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Productivity Growth in Goods and Services Across The Heterogeneous States of America*

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Abstract

In this paper, we compare the relative roles of multi-factor productivity (MFP) growth and factor accumulation in goods and services for states in the US from 1980 to 2007 using the dual growth accounting framework. We find that while MFP growth was relatively high, and converged in the goods sector, it was low and diverged in services. Though the low growth in MFP in services was due to declining real user cost, the divergence itself was due to variation in wage growth. We also document that while the gap between productivity and wage growth was higher in goods, the two series were more strongly correlated in services. Finally, states with higher initial human capital experienced higher growth in both sectors.

JEL: O47, R11

Keywords: Growth Accounting, Regional Economic Growth, Real User Cost, Multi Sector Models, Multi-Factor Productivity, Investment Specific Technological Change

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1 Introduction

The study of income and productivity convergence, and structural transformation are central and recurring themes in economic growth research. The states of USA have been a fertile testing ground for many intellectual advances in these areas. The closed economy assumptions of the underlying models notwithstanding, the states offer compensating advantages such as being subject to the same macroeconomic policy while simultaneously exhibiting considerable heterogeneity along many dimensions of interest to growth researchers- demographics, composition of output, quality of workforce, tax policy, natural resource endowments, geography, etc. At the same time knowledge on multi-factor productivity (MFP) growth, which is central to many growth models, remains sparse for US states. This is mainly due to lack of data on capital accumulation beyond the manufacturing sector. The problem is further aggravated at the sectoral level. In this paper, we seek to address this shortcoming by constructing and analyzing productivity growth for the broadly defined privately produced goods and service sectors at the state level and undertake growth accounting exercises for the period 1980 to 2007.[1] Our main innovation is the use of the dual growth accounting method, which relies on factor prices rather than factor stocks to construct MFP growth. Thus, in the process, not only do we construct and compare MFP growth, but also real wage growth and real user cost growth at the state-sectoral level.

Figure 1, which provides a snapshot of the average annual labor productivity growth in goods versus services for the period of study, can help appreciate the extent of sectoral differences across states. For the goods sector, the difference between Oregon (OR) and Montana (MT) was almost seven percent annually - implying a cumulative six-fold gap in labor productivity levels over the twenty seven years. Even for the service sector, where the range is much smaller, the difference between Connecticut (CT) and Michigan (MI) was almost two and a half percent annually. This implies that Connecticut's labor productivity in services was 90% higher than Michigan's in 2007 relative to 1980. Clearly these are large underlying regional differences. Using our constructed

[1]Following the Bureau of Economic Analysis definitions, mining, construction and manufacturing industries comprise the private goods producing sector. The service sector includes all the private service providing industries. Since most of the literature on post 1950 structural change in advanced economies deals with industry and services, we chose not to include agriculture.

series of MFP growth, and its constituent variables, we provide a range of new insights into regional heterogeneity over and above the standard growth accounting exercise. First, while the goods sector shows convergence, both absolute, and conditional on initial human capital, we see no such evidence for the service sector. However, we also find that labor productivity and multi-factor productivity growth in both sectors were positively associated with higher initial human capital. We also show that the divergence in services was due to diverging wage growth while real user cost growth converged. Second, building on the lack of convergence, we also undertake variance decomposition analysis of the growth in labor productivity. We find that, for the goods producing sector, the bulk of the variation in labor productivity growth is due to MFP growth while for services its the other way round. Third, we also look at the extent to which productivity growth was driven by reallocation of factor inputs between industries within each broad sector. Despite persistent differences in growth rates across states, we find very little evidence of any reallocation of factors towards high growth industries within sectors. In fact, if at all, factor reallocation seems to have weighed down MFP growth.

Our estimates also provide new perspectives regarding the concerns about slowing overall productivity growth in the US as well as the gap between wages and labor productivity growth. We find that, in the goods sector, states with higher labor productivity growth also experienced higher real compensation growth. However, in terms of relative magnitudes, on average, the latter lagged behind by a percentage point annually. While, we also find a strong correlation between labor productivity growth and compensation growth for the service sector, the two series exhibited virtually identical growth rates. In other words, at least our calculations suggest that compensation growth has not lagged behind labor productivity growth in services. Nevertheless, as Figure 1 also indicates, on average growth rates in labor productivity were much lower in the service sector. We find that the proximate source of this low growth was anaemic MFP growth. Underlying the anemic MFP growth rates were *negative* real user cost growth for almost all states. In fact, the simple correlation between labor productivity growth and real user cost growth across states was negative during this time period for the service sector while the correlation was positive for the goods sector. The declining real user cost growth in the service sector turns out to be due to declining relative prices of investment goods and also the declining financial cost of capital. Investigating further, we also find that the real estate services sector experienced the largest declines in the financial cost of capital.

