivity, which will simplify the analysis.

In period 0, the actual labor supply can differ from the frictionless level due to nominal wage rigidities that will be described below. In period 0, labor is also perfectly immobile and specific to the area. These features will ensure that labor income in period 0 will be determined by the local demand for labor.

**Heterogeneous Ownership of Capital.** Importantly, areas can differ in their ownership 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 the same across areas. We normalize this long-run wage level to a constant level denoted by  $\bar{W}$ , that is,

$$W_{a,1} = W_1 \equiv \bar{W}. \quad (\text{A.8})$$

We will characterize all other nominal prices in terms of  $\bar{W}$  and other parameters.

**Nominal Rigidities in the Labor Market.** In period 1, all factors are fully utilized. However, in period 0, there are nominal wage rigidities that can lead to under or over-utilization of labor. Specifically, the actual labor supply,  $L_{a,0}$ , can deviate from its frictionless level,  $\bar{L}_0$ . However, this is also associated with some adjustment in the nominal wage level. We capture the wage adjustment in reduced form with the following ‘‘Wage Phillips Curve’’:

$$W_{a,0}/\bar{W} = (L_{a,0}/\bar{L}_0)^\kappa. \quad (\text{A.9})$$

Here, we normalized the equation so that when labor is at its frictionless level,  $L_{a,0} = \bar{L}_0$ , the wage level in period 0 is equal to its long-run level,  $W_{a,0} = \bar{W}$ . This can be interpreted as the wage level workers expect for period 0 absent shocks. Eq. (A.9) says that shocks that change the actual labor supply also induce changes in nominal wage inflation. The parameter,  $\kappa \in [0, \infty)$ , controls the degree of wage flexibility. When  $\kappa \rightarrow \infty$ , nominal wages are completely flexible and the actual labor supply is always at its frictionless level. When  $\kappa = 0$ , nominal wages are completely sticky and the actual labor supply can deviate substantially from its frictionless level without having an impact on wage inflation.

**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.

Households in different areas start with zero units of the risk-free asset but they can differ in their endowments of capital as described earlier.

**Consumption and Portfolio Choice.** A representative 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:

$$C_{a,t} = (C_{a,t}^N/\eta)^\eta (C_{a,t}^T/(1-\eta))^{1-\eta}. \quad (\text{A.10})$$

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

$$P_{a,t} \equiv (P_{a,t}^N)^\eta (P_t^T)^{1-\eta}. \quad (\text{A.11})$$

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,

$$P_{a,t}^N C_{a,t}^N = \eta P_{a,t} C_{a,t} \text{ and } P_{a,t}^T C_{a,t}^T = (1 - \eta) P_{a,t} C_{a,t}. \quad (\text{A.12})$$

Households' inter-period preferences are described by time-separable log utility (cf. Eq. (2)). They choose how much to consume and save, and how to allocate their savings across capital and the risk-free asset. The households' problem can then be written as,

$$\begin{aligned} \max_{C_{a,0,1+x_{a,1}}} \quad & \log C_{a,0} + \delta \log C_{a,1} & (\text{A.13}) \\ P_{a,0} C_{a,0} + S_{a,0} = & W_{a,0} L_{a,0} + (1 + x_{a,0}) Q_0, \\ S_{a,0} = S_{a,0}^f + & (1 + x_{a,1}) (Q_0 - R_0) \\ P_{a,1} C_{a,1} = \overline{W} \overline{L}_1 + & (1 + x_{a,1}) R_1 + S_{a,0}^f R^f. \end{aligned}$$

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.

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

$$Y_{a,t}^N = C_{a,t}^N \quad (\text{A.14})$$

$$Y_t^T = Y_t^T + \tilde{Y}_t^T = \int_a C_{a,1}^T da, \quad (\text{A.15})$$

where  $Y_{a,t}^N, Y_t^T, \tilde{Y}_t^T$  are given by Eqs. (A.3 – A.5).

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

$$L_{a,0} = L_{a,0}^N + L_{a,0}^T \text{ for each } a \quad (\text{A.16})$$

$$\overline{K} = 1 = \int_a (K_{a,0}^N + K_{a,0}^T) da + \tilde{K}_0^T. \quad (\text{A.17})$$

The analogous conditions for period 1 can be written as,

$$\overline{L}_1 = \int_a (L_{a,1}^N + L_{a,1}^T) da \quad (\text{A.18})$$

$$\overline{K} = 1 = \int_a (K_{a,1}^N + K_{a,1}^T) da + \tilde{K}_1^T. \quad (\text{A.19})$$

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,

$$\int_a x_{a,1} da = 0. \quad (\text{A.20})$$

**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 our analysis, we assume the monetary policy sets  $R^f$  to ensure aggregate employment is on average equal to frictionless employment:

$$R^f = R^{f,*}, \text{ where } R^{f,*} \text{ ensures } \int_a L_{a,0} da = \bar{L}_0. \quad (\text{A.21})$$

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) *Households maximize, that is, they solve problem (A.13).*
- (ii) *Competitive firms maximize according to the production technologies described in (A.1 – A.5).*
- (iii) *The actual labor supply in period 0 is endogenous, and the nominal wage level in period 0 is related to the actual labor supply according to (A.9). Labor supply and nominal wages in period 1 are exogenous and given by Eqs. (A.7) and (A.8). Capital supply is exogenous in both periods and given by (A.6).*
- (iv) *Monetary policy sets  $R^f = R^{f,*}$  to ensure (A.21).*
- (v) *Goods, factors, and asset markets clear (cf. Eqs. (A.14 – A.20)).*

## A.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 (when we focus on special cases), we will ensure this by making appropriate parametric assumptions on  $D_t$ .

**Supply Side.** The production technologies described in (A.1 – A.5) imply that the nominal price of goods are related to nominal factor prices according to,

$$\begin{aligned} P_{a,t}^N &= U_{a,t} \equiv W_{a,t}^{1-\alpha} R_t^\alpha, \\ P_t^T &= \left( \int_a U_{a,t}^{1-\varepsilon} da \right)^{1/(1-\varepsilon)} \\ P_t^T &= R_t / D_t^{1-\alpha}. \end{aligned} \tag{A.22}$$

Here, the second equality in the first line defines the variable,  $U_{a,t}$ , which we refer to as the unit cost of production (for either the nontradable good or the local tradable input) in area  $a$ .

Note that we can combine the last two equations in (A.22) to obtain an expression for the rental rate of capital in terms of wages (and the parameter,  $D_t$ ),

$$R_t^{1-\alpha} = D_t^{1-\alpha} \left( \int_a (W_{a,t}^{1-\alpha})^{1-\varepsilon} da \right)^{1/(1-\varepsilon)}. \tag{A.23}$$

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. Recall also that Eq. (A.11) characterizes the total price of consumption in an area,  $P_{a,t}$ , in terms of the price of nontradable and tradable goods,  $P_{a,t}^N, P_t^T$ . 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. (A.23) uniquely determines the rental rate of capital and Eqs. (A.22) and Eq. (A.11) uniquely determine unit costs and goods prices,  $U_{a,t}, P_{a,t}^N, P_t^T, P_{a,t}$ . If  $W_{a,t} \equiv W_t$  for each  $a$ , then  $R_t = D_t W_t$ ,  $P_{a,t}^N = U_{a,t} = P_t^T = P_{a,t} = D_t^\alpha W_t$ .*

We next characterize the demand for labor in the nontradable and tradable sectors. Note that the Cobb-Douglas production function in (A.3) implies,

$$\begin{aligned} W_{a,t} L_{a,t}^N &= (1 - \alpha) U_{a,t} Y_{a,t}^N, \\ \text{where } U_{a,t} Y_{a,t}^N &= P_{a,t}^N C_{a,t}^N. \end{aligned} \tag{A.24}$$

Here, the second line substitutes the market clearing condition (A.14) and observes that  $U_{a,t} = P_{a,t}^N$ . 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 (A.4) implies,

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

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 (A.5) implies,

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

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. The elasticity parameter,  $\varepsilon$ , captures the sensitivity of demand to the local unit cost.

Combining these expressions, we further obtain,

$$W_{a,t}L_{a,t}^T = (1-\alpha) \left(\frac{U_{a,t}}{P_t^T}\right)^{1-\varepsilon} P_t^T Y_t^T, \quad (\text{A.25})$$

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 substitutes the market clearing condition (A.15) and Eq. (A.5). In particular, the demand for tradables in the aggregate 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. (A.25) 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. (A.24). The demand for tradable labor is given by Eq. (A.25). In equilibrium, the amount of capital employed in the capital-only technology satisfies,*

$$R_t \tilde{K}_t^T = R_t - \frac{\alpha \int_a W_{a,t} L_{a,t} da}{1-\alpha}. \quad (\text{A.26})$$

Therefore, Eq. (A.25) can be further solved as,

$$W_{a,t}L_{a,t}^T = (1-\alpha) \left(\frac{U_{a,t}}{P_t^T}\right)^{1-\varepsilon} \left[ \int_a P_t^T C_{a,t}^T da - R_t + \frac{\alpha}{1-\alpha} \int_a W_{a,t} L_{a,t} da \right]. \quad (\text{A.27})$$

The intuition for Eq. (A.27) is as follows. The amount of production in the capital-only technology depends on the total payoff to capital ( $R_t \bar{K} = R_t$ ) with some slippage due to the fact that some capital is also employed in the standard technologies. The last term in the brackets characterizes the amount of slippage in equilibrium: that is, the payoff to capital in the standard technologies. This payoff is proportional to the total payoff to labor (all of which is employed in standard technologies) because the standard technologies are Cobb-Douglas.

