Productivity Shocks and Inflation in Incomplete Markets

Qiushi Huang
Shanghai Advanced Institute of Finance

Leonid Kogan
MIT Sloan School of Management and NBER

Dimitris Papanikolaou
Kellogg School of Management and NBER

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Abstract

Innovation leads to higher productivity, yet it can lead to higher inflation if markets are incomplete. Exploiting changes in state level R&D tax credit policy, we establish a causal link between the level of innovation and the local price of non-tradable consumption goods. We rationalize this finding in a multi-region model of a monetary union where regions can experience displacive shocks that reallocate output among agents. Because the benefits of economic growth accrue asymmetrically across all agents, prices of non-tradable goods can rise even as regional output increases. Local stock markets provide evidence that is consistent with model predictions. In both the data and the model, returns to local growth firms help households insure against increases in the local price level.

Over the last four decades, inflation in the United States exhibited substantial heterogeneity across regions. For instance, Massachusetts has experienced an average inflation rate equal to 3.6% per year over the last few decades, while Illinois has had an average annualized inflation rate of 2.8%. What explains such persistent differences in inflation across regions? One potential explanation could point to differences in productivity growth across regions. However, accounting for productivity changes deepens the puzzle: Massachusetts has experienced faster productivity growth (1.7% per year) than Illinois (1.2%), and thus conventional wisdom would suggest that Massachusetts should have experienced lower levels of inflation as the unit cost of production has declined relative to that in Illinois. Another answer would be differences in local business cycles across states: in the presence of nominal rigidities, states that experienced positive demand shocks could experience higher inflation and higher output per worker. However, controlling for differences in the output gap (unemployment) across states does little to change the positive correlation between inflation and productivity, which echoes the findings in Hazell, Herreño, Nakamura, and Steinsson (2022), suggesting that demand shocks at the frequency of local business cycles are not the most likely explanation.

In this paper, we provide a supply-side explanation for the positive correlation between inflation and productivity growth that is reminiscent of the Balassa (1964) and Samuelson (1964) effect.[1] In particular, we take the stance that the economic value of innovation cannot be shared fully with financial market participants in different regions—a significant fraction of the value of new technologies created in Massachusetts accrues to the original innovator, key talent, and local investors in Massachusetts. Given the difficulty of establishing property rights to ideas, we assume that the market for selling claims to future ideas is incomplete.[2] Since workers in Illinois cannot invest in securities whose payoff is contingent on the value of innovation in Massachusetts, the value created by these new ideas mainly accrues to (some) households in Massachusetts. As a result, regions that experience increased local innovative activity experience not only productivity improvements, but also a positive local wealth effect. Under certain conditions, the positive pressure on local prices induced by the wealth effect can increase the local price of non-tradable goods, even as their marginal cost of production falls, which leads to higher local inflation.

We begin by providing a set of stylized facts that support our mechanism. Using changes in local R&D tax credits as a plausibly exogenous source of variation in the regional level of innovation, we first confirm that these changes positively impact local innovation measures based on patents. Our

[1] The Balassa-Samuelson hypothesis is that productivity increases in the tradable sector can lead to an increase in wages for the workers employed in the tradable sector in Massachusetts, which in turn can increase the demand for non-tradable goods and therefore their price relative to non-tradable goods in Illinois. Importantly, a key assumption behind this mechanism is that labor is freely mobile within regions across sectors but not mobile across regions within the US. This assumption seems sensible in an international context, but it is perhaps less plausible when focusing on differences across regions in a single country.

[2] This limited risk-sharing arises due to fundamental frictions in creating new ideas, which are often embodied in the human capital of the original innovator (or 'stored' using the language in Crouzet, Eberly, Eisfeldt, and Papanikolaou (2022)).

innovation measures recognize that not all patents are equally valuable; we construct innovation indicators that weigh patents based on their forward citations (Hall, Jaffe, and Trajtenberg, 2005); the stock market reaction of innovating firms (Kogan, Papanikolaou, Seru, and Stoffman, 2017); or their novelty and impact based on their textual similarity to prior and subsequent patents (Kelly, Papanikolaou, Seru, and Taddy, 2021).

Second, we demonstrate that changes in local R&D tax credits result in a noticeable increase in measured productivity and local inflation. The magnitudes are statistically significant and economically meaningful: over the next five years, a one-standard deviation increase in R&D tax credits leads to a 1.3 percentage point surge in the rate of local inflation and a 0.6 percentage point increase in labor productivity growth. These increases in local inflation are primarily concentrated in, though not limited to, non-tradable goods such as housing and services. Interestingly, we find no relation between changes in local R&D tax credits and the median income level at the state level, though we do see that the level of (top) income inequality increases significantly. This positive correlation between local innovation and inflation is robust to alternative ways of measuring the housing component and to varying scales of geographical aggregation, including evidence from both U.S. metropolitan areas and EU member countries.

Importantly, we find that a shock to local innovation leads to increases in top income inequality, but not to the real median income or wages. This pattern is consistent with our intuition that gains from innovation are concentrated and not fully shared across households—both across, but most importantly, also within regions. Thus, our results point to a somewhat more nuanced explanation than the standard Balassa-Samuelson effect: the increase in wealth resulting from local innovation is concentrated in the top of the earnings distribution, rather than across all workers in the region. But, similar to the standard Balassa-Samuelson effect, the increase in local wealth stimulates demand for local non-tradeable goods and hence leads to higher local inflation.

We formalize this intuition using a model with two regions and two goods. Each region produces tradable and non-tradable goods in a continuum of productive units (projects). There are two types of productivity shocks. Neutral productivity shocks increase the supply of tradable and non-tradable goods. Displacive productivity shocks also increase aggregate output, but they also shift the relative share of output produced from incumbent to new productive units. Our formulation of the displacive shock follows Gârleanu, Panageas, Papanikolaou, and Yu (2016) and captures in reduced form the effects of creative destruction or reallocation of economic activity from old to new technologies. In the appendix of the paper, we show how our reduced form assumptions can be microfounded in a quality ladder model with creative destruction as in Aghion and Howitt (1992).

Notably, financial markets in our setting are incomplete. Specifically, increases in output partially occur through the creation of new projects that partly displace the value of incumbent firms. The critical assumption in the model is that the ownership of these new projects cannot be fully shared across all financial market participants in both regions. That is, a significant fraction of this value accrues to the original innovator—a stand-in for entrepreneurs, key employees, or initial investors with a non-diversified stake in the firm. Markets are incomplete: these innovators cannot sell claims against their future potential endowment of these new projects in financial markets. As a result, displacement shocks lead to the redistribution of wealth from the owners of existing firms to innovators. This wealth redistribution increases the cross-sectional dispersion of marginal utilities: most households across both regions suffer small losses while a few lucky households in the home region experience significant wealth increases. Under a convex marginal indirect utility of wealth, which is a feature of common preference specifications (such as CRRA or Epstein and Zin (1989)), the displacement shock raises the level of the local stochastic discount factor, effectively acting as a local demand shock, leading to an appreciation of local price levels.

After illustrating the model's mechanism in closed form, we explore the model mechanism quantitatively. To calibrate the model to the data, we allow foreign investors to own shares in domestic firms, which allows them to own claims on some, but not all, of the benefits of innovation. Our calibrated model replicates several moments of real economic variables, including the mean and volatility of regional consumption and output growth rate. To ensure that magnitudes of displacement shocks are realistic, we also target as a part of the calibration correlation between inflation and inequality and the volatility of relative inflation. In the model, displacement and standard TFP shocks generate distinct implications for the correlations between innovation, inflation, and inequality, so matching these moments helps determine the size of displacement shocks. Our equilibrium model successfully replicates the inflation dynamics and regional real variables.

The fact that the benefits of innovation are concentrated to (some) local households is not the only mechanism that can generate a positive correlation between local productivity changes and local inflation. Another possibility is portfolio home bias: local households may tilt their portfolios toward local firms, which is consistent with the evidence in Becker, Ivkovic, and Weisbenner (2011). To the extent that households in Massachusetts disproportionately invest in firms located in Massachusetts compared to households in Illinois, local productivity improvements can also result in local wealth changes. However, we find weak evidence supporting this channel: stock market returns to local firms are weakly negatively correlated with local inflation, a prediction that is at odds with this explanation but can be actually consistent with our model mechanism if incumbent firms derive most of their value from their assets in place. By contrast, and again consistent with our model mechanism, we document a positive correlation between inflation and returns on a growth-minus-value portfolio. which implies that investors can hedge price increases to local non-tradable goods by investing in the returns of local growth firms.

We then analyze our model's predictions regarding household portfolio holdings. In particular, Coval and Moskowitz (1999) document that investors favor local, non-tradable firms within their portfolios. This pattern is consistent with our model since households aim to hedge against displacement risk. In the model, local non-tradable firms exhibit higher sensitivity to wealth fluctuations compared to tradable firms, making them more effective as hedges against these fluctuations. As a result, our model generates a home bias in households' portfolio holdings — households concentrate their portfolios toward local non-tradable stocks. This prediction aligns with the regional home bias patterns documented in existing literature.[3] In our model, investors favor local non-tradable firms and tilt their portfolios toward local growth stocks, which allows them to hedge local displacement risk. As we discussed above, local growth firms offer a hedge against displacement.

We conclude by offering an additional piece of evidence that supports our mechanism. Specifically, we show that the local price level is correlated with the incidence of Initial Public Offerings (IPOs) in the area. In the context of our model, an IPO can be viewed as the realization of a positive wealth shock to the founders of the new firm—their wealth was illiquid prior to the IPO but became liquid afterward. Thus, our model would predict that an increase in IPO activity would have the same implication for the local price level as an increase in the level of local innovation.

In sum, we contribute to the literature by exploiting regional heterogeneity in innovation intensity and providing causal evidence that technological shocks lead to an increase in local prices of consumption goods, especially for non-tradable goods. Studying cross-sectional differences in inflation, effectively holds monetary policy fixed, which helps isolate the real drivers of inflation. In this way, our paper also relates to recent literature that explores geographic variation in inflation and output to understand the causes of inflation and its relation with regional business cycles (Babb and Detmeister, 2017; Hooper, Mishkin, and Sufi, 2020; Fitzgerald, Jones, Kulish, and Nicolini, 2020; Beraja, Hurst, and Ospina, 2019; McLeay and Tenreyro, 2018; Hazell et al., 2022). We contribute to this literature by documenting that local innovation is a significant driver of local inflation. In addition, we show that local inflation is positively related to local income inequality. Our analysis thus suggests that local inequality and inflation share a common cause – displacive innovation shocks—which complements the evidence in Aghion, Akcigit, Bergeaud, Blundell, and Hemous (2018).

Importantly, our results provide direct evidence in favor of the displacive nature of technological shocks. In particular, a small but growing literature in asset pricing has argued that investors may want to hedge states of the world with high levels of technological innovation (Papanikolaou, 2011; Garleanu, Kogan, and Panageas, 2012; Kogan, Papanikolaou, and Stoffman, 2020; Huang, Kogan, and Papanikolaou, 2024). A key feature of the mechanism in Garleanu et al. (2012) and Kogan

[3]The existing literature has focused on information-based explanations for this pattern. For instance, Huberman (2015), argues that familiarity breeds investment and demonstrates that investors are more likely to invest in stocks of companies headquartered close to their residences. Ivkovic and Weisbenner (2005b) emphasizes the importance of the information content of geography in individual investors' stock investments, suggesting that local knowledge plays a significant role in investment decisions. Van Nieuwerburgh and Veldkamp (2009) highlights the impact of information immobility and the effect of local expertise on asset prices. Grinblatt and Keloharju (2001) emphasizes the role of culture in shaping home bias. However, none of these explanations would predict differences in home bias between firms producing tradable vs non-tradable firms. We contribute to this literature by proposing an alternative mechanism consistent with this pattern.

et al. (2020) is preferences over relative consumption, which induces households to want to hedge both changes in their absolute consumption and their relative wealth share. DeMarzo, Kaniel, and Kremer (2007) develop a theoretical micro-foundation for these preferences that operates through the relative price of goods in fixed supply. Our results provide evidence that increases in local innovation have a potentially negative spillover to other households through increases in the price of non-tradable goods.

Our mechanism is related to the Balassa-Samuelson effect (Balassa, 1964), (Samuelson, 1964), but it operates through changes in the distribution of income rather than through an overall increase in income levels. In particular, the Balassa-Samuelson effect suggests that productivity increases in the tradable sector can lead to higher wages for workers in that sector. Assuming labor can freely move across sectors within a state, this can also raise wages in the non-tradable sector, thereby increasing the prices of non-tradable goods relative to tradable goods. While this mechanism could, in principle, explain a rise in demand for non-tradable goods due to higher wages, our empirical findings suggest a more nuanced explanation. Specifically, we observe a weak negative correlation between fluctuations in median income and our measures of innovation. Furthermore, our results remain robust to controlling for labor productivity growth, indicating that our mechanism works primarily through the tail distribution rather than a broad-based shift in income levels. This suggests that our findings are also unlikely to be driven by inter-regional worker migration in response to skill-biased technological shocks, which would tend to raise local wages in response to local productivity improvements by changing the skill composition of the local workforce.

Differences in inflation across states can significantly impact the quality of living and, as a result, affect real income inequality. A growing body of literature studies how nominal income inequality growth can lead to a more pronounced increase in real income inequality growth, particularly within models incorporating endogenous supply responses. Jaravel (2018) presents evidence that innovation predominantly caters to the expanding market of the top income earners. Faber and Fally (2021) show that more productive firms target wealthier households. Fajgelbaum, Grossman, and Helpman (2011); Fajgelbaum and Khandelwal (2016); Fajgelbaum and Gaubert (2020) examine the welfare implications of trade across the income distribution. Dingel (2016) shows that in U.S. cities, residents with higher incomes stimulate the creation of superior-quality products through an endogenous supply mechanism. Extending this logic to the endogenous development of neighborhoods within cities, Couture, Gaubert, Handbury, and Hurst (2019) quantify its corresponding impact on well-being inequality. Our findings contribute to this literature by identifying a distinct mechanism: innovation elevates both nominal income inequality and inflation, thereby inducing a more substantial real income inequality.

Our empirical analysis using regional portfolio returns builds on the literature examining regional stock return patterns. In particular, Korniotis and Kumar (2013) explores the relationship between local economic variables and stock returns of local firms. Pirinsky and Wang (2006) documents strong comovement in stock returns of local firms. Other papers that examine the impact of local factors on asset prices and firm policies include Garcia and Norli (2012); Becker et al. (2011); Tuzel and Zhang (2017); Parsons, Sabbatucci, and Titman (2020); John, Knyazeva, and Knyazeva (2011). We exploit the heterogeneous exposure of local firms to local displacive innovation shocks to highlight the significant impact of technology shocks on local asset prices.

Last, our findings also contribute to understanding the determinants of the regional home bias. Prior work highlights the role of information asymmetry, behavioral factors, and cultural and social proximity in shaping regional home bias (Coval and Moskowitz, 1999; Huberman, 2015; Becker et al., 2011; Van Nieuwerburgh and Veldkamp, 2009; Grinblatt and Keloharju, 2001; Seasholes and Zhu, 2010; Branikas, Hong, and Xu, 2020; Demarzo, Kaniel, and Kremer, 2004)). By contrast, we provide a novel motivation for portfolio home bias that is based on a hedging motive: in our model, investors rationally tilt their portfolios towards local firms, specifically local firms producing non-tradeable goods, because these firms help investor hedge local wealth and inflation shocks. This model prediction is consistent with Coval and Moskowitz (1999), who document a strong local preference of investors for locally headquartered firms that produce non-tradable goods.

1 Inflation and Innovation

We begin by documenting a set of stylized facts regarding the empirical relation between local inflation indices, income inequality, and innovation outcomes.

1.1 Data Construction

We perform our empirical analysis primarily at the state level within the U.S. Our sample covers the 1978 to 2017 period.[4]. Below, we briefly discuss the construction of the central variables in our analysis and refer the reader to Appendix A for additional details.

Inflation

Our starting point in creating state-level inflation indices is Hazell et al. (2022). Hazell et al. (2022) construct state-level price indexes for the U.S. using the data that the Bureau of Labor Statistics (BLS) collects to compute the aggregate CPI indices. One important shortcoming of this data is that it does not include the rent prices used to construct the shelter component of CPI, which accounts for one-third of the expenditure weight.[5] Therefore, we augment the data with house price data from the Federal Housing Finance Authority (FHFA), which produces nominal state-level price

[4] The time period is constrained by the availability of local inflation data. Figure A.3 shows the 32 states with inflation data available. Due to the limited number of public firms in Alaska and Hawaii, we have excluded these two states from our sample in the analysis.

[5] As of December 2021, the shelter component of CPI enters with a weight of 32.9%, out of which 24.3% is owner's equivalent rent of primary resident – an estimate of the rent that owner-occupants would have to pay if they were renting their homes; 7.4% is rent of primary residence, and 0.9% is lodging away from home. (source).

indices for all states. We construct our headline inflation measure as a weighted average of housing price appreciation and the non-housing inflation measure of Hazell et al. (2022), using a fixed weight on housing equal to 32.9%.[6]

Innovation

We use patents to measure innovation at the state-year level. We assign a patent to a given year based on its grant date and assign it to a state based on the location of the assignee(s) listed on the patent. To associate a patent with a firm (assignee), we use the mapping from patents to Compustat firms provided by Kogan et al. (2017). We then combine this information with the firm's headquarters information from COMPUSTAT to link patents to states. Importantly, we also allow for innovation to spill over to neighboring states. Specifically, we apply the innovation impact of a patent assigned to state $\{i\}$ to a collection of states, including state i itself and its neighboring states, $\{C_i\}$[7]. In what follows, we refer to this collection of neighboring states, including state i, as the vicinity of state i.

Next, we construct three measures of innovation flows that consider differences in patent quality. First, we adjust the number of patents based on their number of forward citations. Second, we adjust patents for their economic value, according to Kogan et al. (2017). Breakthrough patents are defined as being in the top 20% based on citation or economic value. Lastly, we use the patent breakthrough characterization of Kelly et al. (2021), who use textual analysis to identify significant novel patents. The breakthrough patents are defined as being in the top 20% of the distribution in terms of their backward and forward similarity, using a five-year window. We scale the number of breakthrough patents of these three measures by population each year.

We obtain other state-level economic indicators, such as GDP, employment, and population, from the Bureau of Economic Analysis[8]. The real GDP is calculated by deflating state-level GDP by GDP deflator (BEA account code: A191RD). State-level productivity is calculated as the total real GDP divided by employment. The state-level real median income data is from U.S. Census Bureau, retrieved from FRED[9].

Data on state R&D tax credit changes comes from Wilson (2009) and Bloom, Schankerman, and Van Reenen (2013). Wilson (2009) quantifies the rate of each of these credits. There is a variation across states in implementing R&D tax credits, including decisions on whether the credit covers all

[6]Before 1983, the BLS calculated housing-service inflation as a weighted average of changes in housing prices and mortgage costs – an approach similar to our construction. This approach's main drawback is that interest rate changes could directly affect housing prices, affecting CPI. In our estimation strategy, we include state and time-fixed effects to mitigate this effect. After 1983, the BLS switched to using rent inflation as a proxy for overall housing services inflation. However, almost 70% of this component is owner-occupied housing ("rental equivalence"), collected by asking homeowners to estimate the rent they could collect on their homes.

[7]The adjacent states of state i are defined as the collection of states that share the border with state i.

[8]State-level GDP data is from BEA table SAGDP, and the state-level employment and population data are from BEA table SAINC.

[9]The income series is adjusted by the Census Bureau using aggregate CPI.

qualifying expenditures or is incremental, based on prior expenses. In addition, for the incremental tax credits, the basis of previous expenditures could be fixed in time or a moving average of recent activity. We calculate the rate of R&D tax credit following the method outlined in Wilson (2009). See Appendix A.2 for details.

1.2 Inflation and Productivity

We begin by examining the relationship between productivity and inflation. Figure 1 shows that the unconditional correlation between average productivity growth and average inflation in the cross-section of states is positive. That said, there are a number of unobserved factors that could drive this positive correlation. To this end, we focus on variation within states and within time by estimating the following specification:

$$\pi_{i,t,t+s} = \beta\, g_{i,t,t+s} + \gamma\, \mathbf{X}_{i,t} + \varepsilon_{i,t} \tag{1}$$

The dependent variable is the growth in the (log) price level in state i from t to $t+s$. The main independent variable of interest is the growth in labor productivity (defined as the growth in the real level of local output relative to the growth in local employment) between year t and $t+s$. Our benchmark case focuses on the horizon s of 5 years. Depending on the specification, we include a vector of controls $\mathbf{X}$, which includes the lagged level of labor productivity and the (log) price level, state and year fixed effects, and the level of the local output gap (unemployment) in year t. Standard errors are calculated based on Newey-West procedure, with a bandwidth equal to 7 years.

Table 1 shows an economically and statistically significant positive correlation between the level of productivity and the level of local inflation. A one-standard-deviation increase in local productivity growth is associated with approximately a 1.5 percentage point higher cumulative inflation at the five-year horizon. This positive relation is largely invariant to focusing on within-state variation, controlling for lags of the price level and productivity or the level of unemployment. Figure 2 shows that the correlation between productivity and inflation increases with the horizon.

These results point away from a pure demand-side explanation. As we see in column (5) of Table 1, controlling for the local level of the output gap, as measured by local unemployment, does little to affect the positive correlation between inflation and productivity growth. This finding echoes the results of Hazell et al. (2022) regarding the flatness of the Phillips curve at the state level. For our purposes, it strongly suggests that local demand shocks are not the main drivers of the positive relation between productivity and inflation. In particular, if prices are nominally rigid, a local demand shock can boost both the local price level and local output per worker, for instance if investment in physical capital increases.

1.3 The Effect of Innovation on Productivity and Inflation

One possible explanation behind the positive correlation between inflation and productivity in Table 1 is a Balassa-Samuelson effect that can arise in the presence of incomplete markets. In particular, if a fraction of the benefits from increases in local productivity are not shared equally across states, increases in local productivity can raise local demand for non-tradable goods and, therefore, boost prices if supply of non-tradable goods is not perfectly elastic.

One possible channel through which productivity growth may create a local wealth effect is home bias in investors' portfolios. In particular, if investors overweigh local stocks, an increase in productivity of local firms may induce a positive wealth effect and, therefore, increase the price of non-tradable goods in the local area. However, as we see in the last column of Table 1, the correlation between the returns of local firms and inflation is, in fact, negative.

Innovation—creating new intangible capital goods—is another plausible source of productivity gains whose benefits need not be widely shared across different regions. Crouzet et al. (2022) discuss several reasons why the ownership of property rights from intangibles is somewhat fuzzy and likely difficult to contract upon. No matter whether innovation originates in startups or large publicly traded firms, writing contracts that allow for perfect ex-ante sharing of these benefits is likely difficult. In the case of startups, the original innovator, early investors, and key employees likely reap a disproportionately larger share of the benefits than stock market investors who purchase shares in an initial public offering. In the case of large publicly traded companies, top employees largely appropriate a significant share of the value of these technologies (see, e.g. Kogan, Papanikolaou, Schmidt, and Song, 2020, for direct evidence based on publicly traded firms).

We begin by showing that the correlation between inflation in the local area and innovation activity is positive. To do so, we re-estimate versions of equation (1), where we now replace the main independent variable with measures of local innovation. Specifically, we estimate

$$\pi_{i,t,t+5} = \beta \ln(\text{innov}_{\{i\},t,t+5}) + \gamma \, \mathbf{X}_{i,t} + \varepsilon_{i,t}. \tag{2}$$

where independent variable $\ln(\text{innov}_{\{i\},t,t+s})$ is the flow of innovation between year t and $t+s$ at the vicinity of state i. When *innov* is equal to 0, we replace $\ln(\mathit{innov})$ by the minimum value in the sample and add a dummy equal to one if *innov* is equal to 0, thereby preventing the removal of the observation from the data. As before, the vector of controls includes one lag of the (log) price level and state and year fixed effects. In addition, we also estimate versions where we include the unemployment rate at time t as a control as a measure of the output gap.

We summarize the results in Table 2, where each row corresponds to a separate measure of local innovation. As we examine the table, we see that the coefficient β estimate is positive and statistically significant across different innovation measures and specifications. In magnitude, the local price level rises by 3 to 4 percentage points over a five-year horizon in response to a one-standard-deviation increase in local innovation.

We next examine in Figure A.1 how each inflation component responds to the same innovation shock by estimating (2) separately for different categories. From Panel A of Figure A.1, we observe that inflation in non-tradable goods responds significantly more than inflation in tradable goods. In addition, housing inflation responds significantly more than non-housing inflation. Both exhibit a statistically positive response, with housing inflation being considerably more volatile than non-housing inflation (see, e.g. Stock and Watson, 2019; Hazell et al., 2022). Panel B re-estimates these results when different inflation components are normalized to a unit standard deviation. We see that, in terms of relative volatility, innovation accounts for a comparable fraction of housing and non-housing inflation. For example, based on the KPSS measure, a one-standard-deviation increase in local innovation is associated with approximately a 0.3 to 0.4 standard deviation increase in the housing and non-housing inflation components, respectively.

Naturally, both inflation and the level of local innovation are endogenous outcomes. To identify a source of exogenous variation in the level of local innovation, we follow Bloom et al. (2013) and use changes in the state-level R&D tax credits in the vicinity of state i. In particular, shocks to R&D tax credits induce changes in the user cost of R&D capital, which can subsequently affect the level of local innovation intensity.[10] For a given state i at time t, the R&D tax credits in the vicinity of state i is the weighted average of R&D tax credits in these states. The weights are the proportion of each neighboring state's lagged GDP, relative to the total lagged GDP of all neighboring states. Specifically, the R&D tax credit for the vicinity of state i at time t is:

$$RDTC_{\{i\},t} = \sum_{s \in \{i\}} w_{s,i,t} RDTC_{s,t}; \quad w_{s,i,t} = \frac{Y_{s,t-1}}{\sum_{j \in \{i\}} Y_{j,t-1}} \tag{3}$$

where $\{i\}$ is the set of states in the vicinity of state i, $RDTC_{s,t}$ is the R&D tax credit in state s at time t. $w_{s,i,t}$ is the weight of state s in calculating its impact on state i, and $Y_{s,t-1}$ is the GDP in state s at $t-1$.

First, we establish that the tax policy instruments do predict local innovation intensity

$$\ln(\text{innov}_{\{i\},t,t+5}) = \beta RDTC_{\{i\},t} + \gamma \mathbf{X}_{i,t} + \varepsilon_{i,t}. \tag{4}$$

The dependent variables are various innovation measures. The independent variable is the average R&D tax credit in the vicinity of state i. As before, the vector of controls includes state and year fixed effects.

[10] Consistent with this view, Akcigit, Grigsby, Nicholas, and Stantcheva (2022) demonstrate that changes in corporate taxes have significant effects on both the quantity and quality of innovation. That said, one potential concern with using these tax policy changes as instruments is that they may be endogenous to shocks to local economic factors. However, Bloom et al. (2013) argue that this is unlikely to be the case, based on the lack of a significant statistical relation between previous fluctuations in a state's R&D spending or GDP, and subsequent changes in R&D tax policy. This suggests that R&D tax policy changes are unlikely to be endogenously determined by local economic conditions, supporting their validity as instruments in our study.

As we see in Table 3, there is a strong economically and statistically significant relation between the average R&D tax credit in the vicinity of state i and innovation intensity in the same area. For instance, a unit standard deviation increase in our R&D tax instrument leads to a 0.14 to 0.21 standard deviation increase in the different measures of local innovation activity.

Next, we examine the relation between the R&D tax credit, and several local outcomes

$$y_{i,t,t+5} = \beta RDTC_{\{i\},t} + \gamma \mathbf{X}_{i,t} + \varepsilon_{i,t}. \tag{5}$$

The dependent variable is equal to the growth in output per worker, the (log) price level in state i from t to $t+5$, the growth in median income, and the growth in top income inequality (the income share that accrues to the top 1% in that state).

Table 4 shows that an increase in R&D incentives has a positive impact on local productivity and inflation: a one-standard deviation increase in the level of R&D tax credits leads to a 0.6 percentage point (pp) increase in productivity and a 1.2 to 1.3 percentage point increase in cumulative inflation over the next five years. In columns (3) to (4), we see evidence that the gains from innovation are concentrated: an increase in R&D tax credits has no economically or statistically significant effect on the median income at the state, but it does have a meaningful impact on the local level of income inequality. In particular, a one-standard-deviation increase in the R&D tax credit leads to a 1.8 to 1.9 percent increase in the local level of income inequality, as measured by the share of income that accrues to the top 1%.[11] Last, Table A.1 in the Appendix reports the 2SLS results.

In Table 5, we again separately examine the response of different components of inflation to the change in R&D tax credits. Examining the table, we see that all components of inflation increase in response to an increase in R&D tax credits to local firms. However, the magnitude of the response is significantly larger for the non-tradable goods (1.7 pp increase) compared to the tradable goods (0.6 pp increase). The fact that the price of tradables responds at all does suggest that the classification of tradables is imperfect or there are some cross-sectional differences in the prices of tradables due to differences in markups or quality that are not reflected in the price indices. In addition, we see that the housing price responds more (2.7 pp increase) than the other non-housing components of inflation (0.6 pp increase).

Figure A.2 analyzes the response of each inflation component to changes in the R&D tax credit, with each component normalized to a unit standard deviation. While the housing component is

[11]The fact that income at the top of the distribution responds relatively quickly to patent grants is consistent with the findings of Aghion et al. (2018) and Kogan et al. (2020). There are several reasons why income of the highest earners may respond relatively soon. First, firms may commit resources and make payments toward the development and commercialization of the innovation in anticipation of future profits from the innovation. Second, firms may choose to sell products that incorporate the innovation before or after the patent grant. By doing so, they can begin capturing profits from the innovation ahead of the patent grant. Third, even during the application stage, patenting brings certain advantages. For example, it can facilitate access to external financing or increase the likelihood of an initial public offering (IPO) for start-up firms. These favorable circumstances can translate into higher incomes for innovative entrepreneurs. Hsu and Ziedonis (2008) and Haeussler, Harhoff, and Mueller (2014) provide further evidence of the income gains associated with these factors.

more responsive than the non-housing component, both exhibit a comparable magnitude of change relative to their respective volatilities. Specifically, one unit standard deviation increase in our R&D tax instrument leads to a 0.1 to 0.15 standard deviation increase in the different components of inflation.

1.4 Additional Results and Robustness

The analysis above shows that both the housing and non-housing components, at the state level, respond with a similar relative magnitude to changes in local innovation. However, we acknowledge that the unconditional volatility of housing inflation is higher. To further assess the robustness of our findings, we explore alternative ways of measuring housing inflation and examine results at different levels of geographical aggregation.

Rent Based Inflation at the MSA Level

In 1983, the Bureau of Labor Statistics (BLS) shifted from using a weighted average of changes in housing prices and mortgage costs to using rent changes as a proxy for overall housing inflation. We next present additional evidence using this rent-based method to examine the relationship between innovation and inflation.

To this end, we use BLS data on the Consumer Price Index (CPI) at the metropolitan level, focusing on the CPI for All Urban Consumers (CPI-U). Our sample covers 27 metropolitan areas and spans the period from 1983 to 2017.[12]

Building on our state-year analysis, we construct an innovation measure at the MSA-year level using patents. Consistent with the state-level approach, we assign the innovation impact of a patent attributed to MSA i to the collection of states overlapping with this MSA. Using the same methodology, we construct three measures of innovation flows that account for differences in patent quality.

We re-estimate the impact of innovation on inflation at the MSA level using (2). The results are presented in Table A.2. We see that, over the sample period, a one-standard-deviation increase in innovation is associated with a 1.2 to 2.1 percentage point increase in headline inflation.

To identify exogenous variation in local innovation levels, we construct MSA-level R&D tax credit changes using (3). For each MSA i, we aggregate state-level R&D tax credits from overlapping

[12] Similar to our state-level analysis, we exclude Urban Alaska, AK, and Urban Hawaii, HI. Our sample therefore includes the following metropolitan areas: Atlanta-Sandy Springs-Roswell, GA; Baltimore-Columbia-Towson, MD; Boston-Cambridge-Newton, MA-NH; Chicago-Naperville-Elgin, IL-IN-WI; Cincinnati-Hamilton, OH-KY-IN; Cleveland-Akron, OH; Dallas-Fort Worth-Arlington, TX; Denver-Aurora-Lakewood, CO; Detroit-Warren-Dearborn, MI; Houston-The Woodlands-Sugar Land, TX; Kansas City, MO-KS; Los Angeles-Long Beach-Anaheim, CA; Miami-Fort Lauderdale-West Palm Beach, FL; Milwaukee-Racine, WI; Minneapolis-St. Paul-Bloomington, MN-WI; New York-Newark-Jersey City, NY-NJ-PA; Philadelphia-Camden-Wilmington, PA-NJ-DE-MD; Phoenix-Mesa-Scottsdale, AZ; Pittsburgh, PA; Riverside-San Bernardino-Ontario, CA; San Diego-Carlsbad, CA; San Francisco-Oakland-Hayward, CA; Seattle-Tacoma-Bellevue, WA; St. Louis, MO-IL; Tampa-St. Petersburg-Clearwater, FL; Washington-Arlington-Alexandria, DC-VA-MD-WV; and Washington-Baltimore, DC-MD-VA-WV.

states, applying either equal weights or lagged GDP weights. We then examine the relationship between R&D tax credit and inflation at the MSA level by estimating (5). The results, reported in Table A.3, show that a one-standard-deviation increase in local R&D tax credit leads to an approximately 0.7 percentage point increase in local inflation. This finding aligns with our state-level analysis. It provides evidence that the observed relationship between innovation and inflation is robust to an alternative method of measuring the housing component and different geographic scales of aggregation.