While most of our results are new, we can tie them to a number of emerging conclusions about productivity growth, regional convergence and other key developments in the US economy. Ganong and Shoag (2013), for example, have recently shown that convergence in per capita incomes seems to have slowed down from 1980 onwards. As a motivating example, they note that the per capita income in Connecticut relative to Mississippi has not changed since 1980 from a value of around 1.8. Given that the increasing share of the service sector across the US, our finding of a lack of convergence in this sector, is clearly similar in spirit. Second, the recent concern about productivity growth leaving wage growth behind has also been challenged by some including Pessoa and Van Reenen (2013) who argue that some of this is due to the use of different price indices in deflating output (GDP deflator) vs wages (the consumer price index). They show that the conclusion does not hold true when the same deflator is used. In our study, when deflating both wages and output, we use state specific sectoral GDP deflators. Given that the service sector is usually a much larger share of the economy, our findings echo theirs. Third, the main reason why we get a negative real user cost growth, is as we mentioned, declining relative prices of investment goods. There is already a vast literature documenting this phenomenon going back at least to Greenwood et al (1997).[2] Since the goods producing sector is the one that produces investment goods, it is not surprising that the relative price shows less of a decline there compared to services. Finally, recent papers such as that of Fernald (2014) seem to conclusively document, that since late 2003 the economy headed back to the pre-1995 low productivity growth era. This is certainly true in our data as well for the states when we later show that the decline in real user cost growth was dramatic in the post 2003 era causing MFP growth to be low. Thus, taken together, the patterns that we document in this paper, either emerge from, or are consistent with recent findings.

Having outlined our key results, we now devote some space to discussing our methodology, and relating it to some of the existing literature on regional growth accounting and convergence. A

[2] Karabarbounis and Neiman (2014) have also attributed declining labor shares both across countries and also across states to the same phenomenon.

unifying feature of most of this literature at the national, sectoral and cross-country level, is that it uses the "primal" growth accounting technique to back out MFP growth. Primal MFP growth is the measured residual of output per worker growth after subtracting factor accumulation. At regional levels, however, the absence of data on capital stock, or investment, makes similar exercises more challenging to undertake. The existing literature, such as Garofalo and Yamarik, 2002 and Turner et. al., 2013, apportions the industry specific Bureau of Economic Analysis (BEA) national capital stock data to the states based on the national value added share of each state. The dual growth accounting approach which we adopt is based on the idea that any growth in MFP which causes output to grow will also cause real factor prices to grow due to the increases in the marginal product of the factors. MFP growth can then be measured as the weighted average of the growth rates of the real factor prices i.e. real wages and real user cost of capital (in a two factor model). The intellectual origins of this idea extends at least as far back as to Jorgenson and Griliches (1967) and was more recently revived by Hsieh (2002) in the context of East Asian economies.[3] Hsieh expresses concern over utilizing capital stock data from the national accounts as they are prone to errors due to the computational difficulties. Instead, he advocates the use of dual growth accounting over the primal approach as data on real factor prices is directly observable. In terms of the state-sector level analysis, the papers most closely related to ours are Turner et al. (2013) and Caliendo et al. (2014). While Turner et al. compute MFP growth and factor input growth for manufacturing and non-farming-non-manufacturing, they rely on primal accounting and are more focussed on differences at the aggregated state-level and over longer time periods ranging from 1840-2000 to 1960-2000. Caliendo et al., on the other hand, focus on a shorter time period of 2002-2007. Using a static-general equilibrium model which allows tradeable goods, and mobile labor and transport costs, they calculate MFP values at the state-industry level with a goal to quantify the effects of these on the national economy. Because of the period of analysis, they are able to use much more granular inter-regional data in calculating productivity. While, by design, the questions asked in our paper and theirs are different, both underscore the extent of sector-regional heterogeneity in

[3]See Barro (1999) for a review of this approach. Also, see Aiyar and Daalgard (2005) for a cross country application. Ciccone and Peri (2006) and Iranzo and Peri (2009) study US states but equate wage growth to MFP growth. In other words, they adopt a more restrictive form that assumes zero real user cost growth.

productivity.

Before moving on, we briefly address two issues that confront this paper. First, we are not just examining states, but goods and service sectors at the state level. This would invite skepticism with respect to the assumption of zero economic profits that any growth accounting technique, be it primal or dual, relies on. To some extent, we believe that this is mitigated by the fact that we are still considering sectors that are broad enough- it is difficult to think of a state where the entire service sector might be subject to a degree of imperfect competition that this would be truly damaging for our results. However, given the declining share of the goods sector, one might be concerned that it could be subject to a greater degree of firm concentration. Nevertheless, since states have open borders, and manufacturing goods produced in one state are unlikely to be sold only in the same state, firms are unlikely to have monopolistic power. Finally, our main analysis is for a twenty seven year period. We think this is sufficiently long to reduce the chances of short run profits contaminating our measures.