**Proof.** To establish Eq. (A.27), note that the analogue of Eqs. (A.24) and (A.25) also apply for capital. In particular, after aggregating across areas, we have,

$$R_t \int_a K_{a,t}^N da = \alpha \int_a P_{a,t}^N C_{a,t}^N da$$

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

Here, the second line uses  $P_t^T = (\int_a U_{a,t}^{1-\varepsilon} da)^{1/(1-\varepsilon)}$ . Adding these equations, and using the market clearing condition for capital in (A.17) and (A.19), we obtain,

$$R_t (1 - \tilde{K}_t^T) = \alpha \left( \int_a P_{a,t}^N C_{a,t}^N da + \int_a P_t^T C_{a,t}^T da - R_t \tilde{K}_t^T \right). \quad (\text{A.28})$$

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

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

Substituting this into Eq. (A.28), we solve for the production of tradables via capital-only technology as,

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

This establishes Eq. (A.26). Substituting this expression into Eq. (A.25), we obtain Eq. (A.27), 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,

$$R_1 = D_1 \bar{W}. \quad (\text{A.29})$$

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. We next turn to the demand side and characterize 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 (A.13) implies households take a non-zero position on capital if and only if its price satisfies,

$$\begin{aligned} Q_0 &= R_0 + \frac{R_1}{R^f} \\ &= R_0 + \frac{D_1 \bar{W}}{R^f}. \end{aligned} \quad (\text{A.30})$$

Here, the second line substitutes for the future rental rate of capital from Eq. (A.29). 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,

$$H_{a,0} = W_{a,0}L_{a,0} + \frac{\overline{WL}_1}{R^f}. \quad (\text{A.31})$$

We can then rewrite the households' budget constraints in (A.13) 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,

$$P_{a,0}C_{a,0} = \frac{1}{1 + \delta} (H_{a,0} + (1 + x_{a,0})Q_0). \quad (\text{A.32})$$

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. (A.12), we further obtain,

$$P_{a,0}^N C_{a,0}^N = \frac{\eta}{1 + \delta} (H_{a,0} + (1 + x_{a,0})Q_0), \quad (\text{A.33})$$

$$P_0^T C_{a,0}^T = \frac{1 - \eta}{1 + \delta} (H_{a,0} + (1 + x_{a,0})Q_0). \quad (\text{A.34})$$

We next combine Eq. (A.33) with Eq. (A.24) from Lemma 2 to obtain,

$$W_{a,0}L_{a,0}^N = \frac{(1 - \alpha)\eta}{1 + \delta} (H_{a,0} + (1 + x_{a,0})Q_0). \quad (\text{A.35})$$

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 ( $1 - \alpha$ ).

Likewise, we combine Eq. (A.34) with Eq. (A.27) from Lemma 2 to obtain,

$$W_{a,0}L_{a,0}^T = \left(\frac{U_{a,0}}{P_0^T}\right)^{1-\varepsilon} \left(\frac{(1 - \alpha)(1 - \eta)}{1 + \delta} (H_0 + Q_0) - (1 - \alpha)R_0 + \alpha \int_a W_{a,0}L_{a,0} da\right). \quad (\text{A.36})$$

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. (A.35) and (A.36) and rearranging terms, we obtain an expression for the

total labor demand in an area as follows,

$$W_{a,0}L_{a,0} = \frac{(1-\alpha)\eta}{1+\delta}(H_{a,0} + (1+x_{a,0})Q_0) + \left(\frac{U_{a,0}}{P_0^T}\right)^{1-\varepsilon} \left(\frac{(1-\alpha)(1-\eta)}{1+\delta}(H_0 + Q_0) - (1-\alpha)R_0 + \alpha \int_a W_{a,0}L_{a,0}da\right). \quad (\text{A.37})$$

After substituting  $H_{a,0}$  from Eq. (A.31), we can also write the labor demand equation as follows,

$$W_{a,0}L_{a,0} = \frac{(1-\alpha)\eta}{1+\delta} \left(W_{a,0}L_{a,0} + \frac{\overline{WL}_1}{R^f} + (1+x_{a,0})Q_0\right) + \left(\frac{U_{a,0}}{P_0^T}\right)^{1-\varepsilon} \left(\frac{(1-\alpha)(1-\eta)}{1+\delta} \left(\int_a W_{a,0}L_{a,0}da + \frac{\overline{WL}_1}{R^f} + Q_0\right) - (1-\alpha)R_0 + \alpha \int_a W_{a,0}L_{a,0}da\right). \quad (\text{A.38})$$

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,  $U_{a,0}, P_0^T, R_0$  are implicit functions of wages,  $\{W_{a,0}\}_a$ . Therefore, Eq. (A.38) 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. (A.9) that relates wages to employment in each area. This provides  $|I|$  additional equations in  $\{L_{a,0}, W_{a,0}\}_{a \in I}$ . The monetary policy rule in (A.21) provides the remaining equation. The equilibrium is characterized as the solution to these  $2|I| + 1$  equations.

### A.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.**  $D_0 = \frac{\alpha}{1-\alpha}\overline{L}_0$  and  $D_1 \geq \frac{\alpha}{1-\alpha}\overline{L}_1$ .

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  $L_{a,t} = \overline{L}_t$ . Using this observation, together with Lemmas 1 and 2, we obtain  $D_t \tilde{K}_t^T = D_t - \frac{\alpha}{1-\alpha}\overline{L}_t$ . Therefore, the inequality  $D_t \geq \frac{\alpha}{1-\alpha}\overline{L}_t$  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. Assumption D also simplifies the expressions, e.g., it implies that the share of labor is given by its share in the Cobb-Douglas technology,  $1 - \alpha$ .

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,  $W_0, L_0, H_0$ . Recall also that  $L_0 = \bar{L}_0$  due to the monetary policy rule in (A.21). Substituting this into Eq. (A.9), we further obtain  $W_0 = \bar{W}$ . Using Lemma 1, we further obtain,  $R_0 = D_0 \bar{W}$ .

Substituting these observations into the labor demand Eq. (A.37), we obtain,

$$\bar{W}L_0 = \frac{1-\alpha}{1+\delta} (H_0 + Q_0) - (1-\alpha) D_0 \bar{W} + \alpha \bar{W}L_0.$$

After rearranging terms, we obtain,

$$\bar{W}L_0 = \frac{1}{1+\delta} (H_0 + Q_0) - D_0 \bar{W}.$$

Rearranging further, we obtain,

$$(H_0 + Q_0) / \bar{W} = (1 + \delta) (\bar{L}_0 + D_0). \quad (\text{A.39})$$

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. (A.31) and (A.30), human capital and stock wealth are given by, respectively,

$$H_0 / \bar{W} = \bar{L}_0 + \frac{\bar{L}_1}{R^{f,*}}, \quad (\text{A.40})$$

$$Q_0 / \bar{W} = D_0 + \frac{D_1}{R^{f,*}}. \quad (\text{A.41})$$

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

$$R^{f,*} = \frac{1}{\delta} \frac{\bar{L}_1 + D_1}{\bar{L}_0 + D_0}. \quad (\text{A.42})$$

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,

$$H_0 / \bar{W} = \bar{L}_0 + \delta (\bar{L}_0 + D_0) \frac{\bar{L}_1}{\bar{L}_1 + D_1} \quad (\text{A.43})$$

$$Q_0 / \bar{W} = D_0 + \delta (\bar{L}_0 + D_0) \frac{D_1}{\bar{L}_1 + D_1} \quad (\text{A.44})$$

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 (2017): 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. (A.35) and (A.36), we solve for aggregate nontradable and tradable employment as, respectively,

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

Combining this with Eq. (A.39), we further obtain,

$$\begin{aligned} L_0^N &= (1-\alpha)\eta(\bar{L}_0 + D_0) \\ L_0^T &= (1-\alpha)(1-\eta)(\bar{L}_0 + D_0) - (1-\alpha)D_0 + \alpha\bar{L}_0 \end{aligned}$$

Finally, substituting  $D_0 = \frac{\alpha}{1-\alpha}\bar{L}_0$  from Assumption D (which ensures that the share of capital is equal to  $\alpha$ ), we can further simplify these expressions as follows,

$$\begin{aligned} L_0^N &= \eta\bar{L}_0, \\ L_0^T &= (1-\eta)\bar{L}_0. \end{aligned} \tag{A.45}$$

Hence, the share of labor in the nontradable and tradable sectors is determined by the share of the corresponding good in household spending.