Evidence from the Eurozone

We next conduct a similar analysis by looking at a very different setting: the EU area. Countries in the Euro-zone have adopted a common currency and trade frequently with each other. Thus, interactions in these countries likely closely resemble those of U.S. states. Building on this economic parallel, we examine the relation between innovation and inflation in the euro zone.

To this end, we obtain the CPI and population data on euro-zone countries from the World Bank. We follow the same procedure and use patents to measure innovation at the country-year level. Patents data is from European Patent Office (the PATSTAT dataset). To associate a patent with a country, we rely on information on patents applicants (assignee) and inventors. When patents have N co-applicants or co-inventors, we split them evenly and allocate $1/N$ of the patent to each applicant's (inventor's) country. To account for patent quality, we adjust based on forward citations. The top 20% of patents in forward citations each year are regarded as important patents. Our sample covers 1999-2017, allowing patents a five-year window for citation accumulation. Each year, we normalize the count of significant patents by country's population. See Appendix A.1 for details on the data construction.

We then examine the effects of innovation on inflation using the same specification as in (2)

$$\pi_{i,t,t+5} = \beta \ln(\text{innov}_{\{i\},t,t+5}) + \gamma \mathbf{X}_{i,t} + \varepsilon_{i,t}. \tag{6}$$

The dependent variable is equal to the growth in the (log) CPI level in country i from t to $t+5$. As before, the vector of controls includes one lag of the (log) CPI level, country and year fixed effects. The independent variable $innov_{i,t,t+s}$ is the flow of innovation measure at the country i, defined in the same way as the citation-based measure of Table 2.

Table 6 shows that the coefficient β estimate is positive and statistically significant across different innovation measures and specifications. In magnitude, the local price level rises by 4 to 5 percentage points over a three-year horizon in response to a one-standard-deviation increase in regional innovation. The estimates using the five-year horizon are quantitatively similar.

The Balassa-Samuelson Effect

In principle, the patterns we document could be consistent with the standard Balassa-Samuelson effect. The Balassa-Samuelson hypothesis is that productivity increases in the tradable sector can lead to higher wages for workers in that sector. Assuming labor can freely move across sectors within a state, this can also raise wages in the non-tradable sector, thereby increasing the prices of non-tradable goods relative to tradable goods.

To explore the extent to which this mechanism can account for our findings, we first examine the response of median wages at the state level using the Occupational Employment and Wage Survey (OEWS) from the BLS. This dataset provides annual median wages for a given state from 2001 to 2017.[13] Using this dataset, we re-estimate the specification in equation (5), substituting the dependent variable with the real median wage growth of state i over the period t to $t+5$. We deflate the nominal wage by the aggregate CPI-U to obtain real wages. The results, presented in Table 7, show a weakly negative relationship between an increase in local R&D tax credits and real median wage growth.

As an robustness check, we also replicate this analysis using data from the Panel Study of Income Dynamics (PSID), a longitudinal survey that collects individual-level labor outcomes. This data set allows us to construct a panel series of state-level median wages and analyze their response to local innovation shocks. Our sample focuses on individuals aged 20 to 59 during the period from 1978 to 2017, with non-missing geographical information. We use the PSID core sample but also report results including the low-income households from the SEO sample. To calculate state-level real median wages, we take the median of survey respondents' real wages for each year in each state (see Appendix A for a detailed description of the sample construction).

We estimate the relationship between local wage growth and local innovation by estimating the specification in (5), replacing the dependent variable with the median wage growth of state i over the period from t to $t+s$. Given that the PSID becomes biannual after 1998, our benchmark analysis focuses on a 4-year horizon $s=4$. As a robustness check, we also estimate a version of (5) with $s=5$ where missing state-level values are linearly interpolated through adjacent observations for each state.

Table A.4 reports the results. We see that an increase in R&D incentives has a negative impact on subsequent median wage growth. A one-standard deviation increase in local R&D tax credit leads to a 2 log point decline in median wage growth. The estimation using interpolated values produces similar results. Table A.5 reports the results using the full sample. We see that the results are consistent, albeit with a slightly smaller magnitude. This aligns with the intuition that the gains from innovation are not equally shared across households, and is consistent with the recent findings of Kogan et al. (2020) on the impact of creative destruction on labor income.

[13] The Bureau of Labor Statistics Occupational Employment and Wage Statistics provides wage estimates from 1997 onward. However, state-level median wages across all occupations are only available starting in 2001.

In sum, the fact that increases in innovation have a weakly negative impact on local wage growth suggests that the standard Balassa-Samuelson effect is unlikely to account for our results.

1.5 Summary

Overall, we document a robust positive correlation between measures of productivity and inflation at the state level. We argue that this positive relation is partly driven by differences in local innovation intensity, which is positively related to both local productivity and local inflation. Using R&D tax credits as an instrument for local innovation supports a causal interpretation. Furthermore, we provide evidence that this correlation remains robust across different methods of measuring housing inflation and at varying levels of geographic aggregation.

What type of model would generate a positive correlation between inflation and productivity? One possibility is local demand shocks that increase local income and positively affect the empirical measure of productivity. However, the fact that controlling for measures of the output gap (unemployment) does little to affect the magnitude of this correlation suggests that this is unlikely to be a pure demand-side story.

A natural starting point for interpretation is the framework of Balassa (1964) and Samuelson (1964), in which increases in local productivity lead to higher local incomes and wealth. However, our empirical results in Table 4 are only partially consistent with this mechanism: increases in local innovation lead to higher income inequality, but are not associated with higher median wage earnings. This pattern suggests that the gains from increased local innovation intensity are concentrated rather than fully shared across all local households and that incomplete markets, not only across regions, but also within regions, are an important part of the mechanism. The model in the next section proposes a mechanism along this direction: increases in productivity lead to local wealth effects, as in Balassa (1964) and Samuelson (1964), but these gains are concentrated in a few households—the entrepreneurs.

2 The Model

In this section, we develop a model with incomplete financial markets that generates a positive correlation between productivity, innovation, and the local price level. An important difference with Balassa (1964) and Samuelson (1964) is in the type of market incompleteness we emphasize. We first develop a simple model that delivers the intuition for the primary mechanism of the paper. The model has multiple regions that produce tradable and non-tradable goods. To simplify the exposition, we assume flexible prices, and no fiscal or monetary policy. Given the absence of nominal rigidities, the mechanism we propose operates through the real price of non-tradable goods. Markets are exogenously incomplete: a share of the benefits of innovation from local firms accrues only to local investors. This assumption can be justified if part of the value of new ideas accrue to the innovators, who cannot sell claims on proceeds from their future ideas (see, e.g. Kogan et al., 2020; Crouzet et al., 2022, for a discussion). Since the gains from innovation are not shared equally across households, innovation will raise the wealth of some local households, which can afford to spend more on local goods, leading to price increases.

2.1 Model Setup

The economy consists of two regions, which we label as 'home' (H) and 'foreign' (F), and two goods: the tradable good (T) and the non-tradable good (NT). Both types of goods are produced in both regions. While the tradable good can be moved across regions and consumed in either region, the non-tradable good must be consumed in the same region where it is produced. Time is discrete and is indexed by t. Given that the model is symmetric, we focus on solving the problem of the domestic household, with the foreign household solving an identical problem. We use stars to denote variables associated with the foreign region.

Production

There is a continuum of productive units (projects) in each region that produce output. One may think of these units as individual product lines or establishments. There are two types of projects in each region: projects that produce T-goods and projects that produce NT-goods.

We begin by discussing the projects producing non-tradable goods. There is an expanding measure of projects producing non-tradable in each region, indexed by (i, s, NT) where s denotes the creation date of the project, and $i \in [0, 1]$ denotes the index of the project within its cohort in each region. A project (i, s) produces a flow of output $Y^i_{NT,t,s}$ at time t according to

$$Y^i_{NT,t,s} = a^i_{NT,t,s} Y_{NT,t} \tag{7}$$

Here, $a^i_{NT,t,s} \in [0, 1]$ denote the fraction of non-tradable goods produced by project i in the home region. By construction, these shares add to one:

$$\sum_{s \leq t} \int_{i \in [0,1]} a^i_{NT,t,s} = 1 \tag{8}$$

Our model has an element of creative destruction, in which new productive units displace existing ones. We model this process in reduced form, following Gârleanu et al. (2016). Each period a new set of projects arrives exogenously in each region. These new projects, indexed by $i \in [0, 1]$, are heterogeneous in their productivity. The productivity of a newly arriving project i in the home region satisfies the following:

$$a^i_{NT,t,t} = (1 - e^{-u_{NT,t}}) \chi^i_{NT,t}, \tag{9}$$

where $u_{NT,t}$ is a random, non-negative shock affecting all non-tradable projects in the home region at time t. $\chi^i_{NT,t}$ are non-negative idiosyncratic productivity shocks, which are determined at time t and satisfy $\int_{i\in[0,1]} \chi^i_{NT,t} = 1$. It follows that the total fraction of non-tradable goods produced by the cohort of projects created at time t is equal to

$$\int_{i\in[0,1]} Y^i_{NT,t,t} = \left(1 - e^{-u_{NT,t}}\right) Y_{NT,t} \tag{10}$$

The random shocks $u_{NT,t}$ in (10) reallocate revenue from incumbent projects to new projects. Collectively, the fraction of output produced by existing projects is $e^{-u_{NT,t}}$ for home. Specifically, the output share of an existing project created at a time $s < t$ in the home region is given by

$$a^i_{NT,t,s} = a^i_{NT,s,s} e^{-\sum_{n=s+1}^{t} u_{NT,n}} \tag{11}$$

The projects that produce tradable goods are similar. The productivity of newly created projects satisfies:

$$\int_{i\in[0,1]} Y^i_{T,t,t} = \left(1 - e^{-u_{T,t}}\right) Y_{T,t}. \tag{12}$$

Households

Each region contains a unit measure of households, indexed by $h \in [0,1]$. At time zero, households have equal endowments consisting of all projects in existence at that time. Households have access to financial markets and maximize their expected utility of consumption,

$$U_{h,t} = \mathrm{E}_t \left[\sum_{s=t}^{\infty} \beta^s \ln C_{h,s} \right]. \tag{13}$$

Households have finite lives and can hedge their mortality risk using a competitive annuity market. At each date, t, a mass ξ of households, chosen randomly, die, and a new group of households of measure ξ is born so that the entire population size remains constant. The annuity issuer collects the wealth of deceased households, ξW_t, and distributes the proceeds to the surviving population, including the newly born agents. This arrangement implies that newly born households have some initial wealth (recall that there is no labor income in the model).

Households in the home region consume a composite C_t of tradable $C_{T,t}$ and non-tradable $C_{NT,t}$ goods,

$$C_t = (C_{T,t})^{\alpha} (C_{NT,t})^{1-\alpha} \tag{14}$$

The parameter α captures the share of non-tradable goods in the household's utility.

Last, we normalize the price of the tradable good (the numeraire good) to one; hence,

$$p_{T,t} = 1 \tag{15}$$

where $p_{T,t}$ is the price of tradable goods in both regions. We denote the price of non-tradable goods in the home and foreign region as $p_{NT,t}$ and $p^*_{NT,t}$, respectively.

Aggregate Output

The aggregate output of each of the two types of goods $S \in [NT, T]$ in each region $r \in [H, F]$ evolves exogenously according to

$$\Delta \ln Y^r_{S,t+1} = \mu + \varepsilon^r_{S,t+1} + \delta u^r_{S,t+1} \tag{16}$$

Examining equations (16), we see that each output process is driven by two shocks, ε and u. The first shock, ε, affects the output (and dividends) of all projects symmetrically. The second shock, u, is the displacive shock in the model: it reallocates market share from existing projects to new projects (recall equations (9) and (11)). We allow this shock to affect aggregate output—motivated by the standard endogenous growth models—and parameterize its impact on output by $\delta \in (0, 1)$.

In sum, displacement shocks serve two functions in our model. First, positive displacement shocks increase overall output. Second, they reallocate market share from incumbent firms to new entrants. As such, our specification is a reduced-form description of a process of innovation and creative destruction as in expanding varieties models (e.g., Romer, 1987, 1990) or as in models with creative destruction (see e.g., Aghion and Howitt, 1992).

New Projects and Financial Markets

Households in our model can trade a complete set of securities contingent on aggregate shocks. In particular, they can trade equity claims on existing firms and riskless, zero-net-supply bonds in both regions. Consumers can trade state-contingent claims on the displacement shock u and the neutral shock ε. However, financial markets in our model are incomplete along an important dimension related to how new projects are created and how the existing households participate in the resulting wealth creation. In each period, households innovate with some probability. Successful innovation leads to creating a new project. Importantly, households cannot share this risk ex-ante; that is, they cannot sell claims against *their own* future endowment of new projects, as in Kogan et al. (2020). As a result, a shock to the relative profitability of new projects u leads to the redistribution of wealth from the owners of existing projects to the new entrepreneurs. This market incompleteness is the key aspect of the model, as it introduces a wedge between aggregate consumption growth and the marginal utility of the average investor.

At time zero, agents are equally endowed with all projects in existence at that time. From that point onward, new projects arrive in the economy each period, with productivity proportional to

$a^i_{NT,t,t}$. Property rights to these new projects are assigned partly to the inventors and partly to existing firms. Specifically, we assume that a fraction $\eta \in (0,1)$ of the total value of new projects is allocated to a measure $\zeta \in (0,1)$ of the population–inventors or entrepreneurs, and established firms (and therefore all households) own the residual fraction $1-\eta$. To facilitate aggregation, we assume that the likelihood of any household becoming an inventor in any given period is proportional to its wealth entering the period. To highlight the model's central mechanism, we begin by first examining the case where $\eta = 1$ and subsequently relax this assumption when calibrating the model to the data.

2.2 Equilibrium

Our definition of equilibrium is standard. An equilibrium is a set of price processes, consumption choices, and asset allocations such that (a) consumers maximize expected utility over consumption and asset choices subject to their dynamic budget constraint, (b) all asset and goods markets clear.

Markets are incomplete; hence households' marginal utilities are not equalized across states through risk sharing. However, because all agents within a region are solving the same optimization problem, we can represent their collective demand for consumption and financial assets using a representative agent construct, which has a state-dependent utility over the region-level aggregate consumption C_t, and controls the entire region's wealth.

We can describe equilibrium allocations using a central-planner formulation with stochastic Pareto-Negishi utility weight λ_t:

$$\max_{\{C_{NT,t}, C^*_{NT,t}, C_{T,t}, C^*_{T,t}\}} \sum_t \beta^t \left(\ln C_t + \lambda_t \ln C^*_t \right), \tag{17}$$

subject to the aggregate resource constraints

$$C_{T,t} + C^*_{T,t} = Y_{T,t} + Y^*_{T,t}, \quad C_{NT,t} = Y_{NT,t}, \text{ and } \quad C^*_{NT,t} = Y^*_{NT,t}, \tag{18}$$

along with the consumption aggregator in (14).

2.3 Relative prices and inflation

We can define the price level for a region as the ratio of consumer expenditures to real consumption,

$$P_t \equiv \frac{C_{T,t} + P_{NT,t} C_{NT,t}}{C_t}. \tag{19}$$

The relative price level across the two regions is then equal to

$$e_t \equiv \ln\left(\frac{P_t}{P^*_t}\right) = \ln C^*_t - \ln C_t - \ln \lambda_t. \tag{20}$$

Equation (20) highlights the critical element of our model. In complete markets, λ is a constant, and equation (20) reduces to a Backus-Smith condition applied to regional price levels. Relative to the complete-market setting, our model adds the term λ_t, which reflects the wealth redistribution created by innovation shocks under incomplete markets.

To shed further light on the above result, consider the (fictitious) representative consumer's optimization problem. The domestic consumer allocates her chosen level of consumption expenditures $\mathcal{C}_t$ across tradable and non-tradable goods:

$$\begin{aligned} &\max_{\{C_{T,t}, C_{NT,t}\}} \alpha \ln C_{T,t} + (1-\alpha) \ln C_{NT,t} \\ &\text{s.t.} \quad C_{T,t} + P_{NT,t}\, C_{NT,t} \leq \mathcal{C}_t. \end{aligned} \tag{21}$$

Hence, the representative consumer in each region solves the same optimization problem. The problem of the foreign consumer is defined analogously. Given her preferences, the consumer allocates constant expenditure shares across tradable and non-tradable goods:

$$\begin{aligned} C_{T,t} &= \alpha\, \mathcal{C}_t, \qquad & C^*_{T,t} &= \alpha\, \mathcal{C}^*_t, \\ C_{NT,t} &= (1-\alpha)\, \frac{\mathcal{C}_t}{p_{NT,t}}, \qquad & C^*_{NT,t} &= (1-\alpha)\, \frac{\mathcal{C}^*_t}{P^*_{NT,t}}. \end{aligned} \tag{22}$$

Combining the first order condition from the representative agent's problem (17) with those of each representative agent (22), we have that

$$\lambda_t = \frac{C^*_{T,t}}{C_{T,t}} = \frac{P^*_{NT,t}\, C^*_{NT,t}}{P_{NT,t}\, C_{NT,t}}. \tag{23}$$

The first equality follows from the fact that the T goods are tradable, while the second equality follows from agents allocating a constant share of consumption expenditures across goods. Since $\lambda\, \mathcal{C}_t = \mathcal{C}^*_t$, equation (20) follows directly from the definition of the regional price level (19).

Further, since consumption expenditures are proportional to wealth, it also follows that

$$\lambda_t = \frac{W^*_t}{W_t}, \tag{24}$$

where W_t is the total wealth of households in the home region (and W^*_t in the foreign region). Last, illustrating a further connection with international finance models, note that we can also write the ratio of relative prices (20) as the ratio of the two regions' stochastic discount factors—which differ because of market incompleteness and the presence of non-tradable goods,

$$\begin{aligned} \Delta e_{t+1} &= \Delta \ln \frac{\mathcal{C}_{t+1}/C_{t+1}}{\mathcal{C}^*_{t+1}/C^*_{t+1}} = \ln M_{t,t+1} - \ln M^*_{t,t+1} \\ &= \Delta \ln C^*_{t+1} - \Delta \ln C_{t+1} - \Delta \ln \lambda_{t+1}, \end{aligned} \tag{25}$$

where the stochastic discount factor is proportional to the growth in marginal utility for each representative consumer. Overall, the ratio of marginal utilities, λ_t, which also equals the ratio of regions' wealth, affects the real allocations and relative prices. In our model, λ_t varies over time in response to displacement shocks due to market incompleteness.

2.4 The role of displacement risk

Displacement risk introduces a wedge between aggregate consumption growth and the stochastic discount factor. To understand why this is the case, note that because of incomplete markets, the marginal utility of the 'representative' household depends on displacement shock and aggregate consumption.

At each point in time, we can partition the set of all households into two groups, those that receive profitable new projects (fraction ζ) and those that do not (fraction $(1-\zeta)$). Households have a constant consumption-to-wealth ratio; therefore, their consumption process is proportional to the market value of their portfolios. Hence, we can express the equilibrium stochastic discount factor as follows:

$$M_{t,t+1} = \beta \left(\frac{C_{t+1}}{C_t} \right)^{-1} \left(\underbrace{(1-\zeta)\, b_{t+1}^{-1}}_{\text{displacement}} + \underbrace{\zeta \left(\frac{1-(1-\zeta)\, b_{t+1}}{\zeta} \right)^{-1}}_{\text{receiving new projects}} \right) \tag{26}$$

where C_t, C_{t+1} are the aggregate consumption bundles in the home region. b_{t+1} is a key variable in our model: it corresponds to the wealth share of households that do not receive shares in new projects in their home region.

If we denote

$$\Omega_{t+1} \equiv \frac{\Lambda_{t+1}}{\Lambda_t} = (1-\zeta)\, b_{t+1}^{-1} + \zeta \left(\frac{1-(1-\zeta)\, b_{t+1}}{\zeta} \right)^{-1}, \tag{27}$$

then we can express the dynamics of λ as

$$\Delta \ln \lambda_{t+1} = \ln \Omega_{t+1}^{*} - \ln \Omega_{t+1}. \tag{28}$$

To gain better intuition for the properties of the SDF, consider the limiting case in which only a small set of new projects produce non-zero profits while most new projects are worthless, i.e., $\zeta \to 0$. In this case, the expression for the SDF simplifies to

$$M_{t,t+1} = \beta \left(\frac{C_{t+1}}{C_t} \right)^{-1} b_{t+1}^{-1}. \tag{29}$$

According to (29), any economic shock that reallocates wealth from existing firms to new projects increases the SDF. For example, the limit of households having extreme preferences for local non-tradable goods (or equivalently a single-region version of the model), i.e., with $\alpha = 0$, implies that $\ln b_{t+1} = -u_{t+1}$. More generally, the exact mapping from u_t to b_t depends on the structure of the model.

In brief, incomplete markets introduce a wedge between the model's stochastic discount factor and the one arising in a standard, Lucas-tree endowment economy. This additional term, which depends on the wealth share of existing households, reflects that not all households experience the same growth rate in consumption. Successful innovators experience a dramatic increase in wealth as they receive the economic value of new projects. Since marginal utility is a convex function of consumption, an increase in the dispersion of consumption growth raises the stochastic discount factor, similar to the intuition in Constantinides and Duffie (1996).

2.5 Two illustrative special cases

We next discuss two special cases of the model, which help build intuition for the general result. In doing so, we maintain the assumption that all new projects accrue to new innovating households ($\eta = 1$).

Displacement shocks only in the non-tradable good sector

We first focus on the case when displacement shocks affect only the non-tradable sector (that is, $u_T = 0$ whereas $u_{NT_t} = u_t$ and $u^*_{NT_t} = u^*_t$). We also assume that the neutral shocks to the tradable sector are perfectly correlated, that is, $corr(\varepsilon_{T,t}, \varepsilon^*_{T,t}) = 1$. These assumptions allow us to derive explicit solutions. In particular, the wealth shares of the non-innovating households (households that do not receive any shares in new projects) in each region are then given by

$$b_{t+1} = \frac{\alpha\, pd_T + (1-\alpha)\, pd_{NT}\, e^{-u_{t+1}}}{\alpha\, pd_T + (1-\alpha)\, pd_{NT}}, \qquad b^*_{t+1} = \frac{\alpha\, pd_T + (1-\alpha)\, pd^*_{NT}\, e^{-u^*_{t+1}}}{\alpha\, pd_T + (1-\alpha)\, pd_{NT}}, \tag{30}$$

where pd_T, pd_{NT} are the (constant) price-dividend ratios of firms producing T and NT goods.

Equation (30) illustrates how the wealth share λ_{t+1} varies over time as a result of the displacement shock (captured by b_{t+1} and b^*_{t+1}) and imperfect risk sharing. A positive realization of u^*_{t+1} implies that a measure-zero of households in the foreign region received claims to new projects. Due to the limited risk-sharing, these households cannot share their gains with other households in the foreign or the home region. As a result, the relative wealth of the foreign region rises, implying an increase in λ_{t+1}.

Combining the equations above with (20), the solution to the planner's problem (17), and the aggregate resource constraints, at the symmetric steady state, the relative inflation rate can be expressed as

$$\pi_{t+1} = (1-\alpha)\left(-\Delta \ln \lambda_{t+1} - \delta u_{t+1} - \varepsilon_{t+1} + \delta u^*_{t+1} + \varepsilon^*_{t+1}\right). \tag{31}$$

In the limit as the share of households receiving new projects goes to zero, $\zeta \to 0$, we have

$$\pi_{t+1} = (1-\alpha)\left(\left(\frac{(1-\alpha)pd_{NT}}{\alpha pd_T + (1-\alpha)pd_{NT}} - \delta\right)(u_{t+1} - u^*_{t+1}) + \varepsilon^*_{t+1} - \varepsilon_{t+1}\right). \tag{32}$$

Equation (32) reveals that the two types of supply shocks have very different implications for relative price levels across regions in the model economy. The neutral supply shocks ε play the standard role: relative prices fall in a region experiencing a positive supply shock. By contrast, the displacive supply shocks u increase overall output but may lead to higher inflation. A positive displacive shock u increases the supply of non-tradable goods at home and, all else equal, lowers the overall price level. The strength of this channel depends on the value of δ. However, an inflationary effect operates through market incompleteness: a positive u-shock also increases the total wealth of local households (and thus lowers λ_t) and raises local demand for non-tradable goods. The strength of the wealth effect depends on the degree of market incompleteness—the relative share of firms producing non-tradable goods and the relative size of new projects in the economy. Given our simplifying assumption that only firms in the non-tradable sector are subject to displacement risk, the latter effect dominates as long as the valuation of the NT sector is sufficiently large,

$$\delta < \frac{(1-\alpha)\, pd_{NT}}{\alpha\, pd_T + (1-\alpha)\, pd_{NT}}, \tag{33}$$

where pd_{NT} and pd_T are the (cum-dividend) price-dividend ratios for firms in each sector. In this case, a positive displacement shock u_{t+1} leads simultaneously to higher regional output and higher inflation.

The above analysis highlights a nuanced difference between our mechanism and the Balassa-Samuelson hypothesis. The Balassa-Samuelson effect suggests that productivity increases in the tradable sector can lead to higher wages for workers in that sector. Assuming labor can freely move across sectors within a state, this can also raise wages in the non-tradable sector, thereby increasing the prices of non-tradable goods relative to tradable goods. In comparison, our mechanism does not rely on the equalization of wages and production costs but instead operates through limited-risk sharing and the resulting wealth effects. As a result, our mechanism does not require productivity shocks to occur in the tradable sector. Innovations in non-tradable sectors, such as services, can also lead to higher prices for non-tradable goods.

In sum, when displacement shocks affect only the NT sector, the effect of innovation shocks on inflation is theoretically ambiguous: a positive u-shock in the domestic region increases the demand for non-tradable goods and their supply. We show below that the demand effect persists when displacement shocks originate in the tradable-good sector, which, without an increase in supply, leads to an unambiguously positive relation between innovation shocks and local inflation.

Displacement shocks in the tradable-good sector

We next assume that displacement shocks originate only in the tradable-good sector. In this case, $u_{NT_t} = u^*_{NT,t} = 0$, $u_{T,t} = u_t$, and $u^*_{T,t} = u^*_t$. In this setup, a positive displacement shock always raises local inflation. In particular, the displacement shock only affects local inflation through the relative wealth of the two regions,

$$\pi_{t+1} = (1-\alpha)\left(-\Delta \ln \lambda_{t+1} - \varepsilon_{NT,t+1} + \varepsilon^*_{NT,t+1}\right) \tag{34}$$

In the limiting case of $\zeta \to 0$, we can approximate the relative inflation around the stochastic steady state as

$$\pi_{t+1} \approx (1-\alpha)\left(\frac{\alpha pd_{T,s}}{\alpha pd_{T,s} + (1-\alpha) pd_{NT,s}}(u_{t+1} - u^*_{t+1}) + \varepsilon^*_{NT,t+1} - \varepsilon_{NT,t+1}\right), \tag{35}$$

where $pd_{T,s}$ and $pd_{NT,s}$ are the price-dividend ratio of T and NT firms at the steady state, respectively—the model is symmetric, so the sectoral price-dividend ratios are equal across the home and foreign regions in steady state.

Just like before, a positive displacement shock at home always reallocates wealth from the foreign region to the home region, which leads to a fall in λ_t and an increase in demand for domestic non-tradable goods. The difference with the previous case, in which displacement shocks only affect the non-tradable good sector, is that the supply of non-tradable goods remains unchanged. Hence, prices of non-tradable goods move only due to increased demand. As a result, a displacement shock in the tradable-good sector leads to an unambiguously positive relation between u and local inflation.

2.6 The general case

We conclude our discussion of the model mechanism by focusing on the case in which displacement shocks affect projects in both the tradable and non-tradable good sectors (that is, $u_{T_t} = u_{NT,t} = u_t$ and $u^*_{T,t} = u^*_{NT,t} = u^*_t$). In this case, the wealth share of households that do not receive shares in new projects in their home region is given by the following expression:

$$b_{t+1} = 1 - \frac{y_{T,t+1}\,(1+\lambda_{t+1})\,\alpha\, pd_{T,t+1} + (1-\alpha)\, pd_{NT,t+1}}{\alpha\left(y_{T,t+1}\, pd_{T,t+1} + y^*_{T,t+1}\, pd^*_{T,t+1}\right) + (1-\alpha)\left(\frac{1}{1+\lambda_{t+1}} pd_{NT,t+1} + \frac{\lambda_{t+1}}{1+\lambda_{t+1}} pd^*_{NT,t+1}\right)}\left(1 - e^{-u_{t+1}}\right), \tag{36}$$

where $y_{T,t+1} \equiv Y_{T,t+1}/\bar{Y}_{T,t+1}$ is the share of the tradable good produced by the home region. Given the discussion in the previous section, we see that a positive displacement shock induces a positive wealth effect in the local region and therefore tends to increase local inflation.

In the limit of $\zeta \to 0$ and assuming the u shocks are sufficiently small in magnitude, we can approximate the relative inflation around the symmetric steady state as

$$\pi_{t+1} \approx (1-\alpha)\left((1-\delta)\left(u_{t+1}-u^*_{t+1}\right)+\varepsilon^*_{NT,t+1}-\varepsilon_{NT,t+1}\right). \tag{37}$$

2.7 Discussion of Modeling Assumptions

Our model features some assumptions that are not standard in the literature. Here, we discuss these briefly.

Displacement Shock

Our assumptions on the process for aggregate output and contribution of incumbent and new firms in Section 2.1 can be microfounded by a relatively standard model of creative destruction. To conserve space, we briefly summarize the main ingredients of the model here and refer the reader to Appendix C.6. In particular, final goods in each sector are CES aggregates of a continuum of varieties. Each variety is produced by a monopolist who faces CES demand and sets prices accordingly. Firms produce each variety using a Cobb-Douglas technology that employs land and labor. Labor is freely mobile across the country. Lands is locally supplied but can be used in both sectors. An innovation (displacement) shock corresponds to the probability that each existing product line in the non-tradable sector is challenged by a new entrant. New entrants improve on the quality of the existing variety by a factor δ.

Overall, the microfoundation in Appendix C.6 illustrates how a displacement shock can simultaneously increase aggregate productivity in a region, as in equation (16), but also reallocate profits from displaced incumbents to new entrants, as in equation (9). In particular, each period, a fraction of varieties in the non-tradable sector are displaced, with the displacement shock directly determining the fraction of displaced varieties. New, more productive firms replace the incumbents firms in producing these varieties. Entrepreneurs (the innovators) that own these new firms appropriate the benefits of creative destruction, whereas incumbent firms experience declines in profits. The region experiencing the displacement shock experiences an increase in wealth, and thus increased demand for non-tradeable goods, but this increase in wealth is heterogeneous among households: incumbent households that own shares in incumbent firms experience relative wealth declines, whereas the innovators see increases in their relative wealth.

Innovators

Our notion of innovators is rather broad and not limited to new technologies' inventors. Instead, it incorporates all agents who appropriate a non-diversified share of the value of new technologies. First, it can include all the key employees responsible for creating these new technologies since part of these intangibles are embodied or stored in these employees using the language in Crouzet et al. (2022). Beyond the employees directly responsible for innovative activities, it can also include other employees in the innovating firms whose compensation is directly tied to firm value. For instance, Kogan et al. (2020) document that top employees in innovative firms experience a significant increase in wage earnings following an increase in innovation by their firm. In addition to employees in innovating firms, the term also includes angel investors and venture capitalists, who help bring these ideas to market; corporate executives who decide how to optimally finance and implement these new investment opportunities (Frydman and Papanikolaou, 2018); and local investors who hold undiversified stakes in local innovative firms.

In sum, the term 'inventors' in our model includes all parties that share the rents from new investment opportunities with households located in other regions that hold diversified portfolios. Further, the exact process by which inventors and shareholders share the rents from new technologies can take many forms. One possibility is that inventors work for existing firms, generate ideas, and receive compensation commensurate with the economic value of their ideas. Since their talent is in scarce supply, these skilled workers may be able to capture a significant fraction of the economic value of their ideas. Another possibility is that inventors implement the ideas themselves, creating startups that are partly funded by outside investors. Innovators can then sell equity in these startups to investors and thus capture a substantial share of the economic value of their innovations.

Incomplete Financial Markets

The assumption that households cannot share rents from innovation ex-ante can be motivated on theoretical grounds. For instance, workers whose labor income is exposed to the economic value of their firms' innovation cannot easily share that risk in financial markets. More broadly, new ideas are the product of human capital, which is inalienable. Hart and Moore (1994) show that the inalienability of human capital limits the amount of external finance that can be raised by new ventures.

3 Quantitative analysis

So far, we have presented a stylized model to highlight the essential mechanism of the paper. To explore the quantitative fit of the model to the data, we extend the model along several dimensions.

3.1 Setup

To conserve space, we only highlight the difference with the previous formulation.

Preferences

We allow households to have a CRRA utility:

$$\begin{aligned} U_{i,t} &= \mathrm{E}_t\left[\sum_{s=t}^{\infty}\beta^s\frac{C_t^{1-\gamma}}{1-\gamma}\right] \\ \text{where} \qquad C_{i,t} &= [(C_{T,i,t})^{\alpha}(C_{NT,i,t})^{1-\alpha}] \end{aligned} \tag{38}$$

Endowment

Second, we allow for the displacement shocks in each region to be correlated, possibly due to technology spillovers. That is, the effective displacement shock in each region u is a weighted average of each region's idiosyncratic displacement shock $\tilde{u}$,

$$\begin{aligned} u_{t+1} &= (1-\rho_u)\,\tilde{u}_{t+1} + \rho_u\,\tilde{u}^*_{t+1} \\ u^*_{t+1} &= (1-\rho_u)\,\tilde{u}^*_{t+1} + \rho_u\,\tilde{u}_{t+1}. \end{aligned}$$

where $\tilde{u}^r_t, r \in \{H, F\}$ is the idiosyncratic displacement shocks in each region r.