While openness can alleviate concerns regarding economic profits, they can also raise concerns as to why MFP growth should differ at all across states. One can argue that since technology flows freely across states, there is no reason for MFP growth to differ. In principle workers and capital should move to states with the highest marginal products and ultimately differentials should not exist. Kalemli-Ozcan et al. (2010) provides evidence that capital flows freely across state borders. There is however, clear evidence that labor migration has slowed down over the period of our study, though the reasons are not completely agreed upon.[4] While not directly related to migration, Guerron et al (2011) note that rich states have become more specialized while poorer states have become more diversified over the same time period. Over and above these observations it is well known that MFP growth is more than just technological change.

The rest of the paper is structured as follows: section 2 establishes the empirical framework required to conduct the dual accounting exercise and discusses the data sources. In Section 3, we

[4] For example, Kaplan and Schulhofer-Wohl (2013) argue that it is due to the decreasing geographic specificity of occupations and better information on job market opportunities elsewhere. Molloy, Smith and Wozniak (2013) on the other hand, argue that demographic and industry based explanations can be ruled out and it is likely due to more transitions in internal labor markets. Ganong and Shoag (2013) argue that the reason regional incomes have not converged is due to housing supply constraints in the rich states.

present our estimates of MFP growth and the underlying constructs- wage growth and user cost growth. In Section 4, we use the constructed values to gain insights into productivity-wage gaps, convergence, variance decomposition, and factor reallocation. Section 5 concludes.

2 Calculating MFP Growth

To understand the dual approach, we start with the standard national income equality between output generated in the economy and the sum of incomes that accrue to the factors of production, i.e., labor and capital,

$$Y = wL + rK \tag{1}$$

where Y is real GDP, L is labor, K is real capital stock, $w\left(= W/P^Y\right)$ is the real wage and $r\left(= R/P^Y\right)$ is the real user cost of capital and P^Y is the price index used to deflate GDP.

The idea behind dual accounting is that any growth to MFP that increases output, will also raise the return to the factors of production. In that case, MFP growth can be measured as a share weighted average of growth rates of returns to the factors of production i.e. real wage and real user cost growth rates. To see this, and, to also see the equivalence between primal and dual accounting, we can begin by time differentiating equation (1) and dividing it by Y,

$$\dot{Y} = \dot{w}L + w\dot{L} + \dot{r}K + r\dot{K} \tag{2}$$

$$\Rightarrow \frac{\dot{Y}}{Y} = \frac{\dot{w}}{w}\frac{wL}{Y} + \frac{\dot{L}}{L}\frac{wL}{Y} + \frac{\dot{r}}{r}\frac{rK}{Y} + \frac{\dot{K}}{K}\frac{rK}{Y} \tag{3}$$

$$\Rightarrow \hat{Y} = \alpha_L(\hat{w} + \hat{L}) + \alpha_K(\hat{r} + \hat{K}) \tag{4}$$

$$\Rightarrow \hat{Y} - \alpha_K\hat{K} - \alpha_L\hat{L} = \alpha_K\hat{r} + \alpha_L\hat{w} \tag{5}$$

Here α_L is the labor income share and α_K is the capital income share which is equal to $1-\alpha_L$. The hat, $\hat{}$, on the variables denotes their growth rates. In the last equation, the expression on the left represents the traditional MFP growth measures from the primal (quantity) growth accounting and the expression on the right represents the dual accounting counterpart. Thus MFP growth based on primal accounting should be exactly equal to the dual measure. In practice, however this equality rarely holds. Both Hsieh (1999, 2002) and Aiyar and Dalgaard (2005) find divergence between these two measures implying inconsistencies between the observed factor prices and implied factor prices of national accounts. Fernald and Neiman (2011) show that if profits are not zero then primal and dual MFP growth measures will *both* deviate from technological change. The fact that we choose two major sectors, goods and private services, ought to reduce the likelihood that the zero economic profit condition is violated. However, if subsidies and other tax incentives for investment, or taxes on capital income (i.e. factor market distortions) are not measured correctly, then the dual measure of real user cost growth will not be equal to the implied primal real return on capital.[5] As we shall show below, we try and capture explicit taxes and depreciation deductions at the industry-state level to mitigate these problems.

To obtain measures of MFP growth, we need to construct measures of real wage growth, real user cost growth and factor income shares for the sectors at the state level. In the following subsections, we outline our methods to calculate these variables.