**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 at its frictionless level,  $L_0 = \bar{L}_0$ , and nominal wages are at their expected level,  $W_0 = \bar{W}$ ; the nominal interest rate is given by Eq. (A.42); human capital and stock wealth are given by Eqs. (A.43) and (A.44); the share of labor employed in the nontradable sector is equal to  $\eta$  [cf. Eq. (A.45)]. 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.*

## A.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  $Y \in \{L_{a,0}, L_{a,0}^N, L_{a,0}^T, W_{a,0}, U_{a,0}, H_{a,0}\}_a$ . 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.

**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.*

**Proof.** First, we log-linearize the monetary policy Eq. (A.21) to obtain,

$$\int_a l_{a,0} da = 0. \quad (\text{A.46})$$

Thus, the unweighted average of log-linearized total labor is equal to zero. Next, we log-linearize the wage inflation Eq. (A.9) to obtain,

$$w_{a,0} = \kappa l_{a,0}.$$

Combining this with Eq. (A.46), we further obtain,

$$\int_a w_{a,0} da = 0. \quad (\text{A.47})$$

Thus, the unweighted average of log-linearized nominal wages is also equal to zero. This proves the first part of the result.

Next we consider Eqs. (A.22), which characterize the other prices in terms of nominal wages. Log-linearizing the first equation in (A.22), we obtain,

$$u_{a,0} = (1 - \alpha) w_{a,0} + \alpha r_0. \quad (\text{A.48})$$

Log-linearizing the second equation in (A.22), and using Eq. (A.47), we find  $p_0^T = 0$ . Using the third equation in Eq. (A.23), we also find  $r_0 = 0$ . Thus, the price of tradables and the rental rate of capital are the same as in the common-wealth benchmark.

Next we consider Eq. (A.30) that describes the price of capital. Log-linearizing and using  $r_0 = 0$ , we obtain,

$$q_0 Q_0 = -r^f (D_1 \bar{W}). \quad (\text{A.49})$$

Finally, we log-linearize the labor demand Eq. (A.38) to obtain,

$$\begin{aligned}
(w_{a,0} + l_{a,0}) \overline{WL}_0 &= \frac{(1-\alpha)\eta}{1+\delta} \left( (w_{a,0} + l_{a,0}) \overline{WL}_0 + x_{a,0} Q_0 - r^f \overline{WL}_1 + q_0 Q_0 \right) \\
&\quad - (\varepsilon - 1) u_{a,0} \overline{WL}_0^T \\
&\quad + \frac{(1-\alpha)(1-\eta)}{1+\delta} \left( \int_a (w_{a,0} + l_{a,0}) da \overline{WL}_0 - r^f \overline{WL}_1 + q_0 Q_0 \right) \\
&\quad + \alpha \int_a (w_{a,0} + l_{a,0}) da \overline{WL}_0.
\end{aligned} \tag{A.50}$$

Here, we used the earlier results,  $p_0^T = 0$  and  $r_0 = 0$ , to simplify the expression slightly. Integrating Eq. (A.50) over all areas, and using Eqs. (A.46), (A.47), (A.48), and (A.49), we obtain  $q_0 = r^f = 0$ . Thus, the stock prices and the interest rate are also equal to their counterparts in the common-wealth benchmark, completing the proof.  $\square$

We next characterize the log-linearized equilibrium outcomes for the local variables. Consider the log-linearized labor demand Eq. (A.50). Using Lemma 3 to simplify this equation, we obtain,

$$\begin{aligned}
(w_{a,0} + l_{a,0}) \overline{WL}_0 &= \frac{(1-\alpha)\eta}{1+\delta} \left( (w_{a,0} + l_{a,0}) \overline{WL}_0 + x_{a,0} Q_0 \right) \\
&\quad - (\varepsilon - 1) (1-\alpha) w_{a,0} \overline{WL}_0^T.
\end{aligned} \tag{A.51}$$

After rearranging terms, we further obtain,

$$\begin{aligned}
(w_{a,0} + l_{a,0}) \overline{WL}_0 &= \mathcal{M} \left( \frac{(1-\alpha)\eta}{1+\delta} x_{a,0} Q_0 - (\varepsilon - 1) (1-\alpha) w_{a,0} \overline{WL}_0^T \right), \\
\text{where } \mathcal{M} &= \frac{1}{1 - (1-\alpha)\eta / (1+\delta)}
\end{aligned} \tag{A.52}$$

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

Recall that we also had the log-linearized version of the wage inflation Eq. (A.53),

$$w_{a,0} = \kappa l_{a,0}. \tag{A.53}$$

For each  $a$ , Eqs. (A.52) and (A.53) 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,

$$w_{a,0} + l_{a,0} = \frac{1+\kappa}{1+\kappa\zeta} \mathcal{M} \frac{(1-\alpha)\eta x_{a,0} Q_0}{1+\delta \overline{WL}_0} \tag{A.54}$$

$$l_{a,0} = \frac{1}{1+\kappa} (w_{a,0} + l_{a,0}) \tag{A.55}$$

$$w_{a,0} = \frac{\kappa}{1+\kappa} (w_{a,0} + l_{a,0}), \tag{A.56}$$

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

Here, the second-to-last line defines the parameter,  $\zeta$ , and the last line substitutes  $\frac{L_0^T}{L_0} = 1 - \eta$  [cf. Eq. (A.45)]. Eq. (A.54) illustrates that the local spending on nontradables affects the local labor bill. Eqs. (A.55) and (A.56) 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. (A.54) 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. (A.36) (after substituting for  $H_0$  from Eq. (A.31)), and simplifying the expression as before, we obtain an expression for the labor bill in the tradable sector,

$$\begin{aligned}
w_{a,0} + l_{a,0}^T &= -(\varepsilon - 1)(1 - \alpha) w_{a,0} \\
&= -(\varepsilon - 1)(1 - \alpha) \frac{\kappa}{1 + \kappa\zeta} \mathcal{M} \frac{(1 - \alpha)\eta x_{a,0} Q_0}{1 + \delta} \frac{1}{\overline{WL}_0}.
\end{aligned} \tag{A.57}$$

Here, the second line uses Eq. (A.56). 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. (A.38) (after substituting for  $H_{a,0}$  from Eq. (A.31)), and simplifying the expression as before, we obtain an expression for the labor bill in the nontradable sector,

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

$$\begin{aligned}
&= \frac{1}{\overline{WL}_0^N} \mathcal{M} \frac{(1-\alpha)\eta}{1+\delta} \left( (w_{a,0} + l_{a,0}^T) \overline{WL}_0^T + x_{a,0} Q_0 \right) \\
&= \frac{1}{\eta \overline{WL}_0} \mathcal{M} \frac{(1-\alpha)\eta}{1+\delta} \left( (w_{a,0} + l_{a,0}^T) (1-\eta) \overline{WL}_0 + x_{a,0} Q_0 \right) \\
&= \mathcal{M} \frac{1-\alpha}{1+\delta} \left( \frac{x_{a,0} Q_0}{\overline{WL}_0} + (1-\eta) (w_{a,0} + l_{a,0}^T) \right) \tag{A.58}
\end{aligned}$$

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. (A.45) to substitute  $\overline{L}_0^N = \eta \overline{L}_0$  and  $\overline{L}_0^T = (1-\eta) \overline{L}_0$ . The last line simplifies and rearranges terms.

Eq. (A.58) 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. (A.57)). 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, aggregate outcomes are the same as in the common-wealth benchmark characterized in Proposition 1. Local labor and wages in a given area,  $(l_{a,0}, w_{a,0})$ , are characterized as the solution to Eqs. (A.52) and (A.53). The solution is given by Eqs. (A.55) and (A.56). Local labor bill in nontradables and tradable sectors are given by Eqs. (A.57) and (A.58). 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 (A.57)

implies

$$l_{a,0}^T = -(1 + (\varepsilon - 1)(1 - \alpha)) w_{a,0}. \quad (\text{A.59})$$

Since  $(\varepsilon - 1)(1 - \alpha) > -1$  (because  $\varepsilon > 0$ ) and  $dw_{a,0}/dx_{a,0} \geq 0$  (cf. Eq. (A.56)), 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,  $d(l_{a,0}^N + w_{a,0})/dx_{a,0} > 0$ .  $\square$

## A.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,  $L_0 = \bar{L}_0$ ,  $W_0 = \bar{W}$ ,  $L_0^T = \eta \bar{L}_0$ ,  $L_0^N = (1 - \eta) \bar{L}_0$ .

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:

$$\log(W_{a,0}L_{a,0}) \simeq \log(\bar{W}L_0) + w_{a,0} + l_{a,0}.$$

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  $\log(\bar{W}L_0)$ . 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, con-

sidering Eq. (A.54) for  $D_1^{old}$  and  $D_1^{new}$ , we obtain:

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

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. (5) in the main text that describes  $\Delta(w_{a,0} + l_{a,0})$ .