The displacement shock directly affects the allocation of the production of intermediate goods to existing firms. Specifically, at a given point in time t, all existing firms' production lines shrink by e^{-u_t}, and a new measure of $1-e^{-u_t}$ of lines is created—so the total measure of lines remains at one. Given our specification for productivity above, we can interpret part of these new lines as an increase in the measure of intermediate goods (as in an expanding varieties model, see e.g. Romer, 1987, 1990). The fact that existing firms lose product lines should be interpreted as a form of creative destruction (Aghion and Howitt, 1992). A fraction η of these new production lines is randomly allocated to a small set of households as before (the entrepreneurs) while the remaining fraction $1-\eta$ is allocated to existing firms (and, therefore, indirectly to all the households). When calibrating the model, we allow for a common displacement shock to affect both sectors, that is, $u_{NT,t} = u_{T,t} = u_t$.

To ensure the model is stationary, we let the region-specific shocks be co-integrated in each region. The aggregate output of each of the two types of goods $S \in [NT, T]$ in each region $r \in [H, F]$ evolves exogenously according to

$$\begin{aligned} \Delta \ln Y_{S,t+1} &= \mu + \varepsilon_{S,t+1} + \delta u_{S,t+1} + \tau(\ln Y^*_{S,t} - \ln Y_{S,t}) \\ \Delta \ln Y^*_{S,t+1} &= \mu + \varepsilon^*_{S,t+1} + \delta u^*_{S,t+1} - \tau(\ln Y^*_{S,t} - \ln Y_{S,t}) \end{aligned} \tag{39}$$

Thus, both regions will produce tradable and non-tradable goods in steady state.

Firms

We relax the assumption that new projects are allocated only to new firms: we now allow a fraction $1-\eta>0$ for new projects to be allocated to local incumbent firms. Allowing for $\eta<1$ weakens the level of market incompleteness since markets would be complete in the case $\eta=0$. Importantly, how these projects are distributed to local firms is not perfectly symmetric—we assume that firms vary in their investment opportunities.

We allow for two types of firms: high-growth (growth) firms, that is, firms that can receive these new projects, and low-growth (i.e. value) firms, that is, firms that do not receive new projects and derive their value only from assets in place. Since growth firms trade at higher multiples in equilibrium, we denote them by H, whereas we denote the value firms (those that do not receive new projects) by L.Firms can transition between the two types, H and L, according to the following transition probability matrix:

$$\Sigma = \begin{bmatrix} 1-p & p \\ q & 1-q \end{bmatrix}. \tag{40}$$

Given (40), there is a constant fraction of high- and low-growth firms in each region. Note that transition probabilities do not affect aggregate quantities in the model.

3.2 Equilibrium

The equilibrium in the full model is largely similar to the simplified model's, even as the algebra is somewhat more involved. Given our assumptions, the stochastic discount factor in each region depends on regional consumption and displacement shocks:

$$M_{t,t+1} = \beta \left(\frac{C_{t+1}}{C_t}\right)^{-\gamma} \left(\zeta \left(\frac{b_{t+1}\zeta + 1 - b_{t+1}}{\zeta}\right)^{-\gamma} + (1-\zeta) b_{t+1}^{-\gamma}\right) \tag{41}$$

As before, relative inflation equals the ratio of stochastic discount factors. We have

$$\begin{aligned} \pi_{t+1} &= \ln M_{t,t+1} - \ln M^*_{t,t+1} \\ &= \Delta C^*_{t+1} - \Delta C_{t+1} - \Delta \ln \lambda_{t+1} \\ &= \gamma(\Delta \ln C^*_{t+1} - \Delta \ln C_{t+1}) + \ln \Omega_{t+1} - \ln \Omega^*_{t+1} \end{aligned} \tag{42}$$

Examining the above, we note the similarities with the log-utility case: the relative inflation is still driven by relative consumption growth in the two regions, as well as the degree of displacement in the current periods $(\ln \Omega_{t+1}, \ln \Omega^*_{t+1})$.

3.3 Parameter estimation

In this section, we describe how we estimate the model parameters. Given our model's degree of non-linearity, we solve for the global solution of the model by discretizing the state space and using a combination of value and policy function iteration.

To reduce the number of estimated parameters, we impose several restrictions on the dynamics of u shocks: we assume that displacement shocks follow a two-state, i.i.d process. $u \in \{u_l, u_h\}$, with probability density $\{p_l, 1 - p_l\}$. In addition, we assume the displacement shock in the low state is zero. That is, $u_l = 0$. After restricting the evolution of u, the full model has 16 parameters. We set the weight on tradable goods to 0.34, which equals the tradable share used in Hazell et al. (2022). We set the degree of co-integration to 0.1% and the death rate to 2.5%. We set the relative risk aversion coefficient to $\gamma = 5$. We calibrate firms' transition probabilities p and q directly from the data. In particular, each year, we sort firms into growth and value categories based on the median book-to-market breakpoint at the vicinity of each state. Then we estimate the transition probability over the sample period across all the states.

We estimate the remaining ten parameters of the model by minimizing the distance between the model and the data. Specifically, given a vector of X of target statistics in the data, we choose parameters to minimize the following objective function,

$$\hat{p} = \arg\min_{p \in \mathcal{P}} \left(X - \frac{1}{S} \sum_{i=1}^{S} \hat{X}_i(p) \right)' W \left(X - \frac{1}{S} \sum_{i=1}^{S} \hat{X}_i(p) \right), \tag{43}$$

where $\hat{X}_i(p)$ is the vector of statistics computed in one simulation of the model. The weighting matrix W determines the importance of each statistic to the distance criterion to be minimized. We penalize proportional deviations of the model statistics from their empirical counterparts, so $W = diag(XX')^{-1}$.

We report our estimation targets in the first column of Table 8. They include a combination of the first and second moments of aggregate output, consumption, and relative inflation. In addition to these standard moments in the literature, we target a set of correlations at the five-year horizon. The neutral shock and displacement shock have different implications for inflation. Thus, the correlation between inflation and output and the set of bilateral correlations are informative about the relative magnitude of these two sets of shocks. In addition, we target the correlation between top 1% income inequality, inflation, and the level of local innovation. Given that displacement shocks drive the dynamics of inequality, these correlations are informative about the magnitude of displacement shocks in the model. See Appendix A for more details on constructing the moments we target in our estimation.

3.4 Model Fit

Table 8 shows that the baseline model fits data reasonably well. Our model produces realistic growth rates of regional consumption and output, high output volatility, and low consumption volatility. The model matches the low level of interest rate.

Our model successfully replicates the correlations between innovation, output, and inflation. Specifically, the model generates co-movement between displacement shocks and inflation because displacement shocks are positively correlated to the aggregate output and associated with significant wealth reallocation due to imperfect risk sharing. In addition, our model generates a realistic degree of correlation between inequality and inflation. Given that the displacement shock drives most of the dynamics in our model, the magnitude of the displacement shock is directly linked to the observed correlation between inequality and real variables. It is reassuring that our model replicates the above correlation with realistic magnitudes of technology shocks. Further, due to a high degree of technology spillover, our model reproduces high correlations between regional output, consumption, and stock markets. As a result, the model can deliver reasonable volatility of relative inflation despite high output volatility.

Table 9 shows the value of the estimated parameters of the model. The discount rate $\beta = 0.983$ and has a standard error of 0.156. Our estimated parameters imply a right-skewed distribution of displacement shocks. Specifically, the low state has a probability of $p_l = 0.907$, while the high state features a large-magnitude $u_2 = 0.312$. That is, innovation is somewhat rare in the model, with a low probability of a significant technological advance that displaces a large share of incumbent firms. The parameter η, which affects the division of surplus between shareholders and innovators, is estimated at 0.739 with a standard error of 0.318. This implies that approximately 30% of the value generated from new investment opportunities in the economy accrues to the owners of firms' public securities. Moreover, this technology improvement is largely shared across the regions, as indicated by the high level of technology spillover $\rho_u = 0.571$, which is required to match the highly correlated regional consumption, output, and stock markets.

3.5 Model mechanism

Here, we examine the model's implications with two goals in mind. First, we focus on how the central quantities respond to the displacement shock. Second, we examine the forces that allow the model to account for the corresponding empirical patterns.

Quantities

Figure 4 presents the response of the key model quantities to the three shocks in the model: the displacement shock u (Panel A), the neutral shock to the T-sector ε_T, and the neutral shock to the non-tradable sector ε_{NT}. For brevity, we examine responses to shocks in the home region only;

results for the foreign region are symmetric.

First, consider Figure 4. The first three columns show the response of relative inflation and aggregate output to the three shocks. A positive u shock in the home region raises local inflation and output. Since displacement shocks are assumed to be correlated, output in both the home and foreign regions increases. In contrast, neutral shocks lead to higher output and either neutral or deflationary pressure on the local price level.

The next two columns of Figure 4 plot the responses of the consumption expenditure and wealth ratios between the two regions. Specifically, the wealth share of the foreign region declines following a positive u-shock. A positive u-shock is not fully shared between innovators and the rest of the households, and thus raises the relative price level in the home region. Local households hedge against this risk, and, effectively, receive a wealth transfer from the foreign households in response to a positive u-shock. In the competitive equilibrium, this transfer results from the differences in portfolio policies between investors in the two regions.

A positive neutral shock to the tradable sector raises the domestic supply of tradable goods. This shock is shared, so there is no immediate effect on the consumption ratio. However, as the local tradable sector grows, more new tradable firms will be allocated to home households in the future as a result of displacement shocks. That is, the effective size of future displacement increases following a positive neutral shock to the tradable sector. Therefore, a positive ε_T-shock leads to a small and persistent increase in the domestic wealth share. In contrast, a positive neutral non-tradable shock leads to an increase in the wealth share of the foreign region as a result of equilibrium risk sharing. This shock raises the relative price level in the foreign region, prompting foreign households to hedge against this risk. Consequently, when such a shock materializes, foreign-region households effectively receive a wealth transfer from the domestic households.

SDF and Financial Assets

Next, we examine the impact of three shocks on SDF and financial assets. Figure 5 plots impulse responses for log-SDF, consumption, the wealth share of owners of incumbent firms, and stock market returns for both regions.

The first column shows that the neutral shock and the displacement shock have the opposite effect on the growth of log-SDF: a positive displacement (neutral) shock leads to an increase (decrease) of the log-SDF growth. The second and third columns of Figure 5 illustrate why this is the case. Specifically, an increase in u leads to a decline in the wealth share of the owners of incumbent firms in the home region b and therefore raises the log-SDF. As long as the growth effects do not dominate the displacement effect, a positive u shock leads to an increase in the log-SDF and, therefore, an increase in the relative price level.

Consistent with the analyses above, the differences in how the SDF responds to three shocks stem primarily from how the benefits of technological progress are shared among households. Both shocks u and ε lead to an increase in the aggregate output and consumption, which causes SDF to fall. However, the fall in consumption due to the unequal sharing of innovation shocks is sufficiently large to offset the benefits of higher aggregate consumption. As a result, the displacement shock u has a negative risk premium, while the neutral shock carries a positive risk premium.

The last two columns in Figure 5 plot the response of stock returns for the two sectors and highlight an essential feature of our model: the difference between aggregate dividends growth and the growth of dividends accruing to the investment in the stock market. The reason for this difference is that aggregate dividends do not constitute the gains from holding the stock market: investing in the stock market at time t only generates $1-(1-e^{-u})\eta$ share of dividends at time $t+1$. A positive displacement shock u increases the aggregate dividends by introducing new projects but also dilutes the shares of existing firms. As a result, a positive displacement shock lowers stock returns in both sectors, despite increasing aggregate dividends.

In contrast, a positive neutral shock ε_T leads to a positive return for both regions' tradable sectors. The reason is that the neutral shocks raise aggregate dividends at home and the price-dividend ratio of the tradable sector in the foreign region. The positive neutral shock also generates a positive return in the non-tradable sector since the price of the non-tradable good increases relative to the price of the tradable good.

4 Testable Predictions

Our model has several empirical implications, which we discuss here.

4.1 Inflation and income inequality

Our model predicts the link between local income inequality and the price level. To see this, recall that the value of new projects $\eta S(1-e^{-u_t})$ accrues to a measure ζ of the population. For tractability, we assume the gains from innovation are proportional to household wealth. A successful innovator with wealth w_i experiences a positive capital income shock equal to

$$I_i = \frac{\eta S_t(1-e^{-u_t})}{\zeta}\frac{w_i}{W}. \tag{44}$$

The smaller the value of ζ, the more concentrated (and therefore larger) the benefits of the creation of new projects to innovators.

To calculate the level of top income inequality in the model, we next compute the share of total income that accrues to the top 1% of households in each region. This income is a combination of capital gains from creating new projects and dividends from incumbent firms. Households at the top of the income distribution in each period t belong to one of the two groups. The first includes households that received a share of newly created firms (the entrepreneurs) and moved up sufficiently in the income distribution. The total capital gains from the creation of new projects in the home region, as a fraction of total income in the region at time t, is given by

$$I_{E,t}^{capital} = \frac{\eta\, S_t\,(1-e^{-u_t})}{\xi\, W_t + \bar{D}_t' W_t' / \bar{W}_t' + \eta\, S_t\,(1-e^{-u_t})}, \tag{45}$$

where $S_t = S_{T,t} + S_{NT,t}$ is the total market capitalization of the local firms, W_t' and $W_t'^{*}$ are the total wealth of the two regions excluding new projects,

$$W_t' = W_t - \eta\, S_t\,(1-e^{-u_t}), \tag{46}$$

and $\bar{W}_t' = W_t' + W_t'^{*}$ is the total wealth across both regions, excluding the market value of new projects. Then, the share of the total dividend $\bar{D}_t'$ that accrues to the local households equals $\bar{D}_t' W_t' / \bar{W}_t'$.

Examining (45), we see that the realization of the u-shock at time t determines the amount of wealth transferred from existing firms' shareholders to the new projects' entrepreneurs and creators. The value of these new projects constitutes a capital gain for successful entrepreneurs, distributed randomly to a small fraction of the population. Hence, as a result, some of these entrepreneurs or inventors move up to the top 1% of the income distribution.

The second group of households at the top of the income distribution are those sufficiently rich before the current period—households who have received shares in new projects and consequently earn large dividend income. These households derive capital income that is proportional to their wealth share—that is, they each receive a fraction of

$$\xi\, W_t + \bar{D}_t' W_t' / \bar{W}_t'. \tag{47}$$

Households in the region share the dividend and annuity income in (47) in direct proportion to their wealth. The more considerable wealth inequality is in a given region, the more likely it is that these dividend and annuity payments account for a significant portion of the top income share.

In sum, our model implies a positive correlation between the level of income inequality growth and the local price level. In the model, top income shares are a function of the current displacement shock and wealth inequality. Wealth inequality, in turn, is a function of past displacement shocks. This link between innovation and top income inequality is consistent with the evidence in Aghion et al. (2018). In Appendix Table A.16, we verify that the same result obtains using our innovation measures.

Our model also implies a correlation between the growth in income inequality and inflation. We next examine the relation between changes in local income inequality—the share of income that accrues to the top x% of households—and changes in the local price level using the specification

$$\pi_{i,t,t+5} = \beta\left(\ln I^p_{i,t+5} - \ln I^p_{i,t}\right) + \gamma X_{i,t} + \varepsilon_{i,t}. \tag{48}$$

The dependent variable equals the growth in the top income share between year t and $t+5$. We examine different income percentiles, from the top 10 to the top 0.01 percent. The independent variable is the five-year moving average of the inequality series. We take the moving average of the inequality series to mitigate the effect of mean-reversion in the time series of inequality growth. As before, we control for state and year fixed effects and a single lag of the level of independent variable $\ln I^p_{i,t}$. Last, we also examine the correlation of inequality separately with tradable and non-tradable inflation.

Figure 3 plots the estimated β coefficient from equation (48) across different horizons. Examining the figure, we note an economically and statistically significant correlation between the local inflation level and income inequality growth. A one-standard-deviation increase in the share of income that goes to the top 1 percent at the local level is associated with approximately a 2 percentage point increase in headline inflation over the next five years. Tables A.7 and A.8 show that the results are largely robust to different measures for income inequality, particularly for top measures, the results are driven by inflation in non-tradables, and results are invariant to controlling for the local level of unemployment.

4.2 Inflation and stock returns of local firms

So far, we have identified a source of variation in the local price level that is essentially uncorrelated with local measures of the output gap. One relevant question is whether investors can partially hedge these shocks by holding specific financial assets. We already saw in Table 1 that the correlation between the returns of local firms and inflation is negative. In fact, this prediction is consistent with our model. To see this, consider the diversified portfolio of all firms in the local region—the *local* market portfolio. The realized return on the market portfolio is approximately equal to

$$\begin{aligned} R^{mkt}_{t+1} \approx\ & w_{T,t}\left(\underbrace{\mu + \delta u_{t+1} + \varepsilon_{t+1}}_{\Delta \ln Y_{T,t+1}} - \underbrace{\eta\, u_{t+1}}_{\text{displacement on T}} + \ln(pd_{T,t+1}) - \ln(pd_{T,t} - 1)\right) \\ & + (1 - w_{T,t})\left(\Delta \ln \bar{Y}_{T,t+1} + \underbrace{\frac{\lambda_t}{1+\lambda_t}(\Delta \ln \Omega_{t+1} - \Delta \ln \Omega^*_{t+1})}_{\text{wealth effect}} - \underbrace{\eta\, u_{t+1}}_{\text{displacement on NT}} + \ln \frac{pd_{NT,t+1}}{pd_{NT,t} - 1}\right), \end{aligned} \tag{49}$$

where w_T is the share of total market capitalization due to firms producing the tradable good in the home region. Equation (49) shows that a positive neutral shock leads to an increase in the value of the local market portfolio, whereas a positive displacement shock has two offsetting effects on market returns. First, there is a wealth effect, as a positive u_{NT} shock increases the value of local non-tradable firms. Since their output is denominated in tradable goods, a positive neutral shock raises the valuation of non-tradable sector firms. Second, there is a displacement effect since positive u_T and u_{NT} shocks dilute existing firms' share, leading to a decline in the stock market. Overall, the effect of innovation shocks on the local market portfolio is ambiguous. Hence, our model does not predict a clear relation between the local stock market portfolio and inflation.

In our model, there exists a portfolio of local firms that is heavily exposed to the local displacement shock u and therefore helps households hedge against increases in the local price level. This portfolio is long growth firms and short value firms in each local market. In particular, value firms do not receive any new projects, while growth firms do. Therefore, one can use local growth and value firms to construct a *growth-minus-value* (GMV) portfolio, with return approximately equal to the difference in returns on growth opportunities and returns on assets in place in each region. In our estimated model, return on the GMV portfolio R^{gmv}_{t+1} is highly correlated with the displacement shock u_{t+1}. Thus, a positive displacement shock has an economically significant positive effect on the return on the local growth-minus-value (GMV) portfolio, in contrast to its effect on the return on the local market portfolio.

We next test these predictions in the data. To do so, we construct empirical equivalents of the local market and GMV portfolios. We define the market and the GMV portfolio returns for each state using all firms in that state and its neighboring states. The local market return is the value-weighted portfolio of all local firms. In the model, the appropriate GMV portfolio is long growth opportunities and short assets in place, with the weights chosen to isolate the exposure to displacement shocks. In the data, firms are a mix of growth opportunities and assets in place. Empirically, we define the return on the GMV portfolio as the difference between value-weighted returns on the top and bottom halves of local firms in each sector sorted on the market-to-book ratio, adjusting for the stock of intangible capital as in Eisfeldt and Papanikolaou (2013), Eisfeldt, Kim, and Papanikolaou (2022). We exclude utility industry (SIC 4900-4949) and follow the sector classifications in Mian and Sufi (2014). Our model predicts that returns on the GMV portfolio, in combination with returns on the local market portfolio, should provide investors with an exposure to local inflation shocks. See Appendix A for further details.

First, we test the model's prediction that returns on the local GMV portfolio are linked to the local innovation intensity. Specifically, we estimate the following specification:

$$R^{p}_{i,t\to t+5} = \beta \, \ln(\text{innov}_{\{i\},t\to t+5}) + \gamma \, \mathbf{X}_{i,t} + \varepsilon_{i,t}. \tag{50}$$

for $p \in \{GMV, MKT\}$. The dependent variable is the return on the local GMV or MKT portfolio, while the main independent variable is a local innovation measure. The vector of controls $X_{i,t}$ includes state and year fixed effects and lagged portfolio returns over the last five years. Table 10 shows that the local GMV returns are positively correlated with the local innovation intensity, even though the magnitude and precision of the estimates vary somewhat across innovation measures and specifications. The local market portfolio has no significant relation to local innovation. Lastly, in Table A.9, we report the 2SLS results using R&D tax credit policies. We see that innovation leads to an increase in local GMV portfolio returns.

We next examine the relation between local inflation and returns of the GMV portfolio. That is, we estimate

$$\pi_{i,t\to t+5} = \beta\, R^{p}_{i,t\to t+5} + \gamma\, \mathbf{X}_{i,t} + \varepsilon_{i,t}. \tag{51}$$

for $p \in \{GMV, MKT\}$. As before, we include in the vector of controls state and year fixed effects, lagged price level, unemployment, and lagged five-year portfolio returns.

We present the results in Table 11. Overall, there is a positive correlation between the local growth-minus-value (GMV) portfolio and inflation. This implies that investors can hedge price increases of local non-tradable goods by tilting their portfolios toward local growth firms. In contrast, the correlation between returns to the local market portfolio and local inflation is much weaker and point estimates are negative. This aligns qualitatively with the predictions of our model: local growth factor is a better mimicking portfolio for local inflation shocks than the local stock market.

4.3 Portfolio risk exposure and home bias

Next, we study our model's implication for the portfolio choice of households. Coval and Moskowitz (1999) document a strong local preference of investors for locally headquartered firms, particularly firms that produce non-tradable goods. Here, we show that this prediction is in line with our model. To see this, we calculate the portfolio return for owners of incumbent firms:

$$\bar{R}^{H}_{t,t+1} = \Delta \ln \bar{Y}_T + \ln\Big(\frac{1}{1+w_{t+1}}\Big) - \ln\Big(\frac{1}{1+w_t}\Big) + \ln b_{t+1} + \overline{pd}_{t+1} - \overline{pd}_t \tag{52}$$

$$\bar{R}^{F}_{t,t+1} = \Delta \ln \bar{Y}_T + \ln\Big(\frac{w_{t+1}}{1+w_{t+1}}\Big) - \ln\Big(\frac{w_t}{1+w_t}\Big) + \ln b^*_{t+1} + \overline{pd}_{t+1} - \overline{pd}_t \tag{53}$$

Where w_t is the wealth ratio between the foreign and home region. $\overline{pd}$ is the valuation multiple of total wealth relative to total dividends. Given the symmetric setup, the risk exposure of return differential should be informative about their respective holdings. The return differential can be expressed as

$$\bar{R}^{H}_{t,t+1} - \bar{R}^{F}_{t,t+1} = \ln b_{t+1} - \ln b^*_{t+1} - \Delta \ln w_{t+1}. \tag{54}$$

To test whether households' portfolios exhibit home bias, we calculate their risk exposures in our model at the symmetric steady state. Specifically, we simulate the model starting from the symmetric steady state for one period, and repeat 10,000 times. Then we estimate the following equation:

$$\bar{R}^H_{t,t+1} - \bar{R}^F_{t,t+1} = \sum_{p \in \{MKT, GMV\}} \beta^p_c (R^{H,p}_{t,t+1} - R^{F,p}_{t,t+1}) + \varepsilon_{i,t+1} \tag{55}$$

where the dependent variable is the return differential of their portfolio and independent variables include return differentials of local MKT and GMV for home and foreign regions.

Panel A of Table 13 reports the results. Households' portfolios exhibit a home bias — their portfolios have positive loadings on the local market portfolio. In addition, they tend to tilt their portfolios toward local growth stocks (relative to local value stocks), resulting in a positive net exposure to the local GMV factor.

To understand portfolio choice of households in the model, we summarize average differences in risk exposures of households in the two regions using the following regression:

$$\bar{R}^H_{t,t+1} - \bar{R}^F_{t,t+1} = \sum_{c \in \{H,F\}, x \in \{u, e_T, e_{NT}\}} \beta^p_c (x_{H,t,t+1} - x_{F,t,t+1}) + \varepsilon_{i,t+1}, \tag{56}$$

where $x_{H,t,t+1}, x_{F,t,t+1}$ are the primitive shocks in the home and foreign regions, respectively. Panel B of Table 13 shows that households seek a positive exposure to the local displacement shock and the local neutral tradable shock, and a negative exposure to the local neutral non-tradable shock. As we discuss in Section 3.5 above, households aim to hedge neutral tradable shocks because these increase the effective size of future displacement shocks. The negative exposure to the local neutral non-tradable shock is natural because a positive non-tradable neutral shock represents a favorable state of the economy.

In the model, stock returns span all systematic risk exposures, and therefore households can use their stock portfolios to construct their optimal risk exposures. To see how households adjust their portfolios toward their desired risk exposure, we estimate (56) using GMV portfolio return, tradable and non-tradable as dependent variables. Panel C of Table 13 shows that GMV provides a hedge against displacement shocks. In addition, stock returns in both sectors are positively affected by the neutral tradable shocks, but only the non-tradable good sector can provide a negative exposure to the neutral non-tradable shock.

We should note that implications of our model for households' portfolio choice are heavily affected by the available menu of investment opportunities. Households in the model hedge local inflation shocks by tilting their portfolios toward firms in the sector producing non-tradable consumption. In practice, investors have access to other assets that could help them implement their desired risk exposures – local real estate, for instance, may provide a useful hedge against local inflation risk. Thus, our results for differences in risk exposures of households across regions provide a more robust expression of our model's core implications than the results for portfolio choice.

5 Additional Evidence and Robustness Checks

Here we provide some additional evidence consistent with our model as well as check the robustness of our main findings.

Inflation and IPOs of local firms

New and young companies are an important source of job creation and economic growth. However, the wealth generated by these new firms is often illiquid, and becomes liquid only once these firms become public. As a result, the IPO event can be interpreted as a realized wealth shock to the owners of these firms.

Here, we use data from the SDC Platinum and examine whether using IPO as an alternative proxy of the displacement shock u produces comparable patterns to those we have observed earlier. First, we investigate the relationship between IPO intensity and the growth of income inequality. Second, we explore whether an increase in IPO activity leads to a rise in local price levels. To this end, we estimate a variant of our main specification 2:

$$\ln I^p_{i,t+s} - \ln I^p_{i,t} = \beta(\ln \text{IPO}_{\{i\},t,t+s}) + \gamma \mathbf{X}_{i,t} + \varepsilon_{i,t} \tag{57}$$

where the dependent variable is the growth in top income share between year t and $t+s$. We focus on 5-year horizons. The vector of controls $\mathbf{X}$ includes the lagged level of income inequality, together with state and year fixed effects. $\ln(\text{IPO}_{\{i\},t,t+s})$ is the local IPO intensity at the vicinity of state i, calculated as the ratio of the total market value of IPOs to the total market value in the vicinity of a given state. When the independent variable is equal to 0, we use a similar procedure with patent-based measure: i.e., replacing it with the minimum value in the sample and adding a dummy equal to one if IPO is equal to 0, thereby preventing the removal of the observation from the data.

Our key coefficient of interest is β, which measures the relation of an increase in IPO in (the neighborhood) of state $\{i\}$ on growth in measured income inequality. Panel B of Table 12 reports our estimates. The IPO based measures are positively and statistically significantly correlated with growth in top income share. Further, both the magnitude and statistical significance increase toward the right tail of the income distribution. Focusing on the very top of the distribution, a one-standard deviation increase in our IPO measure is associated with a 0.03 log point increase in income share.

We next examine its relation to the local price level. We estimate a specification directly analogous to the one in equation (2):

$$\pi_{i,t,t+5} = \beta(\ln \text{IPO}_{\{i\},t,t+5}) + \gamma \mathbf{X}_{i,t} + \varepsilon_{i,t} \tag{58}$$

The control variables include the past log price level and state, year fixed effects. Panel A of Table

12 reports our estimates. The IPO based measures are positively and statistically significantly correlated with inflation. In terms of magnitude, one standard deviation increase in IPO intensity is associated with 0.01 log point increase in the local price level. In addition, the increase in the local price level is mostly driven by the non-tradable component of inflation.

In addition to the above analysis, we construct an alternative measure of the local-level IPO intensity, calculated as the total number of IPOs normalized by the total population at the vicinity of a given state. Using this alternative measure, we re-examine the specifications in (57) and (58). The estimates are reported in Table A.6. This alternative measure of IPO intensity shows a significant and positive correlation with both inflation and income inequality, albeit with different magnitudes.

Migration

Improved employment prospects and a lower cost of living often drive the decision to relocate. As a result, one might worry that migration may respond to regional innovation shocks, affecting the relation between innovation and inflation. The qualitative effect of migration would depend on the primary reasons: migration due to costs of living would weaken the impact of innovation on local inflation. In contrast, migration due to employment opportunities may strengthen it. Here, we show that changes in population growth do not drive our findings. Specifically, we re-estimate (2) while controlling for population growth. The results, as presented in Table A.15, are similar to the baseline case.

Imperfect sharing of neutral shocks

In the model, neutral shocks can be fully hedged due to full spanning of aggregate shocks by financial assets and absence of trading constraints and frictions. However, in reality, various frictions may lead to imperfect sharing of neutral shocks. Imperfectly shared neutral shocks may affect local inflation. We next examine the extent to which this channel affects our results. Specifically, we re-estimate (5) while controlling for labor productivity growth. The results, as reported in Table A.10 and Table A.11, show that the estimates remain similar to our baseline case. These results provide evidence that imperfectly shared neutral shocks do not drive our results.

Additional robustness checks

Further, we examine whether our results are driven by a small number of states with high intensity of innovation. To this end, we excluded the five states with the highest innovation intensity, namely California, Illinois, Texas, Massachusetts, and New York, and re-estimated our baseline specification (2). Excluding the top 10 innovative states and the bottom 10 innovative states yields similar results. The results in Table A.12 show that both the magnitude and statistical significance align with the baseline case.

We also examine the robustness of our results to alternative weighting methodologies. Table A.13 reports the results of re-estimating (2) with population-weighted regression, while Table A.14 shows the results of the GDP-weighted regression. We observe that the magnitude and statistical significance remain comparable to the baseline case. Therefore, a few highly innovative states do not excessively influence our results.

6 Conclusion

This paper examines the role of productivity shocks in incomplete markets. First, we confirm that innovation represents productivity shocks. Second, we document a positive and significant correlation between innovation and inflation. We provide causal evidence on the effect of innovation on inflation by using changes in state tax incentives for R&D. In addition, we show that an increase in inflation is associated with a rise in top-income inequality. We argue that the above pattern partially reflects the role of productivity shocks in incomplete markets. In addition to the standard endowment shock in each region, regions experience displacement shocks that reallocate output among agents. We solve the model explicitly under log preferences and estimate the model under general constant relative risk aversion. Regional stock returns provide evidence consistent with the model's central mechanism.

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Tables and Figures

Table 1: Inflation and Productivity

	Headline Inflation					
prod growth	1.207***	1.083**	0.911**	1.568***	1.511***	1.546***
	(0.426)	(0.428)	(0.404)	(0.428)	(0.427)	(0.422)
lagged price level			-20.108***	-21.606***	-22.498***	-22.558***
			(2.393)	(2.513)	(2.687)	(2.711)
lagged prod level				4.008**	4.069**	3.742**
				(1.641)	(1.644)	(1.566)
Unemployment					-0.823*	-0.733
					(0.450)	(0.451)
Local MKT						-0.757*
						(0.444)
State FE	No	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Observations	951	951	951	951	951	951
Adj R2	0.673	0.701	0.783	0.789	0.792	0.793

Notes: This table reports the regression coefficients (times 100) of (1):

$$\pi_{i,t,t+5} = \beta_1 g_{\{i\},t,t+5} + \beta_2 \mathbf{X}_{i,t} + \alpha_i + \gamma_t + \varepsilon_{i,t}$$

Dependent variable is equal to the growth in the (log) price level in state i from t to $t+5$, $\pi_{i,t,t+5} = \ln Y_{i,t+5} - \ln Y_{i,t}$. The independent variable $g_{i,t,t+5} = \ln X_{i,t+5} - \ln X_{i,t}$ is the growth of productivity of state i(column 1) from t to $t+5$. Column 1 controls for year fixed effects γ_t. Column 2 adds state fixed effects as additional control α_i. Columns 3-4 report estimates with controls including lagged price level $\ln Y_{i,t}$, lagged productivity level $\ln X_{i,t}$. Column 5 controls for unemployment rate at t. Column 6 adds market return of the vicinity of state i from t to $t+5$ as additional control. Independent variables are standardized to unit standard deviation using unconditional moments. Standard errors in parentheses are robust to autocorrelation and heteroskedasticity, calculated using the Newey-West procedure with a bandwidth of seven years. The sample period is 1978-2017. $^{***}p < 0.01$,$^{**}p < 0.05$,$^{*}p < 0.1$.

Table 2: Innovation, Inflation and Unemployment

Dependent variable: Headline Inflation						
	5-Year	5-Year	5-Year	5-Year	5-Year	5-Year
KPST8005 (Assignee Location)	3.424***	3.608***				
	(0.797)	(0.787)				
Cit(20%) (Assignee Location)			3.734***	3.936***		
			(0.667)	(0.680)		
KPSS(20%) (Assignee Location)					3.693***	3.743***
					(0.752)	(0.745)
Unemployment		-2.026***		-1.313***		-1.146***
		(0.475)		(0.416)		(0.422)
State FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Observations	663	663	951	951	951	951
Adj R2	0.739	0.755	0.792	0.798	0.788	0.792

Notes: This table reports the regression coefficients (times 100) of (2):

$$\pi_{i,t,t+5} = \beta_1 \ln(\text{innov}_{\{i\},t,t+5}) + \beta_2 \mathbf{X}_{i,t} + \alpha_i + \gamma_t + \varepsilon_{i,t}$$

Dependent variable is equal to the growth in the (log) price level in state i from t to $t+5$, $\pi_{i,t,t+5} = \ln Y_{i,t+5} - \ln Y_{i,t}$. The vector of controls includes the (log) price level at time t, $\ln Y_{i,t}$. $\text{innov}_{\{i\},t,t+s}$ is the flow of innovation measure at the *vicinity* of state i. α_i is state-FE, γ_t is time-FE. Unemployment rate is at t. See A for the definition of innovation measures. Independent variables are standardized to unit standard deviation using unconditional moments. Standard errors in parentheses are robust to autocorrelation and heteroskedasticity, calculated using the Newey-West procedure with a bandwidth of seven years. The sample period is 1978-2017. $^{***}p < 0.01$,$^{**}p < 0.05$,$^{*}p < 0.1$.