2.1 Real Wage Growth Rate

Our constructed series on the real wage growth is composition-adjusted based on different kind of labor groups. Following Hsieh (2002), the labor groups are based on four educational categories - some school, high school graduate, some college and college graduates, and gender. The weighted real wage growth rate of the sector 'i' and state 's' is

$$\triangle \ln w_{i,s,t} = \sum_{g} \bar{S}_{L,g,i,s} \triangle \ln w_{g,i,s,t} \tag{6}$$

where 'i' represents the broad sector and 's' the state. Here, $\bar{S}_{L,g,i,s} = \frac{S_{L,g,i,s,t}+S_{L,g,i,s,t-1}}{2}$, where $S_{L,g,i,s,t}$ is the share of labor income of each group in total labor income in year t, and $g = education \times gender$. Total income of each group and sector can be obtained by summing over the labor income of all the individuals. The real wage growth for sector 'i' is obtained by subtracting the growth rate of the State GDP deflator for that sector from the nominal wage growth.

2.2 Real User Cost of Capital

Following Hall and Jorgenson (1967) and Coen (1968), a profit maximizing competitive firm invests in capital till the marginal product of capital is equal to the real user cost of capital,

$$RUC_t = \frac{P_t^I}{P_t^Y}(i_t + \delta_t - \pi_t)\frac{(1 - \tau_t z_t)}{(1 - \tau_t)} \tag{7}$$

Here, a decision to invest in one unit of capital depends on P_t^I/P_t^Y, the price of the new capital

[5]See Fernald and Neiman for an expanded treatment on this subject.

goods relative to the price of the final good; the real interest rate which is the financial cost of this investment ($i_t - \pi_t$) plus the depreciation rate of capital goods (δ_t); and the tax applications in terms of the effective corporate income tax (τ_t) and the present value of depreciation deductions (z_t). $(1-\tau_t z_t)/(1-\tau_t)$ reflects a tax subsidy. If the government does not provide any tax benefits in terms of depreciation deductions, i.e. $z_t = 0$, the real user cost will increase by a fraction $1/(1-\tau_t)$.[6]

The real user cost growth for a sector, i, is the share weighted average of the growth rate of the user cost in each industry, j. Thus, for the goods producing sectors, the user cost growth rate is the weighted sum of user cost growth in manufacturing, mining and construction,

$$\triangle \ln RUC_{i,s,t} = \sum_j \bar{S}_{K,j,i,s} \triangle \ln \left(\frac{P^I_{j,t}}{P^Y_{j,s,t}} (i_t + \delta_{j,t} - \pi_{j,t}) \frac{(1-\tau_{s,t} z_{j,t})}{(1-\tau_{s,t})} \right), \tag{8}$$

$\bar{S}_{K,j,i,s} = \left(S_{K,j,i,s,t} + S_{K,j,i,s,t-1}\right)/2$, where $S_{K,j,i,s,t}$ is the share of capital income of each industry in total capital income of the sector for year t. i_t is the nominal interest rate. $P^Y_{j,s,t}$ is the state GDP (SGDP) deflator. $\tau_{s,t}$ is the state specific effective corporate income tax rate which is constructed following Chirinko and Wilson (2008), $z_{j,t}$ is the present value of depreciation deductions of \$1 investment which is calculated using the double declining balance method from Hall and Jorgenson (1967) using industry specific depreciation rates $\delta_{j,t}$. The inflation rate $\pi_{j,t}$ is constructed as a five year moving average lagged inflation of investment prices indices $P^I_{j,t}$ following Gilchrist and Zakrajšek (2007). Henceforth, we refer to $P^I_{j,t}/P^Y_{i,s,t}$ as the relative price of investment goods, $(i_t + \delta_{j,t} - \pi_{j,t})$ as the financial cost of capital, and $(1-\tau_{s,t} z_{j,t})/(1-\tau_{s,t})$ as the tax component of the real user cost.[7]

2.3 Labor and Capital Income Share

To calculate the sector (or industry) specific time varying labor income shares for the states, we follow the methodology of Gollin (2002) and Gomme and Rupert (2004),

$$\alpha_{L,i,s,t} = \frac{\frac{\text{Compensation of Employees}}{\text{Wage and Salary Employment}} \times \text{Total Employment}}{\text{SGDP-ITS}} \tag{9}$$

[6]Hall and Jorgenson also incorporate investment tax credits. We have omitted investment tax credit while constructing the real user cost as the federal investment tax credit was rolled back in 1986 and although many states allow for investment tax credit, most of the time it is targeted towards specific firms or industries at a finer level.