Applying the same argument to Eqs. (A.55), (A.58), (A.57), we also obtain Eqs. (6), (7), (8) 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.

## A.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,  $\frac{1}{1+\delta} = \rho T$  and write the differenced versions of Eqs. (A.54 – A.58) as follows:

$$\begin{aligned} \frac{\Delta(w_{a,0} + l_{a,0})}{SR} &= \frac{1 + \kappa}{1 + \kappa\zeta} \mathcal{M} (1 - \alpha) \eta \rho, \\ \frac{\Delta l_{a,0}}{SR} &= \frac{1}{1 + \kappa} \frac{\Delta(w_{a,0} + l_{a,0})}{SR} \\ \frac{\Delta w_{a,0}}{SR} &= \frac{\kappa}{1 + \kappa} \frac{\Delta(w_{a,0} + l_{a,0})}{SR} \end{aligned} \tag{A.60}$$

$$\begin{aligned} \frac{\Delta(w_{a,0} + l_{a,0}^T)}{SR} &= -(\varepsilon - 1)(1 - \alpha) \frac{\Delta w_{a,0}}{SR} \\ \frac{\Delta(w_{a,0} + l_{a,0}^N)}{SR} &= \mathcal{M} (1 - \alpha) \rho \left( 1 - (\varepsilon - 1)(1 - \alpha)(1 - \eta) T \frac{\Delta w_{a,0}}{SR} \right) \end{aligned} \tag{A.61}$$

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

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

$$\text{and } \zeta = 1 + (\varepsilon - 1)(1 - \alpha)(1 - \eta) \mathcal{M}.$$

Our calibration relies on two model equations that determine the key parameters  $\kappa$  and  $\rho$ . Specifically, we calibrate  $\kappa$  by using Eq. (A.60), which replicates Eq. (15) from the main text. We calibrate  $\rho$  by using Eq. (A.61) which generalizes Eq. (13) from the main text. For reasons we describe in the main text, we do not use the equations for the tradable labor bill and the total labor

bill for calibration purposes.

Note that combining Eq. (A.60) with the empirical coefficients for employment and the total labor bill from Table 1 (for quarter 7), we obtain:

$$0.69\% \leq \frac{1}{1 + \kappa} 2.25\%$$

As we discuss in the main text, under the assumption that hours respond in the same direction as the number of workers, the empirical counterpart to the equation for labor provides a lower bound to the corresponding equation from theory. This in turn provides the following bound on the wage flexibility parameter [cf. Eq. (16) in the main text]:

$$\kappa \leq 2.26. \tag{A.62}$$

That leaves us with Eq. (A.61) 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 parameter  $\alpha$  so that the share of labor is equal to the standard empirical estimates:

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

### A.6.1 Details of the Baseline Calibration

Setting  $\varepsilon = 1$  in Eq. (A.61) reduces to Eq. (13) in the main text,

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

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

$$\mathcal{M}(1 - \alpha)\rho = 2.83\%. \tag{A.63}$$

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

$$\mathcal{M} = \frac{1}{1 - (1 - \alpha)\rho\eta T} = 1.5 \tag{A.64}$$

With these assumptions, as we discussed in the main text, Eq. (A.63) determines the stock wealth effect parameter independently of the other parameters such as  $\kappa, \eta, T$ . In particular, we have:

$$\rho = 2.83\%.$$

Combining this with Eq. (A.64) to match the multiplier, we also obtain:

$$\eta T = 17.67.$$

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

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:

$$\eta \in [\underline{\eta}, \bar{\eta}], \text{ where } \underline{\eta} = 0.5 \text{ and } \bar{\eta} = 0.8. \quad (\text{A.65})$$

Then, our calibration of the multiplier implies:

$$T = T(\eta) \equiv \frac{17.67}{\eta}, \text{ where } T(\bar{\eta}) = 22.08 \text{ and } T(\underline{\eta}) = 35.34.$$

In particular, for every choice of  $\eta$ , there exists a horizon parameter  $T$  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  $T$  literally but view it as a modeling device to calibrate the multiplier  $\mathcal{M}$ . In particular, we view the implied high levels of  $T$  as capturing reasons outside our model (such as borrowing constraints) that would increase the income multiplier in practice.<sup>2</sup>

### A.6.2 Robustness of the Baseline Calibration

Next consider the case with general  $\varepsilon$ . In this case, Eq. (A.61) is more complicated and given by:

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

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 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  $\varepsilon, \alpha, \eta$ .<sup>3</sup>

Recall also that we have Eq. (A.60) that describes the change in wages as a function of the

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<sup>2</sup>The dependence of  $\mathcal{M}$  on  $T$  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  $T$  increases the time-length of period 0 over which output is determined by aggregate demand. This leads to stronger multiplier effects.

<sup>3</sup>Less obviously, the magnitude also depends on the horizon parameter,  $T$ . This parameter enters the equation for the same reason it enters the equation for the multiplier,  $\mathcal{M}$  (see Footnote 2). As before, the dependence of the equation on  $T$  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.

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. (A.61), 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. (A.63):

$$\mathcal{M}(1 - \alpha) \rho \left( 1 - (\varepsilon - 1)(1 - \alpha)(1 - \eta) T \frac{\kappa}{1 + \kappa} 2.25\% \right) = 2.83\%. \quad (\text{A.66})$$

As this expression illustrates, the stock wealth effect parameter in this case is not determined independently of the remaining parameters,  $\kappa, \eta, T$ . We have already established that  $\kappa$  lies in the range (A.62). We also assume  $\eta$  lies in the range (A.65) that we described earlier. Recall also that we choose  $T$  to ensure Eq. (A.64) given all other parameters. Hence, for any fixed  $\varepsilon$ , Eq. (A.66) describes  $\rho$  as a function of  $\kappa$  and  $\eta$ , where  $\kappa$  and  $\eta$  are required to lie in the ranges described earlier.

Figure A.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 10% of its corresponding level from the baseline calibration even if we set  $\eta = 0.5$ .

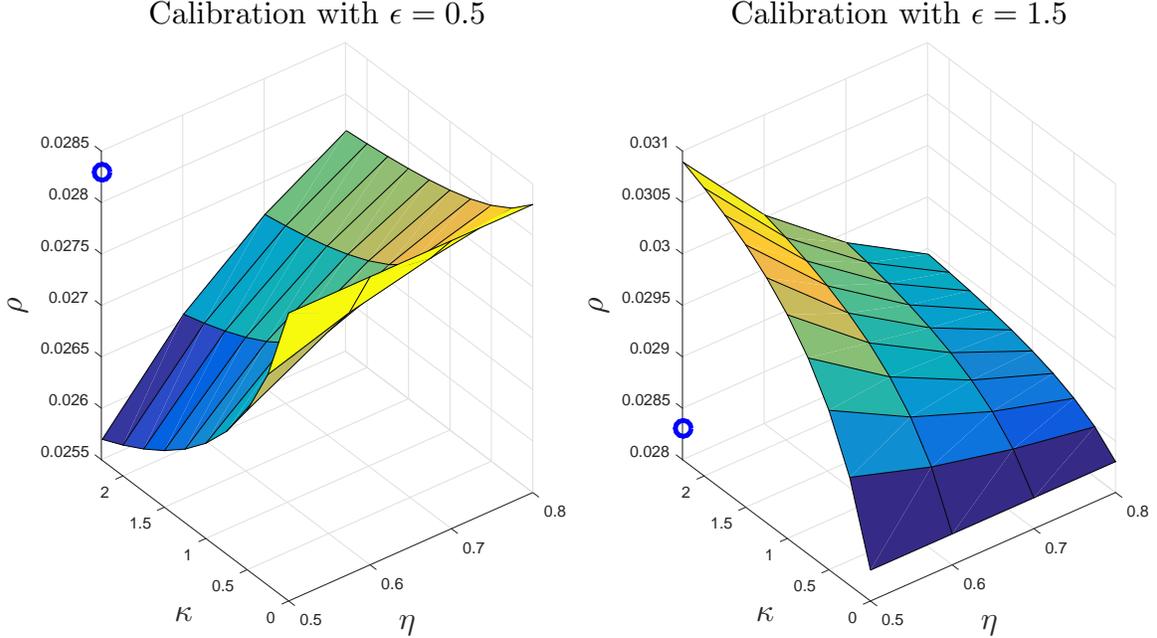
The intuition for robustness can be understood as follows. As we described earlier, the additional effects emerge from the adjustment of the tradable labor bill due to a change in local wages. As long as wages are sufficiently sticky, the effect has a negligible effect on our baseline calibration. In fact, Figure A.1 shows that the largest deviations from the benchmark obtain when the wage flexibility parameter,  $\kappa$ , is at its upper bound. As it turns out, this upper bound is sufficiently tight 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.