Table 3: R&D Tax Credits and Innovation Outcomes

First Stage Regressions			
	KPST8005 (Assignee Location)	Cit(20%) (Assignee Location)	KPSS(20%) (Assignee Location)
RDTC	0.288***	0.284***	0.211***
	(0.042)	(0.045)	(0.027)
State FE	YES	YES	YES
Year FE	YES	YES	YES
Observations	647	938	923
Adj R2	0.535	0.454	0.517

Notes: Columns 1-3 in this table report the regression coefficients of (4):

$$\ln(\text{innov}_{\{i\},t,t+5}) = \beta_1 RDTC_{\{i\},t} + \beta_2 \mathbf{X}_{i,t} + \alpha_i + \gamma_t + \varepsilon_{i,t}$$

Dependent variable is equal to the flow of innovation at the *vicinity* of state i from t to $t+5$. Independent variable $RDTC_{\{i\},t}$ is the R&D tax credit in the vicinity of state i, $\{i\}$. Control variables include (log) price levels $\ln Y_{i,t}$. α_i is state-FE, γ_t is time-FE. See A for the definition of innovation measures. Both dependent variables and independent variables are standardized to unit standard deviation using unconditional moments. Standard errors in parentheses are robust to autocorrelation and heteroskedasticity, calculated using the Newey-West procedure with a bandwidth of seven years. The sample period is 1978-2017. $^{***}p < 0.01$,$^{**}p < 0.05$,$^{*}p < 0.1$.

Table 4: R&D Tax Credits, Inflation, Inequality and Productivity

	Headline Inflation		Productivity Growth		Median Income Growth		Inequality Growth	
RDTC	1.174**	1.331**	0.578**	0.642**	-0.521	-0.396	1.774***	1.863***
	(0.563)	(0.569)	(0.268)	(0.265)	(0.424)	(0.443)	(0.554)	(0.561)
Unemployment		YES		YES		YES		YES
State FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Observations	951	951	951	951	837	837	951	951
Adj R2	0.785	0.789	0.653	0.658	0.683	0.690	0.824	0.826

Notes: Columns of this table report the regression coefficients (times 100) of (5):

$$g_{i,t,t+5} = \beta_1 RDTC_{\{i\},t} + \beta_2 \mathbf{X}_{i,t} + \alpha_i + \gamma_t + \varepsilon_{i,t}$$

Dependent variable is equal to the growth in the (log) price level, productivity, median income, Top 1% income share in state i from t to $t+5$: $g_{i,t,t+5} = \ln Y_{i,t+5} - \ln Y_{i,t}$ for $Y \in \{$price, productivity, median income, Top 1% income share$\}$, and are multiplied by 100. Productivity is measured by real GDP per worker. The vector of controls includes the (log) level at time t, $\ln Y_{i,t}$. Independent variable $RDTC_{\{i\},t}$ is the R&D tax credit rate at the *vicinity* of state i. α_i is state-FE, γ_t is time-FE. Columns 2,4,6,8 repeat columns 1,3,5,7 with unemployment rate at time t as an additional control variable. See A for the definition of innovation measures. Independent variables are standardized to unit standard deviation using unconditional moments. Standard errors in parentheses are robust to autocorrelation and heteroskedasticity, calculated using the Newey-West procedure with a bandwidth of seven years. The sample period is 1978-2017. $^{***}p < 0.01$,$^{**}p < 0.05$,$^{*}p < 0.1$.

Table 5: R&D Tax Credits and Inflation, Tradables vs Non-Tradables

	T		NT		w.o. H		H	
RDTC	0.607*	0.636**	1.457*	1.667**	0.566*	0.622**	2.136*	2.651**
	(0.325)	(0.324)	(0.791)	(0.808)	(0.305)	(0.300)	(1.256)	(1.326)
Unemployment		YES		YES		YES		YES
State FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Observations	951	951	951	951	951	951	951	951
Adj R2	0.797	0.798	0.751	0.756	0.868	0.873	0.707	0.728

Notes: Columns of this table report the regression coefficients (times 100) of (5):

$$\pi_{i,t,t+5} = \beta_1 RDTC_{\{i\},t} + \beta_2 \mathbf{X}_{i,t} + \alpha_i + \gamma_t + \varepsilon_{i,t}$$

Dependent variable is equal to the growth in the (log) price level in state i from t to $t+5$, $\pi_{i,t,t+5} = \ln Y_{i,t+5} - \ln Y_{i,t}$, for different components Y in Tradables(T), non-tradables (NT), headline without housing (w.o. H) and housing (H). The vector of controls includes the (log) price level at time t, $\ln Y_{i,t}$. $RDTC_{\{i\},t}$ is the R&D tax credit rate at the *vicinity* of state i. α_i is state-FE, γ_t is time-FE. Columns 2,4,6,8 add unemployment rate at time t as an additional control variable. Independent variables are standardized to unit standard deviation using unconditional moments. Standard errors in parentheses are robust to autocorrelation and heteroskedasticity, calculated using the Newey-West procedure with a bandwidth of seven years. The sample period is 1978-2017. ***$p < 0.01$,**$p < 0.05$,*$p < 0.1$.

Table 6: Innovation and Inflation in Eurozone

Dependent variable: Headline Inflation				
	3-Year	3-Year	5-Year	5-Year
Cit(20%) (Assignee Location)	4.912***		7.729***	
	(1.405)		(2.343)	
Cit(20%) (Inventor Location)		3.897***		7.618***
		(1.171)		(2.483)
Country FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Obs	332	332	292	292
Adj R^2	0.767	0.752	0.840	0.831

Notes: This table reports the regression coefficients (times 100) of (2) in the euro-zone sample:

$$\pi_{i,t,t+5} = \beta_1 \ln(\text{innov}_{\{i\},t,t+5}) + \beta_2 \mathbf{X}_{i,t} + \alpha_i + \gamma_t + \varepsilon_{i,t}$$

Dependent variable is equal to the growth in the (log) CPI level in country i from t to $t+5$, $\pi_{i,t,t+5} = \ln Y_{i,t+5} - \ln Y_{i,t}$. As before, the vector of controls includes the (log) CPI level at time t, $\ln Y_{i,t}$. $\text{innov}_{\{i\},t,t+s}$ is the flow of innovation measure in country i. α_i is country-FE, γ_t is time-FE. See A for the definition of innovation measures. Independent variables are standardized to unit standard deviation using unconditional moments. Standard errors in parentheses are robust to autocorrelation and heteroskedasticity, calculated using the Newey-West procedure with a bandwidth of seven years. The sample period is 1999-2017. $^{***}p < 0.01$,$^{**}p < 0.05$,$^{*}p < 0.1$.

Table 7: R&D Tax Credits and Median Wages

	Wage (median)	Wage (median)
RDTC	-0.526	0.066
	(0.384)	(0.333)
Unemployment	No	Yes
Observations	352	352
R-squared	0.749	0.794

Notes: Columns of this table report the regression coefficients (times 100) of (5):

$$\Delta W_{i,t,t+s} = \beta_1 RDTC_{\{i\},t} + \beta_2 \mathbf{X}_{i,t} + \alpha_i + \gamma_t + \varepsilon_{i,t}$$

Dependent variable is equal to the growth in the (log) median wages in state i from t to $t+s$, $\Delta W_{i,t,t+s} = \ln W_{i,t+s} - \ln W_{i,t}$. The wage data is from BLS-OEWS database. The vector of controls includes the (log) median wage level at time t, $\ln W_{i,t}$. $RDTC_{\{i\},t}$ is the R&D tax credit rate at the *vicinity* of state i. α_i is state-FE, γ_t is time-FE. Independent variables are standardized to unit standard deviation using unconditional moments. Standard errors in parentheses are robust to autocorrelation and heteroskedasticity, calculated using the Newey-West procedure with a bandwidth of seven years. The sample period is 2001-2017. $^{***}p < 0.01$,$^{**}p < 0.05$,$^{*}p < 0.1$.

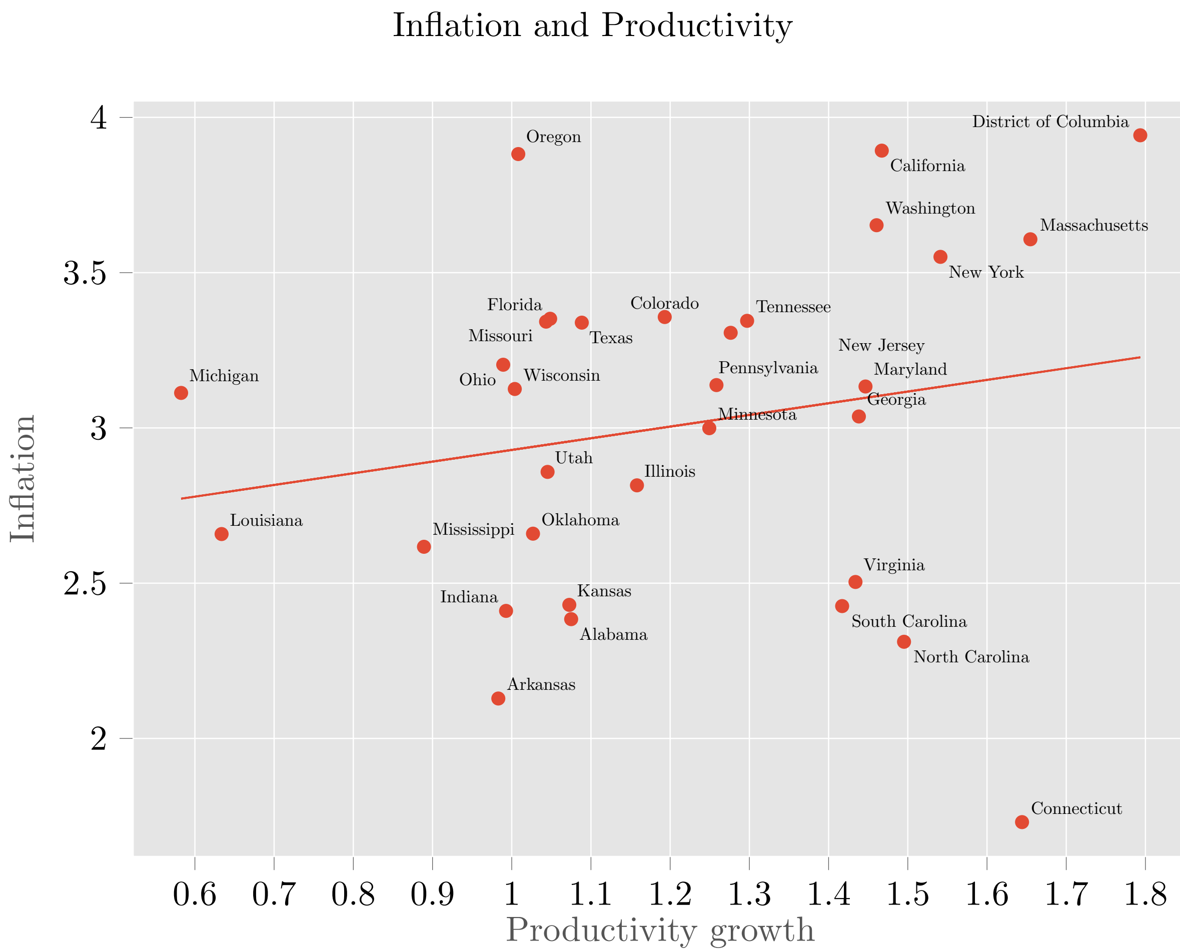


Figure 1: Inflation and Productivity Growth. This figure plots the average inflation against the average productivity growth.

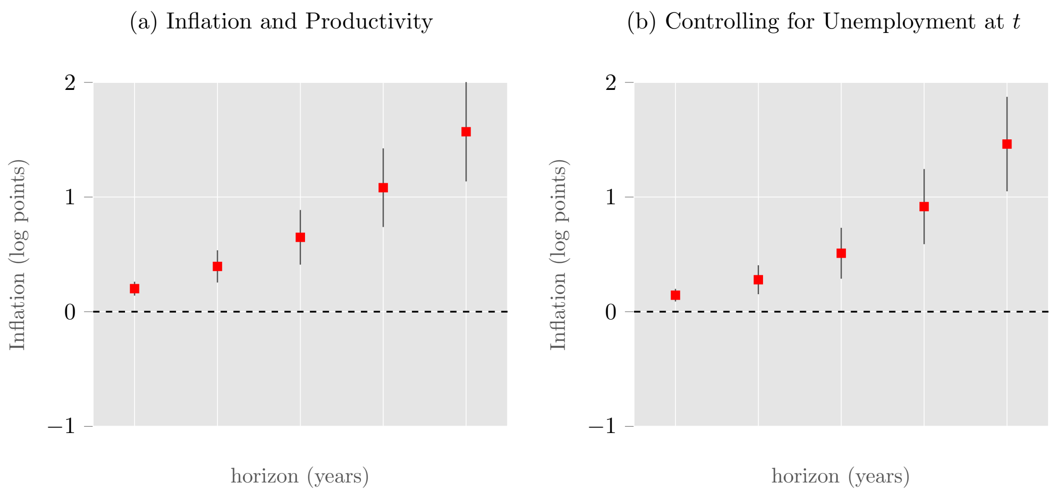


Figure 2: Inflation and Productivity Growth, the horizon is from 1 to 5 years. Left panel reports the coefficients β_i (times 100) in the contemporaneous regression of inflation on productivity, for s = 1 to 5.

$$\pi_{i,t,t+s} = \beta_1 g_{i,t,t+s} + \gamma \mathbf{X}_{i,t} + \varepsilon_{i,t}$$

Dependent variable is the inflation of state i from t to $t+s$, $\pi_{i,t,t+s} = \ln Y_{i,t+s} - \ln Y_{i,t}$. Y is the headline price level. Right panel reports the coefficients on the contemporaneous productivity growth, controlling for the unemployment rate at t. All specifications control for state and year fixed effects, the log price level $\ln Y_{i,t}$, and the log level of independent variables $\ln X_{i,t}$ for X = productivity.

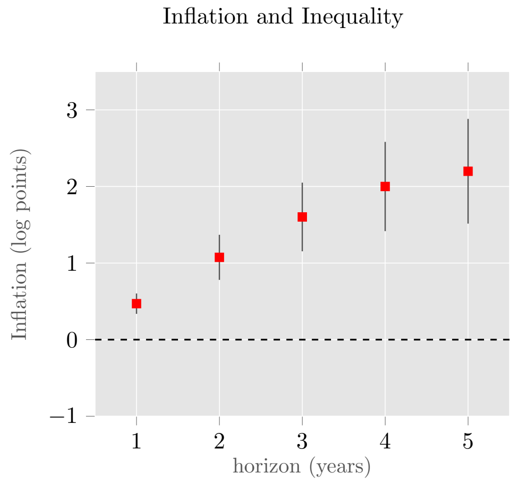


Figure 3: This figure plots the coefficient of β (times 100) for the following estimation

$$\pi_{i,t,t+s} = \beta(\ln I_{i,t+s} - \ln I_{i,t}) + \gamma \mathbf{X}_{i,t} + \varepsilon_{i,t}$$

Dependent variable is the inflation from t to $t+s$, $\pi_{i,t,t+s} = \ln Y_{i,t+s} - \ln Y_{i,t}$. Y is the headline price level. Independent variable is the growth in the 5-year moving average of the share of top 1% income earners. Controls include the log level of price $\ln Y_{i,t}$, the log level of independent variable $\ln I_{i,t}$, and state and year fixed effects.

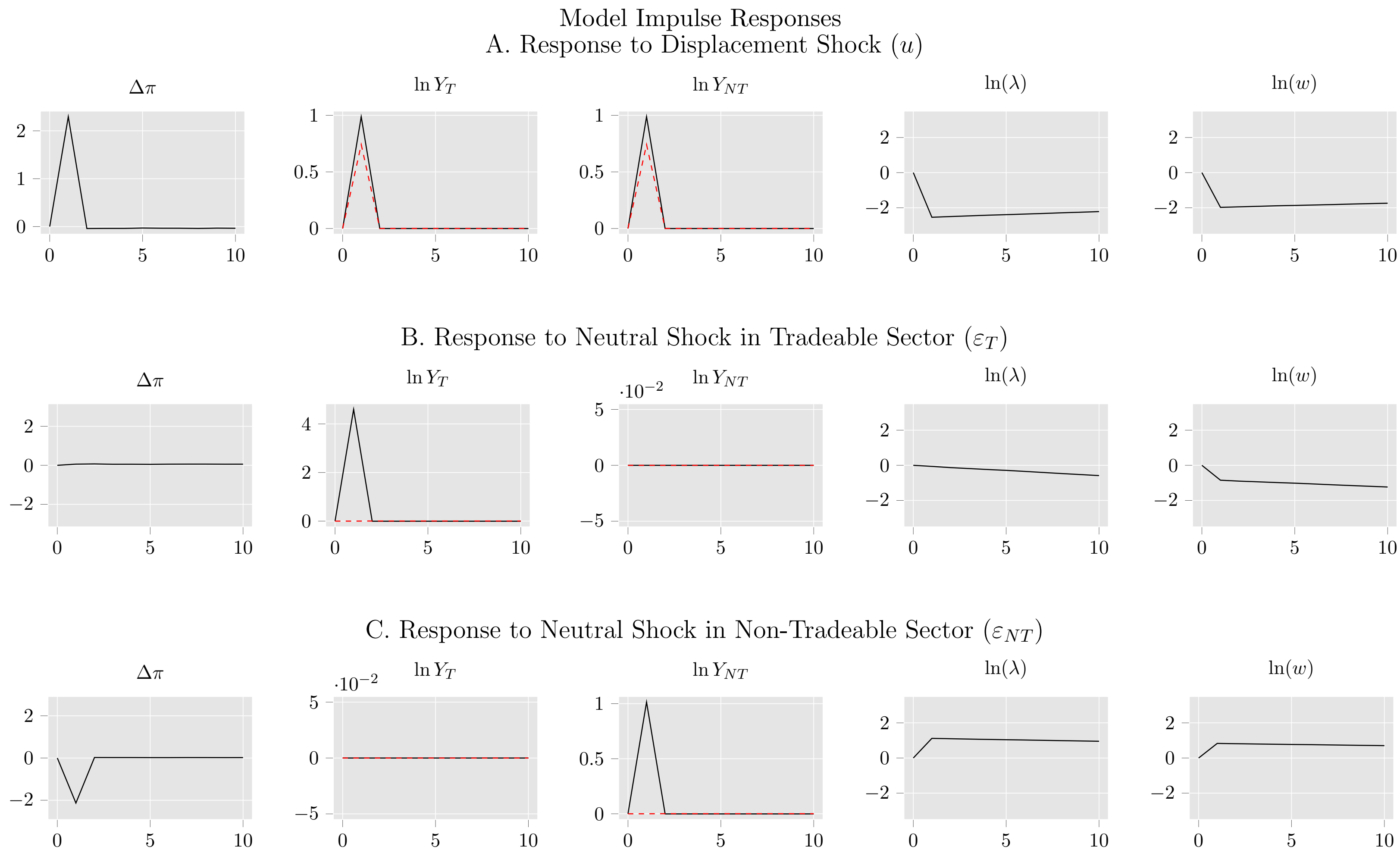


Figure 4: This figure plots the impulse responses of variables to a shock to the home country (u in Panel A , ε_T in Panel B and ε_{NT} in Panel C), for both the home country (the solid line) and the foreign country (the dashed line). All parameters are calibrated to the values reported in Table 9. We construct the impulse responses by introducing an additional one-standard deviation shock at time t=1 without altering the realization of future shocks. The impulse responses are computed at the symmetric steady state.

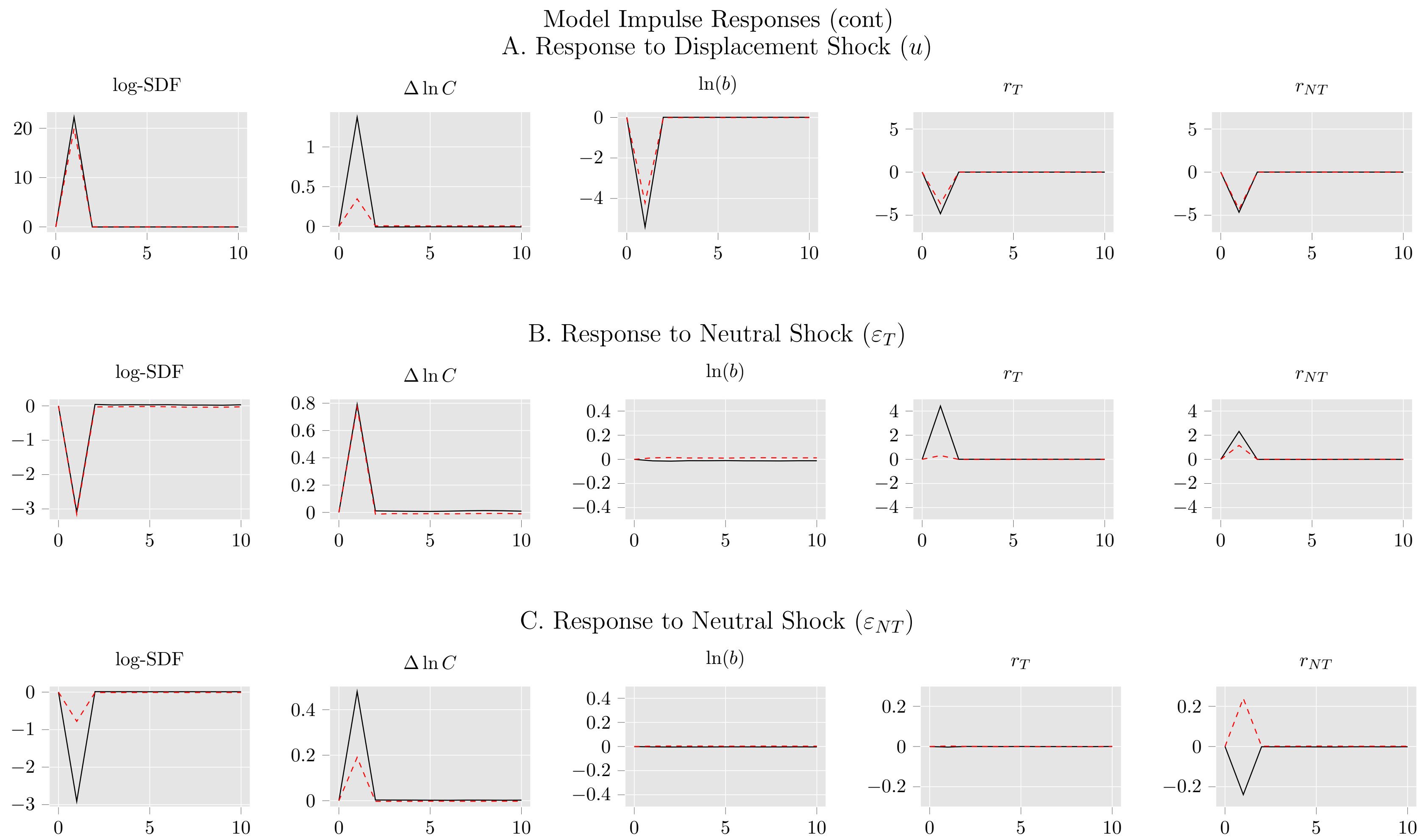


Figure 5: This figure plots the impulse response of variables to a shock to the home country (u in Panel A , ε_T in Panel B and ε_{NT} in Panel C), for both the home country (the solid line) and the foreign country (the dashed line). All parameters are calibrated to the values reported in Table 9. We construct the impulse responses by introducing an additional one-standard deviation shock at time t=1 without altering the realization of future shocks. The impulse responses are computed at the symmetric steady state.

Table 8: Moments used in Model Calibration

	Data	Model
Regional Quantities and Prices		
Output growth, mean	0.017	0.017
Output growth, volatility	0.035	0.039
Consumption growth, mean	0.017	0.017
Consumption growth, volatility	0.016	0.016
Relative Inflation, volatility	0.021	0.024
Risk-free rate, mean	0.017	0.016
Regional Correlations, 5 years		
Inflation and		
—output growth	0.430	0.486
—innovation	0.387	0.412
—inequality growth	0.215	0.151
—consumption growth	0.387	0.259
Innovation and		
—output growth	0.249	0.389
—inequality growth	0.261	0.239
Pairwise Correlations, 5 years		
Consumption growth (H and F)	0.746	0.778
Output growth (H and F)	0.408	0.677
Stock returns-MKT (H and F)	0.787	0.798

Notes: This table reports both empirical moments computed using the regional data and simulated moments from the model. All the parameters are calibrated as in Table 9.

Table 9: Parameter Estimates

Description	Symbol	Value	SE/Source
Preferences:			
Subjective discount rate	β	0.968	0.118
Endowments:			
Displacement shock productivity	δ	0.121	0.218
Mean of output growth	μ	0.013	0.005
Measure of project-receivers	ζ	0.007	0.027
Displacement shock high state	u_2	0.312	0.089
Probability of displacement shock			
— low state	p_l	0.907	0.092
Volatility of neutral T-shock	σ_{e_T}	0.047	0.005
Volatility of neutral NT-shock	$\sigma_{e_{NT}}$	0.010	0.003
Technology spillover	ρ_u	0.571	0.085
Fraction of project that goes to inventors	η	0.739	0.398
Consumption weight on tradables	α	0.340	External
Risk aversion	γ	5.000	External
Death rate	ξ	0.025	External
Displacement shock low state	u_1	0.000	External
Co-integration	τ	0.001	External
Firm's transition probability			
– low state	q	0.232	External
– high state	p	0.277	External

Notes: This table reports the estimated parameters of the model. See the main text and the Appendix B for details on the estimation of the model.

Table 10: Partial Correlations between Innovation and Stock Returns

Dependent Variable: Stock Return				
	Local Market MKT	Local Market MKT	Growth-Value GMV	Growth-Value GMV
KPST8005 (Assignee Location)	1.088	0.927	8.313*	8.351*
	(4.360)	(4.373)	(4.936)	(4.986)
Cit(20%) (Assignee Location)	-2.036	-2.197	11.153**	11.167*
	(4.579)	(4.655)	(5.679)	(5.699)
KPSS(20%) (Assignee Location)	0.900	1.274	12.782**	12.779**
	(3.921)	(3.857)	(6.484)	(6.464)
Control for Unemployment at t	NO	YES	NO	YES
State FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

Notes: This table reports the coefficients (times 100) of a regression of stock returns on different innovation measures.

$$R^x_{\{i\},t,t+5} = \beta_1 \ln(\text{innov}_{\{i\},t,t+5}) + \beta_2 \mathbf{X}_{i,t} + \alpha_i + \gamma_t + \varepsilon_{i,t}$$

where dependent variables $R^x_{\{i\},t,t+5}, x \in \{GMV, MKT\}$ are the portfolio returns of *local market* and *growth-minus-value* of state i between time $t, t+5$. $\text{innov}_{\{i\},t,t+5}$ is the flow of innovation measure at the *vicinity* of state i. All regression controls include lagged 5-year cumulative portfolio return $R_{i,t-5,t}$. In columns 2 and 4 we control for unemployment rate at t. α_i is state-FE, γ_t is time-FE. See A for the definition of innovation measures. Independent variables are standardized to unit standard deviation using unconditional moments. Standard errors in parentheses are robust to autocorrelation and heteroskedasticity, calculated using the Newey-West procedure with a bandwidth of seven years. The sample period is 1978-2017. ***$p < 0.01$,**$p < 0.05$,*$p < 0.1$***.

Table 11: Inflation and Local Stock Market

	Dependent Variable: Headline Inflation				
	5-Year	5-Year	5-Year	5-Year	5-Year
GMV	0.718**		0.702**	0.740**	0.730**
	(0.335)		(0.335)	(0.337)	(0.335)
MKT		-0.923*	-0.850*		-0.765
		(0.529)	(0.474)		(0.481)
Unemployment				-0.836**	-0.807**
				(0.373)	(0.379)
State FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Obs	951	951	951	951	951
Adj R2	0.768	0.765	0.770	0.770	0.773

Notes: This table reports the regression coefficients (times 100) of (51):

$$\pi_{i,t,t+5} = \beta_1 R^x_{i,t,t+5} + \beta_2 \mathbf{X}_{i,t} + \alpha_i + \gamma_t + \varepsilon_{i,t}$$

Dependent variable is equal to the growth in the (log) price level in state i from t to $t+5$, $\pi_{i,t,t+5} = \ln Y_{i,t+5} - \ln Y_{i,t}$. $R^x_{i,t,t+5}, x \in \{GMV, MKT\}$ are the *growth-minus-value* and *local market* portfolio returns of state i from time t to $t+5$. Control variables include past cumulative portfolio returns $R^x_{i,t-5,t}$ and price levels $\ln Y_{i,t}$. $\text{innov}_{\{i\},t,t+s}$ is the flow of innovation measure at the *vicinity* of state i. α_i is state-FE, γ_t is time-FE. Unemployment rate is at t. See A for the definition of innovation measures. Independent variables are standardized to unit standard deviation using unconditional moments. Standard errors in parentheses are robust to autocorrelation and heteroskedasticity, calculated using the Newey-West procedure with a bandwidth of seven years. The sample period is 1978-2017. ***$p < 0.01$,**$p < 0.05$,*$p < 0.1$.

Table 12: IPO, Inequality and Inflation

	Panel A. Market Value of IPO and Inflation					
	Headline		T Inflation		NT Inflation	
IPO (mv)	1.121***	1.138***	-0.047	-0.039	1.785***	1.823***
	(0.354)	(0.356)	(0.224)	(0.222)	(0.524)	(0.526)
Unemployment	NO	YES	NO	YES	NO	YES
State FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Obs	951	951	951	951	951	951
Adj R2	0.768	0.771	0.798	0.799	0.753	0.757

	Panel B. Market Value of IPO and Inequality					
	Top 1%		Top 0.1%		Top 0.01%	
IPO (mv)	1.363***	1.385***	1.731**	1.779**	2.550**	2.655**
	(0.462)	(0.460)	(0.799)	(0.792)	(1.105)	(1.091)
Unemployment	NO	YES	NO	YES	NO	YES
State FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Obs	951	951	951	951	951	951
Adj R2	0.808	0.809	0.803	0.804	0.785	0.787

Notes: Panel A of the table reports the regression coefficients (times 100) of (57) and (58):

$$\pi_{i,t,t+5} = \beta_1 \ln(\text{IPO}_{\{i\},t,t+5}) + \beta_2 \mathbf{X}_{i,t} + \alpha_i + \gamma_t + \varepsilon_{i,t}$$

Dependent variable is equal to the growth in the (log) price level in state i from t to $t+5$, $\pi_{i,t,t+5} = \ln Y_{i,t+5} - \ln Y_{i,t}$, where Y is the price level. Control variables include (log) price level $\ln(Y_{i,t})$. $\text{IPO}_{\{i\},t,t+5}$ is the total market value of IPOs normalized by the total market of the vicinity of state i from t to $t+5$. α_i is state-FE, γ_t is time-FE. Unemployment is at t. Panel B re-estimates the above specification with the dependent variable being the inequality growth between t and $t+5$. In all specifications, the independent variables are standardized to unit standard deviation using unconditional moments. Standard errors in parentheses are robust to autocorrelation and heteroskedasticity, calculated using the Newey-West procedure with a bandwidth of seven years. The sample period is 1978-2017. $^{***}p < 0.01$,$^{**}p < 0.05$,$^{*}p < 0.1$.

Table 13: Portfolio Risk Exposures — Home Relative to Foreign

Panel A. Portfolio home-bias

	Local MKT	GMV
$\bar{R}^H_{t,t+1} - \bar{R}^F_{t,t+1}$	0.422	0.802

Panel B. Portfolio exposure to primitive risks

	Displacement	Neutral, T	Neutral, NT
$\bar{R}^H_{t,t+1} - \bar{R}^F_{t,t+1}$	0.335	0.178	-0.827

Panel C. Stock exposure on primitive risks

	Displacement	Neutral, T	Neutral, NT
$R^{H,GMV}_{t,t+1} - R^{F,GMV}_{t,t+1}$	0.573	0.000	0.000
$R^{H,T}_{t,t+1} - R^{F,T}_{t,t+1}$	-0.569	0.823	0.000
$R^{H,NT}_{t,t+1} - R^{F,NT}_{t,t+1}$	-0.165	0.253	-0.472

Notes: Data is from 10000 sample simulations starting from the symmetric steady state with one period. Panel A of the table reports the regression coefficients of:

$$\bar{R}^H_{t,t+1} - \bar{R}^F_{t,t+1} = \sum_{p \in \{MKT, GMV\}} \beta^p_c (R^{H,p}_{t,t+1} - R^{F,p}_{t,t+1}) + \varepsilon_{i,t+1}$$

Panel B of the table reports the regression coefficients of:

$$\bar{R}^H_{t,t+1} - \bar{R}^F_{t,t+1} = \sum_{x \in \{u, e_T, e_{NT}\}} \beta^p_c (x_{H,t+1} - x_{F,t+1}) + \varepsilon_{i,t+1}$$

Panel C of the table reports the regression coefficients of:

$$R^{H,p}_{t,t+1} - R^{H,p}_{t,t+1} = \sum_{x \in \{u, e_T, e_{NT}\}} \beta^p_c (x_{H,t+1} - x_{F,t+1}) + \varepsilon_{i,t+1}$$

for $p \in \{GMV, T, NT\}$. Dependent variable in Panel A and B is equal to the return differential between home and foreign households excluding the new projects. Dependent variables in Panel C are the stock return differential between home and foreign. Independent variables in Panel A are portfolio return differentials on MKT and GMV at home and foreign region, respectively. Independent variables in Panel B and C are the differences in the primitive shocks in the model.