[7]This follows Gilchrist and Zakrajšek though they refer to $\left(P^I_t/P^Y_t\right)(1-\tau_t z_t)/(1-\tau_t)$ as the tax adjusted relative price of investment goods.

where $\alpha_{L,i,s,t}$ is the labor income share and SGDP-ITS is the Sectoral State GDP less net indirect taxes. This method of computing labor income share also addresses the allocation of the income of the self employed between labor and capital. Their labor income is imputed by assuming a value equal to the average compensation of wage and salary employed (Gollin, 2002). Capital income share is calculated as $1 - \alpha_L$

Finally, in calculating MFP growth, we use the two period averages of factor income shares, i.e.

$$MFPG_{i,s,t} = \bar{\alpha}_{K,i,s} R\hat{U}C_{i,s,t} + \bar{\alpha}_{L,i,s} \hat{w}_{i,s,t}, \tag{10}$$

where, $\bar{\alpha}_{L,i,s} = (\alpha_{L,i,s,t} + \alpha_{L,i,s,t-1})/2$, $\bar{\alpha}_{K,i,s} = (\alpha_{K,i,s,t} + \alpha_{K,i,s,t-1})/2$, and $R\hat{U}C$ and $\hat{w}$ reflect the growth rate of real user cost and real wages respectively for sector 'i' and state 's'.

2.4 Data Sources

This section briefly documents the data used for constructing our series. Section A of the online data appendix deals with the definitions and sources in greater detail.[8] There are two reasons why we begin our analysis in 1980. First, data for industry GDP deflators at the state level go back only to 1977. Instead of starting at 1977 however, we choose to start at 1980 mainly because of the unusually high oil prices during the seventies. Similarly, we stop the exercise at 2007 mainly because of the unusual economic conditions since that time which might have a disproportionate effect on the overall calculations.[9] The data is in Standard Industrial Classification (SIC) for years 1980-1997 and in North American Industrial Classification System (NAICS) for years 1998-2007. Because of incompatibilities, we initially present the results separately for the two classifications. The nominal series are converted to real series using the price indices with base year 1997.

To construct the composition adjusted measure of real wage growth, we rely on the micro data set of March Current Population Survey (CPS) published at IPUMS-CPS for 1980-2008. Our measure of annual real wage growth is based on the weekly wages derived from this data set.[10] Our constructed wage growth and weeks worked corresponds only to full time equivalent employees.

[8] The online appendix can be viewed at http://www.bus.lsu.edu/achanda/research.htm

[9] Thus, our period of study encompasses the Great Moderation (which is conventionally assumed to have begun in 1985).

[10] While we calculate annual growth in weekly wages, all other variables are calculated using yearly data. For the two sets to be compatible, our implicit assumption is that the number of weeks worked in a year has not shown any long term trend.

Anybody working below 35 hours a week and 40 weeks per year is dropped from the sample.[11] Correspondingly, for the state-sector specific labor productivity measure we use output per weeks worked.[12]

To construct the series on real user cost, we require data on the nominal interest rate, investment price deflators, SGDP deflators, depreciation rates and state effective corporate income tax rates.[13] The nominal interest rate is a twelve-month average of the Moody's Seasoned AAA Corporate Bond Yield available at St. Louis Federal Reserve Bank web site and is same across all the states.[14] Industry specific investment price deflators for the US are constructed using industry-specific "Investment in Private Fixed Assets" and its "Chain-type Quantity Indices" from the BEA Standard Fixed Assets tables. Industry specific measures of the real depreciation rates for the US are constructed using the industry specific real depreciation cost and real net capital stock of private fixed assets. We use data from the BEA Standard Fixed Asset tables on "Current Cost Depreciation of Private Fixed Assets by Industry" and its "Chain-type Quantity Indices" to construct real depreciation cost, and "Current Cost Net Stock of Private Fixed Assets by Industry" and it's "Chain-type Quantity Indices" to construct real net capital stock of private fixed assets. Industry specific SGDP deflators for each state are constructed using the state-industry specific data on SGDP, real SGDP and quantity indices of SGDP from the BEA Regional Economic Accounts. Effective corporate income tax rates for the states are constructed using data on federal corporate income tax rates from the Tax Foundation, data on state corporate income tax rates and federal tax deductibility from various editions of the "Book of the States" published by the Council of the State Governments.

To construct the factor income share series at the state level, we use the data on State Gross Domestic Product (SGDP), Compensation of Employees, Indirect Taxes Less Subsidies, Wage and Salary Employment and Total Employment published by the BEA Regional Accounts Section.

[11] We also tried our analysis with different hour and week combinations such as: all hours and all weeks, 40 hours and 40 weeks, 35 hours and 40 weeks, 30 hours and 40 weeks. But this did not alter our results.

[12] We derive the average weeks worked data by state and sector from the IPUMS-CPS and total employment numbers from the BEA.

[13] Present value of depreciation deductions and inflation rates are calculated using the constructed series on the depreciation rates and investment price deflators respectively.