## A.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 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 A.1 with the only difference that the monetary policy keeps the nominal interest rate at a constant level,  $R^f = \bar{R}^f$ . For simplicity, we also focus attention on

Figure A.1:



Notes: Notes: The left panel (resp. the right panel) illustrates the implied  $\rho$  as a function of  $(\kappa, \eta)$  given  $\epsilon = 0.5$  (resp.  $\epsilon = 2$ ), as we vary  $\kappa$  over the range in (A.62) and  $\eta$  over the range in (A.65). The blue circles illustrate the implied  $(\rho, \eta)$  for the baseline calibration with  $\epsilon = 1$ .

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. (A.40) and (A.41) also apply in this setting. In particular, human capital wealth is given by,

$$H_0 = W_0 L_0 + \frac{\overline{W} L_1}{\overline{R}^f} \quad (\text{A.67})$$

and the stock wealth is given by,

$$Q_0 = W_0 D_0 + \frac{\overline{W} D_1}{\overline{R}^f}. \quad (\text{A.68})$$

Next note that the labor demand Eq. (A.37) applies also in this case. Using  $x_{a,0} = 0$ , we obtain,

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

Using  $R_0 = W_0 D_0$  and the expressions for  $H_0$  from Eq. (A.67), and collecting similar terms together, we obtain,

$$W_0 L_0 = \frac{1 - \alpha}{1 + \delta} \left( W_0 L_0 + \frac{\overline{W} L_1}{\overline{R}^f} + Q_0 \right) - (1 - \alpha) W_0 D_0 + \alpha W_0 L_0.$$

Simplifying further, we obtain,

$$W_0 L_0 + W_0 D_0 = \frac{1}{1 + \delta} \left( W_0 L_0 + \frac{\overline{W} \overline{L}_1}{\overline{R}^f} + Q_0 \right). \quad (\text{A.69})$$

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.

Finally, note that the wage inflation Eq. (A.9) implies,

$$W_0 / \overline{W} = (L_0 / \overline{L}_0)^\kappa. \quad (\text{A.70})$$

The equilibrium is characterized by Eqs. (A.68), (A.69) and (A.70) in three variables,  $(Q_0, W_0, L_0)$ . This proves Eqs. (17) in the main text.

Next note that there exists a level of  $D_1$ , denoted by  $\overline{D}_1$ , that ensures these equations are satisfied with  $L_0 = \overline{L}_0$  and  $W_0 = \overline{W}$ , along with  $\overline{Q}_0 \equiv \overline{W} \overline{D}_0 + \frac{\overline{W} \overline{D}_1}{\overline{R}^f}$ . To simplify the expressions further, we next log-linearize the equations around the equilibrium with  $D_1 = \overline{D}_1$ . Log-linearizing the stock pricing Eq. (A.68), we obtain,

$$q_0 \overline{Q}_0 = w_0 \overline{W} \overline{D}_0 + d_1 \frac{\overline{W} \overline{D}_1}{\overline{R}^f}. \quad (\text{A.71})$$

Log-linearizing the wage inflation Eq. (A.70), we obtain,

$$w_0 = \kappa l_0. \quad (\text{A.72})$$

Finally, log-linearizing the labor demand Eq. (A.69), we obtain,

$$(w_0 + l_0) \overline{W} \overline{L}_0 + w_0 \overline{W} \overline{D}_0 = \frac{1}{1 + \delta} \left( (w_0 + l_0) \overline{W} \overline{L}_0 + q_0 \overline{Q}_0 \right).$$

After substituting Eq. (A.71), and rearranging terms to account for the multiplier effects, we further obtain,

$$(w_0 + l_0) \overline{W} \overline{L}_0 + w_0 \overline{W} \overline{D}_0 = \tilde{\mathcal{M}}^A \frac{1}{1 + \delta} d_1 \frac{\overline{W} \overline{D}_1}{\overline{R}^f}, \quad (\text{A.73})$$

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

The log-linearized equilibrium is characterized by Eqs. (A.71), (A.72), and (A.73).

The log-linearized equations can also be solved in closed form. We conjecture a linear solution:

$$\begin{aligned} q_0 \overline{Q}_0 &= A_Q Q^A \\ w_0 \overline{W} \overline{L}_0 &= A_W Q^A \end{aligned} \quad (\text{A.74})$$

$$l_0 \overline{WL}_0 = A_L Q^A,$$

$$\text{where } Q^A = \frac{\overline{WD}_1 d_1}{\overline{R}^f}.$$

Here,  $Q^A$  denotes the log-linear approximation to the exogenous component of stock wealth ( $\frac{\overline{WD}_1}{\overline{R}^f}$ ). 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 (A.74) into Eqs. (A.71), (A.72), and (A.73). We also use Assumption D to substitute  $D_0 = \frac{\alpha}{1-\alpha} \overline{L}_0$  and simplify the expressions, to obtain the system of equations,

$$A_Q = \frac{\alpha}{1-\alpha} A_W + 1$$

$$A_W = \kappa A_L$$

$$A_W + A_L + \frac{\alpha}{1-\alpha} A_W = \tilde{\mathcal{M}}^A \frac{1}{1+\delta}.$$

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

$$A_W + A_L = \mathcal{M}^A \frac{1-\alpha}{1+\delta}, \quad (\text{A.75})$$

$$\text{where } \mathcal{M}^A = \mathcal{F}^A \tilde{\mathcal{M}}^A \text{ and } \mathcal{F}^A = \frac{1+\kappa}{1-\alpha+\kappa}$$

The effect on the aggregate employment and wages are given by

$$A_L = \frac{1}{1+\kappa} (A_W + A_L), \quad (\text{A.76})$$

$$A_W = \frac{\kappa}{1+\kappa} (A_W + A_L). \quad (\text{A.77})$$

Substituting the solutions in (A.75 – A.77) into Eqs. (A.74), we obtain

$$w_0 + l_0 = \mathcal{M}^A \frac{1-\alpha}{1+\delta} \frac{Q_0^A}{\overline{WL}_0}$$

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

Considering the equation for two different levels of future dividends,  $d_1^{old}$  and  $d_1^{new}$ , and taking the difference, we obtain Eqs. (18) and (19) in the main text.

It is instructive to consider the intuition for the labor bill characterized in (A.75). Note that  $1/(1+\delta)$  describes the effect of stock wealth on total spending. Multiplying this with  $1-\alpha$  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  $\mathcal{F}^A = \frac{1+\kappa}{1-\alpha+\kappa} > 1$ . 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 wages are somewhat sticky but the rental rate of capital is not. Conversely, 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,  $\kappa$ , and it approaches one in the limit with perfectly flexible wages,  $\kappa \rightarrow \infty$ .

It is also instructive to compare the aggregate effect in (A.75) with its local counterpart characterized earlier. Specifically, recall that Eqs. (A.55) and (A.56) imply the effect of stock wealth on the *local* labor bill is given by,

$$\frac{(l_{a,0} + w_{a,0}) \overline{WL}_0}{x_{a,0} Q_0} = \mathcal{M} \frac{1 + \kappa}{1 + \kappa \zeta} \frac{(1 - \alpha) \eta}{1 + \delta}. \quad (\text{A.78})$$

Comparing this expression with Eq. (A.75) 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,  $\frac{1-\alpha}{1+\delta} > \frac{\eta(1-\alpha)}{1+\delta}$ . 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.

## A.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 A.8 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,

$$D_1(s) = s, \tag{A.79}$$

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 (2) with,

$$\begin{aligned} & \log C_{a,0} + \delta \log U_{a,1}, \tag{A.80} \\ \text{where } U_{a,1} &= \left( E \left[ C_{a,1}(s)^{1-\gamma} \right] \right)^{1/(1-\gamma)}. \end{aligned}$$

Here,  $U_{a,1}$  captures households' 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. Households choose  $C_{a,0}, S_{a,0}, 1 + x_{a,1}$  to maximize (A.80) subject to the budget constraints:

$$\begin{aligned} P_{a,0}C_{a,0} + S_{a,0} &= W_{a,0}L_{a,0} + (1 + x_{a,0})Q_0 \tag{A.81} \\ S_{a,0} &= S_{a,0}^f + (1 + x_{a,1})(Q_0 - R_0) \\ P_{a,1}(s)C_{a,1}(s) &= \overline{W}L_{a,1}(s) + (1 + x_{a,1})R_1(s) + S_{a,0}^fR^f. \end{aligned}$$

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  $W_{a,1}(s) \equiv \overline{W}$  and  $L_{a,1}(s) = \overline{L}_1$  for each  $a$  and  $s$ . Using Lemma 1, we also obtain the following analogue of Eq. (A.29)

$$R_1(s) = D_1(s)\overline{W}. \tag{A.82}$$

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

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

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

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

After substituting this expression and using (A.82), the aggregate budget constraint implies,

$$\int_a C_{a,1}(s) da = \frac{D_1(s) + \bar{L}_1}{(D_1(s))^\alpha}. \quad (\text{A.83})$$

In the common-wealth benchmark, the areas are identical so Eq. (A.83) provides a closed-form solution for consumption.