Appendix

Section A describes the data sources and the construction for the inflation series. In Section B, we describe the construction of estimation targets and our methodology for estimation. Detailed derivations are provided in Section C.

A Data Appendix

Section A.1 includes variable definitions. Section A.2 discusses the measurement of effective changes in state-level R&D tax credit policies.

A.1 Definition of Variables

We describe the definitions of variables.

State-level inflation

Hazell et al. (2022) constructed state-level price indexes for the U.S. using data collected by the BLS for the purpose of computing the CPI. However, the dataset does not include rent prices, which are used to construct the shelter component of the CPI and account for approximately one-third of the expenditure weight. Therefore, we compute state-level headline inflation as a weighted average of housing price appreciation and the non-housing inflation measures. The housing price data comes from the Federal Housing Finance Agency (FHFA), which produces nominal state-level price indices for all states.

In constructing price indices, we closely follow the steps outlined in Hazell et al. (2022), which provides a simplified version of the procedure used by the BLS to calculate the CPI. Specifically, the first step is to compute price ratios for all-items excluding housing and for housing itself, as follows:

$$r_{i,t} = \frac{P_{i,t}}{P_{i,t-1}} \quad i \in HHNS, H, \tag{A.1}$$

where $HHNS$ refers to the inflation data for all-items excluding housing from Hazell et al. (2022), and H refers to housing price appreciation. In the second step, we aggregate the price ratios using a weighted geometric average:

$$R = \prod r_i^{w_i / \sum w_i} \tag{A.2}$$

As in Hazell et al. (2022), we use fixed CPI expenditure weights for housing, specifically assigning a weight of 32.7% to housing.

Hazell et al. (2022) also provides two components of inflation: tradables and non-tradables. Non-tradables, as defined in their work, primarily consist of services, with tradables being the complement of non-tradables. We construct the non-tradable category by aggregating their non-tradable inflation with housing price data using equation (A.2). In total, we consider the following categories:

- Headline: a combination of all-items inflation from Hazell et al. (2022) and housing price data.
- Tradables: tradables inflation from Hazell et al. (2022).
- Non-tradables: a combination of non-tradable inflation from Hazell et al. (2022) and housing price data.
- W.O. housing (all items): all-items inflation from Hazell et al. (2022).
- Housing: housing price appreciation.

Measures of innovation

- Cites 20%: Important patents per capita in the vicinity of state i (top 20% forward citations within the issuing year).
- KPST8005: Total number of breakthrough patents divided by total population of the *vicinity* of state i. Breakthrough patents are from Kelly et al. (2021) using top 20% cutoff and a 5-year window.
- KPSS (20%): Total number of breakthrough patents divided by total population of the *vicinity* of state i. Breakthrough patents are from Kogan et al. (2017) using top 20% cutoff and a 5-year window.

Measures of stock market return

- GMV: value-weighted growth-minus-value using median book-to-market cutoff of each sector. The set of stocks are firms with headquarters located in the *vicinity* of state i. The book value is adjusted according to Eisfeldt and Papanikolaou (2013).
  - Tradable: Division A - Agriculture, Forestry, And Fishing, Division B - Mining, Division D - Manufacturing
  - Non-tradable: Division G - Retail and Restaurants
  - Construction: Division C - Construction
  - Others: other divisions
- Local MKT: value-weighted market return. The set of stocks are firms with headquarters located in the *vicinity* of state i.

Measures of median wages from PSID

The PSID, which began in 1968, collected data from a sample of approximately 5,000 households. The PSID includes a variety of socioeconomic characteristics of the household, including education, food spending, and the income of household members. Notably, questions about labor income are retrospective; for example, those asked in 1993 refer to the 1992 calendar year.

Our analysis focuses on individuals aged 20 to 59 during the period from 1978 to 2017, with complete geographical information. After imposing these filters, we have 393,228 observations in the sample. To obtain real wages, we deflate nominal wage values using the annual aggregate CPI series. The state-level median real wage is then calculated for each year.

It is important to note that different states are represented unequally in our sample. In the initial year, 1978, states such as Connecticut, Kansas, Oklahoma, and Utah had fewer than 50 observations. Over time, the number of observations increased steadily. By the end of the sample period in 2017, only Connecticut still had fewer than 50 observations, while 27 out of 32 states had more than 100 observations.

Measures of median wages from BLS-OEWS

The data is sourced from the Bureau of Labor Statistics, Occupational Employment and Wage Statistics tables. For our analysis, we use the median wage across all occupations. The sample period spans from 2001 to 2017, as data on the median wage across all occupations is not available prior to 2001.

Measures of median income from Census

Annual median income at the state level is obtained from the Census Bureau and it is adjusted by annual aggregate CPI. The data is obtained from Fred. For instance, for Alabama state: source.

Other variables

We obtain the income inequality measure from Frank (2009), updated to cover our sample period (source). Local economic indicators such as GDP, population, consumption are sourced from BEA regional economic accounts. GDP implicit deflator (BEA account code: A191RD) is used to calculate real variables. IPO data is obtained from the SDC Platinum new issuance database, and stock market data comes from the CRSP database.

- Top x%: Share of income owned by the top x% (x being equal to 1,10,0.01,0.1) of the income distribution of state i. We take 5-year average of this series.
- unemployment: unemployment rate of state i.
- Employment: employment of state i.

- GDP: real GDP of state i.
- Productivity: GDP/Employment of state i

Data from EPO

Here we describe the data construction procedure for the analysis performed in section 1.4.

We obtain CPI and population data for Eurozone countries from the World Bank, while patent data is sourced from the European Patent Office. Specifically, we use the PATSTAT dataset. We exclude patents that are either not granted or have missing publication dates. To associate a patent with a country, we rely on information about the patent applicants (assignees) and inventors. For patents with N co-applicants or co-inventors, we split them evenly, allocating $1/N$ of the patent to each applicant's (or inventor's) country. To account for patent quality, we adjust based on forward citations, with the top 20% of patents in forward citations each year classified as important patents. Our sample covers the period 1999–2017, allowing patents a five-year window for citation accumulation. To calculate the flow of innovation measure, we normalize the count of significant patents by the country's population.

It is important to note that not all current Eurozone member countries adopted the euro as their official currency at the same time. Many joined the Eurozone at its inception in 1999, while others entered in subsequent years in a staggered manner. For example, Germany, France, and Italy were among the countries that adopted the euro at its inception in 1999, whereas nations like Slovenia joined in 2007, Slovakia in 2009, and Lithuania in 2015.

For many late-joining countries, their currencies were de facto pegged to the euro even prior to their formal membership. Figure A.4 presents the exchange rates relative to the U.S. dollar for all twenty Eurozone countries. Upon examining the figure, it is evident that many of these countries had aligned their currencies with the euro well before their official entry. Consequently, our sample includes all these countries from 1999 to 2017, with the exceptions of Latvia prior to 2005, and Lithuania and Malta in 1999. Specifically, our sample covers the following:

- Austria, Belgium, Croatia, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Slovakia, Slovenia, Spain: 1999–2017.
- Latvia: 2005–2017. Prior to 2005, Latvia's currency was not well aligned with the euro (see Figure A.4).
- Malta: 2000–2017. In 1999, Malta's currency was not sufficiently aligned with the euro (see Figure A.4).
- Lithuania: 2000–2017. In 1999, Lithuania's currency was not sufficiently aligned with the euro (see Figure A.4).

A.2 Description of state level R&D tax credit policy

We follow Bloom et al. (2013) and consider the Hall-Jorgenson user cost of R&D capital for firms in state i, denoted by $\rho_{i,t}$:

$$\rho_{i,t} = \frac{(1 - D_{i,t})}{(1 - \tau_{i,t})}[r_t + \delta + \frac{\Delta p_t}{p_{t-1}}] \tag{A.3}$$

where r_t is the real interest rate, δ is the depreciation rate of R&D capital, $\frac{\Delta p_t}{p_{t-1}}$ is the growth of R&D asset price, $D_{i,t}$ is the effective R&D credit rate, $\tau_{i,t}$ is the corporate tax rate. Since $r_t + \delta + \frac{\Delta p_t}{p_{t-1}}$ does not vary between firms, we focus on the tax price component of the user cost. That is, we focus on the variation in $D_{i,t}$ across states and time. Tax credits apply to R&D performed within the state that can be offset against state-level corporate tax liabilities.

We use the state-by-year R&D tax price data, which is compiled in Wilson (2009) and extended by Bloom et al. (2013). Wilson (2009) quantifies the impact of state-level tax credits. In particular, the effective tax credit rate $D_{i,t}$ varies over time and across states depending on the design of the policy. There are three primary designs for R&D tax credits (i) non-incremental, where all qualified R&D is eligible for credit (ii) incremental with a fixed-period base, where eligibility is limited to R&D expenditures exceeding a baseline determined by a company's activity (e.g., R&D to sales ratio) over a fixed period and (iii) incremental with a moving-average base, where the base level is determined by the company's recent activities. For instance, Ohio implements an incremental approach with a moving-average base calculated from the past three years, Pennsylvania sets its moving-average window at four years, West Virginia offers a non-incremental tax credit, and Arizona aligns its criteria with the federal guidelines for R&D tax credits.

For both non-incremental credits and incremental credits with a fixed period base, the effective credit rate on a marginal unit of R&D, assuming that the current R&D is above the base, is $D_{i,t} = \tilde{D}_{i,t}$, where $\tilde{D}_{i,t}$ represents the statutory credit rate. For incremental credits with a moving-average base, the base is current sales multiplied by the company's average R&D to sales ratio over n previous years. The effective credit rate in this case is $D_{i,t} = \tilde{D}_{i,t}(1 - \frac{1}{n}(1 + r_{t-s})^{-s})$, where r_{t-s} is the real interest rate. In our calculation, we use $r = 2\%$ as an average real interest rate during the periods of study. Again, it is assuming that current R&D is above the base. As is well-known, the moving-average formula significantly reduces the value of the credit, as current R&D spending lowers the amount of R&D that qualified for future credits. Note that several states piggyback on the federal definition of R&D base amount, and this was changed in 1990 from a moving-average base of 3 years to a fixed-period base. This increases the effective credit rates in these states for years after 1990. Therefore, we use the moving average formula to calculate the tax credit rate for these states before 1990 and the fixed base formula afterwards.

B Estimation Details

Section B.1 describes the target moments and Section B.2 describes how we fit the model to the data.

B.1 Moments

- Output growth: Output is real gross domestic product per capita, from the BEA regional account. To calculate this variable, we obtain GDP and population series from the BEA regional account, and deflate the series using the GDP implicit deflator (BEA account code: A191RD).

- Consumption growth: Consumption is real consumption per capita, sourced from the BEA regional account. To calculate this variable, we obtain the Personal Consumption Expenditures series from the BEA regional account and deflate the series using the Consumption implicit deflator (BEA account code: DPCERD).

- Inflation volatility: The inflation series for each state is constructed as described in Section A.1. We use the volatility of the inflation series as our target moment, as it corresponds to our regression setup.

- Risk-free rate: The risk-free rate during the sample period is obtained from the Fed (1-year US Treasury yield). The nominal interest rate is adjusted by subtracting the corresponding headline inflation rate to obtain the real interest rate. The headline inflation data is sourced from the Bureau of Labor Statistics.

- To examine the correlations between variables X and Y, we adopt a residualization approach whereby both X and Y are residualized with respect to state and year fixed effects, as well as the lagged levels of X and Y. This approach is consistent with the regression specification outlined in the paper. In particular,

  - Inflation and innovation: the correlation is calculated after both innovation and inflation are residualized with respect to fixed effects and their lagged levels.
  - Inflation and inequality growth: the correlation is calculated after both inequality and inflation are residualized with respect to fixed effects and their lagged levels
  - Inflation and output growth: the correlation is calculated after both output and inflation are residualized with respect to fixed effects and their lagged levels
  - Innovation and inequality: columns of KPST in Table A.16. [14]

[14] Our estimated correlation is close to the elasticity estimated in Aghion et al. (2018), since we have followed their specification in estimating this moment.

- Innovation and output: the correlation is calculated after both output and innovation are residualized with respect to fixed effects and their lagged levels

- Pairwise Correlations: The correlation is calculated as the average of all the state-pairs in our sample. The computing horizon is five years.
  - Consumption/Output growth: Constructed from the the BEA regional account as described above. We calculate the correlation using each pair of states and then compute the average.
  - Stock market return: Defined as the return of the value-weighted market portfolio of the vicinity of state i. Data is from CRSP. We calculate the correlation using each pair of states and then compute the average.

B.2 Estimation Procedure

The model has a total of 16 parameters. We set the weight on tradable goods to 0.34, consistent with Hazell et al. (2022). We set the degree of co-integration to 0.1% and the death rate to 0.025. We calibrate the firm's transition probability p, q directly from the data. In particular, each year we sort firms into growth and value categories based on the median book-to-market breakup at the local market (the vicinity) of each state. Then we estimate the transition probability over the sample period across all the states. We set the relative risk aversion $\gamma = 5$, consistent with the asset pricing literature.

We estimate the remaining parameters of the model using a simulated minimum distance method Lee and Ingram (1991). Specifically, given a vector X of target statistics in the data, we obtain parameter estimates by

$$\hat{p} = \arg\min_{p \in \mathcal{P}} \left(X - \frac{1}{S} \sum_{i=1}^{S} \hat{X}_i(p) \right)' W \left(X - \frac{1}{S} \sum_{i=1}^{S} \hat{X}_i(p) \right), \tag{B.1}$$

where $\hat{X}_i(p)$ is the vector of statistics computed in one simulation of the model. Our choice of weighting matrix $W = diag(XX')^{-1} I_W$ penalizes proportional deviations of the model statistics from their empirical counterparts. I_W is a diagonal matrix that adjusts for the relative importance of the statistics in our estimation.

Our estimation targets are reported in the first column of Table 8. They include a combination of first and second moments of aggregate quantities, risk-free rates and inflation. In addition to these standard moments in the literature, we also target a set of correlations at the five-years horizon. The neutral shock and displacement shock have different implications for the correlation between real quantities, innovation and inflation. Thus, the set of correlation between inflation, output and innovation, are informative about the relative magnitude of these two sets of shocks.

In addition, we target the correlation between inequality, innovation and inflation. An important distinction between these two shocks is that displacement shock drives inequality dynamics whereas neutral shock does not. These sets of correlations help determine the size of displacement shocks.

We simulate the model at an annual frequency. For each simulation, we simulate the data for 50 years – roughly the same length as our empirical sample. The simulation starts with the symmetric steady state where $\lambda = 1, Y_T = Y_T^*, Y_{NT} = Y_{NT}^*$. In each iteration we simulate $S = 10000$ samples, and simulate pseudo-random variables using the same seed in each iteration.

We compute standard errors for the vector of parameter estimates $\hat{p}$ as

$$V(\hat{p}) = (1 + \frac{1}{S}) \left(\frac{\partial}{\partial p} \mathcal{X}(p)' W \frac{\partial}{\partial p} \mathcal{X}(p) \right)^{-1} \frac{\partial}{\partial p} \mathcal{X}(p)' W' V_X(\hat{p}) W \frac{\partial}{\partial p} \mathcal{X}(p) \left(\frac{\partial}{\partial p} \mathcal{X}(p)' W \frac{\partial}{\partial p} \mathcal{X}(p) \right)^{-1} \tag{B.2}$$

where

$$V_X(\hat{p}) = \frac{1}{S} \sum_{i=1}^{S} (\hat{X}_i(p) - \mathcal{X}(\hat{p}))(\hat{X}_i(\hat{p}) - \mathcal{X}(\hat{p}))'$$

is the estimate of the sampling variation of the statistics in X computed across simulations. The standard errors calculated in (B.1) are computed using the sampling variation of the target statistics across simulations (B.2).

Solving each iteration of the model is costly, and thus computing the minimum (B.1) using standard methods is infeasible. We therefore use the Radial Basis Function (RBF) algorithm in Björkman and Holmström (2000). The Björkman and Holmström (2000) algorithm first fits a response surface to data by evaluating the objective function at a few points. Then, it searches for a minimum by balancing between local and global search in an iterative fashion. We use a commercial implementation of the RBF algorithm that is available through the TOMLAB optimization package.

C Detailed Model Derivations

In this section, we provide detailed derivations. We begin in Sections C.1 to C.5 by focusing on the log utility case, describing how quantities are aggregated in each region. Next, we calculate the equilibrium allocation across regions and the SDF in each region. We then discuss the specific form of the solution in three cases: when displacement shocks occur only in the non-tradable sector, only in the tradable sector, and the general case where displacement shocks occur in both sectors. Section C.6 provides a micrfoundation for our reduced form assumptions on output. Section C.7 provides derivations for the CRRA case.

C.1 Representative agents

The representative agent in each region

First, we show that it is possible to construct a representative agent within each region. Although agents within each region are heterogeneous in terms of their wealth, their consumption-wealth ratios are equalized due to the homotheticity of their preferences.

Consider the home region. We define the representative agent as

$$U_t = \int_{h\in[0,1]} U_{h,t} w_t^h \tag{C.1}$$

where $U_{h,t}$ and w_t^h denote the utility and the wealth share of household h. That is, the representative agent takes the region-level endowment and the wealth distribution as given and maximizes the wealth-weighted utility.

Because all agents within a region are solving the same optimization problem (up to scaling determined by their wealth), the wealth-weighted representative agent does so as well. Put differently, the representative agent behaves in the same way as any individual agent but is scaled up to a level of wealth equal to the region's total wealth. Thus, solving for the heterogeneous-agent equilibrium within a region is equivalent to finding the optimal solution for the representative agent. Consequently, the equilibrium allocation problem reduces to a problem with two (representative) agents and incomplete markets.

Aggregation

The home's representative agent's utility can be written as

$$U_t = \sum_{s=t}^{\infty} \beta^{s-t} \ln C_s \tag{C.2}$$

With incomplete markets, the usual construction of a planner's utility as a weighted sum, with constant weights, of individual representative utility function is not possible. Instead, we will employ a fictitious planner with stochastic weights maximizing his utility subject to the resource constraints:

$$\begin{aligned}
\max_{\{C_{T,t},C^*_{T,t},C_{NT,t},C^*_{NT,t}\},t=0,1,2,..} \sum_t \beta^t \left(\ln C_t + \lambda_t \ln C_t\right) \\
\text{s.t.} \qquad C_{T,t} + C^*_{T,t} &= Y_{T,t} \\
C_{NT,t} &= Y_{NT,t} \\
C^*_{NT,t} &= Y^*_{NT,t} \\
C_t &= (C_{T,t})^{\alpha}(C_{NT,t})^{1-\alpha} \\
C^*_t &= (C^*_{T,t})^{\alpha}(C^*_{NT,t})^{1-\alpha}
\end{aligned} \tag{C.3}$$

where we have normalized the weight on the home representative agent to be equal to one and assigned the weight λ_t to the foreign representative agent.

C.2 Allocations and inflation

Allocations

For concreteness, consider the home consumer. First, at each t, we derive the consumer's demands for tradable and nontradable goods, keeping overall consumption expenditure $\mathcal{C}_t$ fixed:

$$\max_{\{C_{T,t},C_{NT,t}\}} \alpha \ln C_{T,t} + (1-\alpha) \ln C_{NT,t} \tag{C.4}$$

$$\text{s.t.} \quad C_{T,t} + P_{NT,t} C_{NT,t} = \mathcal{C}_t. \tag{C.5}$$

The problem for the foreign household is defined analogously. Given the above, we obtain the following demands:

$$C_{T,t} = \alpha \mathcal{C}_t, \quad C_{NT,t} = (1-\alpha) \frac{\mathcal{C}_t}{p_{NT,t}} \tag{C.6}$$

$$C^*_{T,t} = \alpha \mathcal{C}^*_t, \quad C^*_{NT,t} = (1-\alpha) \frac{\mathcal{C}^*_t}{P^*_{NT,t}} \tag{C.7}$$

Denote by V_t the utility of the home-region's representative agent. Denoting the partial derivatives with respect to consumption basket by $V_{C,t}$, we obtain

$$\frac{\partial V_t}{\partial C_t} = \frac{1}{C_t}$$

The intertemporal marginal rate of substitution of the representative agent of region c is

$$M_{t,t+1} = \beta \frac{V_{C,t+1}}{V_{C,t}} \tag{C.8}$$

Trade implies that the marginal utility of the tradable good T for $t = 1, 2, ...$ in each possible state is

$$\beta^t V_{C,t} C_t \frac{\alpha}{c_{T,t}} = \frac{\alpha}{c^*_{T,t}} C^*_t V^*_{C,t} \beta^t \tag{C.9}$$

Define the date-t Pareto weights as

$$\begin{aligned} \Lambda_t &= \Lambda_0 \beta^t V_{C,t} C_t \\ &= \Lambda_{t-1} \beta \frac{V_{C,t}}{V_{C,t-1}} \frac{C_t}{C_{t-1}} = \Lambda_{t-1} M_{t-1,t} \exp(\Delta c_t) \end{aligned} \tag{C.10}$$

Since the economy starts with a symmetric setup, $\Lambda_0 = \Lambda_0^*$. We can rewrite (C.9) as

$$\Lambda_t \frac{\alpha}{C_{T,t}} = \frac{\alpha}{C^*_{T,t}} \Lambda^*_t$$

Denote the ratio of Pareto weights by $\lambda_t = \frac{\Lambda^*_t}{\Lambda_t}$. Then the optimality condition can be written as

$$\lambda_t = \frac{C^*_{T,t}}{C_{T,t}} \tag{C.11}$$

Equation (C.11) shows that λ_t is also the ratio of consumption expenditures between the foreign and home regions:

$$\lambda_t = \frac{P^*_{NT,t} C^*_{NT,t}}{P_{NT,t} C_{NT,t}} = \frac{\mathcal{C}^*_t}{\mathcal{C}_t}. \tag{C.12}$$

Also, from (C.10) and the definition of $\lambda_t = \frac{\Lambda^*_t}{\Lambda_t}$, we infer that

$$\lambda_{t+1} = \lambda_t \frac{M^*_{t,t+1} e^{\Delta c^*_{t+1}}}{M_{t,t+1} e^{\Delta c_{t+1}}} \tag{C.13}$$

Substituting the demand functions into the budget constraints, we find the optimal allocations (C.14)-(C.17):

$$C_{T,t} = \frac{1}{1+\lambda_t} \bar{Y}_{T,t} \tag{C.14}$$

$$C^*_{T,t} = \frac{\lambda_t}{1+\lambda_t} \bar{Y}_{T,t} \tag{C.15}$$

$$C_{NT,t} = Y_{NT,t} \tag{C.16}$$

$$C^*_{NT,t} = Y^*_{NT,t} \tag{C.17}$$

where $\bar{Y}_{T,t} = Y_{T,t} + Y^*_{T,t}$ is the total output of tradable goods.

Given the optimal allocations above, we calculate the consumption bundles:

$$C_t = (C_{T,t})^{\alpha} (C_{NT,t})^{1-\alpha} \tag{C.18}$$

$$C^*_t = (C^*_{T,t})^{\alpha} (C^*_{NT,t})^{1-\alpha} \tag{C.19}$$

We also compute the prices of consumption bundles in both regions:

$$P_t = \frac{\mathcal{C}_t}{C_t} = \frac{C_{T,t} + C_{NT,t} P_{NT,t}}{C_t} \tag{C.20}$$

$$P^*_t = \frac{\mathcal{C}^*_t}{C^*_t} = \frac{C^*_{T,t} + C^*_{NT,t} P^*_{NT,t}}{C^*_t} \tag{C.21}$$

The relative price level across two regions is then equal to

$$e_t \equiv \frac{P_t}{P_t^*} = \frac{C_t^*}{C_t}\frac{1}{\lambda_t} \tag{C.22}$$

where the equality follows directly from (C.11). As a result, the growth in relative price levels (relative inflation) is equal to

$$\pi_{t+1} = \Delta c_{t+1}^* - \Delta c_{t+1} - \Delta \ln \lambda_{t+1}. \tag{C.23}$$

SDF

We focus on the home region, the derivation for the foreign region is similar. Because preferences are homothetic, consumption is proportional to wealth. To calculate the SDF of the representative agent, we need to consider two population groups: the population that receives new firms in the current period (with measure ζ, denoted by N); and the population that does not receive new firms in the current period (with measure $1-\zeta$, denoted by O).

Recall that b_{t+1} is the fraction of wealth of agents in the home region excluding the value of new projects created at time $t+1$ at home. The time-$(t+1)$ wealth shares of the two groups of agents within the home region are

$$b_{t+1}(1-\zeta) \text{ and } b_{t+1}\zeta + 1 - b_{t+1}$$

respectively. Accordingly, the consumption growth for group N is $\frac{C_{t+1}}{C_t}b_{t+1}$, and the consumption growth of group O is $\frac{b_{t+1}\zeta+1-b_{t+1}}{\zeta}\frac{C_{t+1}}{C_t}$. The intertemporal marginal rates of substitution of the above two groups of agents can be written as

$$M_{N,t,t+1} = \beta\left(\frac{C_{t+1}}{C_t}b_{t+1}\right)^{-1}$$
$$M_{O,t,t+1} = \beta\left(\frac{b_{t+1}\zeta+1-b_{t+1}}{\zeta}\frac{C_{t+1}}{C_t}\right)^{-1}$$

Note that the time-$t+1$ state used to define the intertemporal marginal rates of substitution above includes the investor type, N or O, which is idiosyncratic and becomes known only at time $t+1$. Because each agent is assigned new projects in proportion to their current wealth level and becoming an innovator in each period is independent of all other shocks in the economy, the equilibrium SDF in this economy (which prices claims contingent on *aggregate* states) can be expressed as the conditional expectation of the inter-temporal marginal rate of substitution of any agent, which is conditioned on the aggregate state at time $t+1$. This equals a weighted average of $M_{N,t,t+1}$ and

$M_{O,t,t+1}$:

$$M_{t,t+1} = (1-\zeta)M_{O,t,t+1} + \zeta M_{N,t,t+1}$$
$$= \beta\left(\frac{C_{t+1}}{C_t}\right)^{-1}\left(\zeta\left(\frac{b_{t+1}\zeta + 1 - b_{t+1}}{\zeta}\right)^{-1} + (1-\zeta)b_{t+1}^{-1}\right)$$

Stock Market

Stock prices of non-tradable firms are equal to

$$S_{NT} = p_{NT,t}Y_{NT,t} + \mathrm{E}_t[M_{t,t+1}^T(S_{NT,t+1}e^{-u_{t+1}})] = p_{NT,t}Y_{NT,t}(pd_{NT,t}) \tag{C.24}$$
$$S_{NT}^* = p_{NT,t}^*Y_{NT,t}^* + \mathrm{E}_t[M_{t,t+1}^T(S_{NT,t+1}^*e^{-u_{t+1}^*})] = p_{NT,t}^*Y_{NT,t}^*(pd_{NT,t}^*) \tag{C.25}$$

Similarly, for tradable firms, their stock prices are equal to

$$S_T = Y_{T,t} + \mathrm{E}_t[M_{t,t+1}^T(S_{T,t+1})] = Y_{T,t}(pd_{T,t}) \tag{C.26}$$
$$S_T^* = Y_{T,t}^* + \mathrm{E}_t[M_{t,t+1}^T(S_{T,t+1}^*)] = Y_{T,t}^*(pd_{T,t}^*) \tag{C.27}$$

where pd_T, pd_{NT} are price-dividend ratios. Hence, the total market value of the tradable (T) sector is

$$\bar{S}_{T,t} = S_T + S_T^*$$

We have normalized the price of tradable goods to be one. The total output of tradable goods is $\bar{Y}_{T,t} = Y_{T,t} + Y_{T,t}^*$. We denote $M_{t,t+1}^T$ as the SDF using the tradable good as a numeraire. Similarly, $M_{t,t+1}^{NT}$ and $M_{t,t+1}^{NT,*}$ are the SDFs using non-tradable goods as numeraire. By definition, they have the following relationship:

$$M_{t,t+1}^T = M_{t,t+1}^{NT}\frac{p_{NT,t}}{p_{NT,t+1}} = M_{t,t+1}^{NT,*}\frac{p_{NT,t}^*}{p_{NT,t+1}^*} = M_{t,t+1}\frac{p_t}{p_{t+1}} \tag{C.28}$$

Consequently,

$$M_{t,t+1}^T = \beta\left(\frac{C_{T,t+1}}{C_{T,t}}\right)^{-1}\left(\zeta\left(\frac{b_{t+1}\zeta + 1 - b_{t+1}}{\zeta}\right)^{-1} + (1-\zeta)b_{t+1}^{-1}\right) \tag{C.29}$$
$$M_{t,t+1}^{NT} = \beta\left(\frac{C_{NT,t+1}}{C_{NT,t}}\right)^{-1}\left(\zeta\left(\frac{b_{t+1}\zeta + 1 - b_{t+1}}{\zeta}\right)^{-1} + (1-\zeta)b_{t+1}^{-1}\right) \tag{C.30}$$
$$M_{t,t+1}^{NT,*} = \beta\left(\frac{C_{NT,t+1}^*}{C_{NT,t}^*}\right)^{-1}\left(\zeta\left(\frac{b_{t+1}^*\zeta + 1 - b_{t+1}^*}{\zeta}\right)^{-1} + (1-\zeta)(b_{t+1}^*)^{-1}\right) \tag{C.31}$$

where p, p_{NT} are the prices of consumption bundles and non-tradable goods, respectively. The wealth shares of non-innovating households (households that do not receive any shares in new projects) are described in the following expressions:

$$b_{t+1} = 1 - \frac{\textit{value of new projects at home region}}{(\bar{S}_{T,t+1} + S_{NT,t+1} + S^*_{NT,t+1})\left(\frac{1}{1+\lambda_{t+1}}\right)} \tag{C.32}$$

$$b^*_{t+1} = 1 - \frac{\textit{value of new projects at foreign region}}{(\bar{S}_{T,t+1} + S_{NT,t+1} + S^*_{NT,t+1})\left(\frac{\lambda_{t+1}}{1+\lambda_{t+1}}\right)} \tag{C.33}$$

To save space and describe the dynamics of SDFs, we define the following quantities:

$$\Omega_{t+1} = \left(\zeta\left(\frac{b_{t+1}\zeta + 1 - b_{t+1}}{\zeta}\right)^{-1} + (1-\zeta)b^{-1}_{t+1}\right) \tag{C.34}$$

$$\Omega^*_{t+1} = \left(\zeta\left(\frac{b^*_{t+1}\zeta + 1 - b^*_{t+1}}{\zeta}\right)^{-1} + (1-\zeta)(b^*_{t+1})^{-1}\right) \tag{C.35}$$

Given the trade of T-goods, the marginal utility of tradable goods needs to be equalized across regions. Therefore, from (C.11), (C.29), (C.34), and (C.35), we have:

$$\Delta \ln \lambda_{t+1} = \ln \Omega^*_{t+1} - \ln \Omega_{t+1} \tag{C.36}$$

C.3 Displacement shocks only in the non-tradable good sector

Case when $\eta = 1$.