[14] We also experimented with Moody's Seasoned Baa Corporate Bond Yield as the nominal interest rate measure. This did not yield any additional insights.

3 Growth Accounting

In this section we present our calculations of MFP growth and discuss its contribution to sectoral labor productivity growth. In addition, to the usual growth accounting exercise, we also pay attention to the two components of MFP growth- real wage growth and real user cost growth. We first discuss the goods sector and then move on to the service sector. We discuss the 1980-97 period covered by the SIC measures and the 1998-2007 NAICS measures concurrently for each sector.

3.1 The Goods Producing Sector

Figures 2-4 display MFP growth, wage growth and real user cost growth against labor productivity growth based on various definitions and both time periods for the goods producing sector. For the period 1980-1997, the relevant plots are 2(a), 3(a) and 4(a) while the first four columns of Table 1 summarize the key statistics. The unweighted means for state level labor productivity and MFP growth are 2.87% and 2.24% respectively. This implies, on average, a 78% contribution of MFP growth to labor productivity growth. Mining rich states like Wyoming, New Mexico, Louisiana, North Dakota, Oklahoma and Texas have the highest MFP growth rates, outpacing their labor productivity growth. From Figures 3(a) and 4(a), it is evident that, while these states experienced high wage growth, it is the high annual real user cost growth rate of 6% or more that contributes to their high MFP growth. The high real user cost growth can be attributed to high oil prices of the early 1980's which leads to an initially high value of the SGDP deflator for the mining industry, hence a very low initial real user cost. The subsequent decline in oil prices implies rising relative price of investment goods and hence high growth in real user cost. This is further accentuated by high growth in the financial cost of capital due to falling inflation in the investment price deflator of the mining industry.

Given the unusual behavior of oil prices at the start of this period, we recalculated the various growth rates after excluding the mining sector for all states. The modified summary statistics are presented in the remaining four columns of Table 1 and the corresponding scatterplots are Figures 2(b), 3(b) and 4(b). Real user cost growth is now less than half of what it was before. Wage growth falls too, though less dramatically. This results in a much lower mean MFP growth rate of

1.34% which is approximately 48% of the mean labor productivity growth of 2.78%. Once mining is dropped, New Hampshire, Massachusetts, Vermont, New Mexico and Oklahoma are the states with the highest MFP growth rates. They record both high wage growth and high real user cost growth. The observation that real user cost growth for states was not zero, coupled with substantial variation comparable to that of real wage growth, underscores the fact that the marginal product of capital was not constant over this time period.

In Table 2, we list the summary statistics for 1998-2007. Since, this is a much shorter period of time, the numbers are more likely to be sensitive to business cycle fluctuations. The average for labor productivity growth was 2.40% while MFP growth averages to -0.20%. The average real wage growth is 0.85% which is about half of the previous period. More importantly, the real user cost growth is -1.72%. A quick look at Figures 2(c) and 4(c) which plot MFP growth and real user cost growth against labor productivity growth respectively reveal the underlying reasons. States like Wyoming, Louisiana, Oklahoma, Texas, Montana, Nevada and West Virginia with relatively larger shares in the mining industry drive down the average real user cost growth, and consequently, MFP growth. The SGDP and investment price deflators for the mining industry recorded high growth with the former outpacing the latter. This caused the relative price of investment goods to decline. Further, an increase in the rate of inflation in the investment price deflator caused the financial cost of capital to decline. Thus real user cost growth declined for the mining industry, and for the goods sector for these resource rich states.

Given the behavior of prices in mining, like before, we revisit all our calculations for 1998-2007 after dropping this sector. This raises labor productivity growth slightly to 2.86%. Factor price growth rates also increase with real user cost growth being revised upwards by as much as two percentage points and real wage growth increasing to 1.35%. MFP growth increases from a little less than zero to a little more than 1%. Figure 2(d) portrays the relationship between MFP growth and labor productivity growth for the states after dropping the mining industry. The upper end of the distribution is largely unchanged in terms of rankings, except for New Mexico. Most of the changes take place at the lower end with states like Louisiana, Texas, and Wyoming, experiencing large increases in ALP and MFP growth.

Finally, it is important to note that, as opposed to the literature on productivity revival, the statewide average for MFP growth in goods is lower than the previous time period despite dropping the mining industry. Theoretically, any growth to MFP should reflect in higher real factor price growth rates, however, we do not find such trends in our constructed factor price data to provide support for productivity revival. We address this concern in a later sub-section.