Next consider the equilibrium in period 0. The following lemma characterizes households' optimal consumption and portfolio choice. To state the result let  $H_{a,0} = W_{a,0}L_{a,0} + \frac{WL_1}{R^f}$  denote the human capital wealth in area  $a$  as in the baseline model.

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

$$P_{a,0}C_{a,0} = \frac{1}{1 + \delta} [H_{a,0} + (1 + x_{a,0}) Q_0]. \quad (\text{A.84})$$

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

$$1/R^f = E[M_{a,1}(s)] \quad (\text{A.85})$$

*and the price of capital satisfies,*

$$Q_0 = R_0 + E[M_{a,1}(s) R_1(s)], \quad (\text{A.86})$$

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

$$M_{a,1}(s) = \delta \frac{P_{a,0}C_{a,0}}{P_{a,1}(s)C_{a,1}(s)} \frac{C_{a,1}(s)^{1-\gamma}}{E[C_{a,1}(s)^{1-\gamma}]}. \quad (\text{A.87})$$

Eq. (A.32) illustrates that the consumption wealth effect remains unchanged in this case [cf. Eq. (A.32)]. This is because we use Epstein-Zin preferences with an intertemporal elasticity of substitution equal to one. Eqs. (A.85) and (A.86) 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. (A.87) 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. (A.84) remains unchanged (and the remaining features of the model are also unchanged), the rest of the general characterization in Section A.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>.**  $D_0 = \frac{\alpha}{1-\alpha}\bar{L}_0$  and  $D_1(s) \geq \frac{\alpha}{1-\alpha}\bar{L}_1$  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 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,

$$P_{a,1}(s) = (D_1(s))^\alpha \bar{W}. \quad (\text{A.88})$$

Combining these observations with Eq. (A.83), we obtain a closed-form solution for consumption,

$$C_1(s) = \frac{D_1(s) + \bar{L}_1}{(D_1(s))^\alpha}. \quad (\text{A.89})$$

Next note that we also have  $W_{a,0} = \bar{W}$ ,  $L_{a,0} = \bar{L}_0$  and

$$P_{a,0} = D_0^\alpha \bar{W}. \quad (\text{A.90})$$

Therefore, the analogous equation also applies in period 0,

$$C_0 = \frac{D_0 + \bar{L}_0}{D_0^\alpha}. \quad (\text{A.91})$$

Substituting this into Eq. (A.84), and using (A.90), 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. (A.39) also applies in this setting:

$$(H_0 + Q_0) / \bar{W} = (1 + \delta) (\bar{L}_0 + D_0). \quad (\text{A.92})$$

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. (A.89) and (A.91) for consumption and Eqs. (A.88) and (A.90) for goods prices, we obtain a closed-form solution for the stochastic discount factor in (A.87),

$$M_1(s) = \delta \frac{D_0 + \bar{L}_0}{D_1(s) + \bar{L}_1} \frac{\left(\frac{D_1(s) + \bar{L}_1}{(D_1(s))^\alpha}\right)^{1-\gamma}}{E\left[\left(\frac{D_1(s) + \bar{L}_1}{(D_1(s))^\alpha}\right)^{1-\gamma}\right]}. \quad (\text{A.93})$$

Combining this expression with Eqs. (A.85) and (A.86), we also obtain closed-form solutions for  $R^{f,*}$  (“rstar”) and  $Q_0$ :

$$1/R^{f,*} = E[M_1(s)] \quad (\text{A.94})$$

$$Q_0/\bar{W} = D_0 + E[M_1(s)D_1(s)]. \quad (\text{A.95})$$

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,

$$H_0/\bar{W} = \bar{L}_0 + \frac{\bar{L}_1}{R^f} = \bar{L}_0 + \bar{L}_1 E[M_1(s)]. \quad (\text{A.96})$$

Note also that, when  $\gamma = 1$ , we have time-separable log utility and Eq. (A.93) 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. (A.94) (A.95), and (A.96) become identical to their counterparts in the earlier analysis [cf. Eqs. (A.42), (A.44), and (A.43)].

Since the aggregate wealth  $H_0 + Q_0$  remains unchanged (cf. (A.92)), the rest of the characterization in Section A.3 remains unchanged. In particular, labor shares in nontradable and tradable sectors are given by  $L_0^N = \eta\bar{L}_0$  and  $L_0^T = (1 - \eta)\bar{L}_0$  [cf. Eq. (A.45)].

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 (A.79) 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. (A.93); the nominal interest rate is given by Eq. (A.94); the human capital and stock wealth are given by Eqs. (A.96) and (A.95); the share of labor employed in the nontradable sector is equal to  $\eta$  [cf. Eq. (A.45)].*

Consider any one of the following changes:

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

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

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

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. (A.84) remains unchanged, all equilibrium conditions for period 0 derived in Section A.2 continue to apply conditional on  $Q_0$  and  $R^f$ . Therefore, the log-linearized equilibrium conditions derived in Section A.4 also continue to apply conditional on  $Q_0$ . Moreover, as we show in Section A.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,

$$\begin{aligned} \max_{\tilde{S}_{a,0}, \omega_{a,1}} \quad & \log C_{a,0} + \delta \log U_{a,1}, & (A.97) \\ \text{where } U_{a,1} = \quad & \left( E \left[ C_{a,1}(s)^{1-\gamma} \right] \right)^{1/(1-\gamma)} \\ P_{a,0} C_{a,0} + \tilde{S}_{a,0} = \quad & W_{a,0} L_{a,0} + \frac{\overline{WL}_1}{R^f} + (1 + x_{a,0}) Q_0 \\ P_{a,1}(s) C_{a,1}(s) = \quad & \tilde{S}_{a,0} \left( R^f + \omega_{a,1} \left( \frac{R_1(s)}{Q_0 - R_0} - R^f \right) \right) \end{aligned}$$

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 (A.97). 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 (A.84).

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:

$$\frac{1}{P_{a,0}C_{a,0}} = E \left[ \frac{\delta}{P_{a,1}(s) C_{a,1}(s)^\gamma E \left[ C_{a,1}(s)^{1-\gamma} \right]} R^f \right]. \quad (\text{A.98})$$

Rearranging terms and substituting  $M_{a,1}(s)$  from Eq. (A.87), we obtain Eq. (A.85). Finally, to establish the asset pricing condition for capital, consider the optimality condition for  $\omega_{a,1}$  in problem (A.97). 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,

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

$$\begin{aligned}
&= R_0 + \delta E \left[ \frac{P_{a,0} C_{a,0}}{P_{a,1}(s) C_{a,1}(s)^\gamma E [C_{a,1}(s)^{1-\gamma}]} R_1(s) \right] \\
&= R_0 + E [M_1(s) R_1(s)].
\end{aligned}$$

Here, the second line uses Eq. (A.98) to simplify the expression and the last line substitutes for  $M_1(s)$  from Eq. (A.87). This establishes (A.86) 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. (A.39) and (A.96)],

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

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. (A.95) and (A.93), we obtain the following expression for the price of capital:

$$\begin{aligned}
Q_0 &= D_0 + \delta (D_0 + \bar{L}_0) E [f(s)], \tag{A.99} \\
\text{where } f(s) &= \frac{s}{s + \bar{L}_1}.
\end{aligned}$$

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. (A.99) 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. (A.95) and (A.93) imply,

$$\begin{aligned}
Q_0 &= D_0 + \delta (D_0 + \bar{L}_0) \frac{E [f(s) g(s)^{1-\gamma}]}{E [g(s)^{1-\gamma}]}, \tag{A.100} \\
\text{where } g(s) &= \frac{s + \bar{L}_1}{s^\alpha}.
\end{aligned}$$

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,

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

Assumption D<sup>U</sup> implies that  $s \geq \frac{\alpha}{1-\alpha}\bar{L}_1$ , 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. (A.100) 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,

$$\pi_s^* = \frac{\pi_s g(s)^{1-\gamma}}{\sum_{\tilde{s} \in S} \pi_{\tilde{s}} g(\tilde{s})^{1-\gamma}} \text{ for each } s \in S. \quad (\text{A.101})$$

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,

$$\Pi_s^*(\gamma) = \sum_{\tilde{s} \leq s} \pi_{\tilde{s}}^* = \frac{\sum_{\tilde{s} \leq s} \pi_{\tilde{s}} g(\tilde{s})^{1-\gamma}}{\sum_{\tilde{s} \in S} \pi_{\tilde{s}} g(\tilde{s})^{1-\gamma}} \text{ for each } s \in S. \quad (\text{A.102})$$

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. (A.101) and (A.102). 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).  $\square$

## A.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 (2) as in the baseline model. The remaining area, denoted by  $a$ , has the following more general utility function,

$$u(C_{a,0}) + \delta u(C_{a,1}) \text{ where } u(C) = \frac{\varepsilon}{\varepsilon - 1} \left( C^{\frac{\varepsilon-1}{\varepsilon}} - 1 \right). \quad (\text{A.103})$$

We characterize the equilibrium in area  $a$  and illustrate how it depends on the EIS parameter,  $\varepsilon$ .