Displacement Effects

Recall that the displacement effects are summarized by terms b_t, b^*_t, which are the wealth shares of households that do not receive profitable projects within their respective regions. In this case, these shares are equal to

$$b_{t+1} = 1 - \frac{S_{NT,t+1}(1-e^{-u_{t+1}})}{(S_{T,t+1} + S^*_{T,t+1} + S_{NT,t+1} + S^*_{NT,t+1})\left(\frac{1}{1+\lambda_{t+1}}\right)} \tag{C.37}$$

$$b^*_{t+1} = 1 - \frac{S^*_{NT,t+1}(1-e^{-u^*_{t+1}})}{(S_{T,t+1} + S^*_{T,t+1} + S_{NT,t+1} + S^*_{NT,t+1})\left(\frac{\lambda_{t+1}}{1+\lambda_{t+1}}\right)} \tag{C.38}$$

Recall that tradable firms cater to the national demand, and their price-dividend ratio is

$$\begin{aligned} pd_{T,t} &= 1 + \mathrm{E}_t\left[M^T_{t,t+1}\frac{\bar{Y}_{T,t+1}}{\bar{Y}_{T,t}}pd_{T,t+1}\right] \\ &= 1 + \mathrm{E}_t\left[\beta\left(\frac{\bar{Y}_{T,t+1}\frac{1}{1+\lambda_{t+1}}}{\bar{Y}_{T,t}\frac{1}{1+\lambda_t}}\right)^{-1}\frac{\bar{Y}_{T,t+1}}{\bar{Y}_{T,t}}\Omega_{t+1}pd_{T,t+1}\right] \end{aligned}$$

$$= 1 + \mathrm{E}_t \left[\beta \frac{1 + \lambda_{t+1}}{1 + \lambda_t} \Omega_{t+1} \right] \tag{C.39}$$

and the price-dividend ratio for NT firms is

$$\begin{aligned} pd_{NT,t} &= 1 + \mathrm{E}_t \left[M_{t,t+1}^T \frac{p_{t+1} Y_{NT,t+1}}{p_t Y_{NT,t}} (pd_{NT,t+1}) e^{-u_{t+1}} \right] \\ &= 1 + \mathrm{E}_t \left[M_{t,t+1}^T \frac{\bar{Y}_{T,t+1}}{\bar{Y}_{T,t}} \frac{\frac{1}{1+\lambda_{t+1}}}{\frac{1}{1+\lambda_t}} (pd_{NT,t+1}) e^{-u_{t+1}} \right] \\ &= 1 + \mathrm{E}_t \left[\beta \left(\frac{\bar{Y}_{T,t+1} \frac{1}{1+\lambda_{t+1}}}{\bar{Y}_{T,t} \frac{1}{1+\lambda_t}} \right)^{-1} \frac{\bar{Y}_{T,t+1}}{\bar{Y}_{T,t}} \frac{\frac{1}{1+\lambda_{t+1}}}{\frac{1}{1+\lambda_t}} (pd_{NT,t+1}) e^{-u_{t+1}} \Omega_{t+1} \right] \\ &= 1 + \mathrm{E}_t \left[\beta (pd_{NT,t+1}) e^{-u_{t+1}} \Omega_{t+1} \right]. \end{aligned} \tag{C.40}$$

Similarly, for foreign non-tradable firms,

$$pd_{NT,t}^* = 1 + \mathrm{E}_t \left[\beta (pd_{NT,t+1}^*) e^{-u_{t+1}^*} \Omega_{t+1}^* \right]. \tag{C.41}$$

To obtain a closed-form solution, we conjecture and then subsequently verify that pd_T, pd_{NT}, pd_{NT}^* are constant and we denote them as $C_1 = pd_T$, $C_2 = \frac{1-\alpha}{\alpha} pd_{NT} = \frac{1-\alpha}{\alpha} pd_{NT}^*$. Then

$$b_{t+1} = \frac{C_1 + C_2 e^{-u_{t+1}}}{C_1 + C_2} \tag{C.42}$$

$$b_{t+1}^* = \frac{C_1 + C_2 e^{-u_{t+1}^*}}{C_1 + C_2}. \tag{C.43}$$

As a result, from (C.34) and (C.35), the expectation of $\Omega_{t+1}, \Omega_{t+1}^*$ are also constant. Given that u and u^* are symmetric, we can denote them as

$$\mathrm{E}_t \Omega_{t+1} = \mathrm{E}_t \Omega_{t+1}^* = \chi_0 \tag{C.44}$$

Next, we verify our conjecture that the price-dividend ratios are constant. First, note that

$$\begin{aligned} &\mathrm{E}_t \left[\beta \frac{1 + \lambda_{t+1}}{1 + \lambda_t} \Omega_{t+1} \right] \\ =& \beta \frac{1}{1 + \lambda_t} \mathrm{E}_t \left[(1 + \lambda_t \frac{\Omega_{t+1}^*}{\Omega_{t+1}}) \Omega_{t+1} \right] \\ =& \beta \frac{1}{1 + \lambda_t} \mathrm{E}_t \left[\Omega_{t+1} + \Omega_{t+1}^* \right]. \end{aligned} \tag{C.45}$$

Solving for the price-dividend ratios recursively as

$$pd_T = 1 + \mathrm{E}_t \left[(\beta \frac{1 + \lambda_{t+1}}{1 + \lambda_t} \Omega_{t+1}) + (\beta \frac{1 + \lambda_{t+1}}{1 + \lambda_t} \Omega_{t+1})^2 + \ldots \right]$$

$$= 1 + \frac{\beta\chi_0}{1 - \beta\chi_0}. \tag{C.46}$$

In the above calculation, we use the fact that

$$\frac{1 + \lambda_{t+1}}{1 + \lambda_t}\Omega_{t+1} = \frac{1 + \lambda_t \frac{\Omega^*_{t+1}}{\Omega_{t+1}}}{1 + \lambda_t}\Omega_{t+1} = \frac{\Omega_{t+1} + \lambda_t \Omega^*_{t+1}}{1 + \lambda_t} = \chi_0. \tag{C.47}$$

For the price-dividend ratio in the NT sector

$$\begin{aligned} \mathrm{E}_t\left[\beta\Omega_{t+1}e^{-u_{t+1}}\right] &= \beta\left(\zeta \mathrm{E}_t\left(\frac{b_{t+1}\zeta + 1 - b_{t+1}}{\zeta}\right)^{-1} e^{-u_{t+1}} + (1-\zeta)\mathrm{E}_t\left(b_{t+1}^{-1}e^{-u_{t+1}}\right)\right) \\ &= \beta\chi_1 \end{aligned} \tag{C.48}$$

where χ_1 is a constant, defined as

$$\chi_1 = \left(\zeta \mathrm{E}_t\left(\frac{b_{t+1}\zeta + 1 - b_{t+1}}{\zeta}\right)^{-1} e^{-u_{t+1}} + (1-\zeta)\mathrm{E}_t\left(b_{t+1}^{-1}e^{-u_{t+1}}\right)\right). \tag{C.49}$$

Therefore,

$$pd_{NT} = pd^*_{NT} = 1 + \frac{\beta\chi_1}{1 - \beta\chi_1}. \tag{C.50}$$

Thus, we have verified our conjecture that the price-dividend ratios pd_T and pd_{NT} are constant. Note that for small values of u, b can be approximated as

$$b = \frac{C_1 + C_2 e^{-u}}{C_1 + C_2} \approx \frac{C_1 + C_2 - C_2 u}{C_1 + C_2} = 1 - \frac{C_2}{C_1 + C_2}u. \tag{C.51}$$

As a result, in the limiting case $\zeta \to 0$, the dynamics of λ can be approximated as

$$\begin{aligned} \Delta \ln \lambda_{t+1} &= \ln b - \ln b^* \\ &= \ln \frac{C_1 + C_2 e^{-u}}{C_1 + C_2} - \ln \frac{C_1 + C_2 e^{-u^*}}{C_1 + C_2} \\ &\approx \frac{C_2}{C_1 + C_2}(u^* - u) \\ &= \frac{(1-\alpha)pd_{NT}}{\alpha pd_T + (1-\alpha)pd_{NT}}(u^* - u). \end{aligned} \tag{C.52}$$

Case when $\eta < 1$

In this case, new projects are allocated not only to the inventors but also to the existing firms. Assume there are two types of firms: those that can receive these new projects and those that cannot. The former type trades at a higher valuation multiple in equilibrium, and we denote such firms by H-"growth". We denote the type that can not receive projects as L–"value". Non-tradables firms can transit between these two states according to the following transition probability:

$$\Sigma = \begin{bmatrix} 1-p & p \\ q & 1-q \end{bmatrix}. \tag{C.53}$$

Suppose that the fraction of new projects that go to H type is ω, so the L type get $1-\omega$ of the total $1-\eta$ projects. In our case, $\omega = 1$ and value firms do not receive projects. Among the all the NT firms, a fraction of m_H is the H type, and the remaining fraction $1 - m_H$ is the L type. In the steady state, we have

$$m_H(1-p) + q(1-m_H) = m_H$$
$$pm_H + (1-q)(1-m_H) = 1 - m_H$$

$m_H = \frac{q}{p+q}, 1 - m_H = \frac{p}{p+q}$.

When $\eta < 1$, the wealth share (C.37) and (C.38) become

$$b_{t+1} = 1 - \frac{S_{NT,t+1}(1-e^{-u_{t+1}})\eta}{(\bar{S}_{T,t+1} + S_{NT,t+1} + S^*_{NT,t+1})(\frac{1}{1+\lambda_{t+1}})} \tag{C.54}$$

$$b^*_{t+1} = 1 - \frac{S^*_{NT,t+1}(1-e^{-u^*_{t+1}})\eta}{(\bar{S}_{T,t+1} + S_{NT,t+1} + S^*_{NT,t+1})(\frac{\lambda_{t+1}}{1+\lambda_{t+1}})} \tag{C.55}$$

So we have

$$\begin{aligned} b &= \frac{C_1 + C_2 - C_2\eta(1-e^{-u})}{C_1 + C_2} \\ &\approx \frac{C_1 + C_2 - C_2\eta u}{C_1 + C_2} = 1 - \frac{C_2}{C_1 + C_2}\eta u \end{aligned} \tag{C.56}$$

The valuation of NT trees consists of two parts: asset in place (A) and growth opportunities (G). Asset in place are the same in both types of firms,

$$pd_{NT} = pd^*_{NT} = 1 + \mathrm{E}_t\left[\beta(pd_{NT,t+1})e^{-u_{t+1}}\Omega_{t+1}\right] \tag{C.57}$$

$$= 1 + \frac{\beta\chi_1}{1-\beta\chi_1} \tag{C.58}$$

The value of growth opportunities, expressed as a multiple of dividends, satisfies

$$G_{H,t} = \mathrm{E}_t\Bigg(M^T_{t,t+1}\frac{p_{NT,t+1}Y_{NT,t+1}}{p_{NT,t}Y_{NT,t}}\Bigg[(1-e^{-u_{t+1}})pd_{NT}(1-\eta)(\frac{\omega}{m_H})$$

$$+ ((1-p)G_{H,t+1} + (p)G_{L,t+1})\Big]\Big)$$

$$G_{L,t} = \mathrm{E}_t\Bigg(M^T_{t,t+1}\frac{p_{NT,t+1}Y_{NT,t+1}}{p_{NT,t}Y_{NT,t}}\Bigg[(1-e^{-u_{t+1}})pd_{NT}(1-\eta)(\frac{1-\omega}{1-m_H})$$

$$+ ((q)G_{H,t+1} + (1-q)G_{L,t+1})\Big]\Big)$$

From the expression of marginal utility we know that

$$M^T_{t,t+1} = \beta(\frac{\bar{Y}_{T,t+1}}{\bar{Y}_{T,t}})^{-1}\frac{\Omega_{t+1} + \lambda_t\Omega^*_{t+1}}{(1+\lambda_t)} \tag{C.59}$$

Similarly,

$$\frac{p_{NT,t+1}Y_{NT,t+1}}{p_{NT,t}Y_{NT,t}} = \frac{1+\lambda_t}{1+\lambda_{t+1}}\frac{\bar{Y}_{T,t+1}}{\bar{Y}_{T,t}} \tag{C.60}$$

Substituting the above equations into the valuation of the new projects, one can see that the total value (as a multiple of dividends) of all new projects is equal to

$$\chi_G = \mathrm{E}_t\left[M^T_{t,t+1}\frac{p_{NT,t+1}Y_{NT,t+1}}{p_{NT,t}Y_{NT,t}}(1-e^{-u_{t+1}})\chi_G\right] \tag{C.61}$$

$$= \mathrm{E}_t\beta\Omega_{t+1}(1-e^{-u_{t+1}})\chi_G \tag{C.62}$$

The relative inflation is given by

$$\begin{aligned}\pi_{t+1} &= M_{t,t+1} - M^*_{t,t+1}\\ &= -\Delta c_{t+1} + \Delta c^*_{t+1} + \ln\Omega_{t+1} - \ln\Omega^*_{t+1}\\ &= (1-\alpha)\left(\ln\Omega_{t+1} - \ln\Omega^*_{t+1} - \delta u_{t+1} - \varepsilon_{t+1} + \delta u^*_{t+1} + \varepsilon^*_{t+1}\right)\end{aligned} \tag{C.63}$$

Without displacement effects, relative inflation is purely determined by the change in the relative supply of non-tradable goods, $\delta u^* + \varepsilon^*_{t+1} - \delta u - \varepsilon_{t+1}$. However, displacement effects lead to a reallocation of wealth and consequently alter the demand for non-tradable goods, which is characterized by $\ln\Omega_{t+1} - \ln\Omega^*_{t+1}$. When $\zeta \to 0$, we have

$$\ln\Omega_{t+1} - \ln\Omega^*_{t+1} = (\frac{(1-\alpha)pd_{NT}}{\alpha pd_T + (1-\alpha)pd_{NT}})(u_{t+1} - u^*_{t+1}) \tag{C.64}$$

So

$$\pi_{t+1} = (1-\alpha)\left(\left(\frac{(1-\alpha)pd_{NT}}{\alpha pd_T + (1-\alpha)pd_{NT}} - \delta\right)(u_{t+1} - u^*_{t+1}) + \varepsilon^*_{t+1} - \varepsilon_{t+1}\right). \tag{C.65}$$

C.4 Displacement shocks only in the tradable good sector

Case when $\eta \leq 1$

Most of the equations that describe the equilibrium conditions remain unchanged. They are as follows:

$$pd_{T,t} = 1 + \mathrm{E}_t \left[\beta \frac{1+\lambda_{t+1}}{1+\lambda_t} \Omega_{t+1} \frac{Y_{T,t+1}/\bar{Y}_{T,t+1}}{Y_{T,t}/\bar{Y}_{T,t}} (pd_{T,t+1}) \right] \tag{C.66}$$

$$pd^*_{T,t} = 1 + \mathrm{E}_t \left[\beta \frac{1+\lambda_{t+1}}{1+\lambda_t} \Omega_{t+1} \frac{Y^*_{T,t+1}/\bar{Y}_{T,t+1}}{Y^*_{T,t}/\bar{Y}_{T,t}} (pd^*_{T,t+1}) \right] \tag{C.67}$$

$$pd_{NT,t} = 1 + \mathrm{E}_t \left[\beta (pd_{NT,t+1}) \Omega_{t+1} \right] \tag{C.68}$$

$$pd^*_{NT,t} = 1 + \mathrm{E}_t \left[\beta (pd^*_{NT,t+1}) \Omega_{t+1} \right] \tag{C.69}$$

$$b_{t+1} = 1 - \frac{\frac{Y_{T,t+1}}{\bar{Y}_{T,t+1}} (pd_{T,t+1})(1 - e^{-u_{t+1}})\eta}{\left(\widetilde{pd}_{T,t+1} + \frac{1-\alpha}{\alpha} (\widetilde{pd}_{NT,t+1}) \right) (\frac{1}{1+\lambda_{t+1}})} \tag{C.70}$$

$$b^*_{t+1} = 1 - \frac{\frac{Y^*_{T,t+1}}{\bar{Y}_{T,t+1}} (pd^*_{T,t+1})(1 - e^{-u^*_{t+1}})\eta}{\left(\widetilde{pd}_{T,t+1} + \frac{1-\alpha}{\alpha} (\widetilde{pd}_{NT,t+1}) \right) (\frac{\lambda_{t+1}}{1+\lambda_{t+1}})} \tag{C.71}$$

$$\Omega_{t+1} = \left(\zeta \left(\frac{b_{t+1}\zeta + 1 - b_{t+1}}{\zeta} \right)^{-1} + (1-\zeta) b_{t+1}^{-1} \right) \tag{C.72}$$

$$\Omega^*_{t+1} = \left(\zeta \left(\frac{b^*_{t+1}\zeta + 1 - b^*_{t+1}}{\zeta} \right)^{-1} + (1-\zeta) (b^*_{t+1})^{-1} \right) \tag{C.73}$$

$$\Delta \ln \lambda_{t+1} = \ln \Omega^*_{t+1} - \ln \Omega_{t+1} \tag{C.74}$$

where

$$\widetilde{pd}_{T,t+1} = \frac{Y_{T,t+1}}{\bar{Y}_{T,t+1}} pd_{T,t+1} + \frac{Y^*_{T,t+1}}{\bar{Y}_{T,t+1}} pd^*_{T,t+1} \tag{C.75}$$

$$\widetilde{pd}_{NT,t+1} = \frac{1}{1+\lambda_{t+1}} pd_{NT,t+1} + \frac{\lambda_{t+1}}{1+\lambda_{t+1}} pd^*_{NT,t+1}. \tag{C.76}$$

When $\zeta \to 0$ and u shocks are small, around the symmetric steady state, we have the following approximation:

$$\Delta \ln \lambda_{t+1} \approx \ln b_{t+1} - \ln b^*_{t+1} \tag{C.77}$$

$$\approx \frac{\alpha pd_{T,s}}{\alpha pd_{T,s} + (1-\alpha)pd_{NT,s}}(u_{t+1} - u^*_{t+1}), \tag{C.78}$$

where $pd_{T,s}, pd_{NT,s}$ are the price-dividend ratio at the steady states for T and NT firms. The value of growth opportunities, expressed as a multiple of dividends, satisfies

$$G_{H,t} = \mathrm{E}_t\left(M^T_{t,t+1}\frac{Y_{T,t+1}}{Y_{T,t}}\left[(1-e^{-u_{t+1}})pd_{t+1}(1-\eta)(\frac{\omega}{m_H}) + ((1-p)G_{H,t+1} + (p)G_{L,t+1})\right]\right) \tag{C.79}$$

$$G_{L,t} = \mathrm{E}_t\left(M^T_{t,t+1}\frac{Y_{T,t+1}}{Y_{T,t}}\left[(1-e^{-u_{t+1}})pd_{t+1}(1-\eta)(\frac{1-\omega}{1-m_H}) + ((q)G_{H,t+1} + (1-q)G_{L,t+1})\right]\right) \tag{C.80}$$

where

$$\begin{aligned} M^T_{t,t+1} &= \beta\left(\frac{C_{T,t+1}}{C_{T,t}}\right)^{-1}\left(\zeta\left(\frac{b_{t+1}\zeta + 1 - b_{t+1}}{\zeta}\right)^{-1} + (1-\zeta)b^{-1}_{t+1}\right) \\ &= \beta(\frac{\bar{Y}_{T,t+1}}{\bar{Y}_{T,t}})^{-1}\frac{1+\lambda_{t+1}}{1+\lambda_t}\Omega_{t+1} \end{aligned} \tag{C.81}$$

The relative inflation is given by

$$\begin{aligned} \pi_{t+1} &= -\Delta c_{t+1} + \Delta c^*_{t+1} + \ln\Omega_{t+1} - \ln\Omega^*_{t+1} \\ &= (1-\alpha)\left(\varepsilon^*_{NT,t+1} - \varepsilon_{NT,t+1} + \ln\Omega_{t+1} - \ln\Omega^*_{t+1}\right) \\ &\approx (1-\alpha)\left(\frac{\alpha pd_{T,s}}{\alpha pd_{T,s} + (1-\alpha)pd_{NT,s}}(u_{t+1} - u^*_{t+1}) + \varepsilon^*_{NT,t+1} - \varepsilon_{NT,t+1}\right). \end{aligned} \tag{C.82}$$

Without displacement effects, the relative inflation is purely determined by the change in the relative supply of non-tradable goods, $\varepsilon^*_{NT,t+1} - \varepsilon_{NT,t+1}$. However, displacement effects lead to a reallocation of wealth and consequently alter the demand for non-tradable goods, which is characterized by $\ln\Omega_{t+1} - \ln\Omega^*_{t+1}$.

A positive u shock at home would always lead to a larger displacement effect at home—smaller b (the wealth share of non-innovators), larger Ω—and an increase in the relative price of home goods. The intuition is straightforward: the displacement T shock reallocates wealth to the home but does not increase the supply of non-tradables, hence the price of non-tradables increases. Therefore, a positive T displacement shock always increases local price levels.

C.5 Displacement shocks in both sectors

Case when $\eta \leq 1$.

The equilibrium conditions become:

$$pd_{T,t} = 1 + \mathrm{E}_t\left[\beta \frac{1+\lambda_{t+1}}{1+\lambda_t}\Omega_{t+1}\frac{Y_{T,t+1}/\bar{Y}_{T,t+1}}{Y_{T,t}/\bar{Y}_{T,t}}(pd_{T,t+1})e^{-u_{T,t+1}}\right] \tag{C.83}$$

$$pd_{NT,t} = 1 + \mathrm{E}_t\left[\beta(pd_{NT,t+1})\Omega_{t+1}e^{-u_{NT,t+1}}\right] \tag{C.84}$$

$$b_{t+1} = 1 - \frac{\frac{Y_{T,t+1}}{\bar{Y}_{T,t+1}}\eta\left((pd_{T,t+1})(1-e^{-u_{T,t+1}})\right) + \frac{1-\alpha}{\alpha}pd_{NT}\frac{1}{1+\lambda_{t+1}}\eta\left(1-e^{-u_{NT,t+1}}\right)}{\left(\widetilde{pd}_{T,t+1} + \frac{1-\alpha}{\alpha}\widetilde{pd}_{NT,t+1}\right)(\frac{1}{1+\lambda_{t+1}})} \tag{C.85}$$

$$b^*_{t+1} = 1 - \frac{\frac{Y^*_{T,t+1}}{\bar{Y}_{T,t+1}}\eta(pd^*_{T,t+1})(1-e^{-u^*_{T,t+1}}) + \frac{1-\alpha}{\alpha}\frac{\lambda_{t+1}}{1+\lambda_{t+1}}\eta(pd^*_{NT})(1-e^{-u^*_{NT,t+1}})}{\left(\widetilde{pd}_{T,t+1} + \frac{1-\alpha}{\alpha}\widetilde{pd}_{NT,t+1}\right)(\frac{\lambda_{t+1}}{1+\lambda_{t+1}})} \tag{C.86}$$

$$\Omega_{t+1} = \left(\zeta\left(\frac{b_{t+1}\zeta + 1 - b_{t+1}}{\zeta}\right)^{-1} + (1-\zeta)b_{t+1}^{-1}\right) \tag{C.87}$$

$$\Omega^*_{t+1} = \left(\zeta\left(\frac{b^*_{t+1}\zeta + 1 - b^*_{t+1}}{\zeta}\right)^{-1} + (1-\zeta)(b^*_{t+1})^{-1}\right) \tag{C.88}$$

$$\Delta \ln \lambda_{t+1} = \ln \Omega^*_{t+1} - \ln \Omega_{t+1} \tag{C.89}$$

where

$$\widetilde{pd}_{T,t+1} = \frac{Y_{T,t+1}}{\bar{Y}_{T,t+1}}pd_{T,t+1} + \frac{Y^*_{T,t+1}}{\bar{Y}_{T,t+1}}pd^*_{T,t+1} \tag{C.90}$$

$$\widetilde{pd}_{NT,t+1} = \frac{1}{1+\lambda_{t+1}}pd_{NT,t+1} + \frac{\lambda_{t+1}}{1+\lambda_{t+1}}pd^*_{NT,t+1}. \tag{C.91}$$

When $\zeta \to 0$ and u shocks are small, around the symmetric steady state, we obtain:

$$\Delta \ln \lambda_{t+1} \approx \ln b_{t+1} - \ln b^*_{t+1} \approx (u_{t+1} - u^*_{t+1}), \tag{C.92}$$

where we use the approximation that around the symmetric steady state $Y_T \approx Y^*_T$, $u_T = u_{NT}$ and $\lambda \approx 1$. The relative inflation is equal to

$$\begin{aligned}\pi_{t+1} &= M_{t,t+1} - M^*_{t,t+1} \\ &= -\Delta c_{t+1} + \Delta c^*_{t+1} + \ln \Omega_{t+1} - \ln \Omega^*_{t+1}\end{aligned}$$

$$
\begin{aligned}
&= (1-\alpha)(\Delta Y^*_{NT,t+1} - \Delta Y_{NT,t+1} + \ln \Omega_{t+1} - \ln \Omega^*_{t+1}) \\
&= (1-\alpha)\left(\varepsilon^*_{t+1} - \varepsilon_{NT,t+1} + \delta(u^*_{t+1} - u_{NT,t+1}) + \ln \Omega_{t+1} - \ln \Omega^*_{t+1}\right) \\
&\approx (1-\alpha)\left((1-\delta)\left(u_{t+1} - u^*_{t+1}\right) + \varepsilon^*_{NT,t+1} - \varepsilon_{NT,t+1}\right). \qquad \text{(C.93)}
\end{aligned}
$$

Without displacement effects, relative inflation is purely determined by the change in the relative supply of non-tradable goods, $\varepsilon^*_{NT,t+1} - \varepsilon_{NT,t+1} + \delta(u^*_{t+1} - u_{t+1})$. However, displacement effects lead to a reallocation of wealth and consequently alter the demand for non-tradable goods, which is characterized by $\ln \Omega_{t+1} - \ln \Omega^*_{t+1}$.

Examining equilibrium conditions, a positive u_T shock at home would lead to a larger displacement effect at home—smaller b (the wealth share of non-innovators), larger Ω—and an increase in the relative price of home goods. A positive u_{NT} shock would lead to the same result. The relative magnitude of these two shocks is determined by the valuation of these firms and the relative variance of these shocks.

C.6 Detailed Microfoundation

We present a two-region, two-sector micro-foundation in which Schumpeterian creative destruction takes place. Labor is freely mobile across the country. Firms use labor and land to produce output. Land input is locally supplied and used in both sectors. The micro-foundation aims to provide an environment in which innovation shocks

1. Increase total output
2. Reallocate resources from incumbents to new entrants

To simplify the exposition, we assume that creative destruction only occurs in the non-tradeable sector. The more general case in which creative destruction occurs in both sectors leads to similar insights at the cost of some additional analytic complexity.

Setup: Aggregation, Production, and Factor Inputs

Output in each region $c \in \{H, F\}$ is produced in two sectors $S \in \{T, NT\}$. Final goods in each sector are CES aggregates of a continuum of varieties indexed by $j \in [0, 1]$. Each variety is produced by a monopolist who faces CES demand and sets prices accordingly.

Final Goods. Non-tradable output is aggregated locally:

$$
Y^c_{NT,t} = \left(\int_0^1 x^c_{NT,t}(j)^{\frac{\sigma-1}{\sigma}}\, dj\right)^{\frac{\sigma}{\sigma-1}}, \quad \sigma > 1. \qquad \text{(C.94)}
$$

Tradable goods are aggregated at the national level:

$$Y_{T,t} = \left(\int_0^1 x_{T,t}(j)^{\frac{\sigma-1}{\sigma}} \, dj \right)^{\frac{\sigma}{\sigma-1}}, \quad \sigma > 1, \tag{C.95}$$

where total output of each tradable variety is the sum of quantities produced in both regions:

$$x_{T,t}(j) = x^H_{T,t}(j) + x^F_{T,t}(j). \tag{C.96}$$

Production Technology. Each intermediate good $x^c_{S,t}(j)$ is produced using Cobb–Douglas technology with local land and labor:

$$x^c_{T,t}(j) = Z^c_{T,t} A^c_{T,t}(j) \left(K^c_{T,t}(j)\right)^\theta \left(L^c_{T,t}(j)\right)^{1-\theta}, \tag{C.97}$$

$$x^c_{NT,t}(j) = Z^c_{NT,t} A^c_{NT,t}(j) \left(K^c_{NT,t}(j)\right)^\theta \left(L^c_{NT,t}(j)\right)^{1-\theta}, \tag{C.98}$$

where $\theta \in (0, 1)$ is the land share in both sectors, and $A^c_{S,t}(j)$ captures variety-level productivity.

Exogenous productivity enters at two levels:

- Sector-region-wide productivity shifters $Z^c_{S,t}$ follow:

$$\Delta \ln Z^c_{S,t} = \mu + \varepsilon^c_{S,t}, \tag{C.99}$$

  where $\varepsilon^c_{S,t}$ is a region-sector-specific shock.

- Variety-specific productivity $A^c_{S,t}(j)$ evolves through innovation shocks, as described in later sections.

Factor Inputs and Market Clearing.

- **Land:** Land is specific to each region and fixed in supply at $\bar{K}^c$. Let R^c_t be the land rental price in region c. Land is used in both sectors and must satisfy:

$$\sum_{S \in \{T,NT\}} \int_0^1 K^c_{S,t}(j) \, dj = \bar{K}^c. \tag{C.100}$$

- **Labor:** Labor is mobile across regions and sectors, earning a common wage w_t. The total labor endowment L_t is allocated across all varieties and regions:

$$\sum_{c \in \{H,F\}} \sum_{S \in \{T,NT\}} \int_0^1 L^c_{S,t}(j) \, dj = L_t. \tag{C.101}$$

Production and Cost Minimization

Each monopolist minimizes costs and charges a markup over marginal cost.

Tradable Sector. Marginal cost is:

$$MC^c_{T,t}(j) = \frac{1}{Z^c_{T,t}A^c_{T,t}(j)}(R^c_t)^\theta w_t^{1-\theta}\theta^{-\theta}(1-\theta)^{-(1-\theta)}. \tag{C.102}$$

The firm sets:

$$p^c_{T,t}(j) = \kappa\frac{(R^c_t)^\theta w_t^{1-\theta}}{Z^c_{T,t}A^c_{T,t}(j)}, \tag{C.103}$$

with $\kappa = \frac{\sigma}{\sigma-1}\theta^{-\theta}(1-\theta)^{-(1-\theta)}$.

Bertrand competition implies:

$$p_{T,t}(j) = \min_{c\in\{H,F\}}\left\{p^c_{T,t}(j)\right\}. \tag{C.104}$$

Define:

$$\widehat{A}_{T,t}(j) = \max_{c\in\{H,F\}}\left\{\frac{Z^c_{T,t}A^c_{T,t}(j)}{(R^c_t)^\theta}\right\}, \tag{C.105}$$

so that:

$$P_{T,t} = \left(\int_0^1\left[\kappa w_t^{1-\theta}/\widehat{A}_{T,t}(j)\right]^{1-\sigma}dj\right)^{\frac{1}{1-\sigma}}, \tag{C.106}$$

$$\widetilde{A}_{T,t} = \left(\int_0^1\widehat{A}_{T,t}(j)^{\sigma-1}dj\right)^{\frac{1}{\sigma-1}}, \tag{C.107}$$

$$P_{T,t} = \kappa w_t^{1-\theta}\widetilde{A}_{T,t}^{-1}. \tag{C.108}$$

Non-tradable Sector. Marginal cost:

$$MC^c_{NT,t}(j) = \frac{1}{Z^c_{NT,t}A^c_{NT,t}(j)}(R^c_t)^\theta w_t^{1-\theta}\theta^{-\theta}(1-\theta)^{-(1-\theta)}. \tag{C.109}$$

Price and index:

$$p^c_{NT,t}(j) = \kappa\frac{(R^c_t)^\theta w_t^{1-\theta}}{Z^c_{NT,t}A^c_{NT,t}(j)}, \tag{C.110}$$

$$P^c_{NT,t} = \left(\int_0^1\left[\kappa(R^c_t)^\theta w_t^{1-\theta}/(Z^c_{NT,t}A^c_{NT,t}(j))\right]^{1-\sigma}dj\right)^{\frac{1}{1-\sigma}}, \tag{C.111}$$

$$\widetilde{A}^c_{NT,t} = \left(\int_0^1(Z^c_{NT,t}A^c_{NT,t}(j))^{\sigma-1}dj\right)^{\frac{1}{\sigma-1}}, \tag{C.112}$$

$$P^c_{NT,t} = \kappa(R^c_t)^\theta w_t^{1-\theta}(\widetilde{A}^c_{NT,t})^{-1}. \tag{C.113}$$

Displacement and Aggregate Productivity

At the beginning of each period $t+1$, a displacement (or innovation) shock $u^c_{NT,t+1}$ is realized in region c. This shock raises the probability that each product line in the non-tradable sector is challenged by a new entrant:

$$m^c_{NT,t+1} = 1 - e^{-u^c_{NT,t+1}}, \qquad \text{with } 0 < m^c_{NT,t+1} < 1. \tag{C.114}$$

If an entrant arrives at line j, it competes with the incumbent under Bertrand pricing. The entrant operates with a productivity advantage: it can produce at productivity $e^{\delta} A^c_{NT,t}(j)$, where $\delta > 0$ and $A^c_{NT,t}(j)$ is the incumbent's productivity. As a result, the entrant undercuts the incumbent and takes over the product line. Thus, productivity at line j in region c evolves as:

$$A^c_{NT,t+1}(j) = \begin{cases} e^{\delta} A^c_{NT,t}(j), & \text{with probability } m^c_{NT,t+1}, \\ A^c_{NT,t}(j), & \text{with probability } 1 - m^c_{NT,t+1}. \end{cases} \tag{C.115}$$

A fraction $m^c_{NT,t+1}$ of incumbents are therefore displaced and replaced by more productive entrants. In each displaced line, the old firm's profits fall to zero, and the entrant captures the full profit stream.

Aggregate Productivity and Output We define the effective productivity in region c as the CES aggregator:

$$\widetilde{A}^c_{NT,t} = Z^c_{NT,t} \left(\int_0^1 A^c_{NT,t}(j)^{\sigma-1} dj \right)^{1/(\sigma-1)}. \tag{C.116}$$

Using the updating rule and noting that displacement occurs independently across product lines, the evolution of aggregate productivity is:

$$\begin{aligned} (\widetilde{A}^c_{NT,t+1})^{\sigma-1} &= (Z^c_{NT,t+1})^{\sigma-1} \left[(1 - m^c_{NT,t+1}) + m^c_{NT,t+1} e^{\delta(\sigma-1)} \right] (\widetilde{A}^c_{NT,t}/Z^c_{NT,t})^{\sigma-1}, \\ \widetilde{A}^c_{NT,t+1} &= \widetilde{A}^c_{NT,t} \left(\frac{Z^c_{NT,t+1}}{Z^c_{NT,t}} \right) \left[(1 - m^c_{NT,t+1}) + m^c_{NT,t+1} e^{\delta(\sigma-1)} \right]^{1/(\sigma-1)}. \end{aligned}$$

Taking logs and linearizing for small $u^c_{NT,t+1}$ and $\Delta \ln Z^c_{NT,t+1}$ yields:

$$\Delta \ln \widetilde{A}^c_{NT,t+1} \approx \mu + \varepsilon^c_{NT,t+1} + \delta u^c_{NT,t+1}, \tag{C.117}$$

where μ is the drift term and $\varepsilon^c_{NT,t+1}$ is a productivity shock.

Summary. This setup captures how a displacement shock $u^c_{NT,t+1}$ can simultaneously:

1. Increase aggregate productivity in region c by δ for the fraction $m^c_{NT,t+1}$ of replaced varieties.

2. Reallocate profits from displaced incumbents to new entrants.

- **Creative destruction:** A fraction $m^c_{NT,t+1}$ of varieties in the non-tradable sector is displaced each period, representing Schumpeterian creative destruction. New, more productive firms replace old incumbents.
- **Reallocation:** Ownership of displaced product lines switches to new entrants. Incumbents lose the revenue from those lines; new entrepreneurs gain it.
- **Unspanned risk:** If households cannot insure ex ante over "who will be the successful innovator," markets are incomplete. This introduces idiosyncratic risk over who gains or loses from each period's displacement.