3.2 The Service Sector

Figures 5-7 present the scatterplots while Table 3 lists the summary statistics for MFP growth, wage growth and real user cost growth in the service sector for the two time periods. Compared to the goods sector, the service sector exhibits lower productivity growth during 1980-1997. This is in line with the national trend of productivity slowdown. Compared to the non-mining goods sector (in Table 1) the average values for ALP, MFP and factor price growth rates are all at least a full percentage point lower. ALP and real user cost growth were, in fact a full two percentage points lower. The difference is visually starker if we compare Figure 2(b) to 5(a). In the former, we can see that only four states had negative MFP growth during this time period. The latter figure, on the other hand reflects the fact that as many as 27 states had negative MFP growth during the same period. While wage growth was weak for most states, the proximate source for negative MFP growth is real user cost growth. Indeed, as Figure 7(a) indicates, all but one state experience negative real user cost growth. Moreover, Figures 5(a) and 7(a) reveal two interesting observations: first, there is some indication from Figure 7(a) that the real user cost growth and labor productivity growth in services exhibited a negative correlation. This suggests that states with higher labor productivity growth experienced rapid fall in the real user cost and in turn, implying faster physical capital accumulation. This is consistent with the narrative of productivity slowdown at the national level, where the relative contribution of capital growth was larger than that of MFP growth. Delving further, we find that the negative real user cost growth for the states stems from a rapid fall in the relative price of investment goods at a rate of -2.23% annually.[15] In other words, the service sector experienced a more rapid pace of investment specific technological change. This might reflect

[15]Decomposing the growth rate of real user cost, we find the relative price ratio, the financial cost of capital and the tax component to grow at the rates of -2.23%, 2.36% and -0.95% respectively.

the fact that the good sector produces many of these investment goods and hence does not show a rapid decline in the relative price of investment goods. Interestingly, there is also more variation in the user cost growth in the goods sector compared to the service sector. Second, it is evident from Figure 5(a) that though MFP growth is lower and negative for majority of the states, we still see a positive association between ALP growth and MFP growth.[16]

The summary statistics for the more recent time period 1998-2007 are displayed in columns 5-8 in Table 3. We find that while labor productivity growth increases compared to the earlier period, MFP growth does not follow suit. Though the average for labor productivity growth shows a significant improvement to 1.73% (Table 3, column 5) in comparison to 0.74% in the previous period (Table 3, column 1), MFP growth clearly shows the opposite behavior with an average of -0.99%. This contradicts the existing literature which finds a surge in productivity growth for the service sector post 1995. Real wage growth during this period is an anemic 0.65%, while real user cost growth declines further at -3.50%. In fact, it can be gleaned from Figure 7(b) that all the states saw real user cost declining at a rate of 3% or greater.

3.3 Explaining Low MFP Growth

Our measures of MFP growth so far clearly highlight a wide range of values across states for both broad sectors of the economy. At the same time, an obvious concern with our MFP growth measures is that it is lower for 1998-2007 period. This conflicts with the well documented productivity revival that began from 1995. In this section, we reconcile our numbers with the current literature by pursuing three possibilities - a) Using an alternative measure of labor income growth based on compensation data, b) A documented decline in productivity growth around 2004 and c) the effect of excluding the real estate service sector. Our main conclusion from the ensuing discussion is that while the first can partially help reconcile the anomaly, (b) and (c) have more substantive roles.

[16] Since labor on average has 0.62 factor share during this period, the positive association between wage growth and ALP growth dominates the negative association between real user cost growth and ALP growth.

3.3.1 Revisiting Wage Growth

The IPUMS-CPS data used for constructing real wage growth has two problems. First, it is top-coded, and second, it does not reflect non-wage benefits. This may underestimate the real wage growth given the increasing share of non-wage compensation over the last decade. As an alternative exercise, we use compensation per worker data from the BEA as a measure of labor income. The downside of this exercise is that the compensation data is not refined by education level and gender, hence the resulting wage growth may simply reflect reallocation effects.

Table 4 summarizes all our calculations.[17] For easier comparison, columns (1)-(3) summarize the IPUMS-CPS based results earlier presented in Tables 1-3. Columns (4)-(6) present the new results based on compensation data. To calculate average labor productivity growth numbers, we now have to use annual labor force growth rather than annual growth in weeks worked. Comparing column (1) to column (4), one can be reassured that this hardly makes a difference. Like before, the overall pattern on labor productivity growth include higher growth in goods producing sectors in both time periods and within the goods sector, once mining has been dropped, we see a marginally higher growth rate post 1998. The introduction of compensation data leads to large adjustments in wage growth for 1998-2007. For services, the implied wage growth more than doubles. Irrespective of the sector, for the second period, these adjustments mean that MFP growth is now higher by about 0.5 to 0.6 percentage points annually. While these are large adjustments, it still does not alter the fact that MFP growth in services is both negative, and lower compared to the earlier period.