We make two additional simplifying assumptions. First, 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 A.7. Second, we also assume the wages in area  $a$  are perfectly sticky,  $\kappa_a = 0$ , which helps to simplify some of the expressions below.

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 (A.103) subject to this constraint. The optimality condition gives the Euler equation,

$$\begin{aligned} P_{a,1}C_{a,1} &= \delta^\varepsilon R^f \left( R^{fr} \right)^{\varepsilon-1} P_{a,0}C_{a,0} \\ \text{where } R_a^{fr} &= R^f \frac{P_{a,0}}{P_{a,1}} \end{aligned} \quad (\text{A.104})$$

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. (3),

$$P_{a,0}C_{a,0} = \frac{1}{1 + \delta^\varepsilon \left( R_a^{fr} \right)^{\varepsilon-1}} \left( H_{a,0} + (1 + x_{a,0})Q_0 \right), \quad (\text{A.105})$$

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 A.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. (A.38):

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

Here, recall that  $R_a^{fr}$  is given by Eq. (A.104) 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  $U_{a,t}$  are characterized by Lemma 1. Using  $x_{\tilde{a},0} = 0$ , we also have,

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

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

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

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

The equilibrium in area  $a$  is characterized by solving this equation together with the wage inflation equation,

$$W_{a,0}/\overline{W} = (L_{a,0}/\overline{L}_0)^{\kappa_a}.$$

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

$$\begin{aligned} \overline{W}L_{a,0} &= \frac{(1-\alpha)\eta}{1+\delta^\varepsilon (R^{fr})^{\varepsilon-1}} \left( \overline{W}L_{a,0} + \frac{\overline{WL}_1}{R^f} + (1+x_{a,0})Q_0 \right) + \overline{WL}_0^T, \quad (\text{A.106}) \\ \text{where } R^{fr} &= R^f \frac{D_0^\alpha}{D_1^\alpha}. \end{aligned}$$

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,  $\frac{(1-\alpha)\eta}{1+\delta^\varepsilon (R^{fr})^{\varepsilon-1}}$ . The new coefficient illustrates that the level of the real interest rate affects the nontradable labor bill and thus also the total labor bill.

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

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

Thus, the real interest rate is characterized by,

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

Note that, we have:

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

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. (A.106) 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  $\varepsilon < 1$ .

## B Data Appendix

### B.1 Details on the IRS SOI

The IRS Statistics of Income (SOI) data 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>4</sup> To obtain a consistent panel, we, therefore, 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

<sup>4</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>.

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>5</sup>

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.

## B.2 Measurement Error in Capitalization Approach

In this appendix we investigate three sources of potential measurement error arising from the capitalization approach and conclude the magnitude of measurement error is likely to be small.

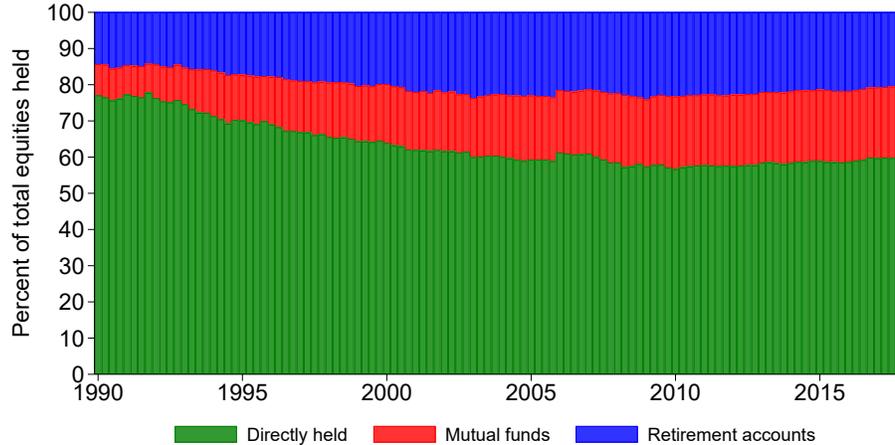
**Heterogeneous stock portfolios.** The capitalization method implicitly assumes all counties hold the same stock market portfolio. In reality, households residing in different counties may hold different portfolios, for example due to home bias (Coval and Moskowitz, 1999) or differences in risk preferences. The aggregate return and price-dividend ratio used to construct  $S_{a,t-1}R_{t-1,t}$  may then differ from the return and price-dividend ratio of the local portfolio. We can distinguish three cases. First, purely idiosyncratic differences in holdings (including due to home bias) would cause classical error in the measurement of changes in local stock market wealth and *attenuate* our empirical results. Second, high wealth areas may have systematically better portfolios in the sense of earning positive alpha, as suggested by Fagereng et al. (2016). County fixed effects will absorb this type of heterogeneity without biasing the estimated coefficients. Third, high wealth areas may have systematically riskier or less risky stock portfolios. This dimension of heterogeneity would result in systematic under-counting (if riskier) or over-counting (if less risky) of changes in wealth in high wealth areas when the stock market changes, leading us to over-estimate or under-estimate the consumption wealth effects. Importantly, 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.

**Retirement wealth.** A second measurement issue pertains to stock market wealth held in retirement accounts. Even if households in different counties hold the same portfolio, they may vary in their holdings of stocks in retirement accounts which do not generate taxable dividend income and therefore do not appear in the SOI data. We begin by plotting in Figure B.1 the distribution of household holdings of corporate equity between non-retirement (directly held and mutual funds) and retirement accounts using data from the Financial Accounts of the United States.

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<sup>5</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.

Figure B.1: Household Stock Market Wealth in the FAUS



Notes: The figure reports household equity wealth as reported in the Financial Accounts of the United States table B.I01.e line 7. Retirement accounts include equities held through life insurance companies (line 10) and in defined contribution accounts of private pension funds (line 11), federal government retirement funds (line 12), and state and local government retirement funds (line 13).

Throughout our sample period, the majority of equity is directly held and less than 20% is held in retirement accounts.<sup>6</sup>

We next use data from the Survey of Consumer Finances to examine the relationship between total stock-market wealth and non-retirement stock-market wealth in the cross-section of U.S. households. We pool all waves from 1992 to 2013, consistent with the sample period for our benchmark analysis. We create two definitions of stock-market wealth (both total and retirement) – one based on a narrow definition of stock funds and a second broader definition. For the first definition we include funds (individual retirement accounts, employer-sponsored pension plans, mutual funds, trusts and managed investment accounts) that are fully invested in stocks. For the second definition we include funds are diversified between stocks and bonds or other financial assets or (from 2004 onward) have at least 50% of their value invested in stocks. We define non-retirement stock-market wealth as the stock-market wealth from direct holdings of stocks and from mutual funds, while total stock-market wealth sums the wealth from direct holdings of stocks and all stock funds. Finally, we deflate all nominal values using the CPI to convert to 1992 dollars. Table B.1 reports summary statistics for the stock-market wealth variables based on the narrow and broader definition of stock funds, respectively. The average values of total and non-retirement stock-market wealth are fairly similar with a difference of around \$15,000 in the first case and \$25,000 in the second case.

Table B.2 reports the coefficients from regressions of total stock market wealth on non-retirement wealth. Columns (1) and (2) use the narrow definition of stock market wealth and columns (3) and (4) the broad definition. There is a positive constant term in columns (1) and (3), indicating that

<sup>6</sup> 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.

Table B.1: Summary Statistics (values are in 1992 dollars).

Variable	Mean	Std. Dev.	Min	Max
total stock wealth	45,642	514,777	0	$4.69 \times 10^8$
non-retirement stock wealth	31,109	472,259	0	$4.69 \times 10^8$
total stock wealth (broad)	56,040	572,393	0	$5.57 \times 10^8$
non-retirement stock wealth (broad)	32,564	483,605	0	$5.54 \times 10^8$

retirement stock market wealth is more evenly distributed than non-retirement wealth. Moreover, the coefficients on non-retirement wealth are between 1.05 and 1.08 and the  $R^2$ s are between 0.83 (broad) and 0.94 (narrow). Therefore, total stock-market wealth and non-retirement stock market wealth vary almost one-for-one. The relationship changes little in columns (2) and (4) which include controls for demographics (age, college degree) and year fixed effects. Thus, disregarding heterogeneity in retirement stock market wealth is unlikely to impact our estimation results substantially.

**Non-public companies.** A third source of measurement error 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 B.2 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>7</sup> This share never exceeds 7% of total equity, indicating that as a practical matter dividend income from non-public C-corporations is small. Moreover, as described in Appendix B.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, and Table 3 reports a specification which excludes counties containing the headquarters of a private corporation on the Forbes list of the largest private companies. Therefore, non-public C-corporation wealth does not appear to meaningfully affect our results.

### B.3 Summary Statistics

Table B.3 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.

<sup>7</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 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.

Table B.2: Total stock wealth and non-retirement stock wealth.