C.7 Allowing for CRRA utility

In this section, we derive the solution for CRRA utility. We follow the sequence outlined in the previous section on log utility. The aggregation result still applies because it relies solely on the homotheticity of preferences. The sections on allocations (Section C.7), the SDF (Section C.7), and stock markets (Section C.7) closely resemble those with log utility. The key difference, as derived in Section C.7, is that the consumption-wealth ratio is no longer constant.

Allocations and inflation

Allocations First, at each t, we derive the consumer's demands for tradable and nontradable goods, keeping overall consumption expenditure $\mathcal{C}_t$ fixed.

$$\max_{\{C_{T,t},C_{NT,t}\}} C_{T,t}^{\alpha} C_{NT,t}^{1-\alpha} \tag{C.118}$$

$$\text{s.t.} \quad C_{T,t} + P_{NT,t}\, C_{NT,t} = \mathcal{C}_t. \tag{C.119}$$

The problem for the foreign household is defined analogously. Given the above, we obtain the following demands

$$C_{T,t} = \alpha\, \mathcal{C}_t, \quad C_{NT,t} = (1-\alpha)\, \frac{\mathcal{C}_t}{p_{NT,t}} \tag{C.120}$$

$$C^*_{T,t} = \alpha\, \mathcal{C}^*_t, \quad C^*_{NT,t} = (1-\alpha)\, \frac{\mathcal{C}^*_t}{P^*_{NT,t}} \tag{C.121}$$

Dynamics of the consumption ratio Let V_t denote the utility of the representative agent in the home region. Denote the partial derivative of V_t with respect to the consumption basket by $V_{C,t}$, which is given by

$$\frac{\partial V_t}{\partial C_t} = \frac{1}{C_t^{\gamma}}.$$

The intertemporal marginal rate of substitution for the representative agent in region c is then

$$M_{t,t+1} = \beta \frac{V_{C,t+1}}{V_{C,t}} \frac{C_{c,t+1}}{C_{c,t}}. \tag{C.122}$$

Trade implies that the marginal utilities of tradable good T for $t = 1, 2, ...$ in each possible state is

$$\beta^t V_{C,t} \psi \frac{\bar{C}}{C_t} C_t \frac{\alpha}{c_{T,t}} = \frac{\alpha}{c^*_{T,t}} \psi \frac{\bar{C}^*}{C^*_t} C^*_t V^*_{C,t} \beta^t \tag{C.123}$$

Define the Pareto weights at period t as

$$\begin{aligned} \Lambda_t &= \Lambda_0 \beta^t V_{C,t} \bar{C}_t \\ &= \Lambda_{t-1} \beta \frac{V_{C,t}}{V_{C,t-1}} \frac{\bar{C}_t}{\bar{C}_{t-1}} = \Lambda_{t-1} M_{t-1,t} \exp(\Delta \bar{c}_t) \end{aligned} \tag{C.124}$$

Since the economy starts with a symmetric setup $\Lambda_0 = \Lambda^*_0$. We can rewrite (C.123) as

$$\Lambda_t \frac{\alpha}{C_{T,t}} = \frac{\alpha}{C^*_{T,t}} \Lambda^*_t$$

Define $\lambda_t = \frac{\Lambda^*_t}{\Lambda_t}$ as the ratio of Pareto weights. The optimality condition can be written as

$$\lambda_t = \frac{C^*_{T,t}}{C_{T,t}} \tag{C.125}$$

Similar to the log utility case, note that with Cobb-Douglas preferences over different goods, households' consumption expenditure shares for each good are fixed. Therefore, (C.125) shows that λ_t is also the ratio of consumption expenditures between foreign and home regions:

$$\lambda_t = \frac{P^*_{NT,t} C^*_{NT,t}}{P_{NT,t} C_{NT,t}} = \frac{\mathcal{C}^*_t}{\mathcal{C}_t}. \tag{C.126}$$

Additionally, from the definition of $\lambda_t = \frac{\Lambda^*_t}{\Lambda_t}$, we have

$$\lambda_{t+1} = \lambda_t \frac{M^*_{t,t+1} e^{\Delta c^*_{t+1}}}{M_{t,t+1} e^{\Delta c_{t+1}}}. \tag{C.127}$$

Substituting the demand functions into the budget constraints, we obtain the allocations:

$$C_{T,t} = \frac{1}{1 + \lambda_t} \bar{Y}_{T,t}, \tag{C.128}$$

$$C^*_{T,t} = \frac{\lambda_t}{1 + \lambda_t} \bar{Y}_{T,t}, \tag{C.129}$$

$$C_{NT,t} = Y_{NT,t}, \tag{C.130}$$

$$C^*_{NT,t} = Y^*_{NT,t}, \tag{C.131}$$

where $\bar{Y}_{T,t} = Y_{T,t} + Y^*_{T,t}$ is the total output of tradable goods.

Given the above allocations, we calculate the consumption bundles:

$$C_t = (C_{T,t})^\alpha (C_{NT,t})^{1-\alpha} \tag{C.132}$$

$$C^*_t = (C^*_{T,t})^\alpha (C^*_{NT,t})^{1-\alpha} \tag{C.133}$$

We also compute the price of consumption bundles in home and foreign regions:

$$P_t = \frac{\mathcal{C}_t}{C_t} = \frac{C_{T,t} + C_{NT,t}\, P_{NT,t}}{C_t} \tag{C.134}$$

$$P^*_t = \frac{\mathcal{C}^*_t}{C^*_t} = \frac{C^*_{T,t} + C^*_{NT,t}\, P^*_{NT,t}}{C^*_t} \tag{C.135}$$

The relative price level across the two regions is then equal to

$$e_t \equiv \frac{P_t}{P^*_t} = \frac{C^*_t}{C_t}\frac{1}{\lambda_t} \tag{C.136}$$

where the equality follows directly from (C.125). As a result, the growth in relative price levels (relative inflation) is equal to

$$\pi_{t+1} = \Delta c^*_{t+1} - \Delta c_{t+1} - \Delta \ln \lambda_{t+1}. \tag{C.137}$$

SDF

We follow the same argument in the log utility case and consider two population groups: the population that receives the new firms in the current period (with measure ζ, denoted as N); and the population that does not receive the new firms in the current period (with measure $1-\zeta$, denoted as O).

The SDF of these two groups can be written as

$$M_{O,t,t+1} = \beta(\frac{C_{t+1}}{C_t} b_{t+1})^{-\gamma}$$

$$M_{N,t,t+1} = \beta(\frac{b_{t+1}\zeta + 1 - b_{t+1}}{\zeta}\frac{C_{t+1}}{C_t})^{-\gamma}$$

In this economy, the conditional expectation of investors' inter-temporal marginal rates of substitution is a valid stochastic discount factor. That is,

$$M_{t,t+1} = (1-\zeta)M_{O,t,t+1} + \zeta M_{N,t,t+1}$$

$$= \beta \left(\frac{C_{t+1}}{C_t} \right)^{-\gamma} \left(\zeta \left(\frac{b_{t+1}\zeta + 1 - b_{t+1}}{\zeta} \right)^{-\gamma} + (1-\zeta) b_{t+1}^{-\gamma} \right)$$

Stock Market

The value of non-tradable firms and tradable firms are equal to

$$S_{NT} = p_{NT,t} Y_{NT,t} + \mathrm{E}_t[M^T_{t,t+1}(S_{NT,t+1} e^{-u_{t+1}})] = p_{NT,t} Y_{NT,t}(pd_{NT,t}) \tag{C.138}$$

$$S^*_{NT} = p^*_{NT,t} Y^*_{NT,t} + \mathrm{E}_t[M^T_{t,t+1}(S^*_{NT,t+1} e^{-u^*_{t+1}})] = p^*_{NT,t} Y^*_{NT,t}(pd^*_{NT,t}) \tag{C.139}$$

$$S_T = Y_{T,t} + \mathrm{E}_t[M^T_{t,t+1}(S_{T,t+1})] = Y_{T,t}(pd_{T,t}) \tag{C.140}$$

$$S^*_T = Y^*_{T,t} + \mathrm{E}_t[M^T_{t,t+1}(S^*_{T,t+1})] = Y^*_{T,t}(pd^*_{T,t}) \tag{C.141}$$

And the total value of T sector is equal to

$$\bar{S}_{T,t} = S_T + S^*_T$$

We have normalized the price of tradable goods to be one. The total output of tradable goods is $\bar{Y}_{T,t} = Y_{T,t} + Y^*_{T,t}$. We denote $M^T_{t,t+1}$ as the SDF using the tradable good as a numeraire. Similarly, $M^{NT}_{t,t+1}$ and $M^{NT,*}_{t,t+1}$ are the SDFs using non-tradable goods as numeraire. By definition, they have the following relationship:

$$M^T_{t,t+1} = M^{NT}_{t,t+1} \frac{p_{NT,t}}{p_{NT,t+1}} = M^{NT,*}_{t,t+1} \frac{p^*_{NT,t}}{p^*_{NT,t+1}} = M_{t,t+1} \frac{p_t}{p_{t+1}} \tag{C.142}$$

and

$$M^T_{t,t+1} = \beta \left(\frac{C_{t+1}}{C_t} \right)^{1-\gamma} \left(\frac{C_{T,t+1}}{C_{T,t}} \right)^{-1} \left(\zeta \left(\frac{b_{t+1}\zeta + 1 - b_{t+1}}{\zeta} \right)^{-\gamma} + (1-\zeta) b_{t+1}^{-\gamma} \right) \tag{C.143}$$

$$M^{T,*}_{t,t+1} = \beta \left(\frac{C^*_{t+1}}{C^*_t} \right)^{1-\gamma} \left(\frac{C^*_{T,t+1}}{C^*_{T,t}} \right)^{-1} \left(\zeta \left(\frac{b^*_{t+1}\zeta + 1 - b^*_{t+1}}{\zeta} \right)^{-\gamma} + (1-\zeta) (b^*_{t+1})^{-\gamma} \right) \tag{C.144}$$

$$M^{NT}_{t,t+1} = \beta \left(\frac{C_{t+1}}{C_t} \right)^{1-\gamma} \left(\frac{C_{NT,t+1}}{C_{NT,t}} \right)^{-1} \left(\zeta \left(\frac{b_{t+1}\zeta + 1 - b_{t+1}}{\zeta} \right)^{-\gamma} + (1-\zeta) b_{t+1}^{-\gamma} \right) \tag{C.145}$$

$$M^{NT,*}_{t,t+1} = \beta \left(\frac{C^*_{t+1}}{C^*_t} \right)^{1-\gamma} \left(\frac{C^*_{NT,t+1}}{C^*_{NT,t}} \right)^{-1} \left(\zeta \left(\frac{b^*_{t+1}\zeta + 1 - b^*_{t+1}}{\zeta} \right)^{-\gamma} + (1-\zeta) (b^*_{t+1})^{-\gamma} \right) \tag{C.146}$$

where p, p_{NT} are the prices of consumption bundles and nontradable goods, respectively. The wealth share of non-innovators is equal to

$$b_{t+1} = 1 - \frac{\textit{new projects at home}}{(\bar{S}_{T,t+1} + S_{NT,t+1} + S^*_{NT,t+1})(\frac{1}{1+w_{t+1}})} \tag{C.147}$$

$$b^*_{t+1} = 1 - \frac{new\ projects\ at\ foreign}{(\bar{S}_{T,t+1} + S_{NT,t+1} + S^*_{NT,t+1})(\frac{w_{t+1}}{1+w_{t+1}})} \tag{C.148}$$

We define the following quantities as in the log utility case:

$$\Omega_{t+1} = \left(\pi\left(\frac{b_{t+1}\pi + 1 - b_{t+1}}{\pi}\right)^{-\gamma} + (1-\pi)b_{t+1}^{-\gamma}\right) \tag{C.149}$$

$$\Omega^*_{t+1} = \left(\pi\left(\frac{b^*_{t+1}\pi + 1 - b^*_{t+1}}{\pi}\right)^{-\gamma} + (1-\pi)(b^*_{t+1})^{-\gamma}\right) \tag{C.150}$$

From the equalization of marginal utility of tradable goods, we obtain

$$\begin{aligned} 0 &= \ln \Omega^*_{t+1} - \ln \Omega_{t+1} - \Delta \ln \lambda_{t+1} + (1-\gamma)\left(\alpha \ln \frac{C^*_{T,t+1}/C_{T,t+1}}{C^*_{T,t}/C_{T,t}} + (1-\alpha)\ln \frac{Y^*_{NT,t+1}/Y_{NT,t+1}}{Y^*_{NT,t}/Y_{NT,t}}\right) \\ &= \ln \Omega^*_{t+1} - \ln \Omega_{t+1} - \Delta \ln \lambda_{t+1} + (1-\gamma)\left(\alpha \Delta \ln \lambda_{t+1} + (1-\alpha)\ln \frac{Y^*_{NT,t+1}/Y_{NT,t+1}}{Y^*_{NT,t}/Y_{NT,t}}\right) \end{aligned} \tag{C.151}$$

Price dividend ratios The price-dividend ratio of tradable firms is equal to

$$pd_{T,t} = 1 + \mathrm{E}_t[M^T_{t,t+1}\frac{Y_{T,t+1}}{Y_{T,t}}(pd_{T,t+1})(1-(1-e^{-u_{T,t+1}})\eta)]. \tag{C.152}$$

Similarly for foreign tradable firms,

$$pd^*_{T,t} = 1 + \mathrm{E}_t[M^T_{t,t+1}\frac{Y^*_{T,t+1}}{Y^*_{T,t}}(pd^*_{T,t+1})(1-(1-e^{-u^*_{T,t+1}})\eta)]. \tag{C.153}$$

The price-dividend ratio of non-tradable firms is equal to

$$\begin{aligned} pd_{NT,t} &= 1 + \mathrm{E}_t\left[M^T_{t,t+1}\frac{p_{t+1}Y_{NT,t+1}}{p_t Y_{NT,t}}(pd_{NT,t+1})(1-(1-e^{-u_{t+1}})\eta)\right] \\ &= 1 + \mathrm{E}_t\left[M^T_{t,t+1}\frac{\bar{Y}_{T,t+1}}{\bar{Y}_{T,t}}\frac{\frac{1}{1+\lambda_{t+1}}}{\frac{1}{1+\lambda_t}}(pd_{NT,t+1})(1-(1-e^{-u_{NT,t+1}})\eta)\right] \end{aligned} \tag{C.154}$$

Similarly for foreign non-tradable firms,

$$pd^*_{NT,t} = 1 + \mathrm{E}_t\left[M^T_{t,t+1}\frac{\bar{Y}_{T,t+1}}{\bar{Y}_{T,t}}\frac{\frac{\lambda_{t+1}}{1+\lambda_{t+1}}}{\frac{\lambda_t}{1+\lambda_t}}(pd^*_{NT,t+1})(1-(1-e^{-u^*_{NT,t+1}})\eta)\right] \tag{C.155}$$

In what follows, we derive the expressions for sector stock returns and the returns for various portfolios.

Sector Returns The total return of non-tradable firms is

$$
\begin{aligned}
r_{NT,t+1} &= \ln \frac{p_{NT,t+1}Y_{NT,t+1}(1-(1-e^{-u_{NT,t+1}})\eta)}{p_{NT,t}Y_{NT,t}} \frac{pd_{NT,t+1}}{pd_{NT,t}-1} \\
&\approx \ln \frac{\bar{Y}_{T,t+1}}{\bar{Y}_{T,t}} + \frac{\lambda_t}{1+\lambda_t}(\Delta \ln \Omega_{t+1} - \Delta \ln \Omega^*_{t+1}) - u_{NT,t+1}\eta + \ln \frac{pd_{NT,t+1}}{pd_{NT,t}-1} \qquad \text{(C.156)}
\end{aligned}
$$

A positive u_{NT} shock at home leads to both an increase in Ω and an increase in $\frac{\bar{Y}_{T,t+1}}{\bar{Y}_{T,t}}$, but also causes a displacement effect $u_{NT}\eta$.

The total return of tradable firms at home is

$$
\begin{aligned}
r_{T,t+1} &= \ln(\frac{Y_{T,t+1}(1-(1-e^{-u_{T,t+1}})\eta)}{Y_{T,t}} \frac{pd_{T,t+1}}{pd_{T,t}-1}) \\
&\approx \ln(\frac{Y_{T,t+1}(1-u_{T,t+1}\eta)}{Y_{T,t}} \frac{pd_{T,t+1}}{pd_{T,t}-1}) \\
&\approx \Delta \ln(Y_{T,t+1}) - \Delta \ln(Y_{T,t}) - u_{T,t+1}\eta + \ln(pd_{T,t+1}) - \ln(pd_{T,t}-1) \\
&= \mu + (\delta-\eta)u_{T,t+1} + \varepsilon_{t+1} + \ln(pd_{T,t+1}) - \ln(pd_{T,t}-1) \qquad \text{(C.157)}
\end{aligned}
$$

Market Returns The market return is the weighted average of T and NT firms. The weights of these firms are given by $w_T = \frac{\alpha(pd_{T,t}-1)}{\alpha(pd_{T,t}-1)+(1-\alpha)(pd_{NT,t}-1)}$ and $w_{NT} = \frac{(1-\alpha)(pd_{NT,t}-1)}{\alpha(pd_{T,t}-1)+(1-\alpha)(pd_{NT,t}-1)}$. Therefore, the value-weighted return is:

$$
\begin{aligned}
r_{MKT,t} &= w_T r_{T,t+1} + w_{NT} r_{NT,t+1} \qquad \text{(C.158)} \\
&\approx w_T \left(\underbrace{\mu + (\delta-\eta)u_{T,t+1} + \varepsilon_{t+1}}_{\ln \frac{Y_{T,t+1}}{Y_{T,t}}} + \ln(pd_{T,t+1}) - \ln(pd_{T,t}-1) \right) \\
&+ w_{NT} \left(\ln \frac{\bar{Y}_{T,t+1}}{\bar{Y}_{T,t}} + \frac{\lambda_t}{1+\lambda_t}(\Delta \ln \Omega_{t+1} - \Delta \ln \Omega^*_{t+1}) - u_{NT,t+1}\eta + \ln \frac{pd_{NT,t+1}}{pd_{NT,t}-1} \right) \qquad \text{(C.159)}
\end{aligned}
$$

GMV Returns We focus on the home region in our derivation. Recall that value firms are those that do not receive new projects, while growth firms are those that do. Note that pd_t^V and pd_t^G denote the price-dividend ratios of firms that were sorted into value and growth categories, respectively, at period t.

For tradable firms that are sorted into the value group, their return is equal to

$$
r^T_{V,t+1} = (1-q)r^T_{V\to V,t+1} + q r^T_{V\to G,t+1} \qquad \text{(C.160)}
$$

where

$$
r^T_{V\to V,t+1} = \ln\left(\frac{Y_{T,t+1}e^{-u_{t+1}}}{Y_{T,t}} \frac{pd_{T,t+1}}{pd_{T,t}-1}\right) = \mu + (\delta-1)u_{T,t+1} + \varepsilon_{T,t+1} + \ln \frac{pd^V_{T,t+1}}{pd^V_{T,t}-1} \qquad \text{(C.161)}
$$

$$r^T_{V\to G,t+1} = \mu + (\delta - 1)u_{T,t+1} + \varepsilon_{T,t+1} + \ln \frac{pd^G_{T,t+1}}{pd^V_{T,t} - 1} \tag{C.162}$$

For non-tradable firms that are sorted into the value group, their return is equal to

$$r^{NT}_{V,t+1} = (1-q)r^{NT}_{V\to V,t+1} + qr^{NT}_{V\to G,t+1} \tag{C.163}$$

where

$$\begin{aligned} r^{NT}_{V\to V,t+1} &= \ln\left(\frac{p_{NT,t+1}Y_{NT,t+1}e^{-u_{t+1}}}{p_{NT,t}Y_{NT,t}}\frac{pd_{NT,t+1}}{pd_{NT,t}}\right) \\ &\approx \ln\frac{\bar{Y}_{T,t+1}}{\bar{Y}_{T,t}} + \frac{\lambda_t}{1+\lambda_t}(\ln\Omega_{t+1} - \ln\Omega^*_{t+1}) - u_{NT,t+1} + \ln\frac{pd^V_{NT,t+1}}{pd^V_{NT,t}} \end{aligned} \tag{C.164}$$

$$r^{NT}_{V\to G,t+1} = \ln\frac{\bar{Y}_{T,t+1}}{\bar{Y}_{T,t}} + \frac{\lambda_t}{1+\lambda_t}(\ln\Omega_{t+1} - \ln\Omega^*_{t+1}) - u_{NT,t+1} + \ln\frac{pd^G_{NT,t+1}}{pd^V_{NT,t}} \tag{C.165}$$

Similarly, we can derive the stock returns for growth firms. For tradable firms, we obtain

$$r^T_{G,t+1} = (1-p)r^T_{G\to G,t+1} + pr^T_{G\to V,t+1} \tag{C.166}$$

where

$$r^T_{G\to V,t+1} = \mu + (\delta + \frac{1-\eta}{m_H} - 1)u_{T,t+1} + \varepsilon_{T,t+1} + \ln\frac{pd^V_{T,t+1}}{pd^G_{T,t} - 1} \tag{C.167}$$

$$\begin{aligned} r^T_{G\to G,t+1} &= \Delta\ln X_{t+1} + \ln\frac{pd^G_{T,t+1}}{pd^G_{T,t} - 1} \\ &= \ln\left(\frac{Y_{T,t+1}e^{-u_{T,t+1}} + Y_{T,t+1}(1-e^{-u_{T,t+1}})\frac{1-\eta}{m_H}}{Y_{T,t}}\frac{pd^G_{T,t+1}}{pd^G_{T,t} - 1}\right) \\ &\approx \mu + (\delta + \frac{1-\eta}{m_H} - 1)u_{T,t+1} + \varepsilon_{T,t+1} + \ln\frac{pd^G_{T,t+1}}{pd^G_{T,t} - 1} \end{aligned} \tag{C.168}$$

And for non-tradable firms, their return is equal to

$$r^{NT}_{G,t+1} = (1-p)r^{NT}_{G\to G,t+1} + pr^{NT}_{G\to V,t+1} \tag{C.169}$$

where

$$\begin{aligned} r^{NT}_{G\to G,t+1} &= \ln\left(\frac{p_{NT,t+1}Y_{NT,t+1}(e^{-u_{NT,t+1}} + (1-e^{-u_{NT,t+1}})\frac{1-\eta}{m_H})}{p_{NT,t}Y_{NT,t}}\frac{pd^G_{NT,t+1}}{pd^G_{NT,t} - 1}\right) \\ &\approx \ln\frac{\bar{Y}_{T,t+1}}{\bar{Y}_{T,t}} + \frac{\lambda_t}{1+\lambda_t}(\ln\Omega_{t+1} - \ln\Omega^*_{t+1}) - (1 - \frac{1-\eta}{m_H})u_{NT,t+1} + \ln\frac{pd^G_{NT,t+1}}{pd^G_{NT,t} - 1} \end{aligned} \tag{C.170}$$

$$r^{NT}_{G\to V,t+1} = \ln\frac{\bar{Y}_{T,t+1}}{\bar{Y}_{T,t}} + \frac{\lambda_t}{1+\lambda_t}(\ln\Omega_{t+1} - \ln\Omega^*_{t+1}) - (1 - \frac{1-\eta}{m_H})u_{NT,t+1} + \ln\frac{pd^V_{NT,t+1}}{pd^G_{NT,t} - 1} \quad \text{(C.171)}$$

Thus, the return differential between value and growth firms is

$$\begin{aligned} r_{GMV,t+1} &= w_T(r^T_{G,t+1} - r^T_{V,t+1}) + (1-w_T)(r^{NT}_{G,t+1} - r^{NT}_{V,t+1}) \\ &\propto w_T u_{T,t+1} + (1-w_T)u_{NT,t+1} \end{aligned} \quad \text{(C.172)}$$

Where w_T is the weight on the tradable firms in the growth portfolio. Therefore, GMV correlates positively with the linear combination of displacement shocks on both T and NT firms.

Wealth ratio

Given the recursive definition

$$V^{1-\gamma} = C^{1-\gamma} + \beta \mathrm{E} V^{1-\gamma}, \quad \text{(C.173)}$$

the marginal utility of consumption of T-good for the representative agent is equal to

$$\frac{\partial V}{\partial c_T} = \frac{\partial V}{\partial C}\frac{\partial C}{\partial c_T} = V^\gamma C^{-\gamma}\alpha\frac{C}{c_T}. \quad \text{(C.174)}$$

The wealth of the representative agent (in units of T-good) is

$$W_H = \left(\frac{V}{C}\right)^{1-\gamma} c_T \frac{1}{\alpha} \quad \text{(C.175)}$$

Similarly the wealth of the representative agent in the foreign region is equal to

$$W_F = \left(\frac{V^*}{C^*}\right)^{1-\gamma} c^*_T \frac{1}{\alpha} \quad \text{(C.176)}$$

So the wealth ratio

$$w_t = \frac{W_F}{W_H} = \left(\frac{(\frac{V^*}{C^*})}{(\frac{V}{C})}\right)^{1-\gamma} \lambda_t \quad \text{(C.177)}$$

The recursive definition of Utility-Consumption ratio We can express $(\frac{V}{C})^{1-\gamma}$ as follows :

$$VC = (\frac{V}{C})^{1-\gamma} = \left[1 + \beta \mathrm{E}\left((\frac{V}{C})^{1-\gamma}(\frac{C_{t+1}}{C_t})^{1-\gamma}\right)\right] \quad \text{(C.178)}$$

The consumption growth is

$$\ln(\frac{C_{t+1}}{C_t}) = \alpha\Delta\ln c_T + (1-\alpha)\Delta Y_{NT}, \tag{C.179}$$

where

$$\Delta\ln c_T = \frac{\bar{Y}_{T,t+1}(\frac{1}{1+\lambda_{t+1}})}{\bar{Y}_{T,t}\frac{1}{1+\lambda_t}} = \frac{\bar{Y}_{T,t+1}}{\bar{Y}_{T,t}}\frac{1+\lambda_t}{1+\lambda_{t+1}}. \tag{C.180}$$

Therefore from the recursive definition, we obtain

$$\begin{aligned} VC_t &= \left[1+\beta\mathrm{E}\left(VC_{t+1}(\frac{C_{t+1}}{C_t})^{1-\gamma}\right)\right] \\ &= 1+\beta\mathrm{E}_t\left[(1-\pi)VC_{t+1}(\frac{C_{t+1}}{C_t}b)^{1-\gamma} + \pi VC_{t+1}(\frac{C_{t+1}}{C_t}\frac{b\pi+1-b}{\pi})^{1-\gamma}\right] \end{aligned} \tag{C.181}$$

Appendix Tables and Figures

Table A.1: Innovation, Productivity and Inflation using IV

	Real GDP/Employment Growth			Headline Inflation		
	5-Year	5-Year	5-Year	5-Year	5-Year	5-Year
KPST8005 (Assignee Location)	3.192**			8.779***		
	(1.597)			(2.152)		
Cit(20%) (Assignee Location)		2.412**			5.407**	
		(1.165)			(2.262)	
KPSS(20%) (Assignee Location)			4.618***			11.029***
			(1.717)			(3.833)
State FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Obs	647	938	923	647	938	923
Adj R2	0.576	0.620	0.586	0.636	0.789	0.665

Notes: This table reports regression coefficients (times 100) of 2SLS estimates. Columns 1-3 of this table report the regression results:

$$g_{i,t,t+5} = \beta_1 \ln(\text{innov}_{\{i\},t,t+5}) + \beta_2 \mathbf{X}_{i,t} + \alpha_i + \gamma_t + \varepsilon_{i,t}$$

Dependent variable is equal to the growth in the (log) GDP per worker in state i from t to $t+5$, $g_{i,t,t+5} = \ln Y_{i,t+5} - \ln Y_{i,t}$. The vector of controls includes the (log) GDP per worker at time t, $\ln Y_{i,t}$. $\text{innov}_{\{i\},t,t+s}$ is the flow of innovation measure at the *vicinity* of state i, instrumented by the R&D tax credit. α_i is state-FE, γ_t is time-FE. See A for the definition of innovation measures. Columns 4-6 of this table report the regression results of (2):

$$\pi_{i,t,t+5} = \beta_1 \ln(\text{innov}_{\{i\},t,t+5}) + \beta_2 \mathbf{X}_{i,t} + \alpha_i + \gamma_t + \varepsilon_{i,t}$$

Dependent variable is equal to the growth in the (log) price level in state i from t to $t+5$, $\pi_{i,t,t+5} = \ln P_{i,t+5} - \ln P_{i,t}$. The vector of controls includes the (log) price level at time t, $\ln P_{i,t}$. Independent variables are standardized to unit standard deviation using unconditional moments. Standard errors in parentheses are robust to autocorrelation and heteroskedasticity, calculated using the Newey-West procedure with a bandwidth of seven years. The sample period is 1978-2017. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table A.2: Innovation and Inflation, MSA Level

Dependent Variable: Headline Inflation			
	5-year	5-year	5-year
KPST8005 (Assignee Location)	0.927***		
	(0.329)		
Cit(20%) (Assignee Location)		1.232***	
		(0.313)	
KPSS(20%) (Assigness Location)			2.113***
			(0.323)
Observations	528	849	849
R-squared	0.788	0.814	0.829

Notes: This table reports the regression coefficients (times 100) of (2):

$$\pi_{i,t,t+5} = \beta_1 \ln(\text{innov}_{\{i\},t,t+5}) + \beta_2 \mathbf{X}_{i,t} + \alpha_i + \gamma_t + \varepsilon_{i,t}$$

Dependent variable is equal to the growth in the (log) price level in MSA i from t to $t+5$, $\pi_{i,t,t+5} = \ln Y_{i,t+5} - \ln Y_{i,t}$. As before, the vector of controls includes the (log) price level at time t, $\ln Y_{i,t}$. $\text{innov}_{\{i\},t,t+s}$ is the flow of innovation measure at the MSA i. α_i is MSA-FE, γ_t is time-FE. See A for the definition of innovation measures. Independent variables are standardized to unit standard deviation using unconditional moments. Standard errors in parentheses are robust to autocorrelation and heteroskedasticity, calculated using the Newey-West procedure with a bandwidth of seven years. The sample period is 1983-2017. $^{***}p < 0.01$,$^{**}p < 0.05$,$^{*}p < 0.1$.

Table A.3: R&D Tax Credit and Inflation, MSA Level

Dependent Variable: Headline Inflation		
	5-year	5-year
$\overline{RDTC}$	0.698**	
	(0.296)	
$\overline{RDTC}_{GDP}$		0.700**
		(0.298)
Observations	849	849
R-squared	0.804	0.804

Notes: Columns of this table report the regression coefficients (times 100) of (5):

$$\pi_{i,t,t+5} = \beta_1 RDTC_{\{i\},t} + \beta_2 \mathbf{X}_{i,t} + \alpha_i + \gamma_t + \varepsilon_{i,t}$$

Dependent variable is equal to the growth in the (log) price level in MSA i from t to $t+5$, $\pi_{i,t,t+5} = \ln Y_{i,t+5} - \ln Y_{i,t}$. The vector of controls includes the (log) price level. In column 1, $\overline{RDTC}$ is the simple average of R&D tax credit rate of state j that overlap with MSA i. In column 2, $\overline{RDTC}_{GDP}$ is the GDP weighted average of R&D tax credit rate of state j that overlaps with MSA i, using lagged GDP as weight. α_i is MSA-FE, γ_t is time-FE. Independent variables are standardized to unit standard deviation using unconditional moments. Standard errors in parentheses are robust to autocorrelation and heteroskedasticity, calculated using the Newey-West procedure with a bandwidth of seven years. The sample period is 1983-2017. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table A.4: R&D Tax Credits and Median Wages

Dependent variable = Median Wages Growth				
	(1)	(2)	(3)	(4)
RDTC	-2.027*	-1.862*	-2.742**	-2.653**
	(1.097)	(1.128)	(1.291)	(1.325)
Unemployment		YES		YES
State FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Observations	695	695	951	951
Adj R2	0.533	0.535	0.572	0.572

Notes: Columns of this table report the regression coefficients (times 100) of (5):

$$\Delta W_{i,t,t+s} = \beta_1 RDTC_{\{i\},t} + \beta_2 \mathbf{X}_{i,t} + \alpha_i + \gamma_t + \varepsilon_{i,t}$$

Dependent variable is equal to the growth in the (log) median wages in state i from t to $t+s$, $\Delta W_{i,t,t+s} = \ln W_{i,t+s} - \ln W_{i,t}$. The vector of controls includes the (log) median wage level at time t, $\ln W_{i,t}$. $RDTC_{\{i\},t}$ is the R&D tax credit rate at the *vicinity* of state i. α_i is state-FE, γ_t is time-FE. Column 1 reports estimates using the unbalanced panel with $s = 4$. Column 3 reports estimates using the balanced panel with $s = 5$, where missing values have been filled through linear interpolation based on adjacent observations. Columns 2 and 4 add unemployment rate at time t as an additional control variable. Independent variables are standardized to unit standard deviation using unconditional moments. Standard errors in parentheses are robust to autocorrelation and heteroskedasticity, calculated using the Newey-West procedure with a bandwidth of seven years. The sample period is 1978-2017. $^{***}p < 0.01$,$^{**}p < 0.05$,$^{*}p < 0.1$.

Table A.5: R&D Tax Credits and Median Wages

Dependent variable = Median Wages Growth				
	(1)	(2)	(3)	(4)
RDTC	-1.337*	-1.350*	-1.627**	-1.606**
	(0.703)	(0.708)	(0.754)	(0.756)
Unemployment		YES		YES
State FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Observations	695	695	951	951
R2	0.640	0.640	0.662	0.662

Notes: Columns of this table report the regression coefficients (times 100) of (5):

$$\Delta W_{i,t,t+s} = \beta_1 RDTC_{\{i\},t} + \beta_2 \mathbf{X}_{i,t} + \alpha_i + \gamma_t + \varepsilon_{i,t}$$

Dependent variable is equal to the growth in the (log) median wages in state i from t to $t+s$, $\Delta W_{i,t,t+s} = \ln W_{i,t+s} - \ln W_{i,t}$. The vector of controls includes the (log) median wage level at time t, $\ln W_{i,t}$. $RDTC_{\{i\},t}$ is the R&D tax credit rate at the *vicinity* of state i. α_i is state-FE, γ_t is time-FE. Column 1 reports estimates using the unbalanced panel with $s = 4$. Column 3 reports estimates using the balanced panel with $s = 5$, where missing values have been filled through linear interpolation based on adjacent observations. Columns 2 and 4 add unemployment rate at time t as an additional control variable. Independent variables are standardized to unit standard deviation using unconditional moments. Standard errors in parentheses are robust to autocorrelation and heteroskedasticity, calculated using the Newey-West procedure with a bandwidth of seven years. The sample period is 1978-2017. $^{***}p < 0.01$,$^{**}p < 0.05$,$^{*}p < 0.1$.

Table A.6: IPO, Inequality and Inflation

	Panel A. Number of IPO and Inflation					
	Headline		T Inflation		NT Inflation	
IPO (pc)	2.612***	2.503***	-0.100	-0.145	4.468***	4.308***
	(0.800)	(0.819)	(0.452)	(0.455)	(1.225)	(1.267)
Unemployment	NO	YES	NO	YES	NO	YES
State FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Obs	951	951	951	951	951	951
Adj R2	0.773	0.775	0.798	0.799	0.762	0.764

	Panel B. Number of IPO and Inequality					
	Top 1%		Top 0.1%		Top 0.01%	
IPO (pc)	2.594**	2.520**	4.250**	4.118**	6.702***	6.387**
	(1.084)	(1.098)	(1.823)	(1.849)	(2.564)	(2.599)
Unemployment	NO	YES	NO	YES	NO	YES
State FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Obs	951	951	951	951	951	951
Adj R2	0.809	0.810	0.806	0.806	0.788	0.790

Notes: Panel A of the table reports the regression coefficients (times 100) of (57) and (58):

$$\pi_{i,t,t+5} = \beta_1 \ln(\text{IPO}_{\{i\},t,t+5}) + \beta_2 \mathbf{X}_{i,t} + \alpha_i + \gamma_t + \varepsilon_{i,t}$$

Dependent variable is equal to the growth in the (log) price level in state i from t to $t+s$, $\pi_{i,t,t+s} = \ln Y_{i,t+5} - \ln Y_{i,t}$, where Y is the price level. Control variables include (log) price level $\ln(Y_{i,t})$. $\text{IPO}_{\{i\},t,t+5}$ is the number of IPOs normalized by the total population of the vicinity of state i from t to $t+5$. α_i is state-FE, γ_t is time-FE. Unemployment is at t. Panel B re-estimates the above specification with dependent variable being the inequality growth between t and $t+5$. In all specifications, the independent variables are standardized to unit standard deviation using unconditional moments. Standard errors in parentheses are robust to autocorrelation and heteroskedasticity, calculated using the Newey-West procedure with a bandwidth of seven years. The sample period is 1978-2017. ***$p < 0.01$,**$p < 0.05$,*$p < 0.1$.

Table A.7: Inflation and Income Inequality

Dependent variable: Inflation				
	Top 10%	Top 1%	Top 0.1%	Top 0.01%
Headline inflation	0.569	2.131***	2.099***	1.978***
	(0.464)	(0.658)	(0.577)	(0.562)
T inflation	0.100	0.436	0.275	0.289
	(0.242)	(0.369)	(0.358)	(0.334)
NT inflation	0.758	3.077***	3.126***	2.941***
	(0.697)	(0.984)	(0.857)	(0.831)
State FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

Notes: This table reports the regression coefficients (times 100) of (48):

$$\pi_{i,t,t+5} = \beta_1(\ln I_{i,t+5} - \ln I_{i,t}) + \beta_2 \mathbf{X}_{i,t} + \alpha_i + \gamma_t + \varepsilon_{i,t}$$

Dependent variable is equal to the growth in the (log) price level in state i from t to $t+5$, $\pi_{i,t,t+5} = \ln Y_{i,t+5} - \ln Y_{i,t}$. Independent variable is the growth in the (log) 5-year average of inequality level in state i from t to $t+5$. Control variables include (log) price levels $\ln Y_{i,t}$ and (log) 5-year average top income share levels $\ln I_{i,t}$. α_i is state-FE, γ_t is time-FE. See A for the definition of innovation measures. Independent variables are standardized to unit standard deviation using unconditional moments. Standard errors in parentheses are robust to autocorrelation and heteroskedasticity, calculated using the Newey-West procedure with a bandwidth of seven years. The sample period is 1978-2017. $^{***}p < 0.01$,$^{**}p < 0.05$,$^{*}p < 0.1$.

Table A.8: Inflation and Income Inequality

Dependent variable: Inflation				
	Top 10%	Top 1%	Top 0.1%	Top 0.01%
Headline inflation	0.596	2.048***	2.020***	1.900***
	(0.472)	(0.658)	(0.577)	(0.562)
T inflation	0.123	0.417	0.255	0.265
	(0.244)	(0.368)	(0.358)	(0.336)
NT inflation	0.778	2.930***	2.988***	2.808***
	(0.710)	(0.994)	(0.868)	(0.840)
Unemployment	YES	YES	YES	YES
State FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

Notes: This table reports the regression coefficients (times 100) of (48):

$$\pi_{i,t,t+5} = \beta_1(\ln I_{i,t+5} - \ln I_{i,t}) + \beta_2 \mathbf{X}_{i,t} + \alpha_i + \gamma_t + \varepsilon_{i,t}$$

Dependent variable is equal to the growth in the (log) price level in state i from t to $t+5$, $\pi_{i,t,t+5} = \ln Y_{i,t+5} - \ln Y_{i,t}$, and unemployment rate at time t. Independent variable is the growth of the (log) 5-year average of inequality level in state i from t to $t+5$. Control variables include (log) price levels $\ln Y_{i,t}$ and (log) 5-year average top income share levels $\ln I_{i,t}$. α_i is state-FE, γ_t is time-FE. See A for the definition of innovation measures. Unemployment is at time t. Independent variables are standardized to unit standard deviation using unconditional moments. Standard errors in parentheses are robust to autocorrelation and heteroskedasticity, calculated using the Newey-West procedure with a bandwidth of seven years. The sample period is 1978-2017. $^{***}p < 0.01$,$^{**}p < 0.05$,$^{*}p < 0.1$.

Table A.9: Innovation and GMV Portfolio returns using IV

Growth-Value			
	5-Year	5-Year	5-Year
KPST8005 (Assignee Location)	19.520***		
	(5.721)		
Cit(20%) (Assignee Location)		19.271***	
		(6.293)	
KPSS(20%) (Assignee Location)			34.066***
			(8.261)
State FE	YES	YES	YES
Year FE	YES	YES	YES
Obs	647	938	923
Adj R2	0.492	0.419	0.388

Notes: This table reports regression results of 2SLS estimates:

$$R^x_{\{i\},t,t+5} = \beta_1 \ln(\text{innov}_{\{i\},t,t+5}) + \beta_2 \mathbf{X}_{i,t} + \alpha_i + \gamma_t + \varepsilon_{i,t}$$

where dependent variables $R^x_{\{i\},t,t+5}, x \in \{GMV, MKT\}$ are the portfolio returns of *local market* and *growth-minus-value* of state i between time $t, t+5$. $\text{innov}_{\{i\},t,t+5}$ is the flow of innovation measure at the *vicinity* of state i, instrumented by R&D tax credit. All regression controls include lagged 5-year cumulative portfolio return $R_{i,t-5,t}$. In columns 2 and 4 we control for unemployment rate at t. α_i is state-FE, γ_t is time-FE. See A for the definition of innovation measures. Independent variables are standardized to unit standard deviation using unconditional moments. Standard errors in parentheses are robust to autocorrelation and heteroskedasticity, calculated using the Newey-West procedure with a bandwidth of seven years. The sample period is 1978-2017. ***$p < 0.01$,**$p < 0.05$,*$p < 0.1$***.

Table A.10: R&D Tax Credits, Inflation and Inequality, controlling for Productivity Growth

	Headline Inflation		Median Income Growth		Inequality Growth	
RDTC	1.135**	1.300**	-0.847**	-0.706*	1.682***	1.774***
	(0.534)	(0.535)	(0.357)	(0.369)	(0.563)	(0.571)
Unemployment		YES		YES		YES
State FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Observations	951	951	837	837	951	951
Adj R2	0.796	0.799	0.719	0.726	0.827	0.828

Notes: Columns of this table report the regression coefficients (times 100) of (5):

$$g_{i,t,t+5} = \beta_1 RDTC_{\{i\},t} + \beta_2 \mathbf{X}_{i,t} + \alpha_i + \gamma_t + \varepsilon_{i,t}$$

Dependent variable is equal to the growth in the (log) price level, median income, Top 1% income share in state i from t to $t+5$, $g_{i,t,t+5} = \ln Y_{i,t+5} - \ln Y_{i,t}$ for $Y \in \{$price, median income, Top 1% income share$\}$, and is multiplied by 100. Productivity is measured by real GDP per worker. The vector of controls includes the (log) level at time t, $\ln Y_{i,t}$. Independent variable $RDTC_{\{i\},t}$ is the R&D tax credit rate at the *vicinity* of state i. α_i is state-FE, γ_t is time-FE. Columns 2,4,6,8 repeat columns 1,3,5,7 with unemployment rate at time t as an additional control variable. See A for the definition of innovation measures. Independent variables are standardized to unit standard deviation using unconditional moments. Standard errors in parentheses are robust to autocorrelation and heteroskedasticity, calculated using the Newey-West procedure with a bandwidth of seven years. The sample period is 1978-2017. ***$p < 0.01$,**$p < 0.05$,*$p < 0.1$.

Table A.11: R&D Tax Credits and Inflation, Tradables vs Non-Tradables, Controlling for Productivity Growth

	T		NT		w.o. H		H	
RDTC	0.573*	0.602*	1.433*	1.681**	0.548*	0.614**	2.142*	2.955**
	(0.320)	(0.320)	(0.754)	(0.761)	(0.296)	(0.292)	(1.226)	(1.202)
Unemployment		YES		YES		YES		YES
State FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Observations	951	951	951	951	951	951	951	951
Adj R2	0.797	0.798	0.751	0.756	0.868	0.873	0.707	0.728

Notes: Columns of this table report the regression coefficients (times 100) of (5):

$$\pi_{i,t,t+5} = \beta_1 RDTC_{\{i\},t} + \beta_2 \mathbf{X}_{i,t} + \alpha_i + \gamma_t + \varepsilon_{i,t}$$

Dependent variable is equal to the growth in the (log) price level in state i from t to $t+5$, $\pi_{i,t,t+5} = \ln Y_{i,t+5} - \ln Y_{i,t}$, for different components Y in Tradables(T), non-tradables (NT), headline without housing (w.o. H) and housing (H). The vector of controls includes the (log) price level and labor productivity at time t, and labor productivity growth between t and $t+5$. $RDTC_{\{i\},t}$ is the R&D tax credit rate at the *vicinity* of state i. α_i is state-FE, γ_t is time-FE. Columns 2,4,6,8 add unemployment rate at time t as an additional control variable. Independent variables are standardized to unit standard deviation using unconditional moments. Standard errors in parentheses are robust to autocorrelation and heteroskedasticity, calculated using the Newey-West procedure with a bandwidth of seven years. The sample period is 1978-2017. $^{***}p < 0.01$,$^{**}p < 0.05$,$^{*}p < 0.1$.

Table A.12: Innovation and Inflation, Excluding Top Innovative States

	Dependent variable: Headline Inflation					
	5-Year	5-Year	5-Year	5-Year	5-Year	5-Year
KPST8005 (Assignee Location)	3.768***	3.788***				
	(0.805)	(0.818)				
Cit(20%) (Assignee Location)			3.985***	4.055***		
			(0.656)	(0.679)		
KPSS(20%) (Assignee Location)					3.192***	3.188***
					(0.803)	(0.800)
Unemployment		-1.510***		-0.895*		-0.873*
		(0.533)		(0.478)		(0.506)
State FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Obs	543	543	786	786	786	786
Adj R2	0.717	0.726	0.776	0.779	0.760	0.763

Notes: This table reports the regression coefficients (times 100) of (2):

$$\pi_{i,t,t+5} = \beta_1 \ln(\text{innov}_{\{i\},t,t+5}) + \beta_2 \mathbf{X}_{i,t} + \alpha_i + \gamma_t + \varepsilon_{i,t}$$

Dependent variable is equal to the growth in the (log) price level in state i from t to $t+5$, $\pi_{i,t,t+5} = \ln Y_{i,t+5} - \ln Y_{i,t}$. As before, the vector of controls includes the (log) price level at time t, $\ln Y_{i,t}$. $\text{innov}_{\{i\},t,t+s}$ is the flow of innovation measure at the *vicinity* of state i. α_i is state-FE, γ_t is time-FE. Unemployment rate is at t. See A for the definition of innovation measures. Independent variables are standardized to unit standard deviation using unconditional moments. Standard errors in parentheses are robust to autocorrelation and heteroskedasticity, calculated using the Newey-West procedure with a bandwidth of seven years. The sample excludes the top five states with the highly cited patents: California, New York, Illinois, Texas and Massachusetts. The sample period is 1978-2017. $^{***}p < 0.01$,$^{**}p < 0.05$,$^{*}p < 0.1$.

Table A.13: Innovation and Inflation, Population Weighted

Dependent variable: Headline Inflation						
	5-Year	5-Year	5-Year	5-Year	5-Year	5-Year
KPST8005 (Assignee Location)	3.428***	4.406***				
	(1.043)	(1.040)				
Cit(20%) (Assignee Location)			3.669***	4.453***		
			(0.843)	(0.841)		
KPSS(20%) (Assignee Location)					4.813***	5.218***
					(0.906)	(0.920)
Unemployment		-2.777***		-1.939***		-1.539***
		(0.619)		(0.544)		(0.513)
State FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Obs	663	663	951	951	951	951
Adj R2	0.781	0.803	0.842	0.850	0.847	0.853

Notes: This table reports the regression coefficients (times 100) of (2):

$$\pi_{i,t,t+5} = \beta_1 \ln(\text{innov}_{\{i\},t,t+5}) + \beta_2 \mathbf{X}_{i,t} + \alpha_i + \gamma_t + \varepsilon_{i,t}$$

Dependent variable is equal to the growth in the (log) price level in state i from t to $t+5$, $\pi_{i,t,t+5} = \ln Y_{i,t+5} - \ln Y_{i,t}$. As before, the vector of controls includes the (log) price level at time t, $\ln Y_{i,t}$. $\text{innov}_{\{i\},t,t+s}$ is the flow of innovation measure at the *vicinity* of state i. α_i is state-FE, γ_t is time-FE. Unemployment rate is at t. See A for the definition of innovation measures. Independent variables are standardized to unit standard deviation using unconditional moments. Standard errors in parentheses are robust to autocorrelation and heteroskedasticity, calculated using the Newey-West procedure with a bandwidth of seven years. We use local population at t as the weight. The sample period is 1978-2017. ***$p < 0.01$,**$p < 0.05$,*$p < 0.1$.

Table A.14: Innovation and Inflation, GDP weighted

Dependent variable: Headline Inflation						
	5-Year	5-Year	5-Year	5-Year	5-Year	5-Year
KPST8005 (Assignee Location)	3.725***	4.664***				
	(1.000)	(1.028)				
Cit(20%) (Assignee Location)			3.791***	4.607***		
			(0.854)	(0.866)		
KPSS(20%) (Assignee Location)					4.916***	5.342***
					(0.899)	(0.929)
Unemployment		-2.842***		-1.889***		-1.507***
		(0.666)		(0.598)		(0.556)
State FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Obs	663	663	663	951	951	951
Adj R2	0.759	0.782	0.760	0.839	0.837	0.846

Notes: This table reports the regression coefficients (times 100) of (2):

$$\pi_{i,t,t+5} = \beta_1 \ln(\text{innov}_{\{i\},t,t+5}) + \beta_2 \mathbf{X}_{i,t} + \alpha_i + \gamma_t + \varepsilon_{i,t}$$

Dependent variable is equal to the growth in the (log) price level in state i from t to $t+5$, $\pi_{i,t,t+5} = \ln Y_{i,t+5} - \ln Y_{i,t}$. As before, the vector of controls includes the (log) price level at time t, $\ln Y_{i,t}$. $\text{innov}_{\{i\},t,t+s}$ is the flow of innovation measure at the *vicinity* of state i. α_i is state-FE, γ_t is time-FE. Unemployment rate is at t. See A for the definition of innovation measures. Independent variables are standardized to unit standard deviation using unconditional moments. Standard errors in parentheses are robust to autocorrelation and heteroskedasticity, calculated using the Newey-West procedure with a bandwidth of seven years. We use local GDP at t as the weight. The sample period is 1978-2017. $^{***}p < 0.01$,$^{**}p < 0.05$,$^{*}p < 0.1$.

Table A.15: Innovation and Inflation, Control for Population Growth

	Dependent variable: Headline Inflation					
	5-Year	5-Year	5-Year	5-Year	5-Year	5-Year
KPST8005 (Assignee Location)	3.437***	3.555***				
	(0.809)	(0.807)				
Cit(20%) (Assignee Location)			3.257***	3.389***		
			(0.718)	(0.714)		
KPSS(20%) (Assignee Location)					3.659***	3.664***
					(0.765)	(0.763)
Unemployment		-1.449***		-0.778*		-0.451
		(0.452)		(0.406)		(0.408)
State FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Obs	663	663	951	951	951	951
Adj R2	0.765	0.773	0.828	0.830	0.824	0.825

Notes: This table reports the regression coefficients (times 100) of (2):

$$\pi_{i,t,t+5} = \beta_1 \ln(\text{innov}_{\{i\},t,t+5}) + \beta_2 \mathbf{X}_{i,t} + \alpha_i + \gamma_t + \varepsilon_{i,t}$$

Dependent variable is equal to the growth in the (log) price level in state i from t to $t+5$, $\pi_{i,t,t+5} = \ln Y_{i,t+5} - \ln Y_{i,t}$. The vector of controls includes the (log) price level at time t, $\ln Y_{i,t}$, population growth from t to $t+5$ and the (log) level of population at period t. $\text{innov}_{\{i\},t,t+s}$ is the flow of innovation measure at the *vicinity* of state i. α_i is state-FE, γ_t is time-FE. Unemployment rate is at t. See A for the definition of innovation measures. Independent variables are standardized to unit standard deviation using unconditional moments. Standard errors in parentheses are robust to autocorrelation and heteroskedasticity, calculated using the Newey-West procedure with a bandwidth of seven years. The sample period is 1978-2017. $^{***}p < 0.01$,$^{**}p < 0.05$,$^{*}p < 0.1$.

Table A.16: Innovation and Income Inequality

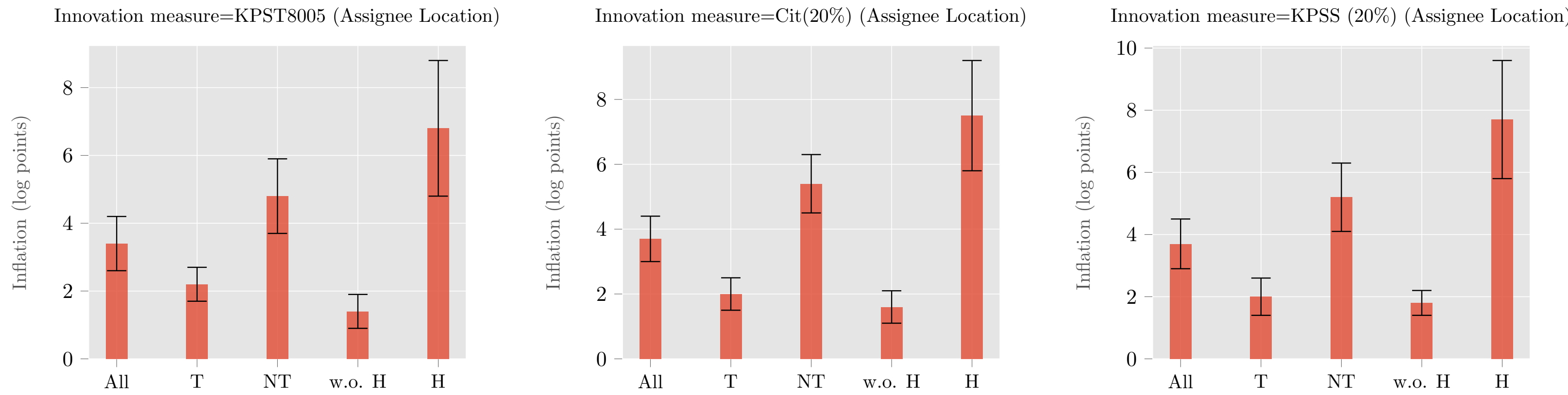
Dependent Variable: Top Income Share				
	Top 10%	Top 1%	Top 0.1%	Top 0.01%
KPST8005 (Assignee Location)	2.075***	4.225***	6.520***	8.636***
	(0.506)	(0.989)	(1.566)	(2.133)
Cit(20%) (Assignee Location)	1.998***	3.303***	4.937***	6.131***
	(0.379)	(0.682)	(1.066)	(1.501)
KPSS(20%) (Assignee Location)	1.480***	3.209***	5.168***	7.104***
	(0.403)	(0.735)	(1.185)	(1.656)
State FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

Notes: This table reports the regression coefficients (times 100) of:

$$\ln(I_{i,t}) = \beta_1 \ln(\text{innov}_{\{i\},t-2}) + \beta_2 \mathbf{X}_{i,t} + \alpha_i + \gamma_t + \varepsilon_{i,t}$$

Here, we closely follow the specification of Aghion et al. (2018) where $I_{i,t}$ is the top income share of state i at time t. Control variables include GDP per capita growth, unemployment and population growth. $\text{innov}_{\{i\},t,t+s}$ is the flow of innovation measure at the *vicinity* of state i. α_i is state-FE, γ_t is time-FE. See A for the definition of innovation measures. Independent variables are standardized to unit standard deviation using unconditional moments. Standard errors in parentheses are robust to autocorrelation and heteroskedasticity, calculated using the Newey-West procedure with a bandwidth of two years. The sample period is 1978-2017. $^{***}p < 0.01$,$^{**}p < 0.05$,$^{*}p < 0.1$.

Panel A. Components of Inflation and Innovation.



Panel B. Components of Inflation and Innovation (Relative Magnitude).

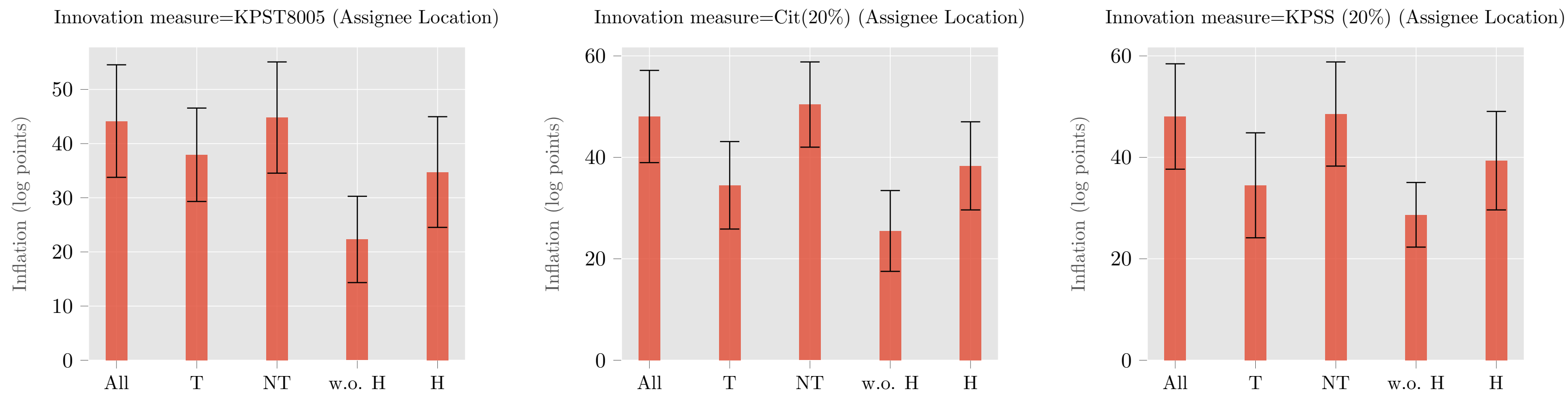


Figure A.1: Components of inflation and innovation, horizon = 5 years. Panel A of this figure reports the coefficient (times 100) of regression (2) where independent variables are standardized to unit standard deviation. Panel B reports the coefficient (times 100) of regression (2) where both dependent and independent variables are standardized to unit standard deviation. All: headline inflation; T: tradables; NT: non-tradables, w.o. H: headline excluding housing; H: housing. Coefficients are reported in 100 x log points.

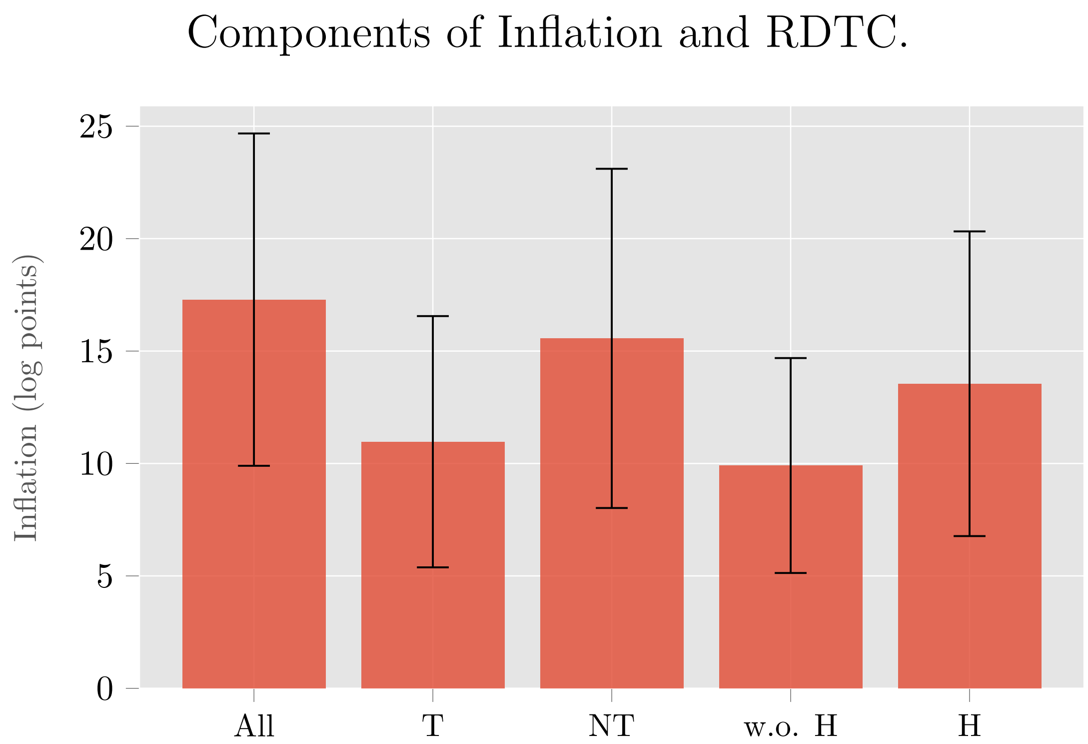


Figure A.2: Components of inflation and innovation, horizon = 5 years. This figure reports the coefficient (times 100) of regression (5) where both dependent and independent variables are standardized to a unit standard deviation. All: headline inflation; T: tradables; NT: non-tradables, w.o. H: headline excluding housing; H: housing. Coefficients are reported in 100 x log points.

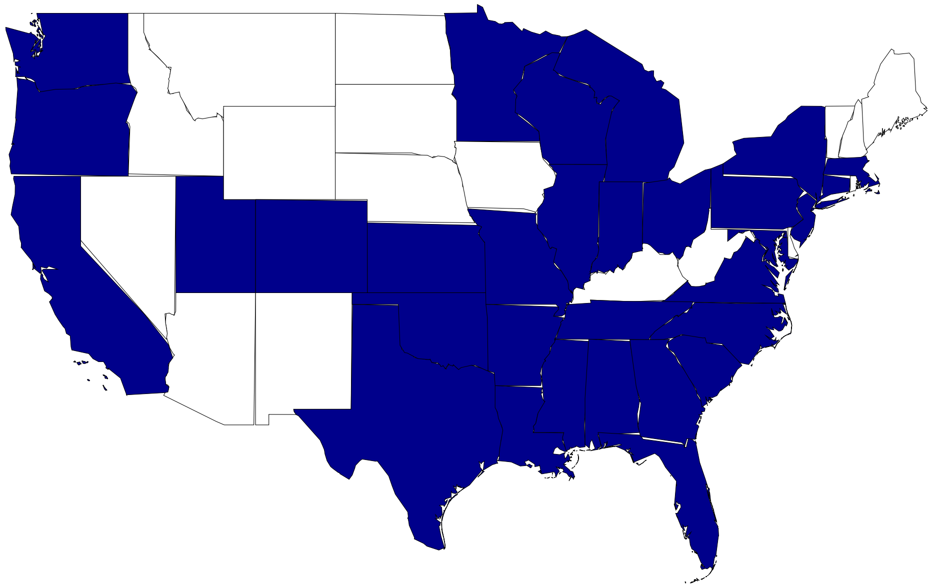


Figure A.3: States with inflation data: 1978-2017. Data is from Hazell et al. (2022).

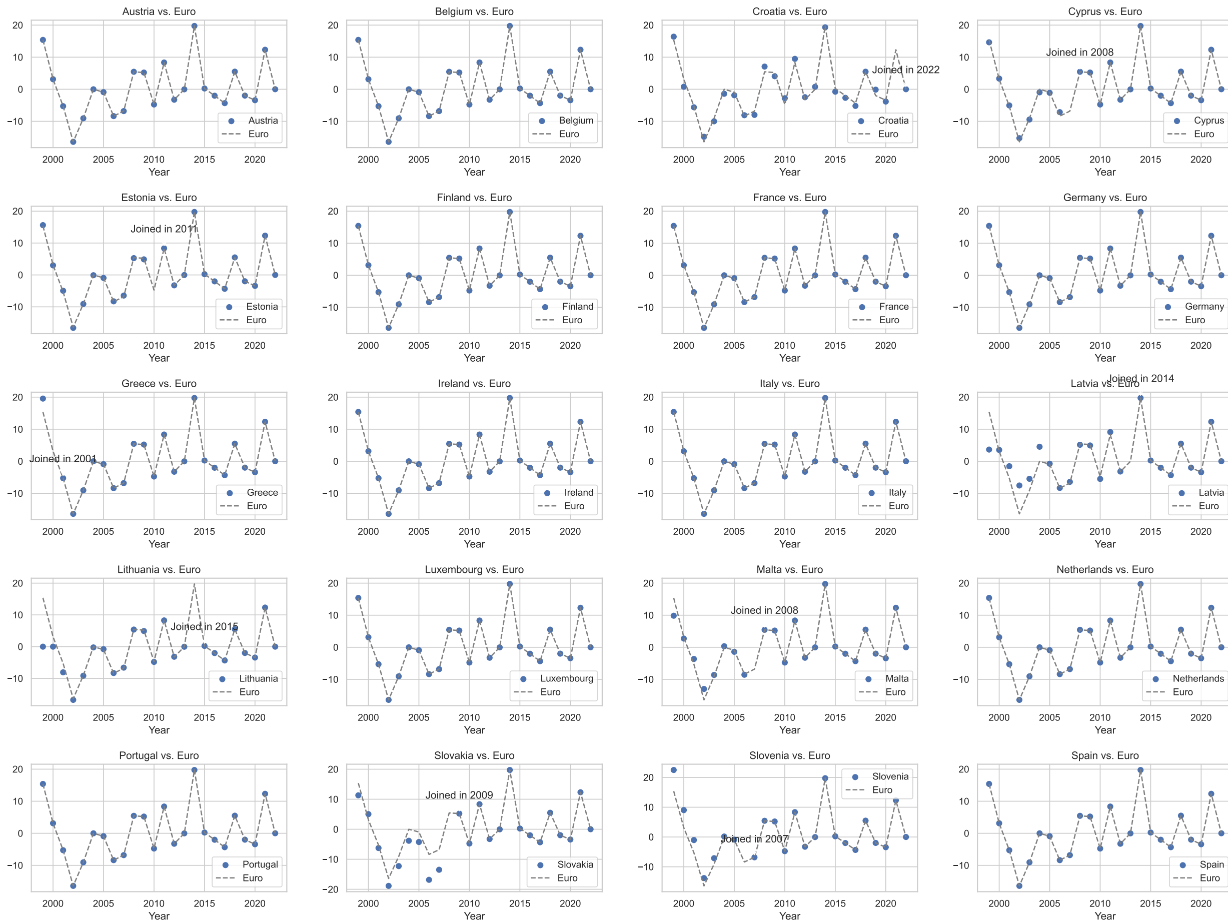


Figure A.4: Exchange rate movement comparison. This figure reports the exchange rate growth at year t, defined as percentage change of U.S. dollar exchange rate from t to $t+1$, for twenty euro-zone member countries. Y-axis is reported in 100 x percentage points. For Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, their currency movements are identical to the euro, as they join the eurozone at inception. For nations that became part of the Eurozone post-1999, we indicate the year they adopted the Euro. The data for the year preceding their joining is excluded due to significant measurement inconsistencies.