	Narrow definition		Broad definition	
	(1)	(2)	(3)	(4)
non-pension stock wealth	1.056** (0.00893)	1.053** (0.00893)	1.080** (0.0122)	1.077** (0.0122)
age		2019.5** (93.89)		2848.4** (1.690)
age <sup>2</sup>		-16.79** (0.887)		-21.61** (1.690)
college degree		22874.4** (1089.7)		37017.9** (1567.7)
Constant	12803.0** (423.3)		20854.3** (616.0)	
Year FE	No	Yes	No	Yes
unique observations	36,688	36,682	36,688	36,682
adj. $R^2$	0.938	0.939	0.833	0.835

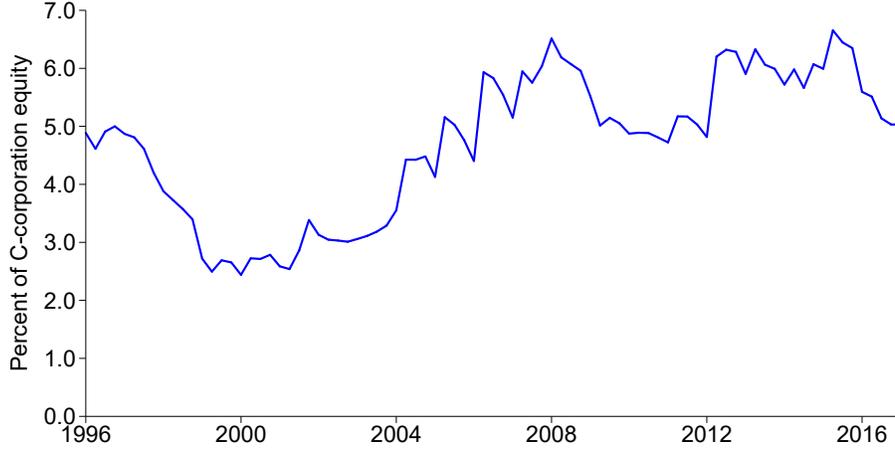
*Notes.* Standard errors in parentheses. In columns (1) and (2), total stock wealth is defined as the sum of the value of directly held stocks as well as the value of IRA accounts, mutual funds, trusts, annuities and managed investment funds, and employer-sponsored pension funds that are primarily invested in stocks and non-retirement stock wealth is defined as the sum of the value of directly held stocks and mutual funds that are primarily invested in stocks. In columns (3) and (4), total stock wealth is defined as the sum of the value of directly held stocks as well as the value of IRA accounts, mutual funds, trusts, annuities and managed investment funds, and employer-sponsored pension funds that are primarily invested in stocks or are diversified between stocks and other financial assets (with at least 50% invested in stocks from 2004 onwards) and non-retirement stock wealth is defined as the sum of the value of directly held stocks and mutual funds that are primarily invested in stocks or are diversified between stocks and other financial assets (with at least 50% invested in stocks from 2004 onward). All dollar values are in 1992 dollars. All regressions are weighted using the SCF sampling weights. \*\* denotes significance at 1%, \* denotes significance at 5%.

## B.4 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 of the resident population identifying themselves as white.<sup>8</sup> Table B.4 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

<sup>8</sup>For the college share we use the American Community Survey rather than the 2010 US Census.

Figure B.2: 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.

Table B.3: Summary Statistics

Variable	Source	Mean	SD	Within county SD	Within county and state-quarter SD	Obs.
Quarterly total return on S&P 500	Shiller	0.019	0.072			108
Capitalized dividends/labor income	IRS SOI	1.558	1.252	0.592	0.355	314 912
Log empl., 8Q change	QCEW	0.024	0.054	0.048	0.033	316 751
Log payroll, 8Q change	QCEW	0.085	0.077	0.072	0.049	316 751
Log nontradable empl., 8Q change	QCEW	0.030	0.071	0.065	0.056	309 296
Log nontradable payroll, 8Q change	QCEW	0.080	0.090	0.085	0.066	309 296
Log tradable empl., 8Q change	QCEW	-0.021	0.130	0.123	0.106	294 728
Log tradable payroll, 8Q change	QCEW	0.044	0.159	0.152	0.130	294 728

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.

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.

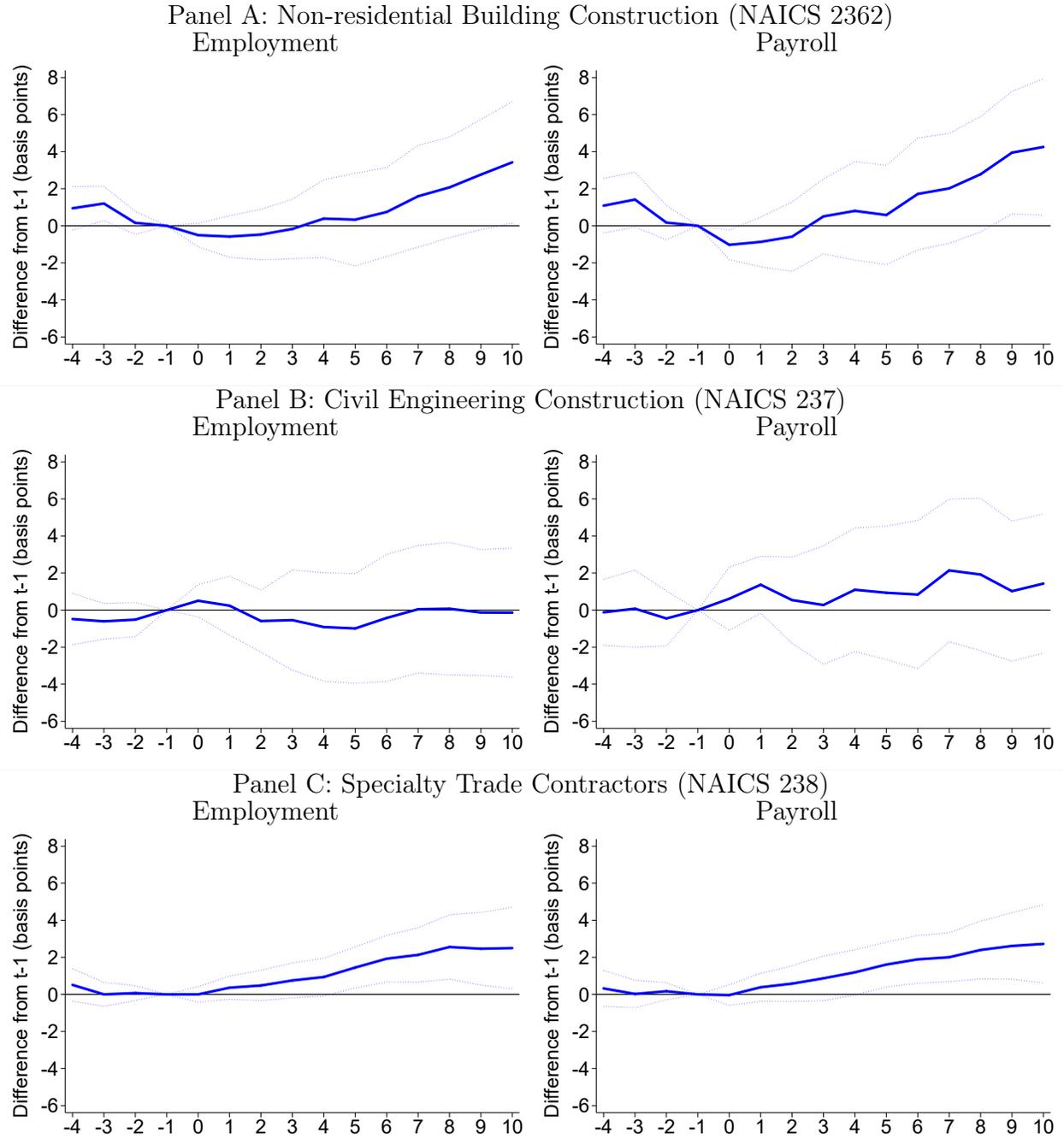
Table B.4: County demographics regressions

	(1)	(2)	(3)	(4)	(5)	(6)
Bachelor degree or higher (%)	0.05** (0.01)					0.08** (0.01)
Median age		0.08* (0.04)				-0.03 (0.02)
Retired (%)			0.10* (0.04)			0.26** (0.03)
Female (%)				0.16** (0.03)		-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
$R^2$	0.29	0.19	0.20	0.17	0.15	0.49
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 capitalized dividends/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.

## B.5 Construction Sub-components

Figure B.3: Non-residential Construction Results



Notes: The figure reports the coefficients  $\beta_h$  from estimating Eq. (11) for total quarterly employment (left panel) and wages (right panel) at each quarterly horizon  $h$  shown on the lower axis. The shock occurs in period 0 and is an increase in stock market wealth equivalent to 1% of annual labor income. The dashed lines show the 95% confidence interval bands based on standard errors two-way clustered by county and quarter.