This substitution also affects the ranking of the states. In section B of the online appendix, we include plots for compensation based wage growth against the earlier estimates obtained from the IPUMS-CPS. We focus on the 1998-2007 period given the larger impact of this substitution during this period. Figures B.1 (a) and (b) present the scatter-plots for the goods and non-mining goods sector respectively. For these sectors, the ranking of the states remain relatively unchanged even with the alternative wage growth measures. On the other hand, this observation does not hold true for the service sector (Figure B.1 (c)). There is almost no correlation between wage growth and

[17]Table 4 does not report the real user cost growth numbers as they are same irrespective of the data source for the real wage growth.

compensation growth and while the minimum values for the latter are higher, overall the range of values is compressed. Moving from IPUMS to BEA compensation data obviously has the most drastic effect on Wyoming. It is also interesting to note that some other states which had mediocre rankings based on wage growth such as New York, Virginia, and Maryland, now have the highest compensation growth rates.

3.3.2 Mid-2000's Productivity Slowdown

The 1997-1998 divide that we have implemented is due to changes in industrial classification, and not due to any economic or political event. The productivity revival on the other hand is known to have begun around 1995-96. A body of research has now emerged that documents the re-emergence of the productivity slowdown since late 2003. Examples include Fernald (2014), Gordon (2013) and Byrne, Oliner, and Sichel (2013).[18] In order to examine if this behavior of productivity plays a role in our low estimates, we break up the second period to 1998-2003 and 2003-07. The downside of doing this is that it makes our productivity measures even more susceptible to short-term price fluctuations. With that caveat, the results are reported in Table 5. A comparison of the results for 1998-2003 (presented in upper panel) with those for 2003-2007 (presented in lower panel) indicates that our low values are indeed partly driven by the return of the slowdown. There is a sizeable difference in the labor productivity growth rates between these two sub periods irrespective of the sector. Furthermore, MFP growth in services during 1998-2003 is now higher than what was calculated for 1980-1997 while the non-mining goods sectors shows an even larger jump. Thus our numbers are also consistent with the productivity revival. If we examine the lower half of Table 5, we also see that the 2003-07 period was worse than the 1980-1997 period for both sectors.

3.3.3 Real Estate Services

An interesting feature of the data is that real user cost in services continues to decline over the entire time period, and this decline even accelerates during the productivity revival. This is true despite breaking the second period up into two sub-periods and an acceleration in labor productivity growth. Recall that the real user cost comprises of three components: the relative price

[18] The explanations for this slowdown differ, but are usually centered around the changing role of technological progress in the information technology and communications sector.

of investment goods (P^I/P^Y), the financial cost of capital ($i+\delta-\pi$) and the tax component ($(1-\tau z)\,/\,(1-\tau)$). All the three components contribute to this rapid fall in the user cost with a corresponding average growth rate of -0.54%, -2.67% and -0.28% respectively during 1998-2007. Pursuing this problem further, we looked at the various industries that comprise the service sector. We found that real estate industry could potentially be an important source of the large decline in real user cost growth. The 1998-2007 period includes the real estate boom in the US. Not surprisingly, the price indices of the real estate services industry increased as well. In fact, the average annual growth rates for GDP deflator and the investment price deflator were 2.79% and 3.82% respectively. This meant that P^I/P^Y increased at a moderate rate of 1.03% annually. However, the five-year lagged inflation rate derived from the investment price deflator nearly doubled from 2.37% to 4.36% between 1998-2007. As a result the financial cost of capital fell at the rate of -6.43%. Furthermore, real estate services accounts nearly 42% of the entire service sector with respect to capital income, while its average GDP share is only around twenty percent of all services.[19] So as an additional exercise, we dropped the real estate industry from the service sector.[20] In Table 6, we summarize the statistics for the service sector after dropping real estate services. The results are based on compensation based real wage growth and shown for 1998-2007, 1998-2003 and 2003-2007. Compared to the earlier results for the aggregate service sector presented in Table 4, we can see that the MFP growth rate for 1998-2007 is higher compared to earlier calculations. The real user cost growth increases from -3.50% to -1.99%. Even for the 1998-2003 subperiod, MFP growth rate goes up by more than half a percentage point owing to this composition effect.

4 Growth Empirics over the Medium Run (1980-2007)

Having documented some of the patterns for MFP growth and its components in both sectors, we now devote the rest of the paper to understand its implications along several lines. We undertake four different kinds of analysis- the extent of correlation across sectors and over time in productivity growth, a variance decomposition of labor productivity growth, convergence in sectoral growth and the role of reallocation of inputs in explaining sectoral growth. Since both 1980-1997 and

[19] These are unweighted means.

[20] While one can debate the usefulness of dropping such a large industry, there are numerous examples in the primal growth accounting literature of doing so. See for instance, van Ark et al. (2008), Gordon (2010).

1998-2007 are relatively short periods, specially when one wants to infer convergence and reallocation patterns, we take the liberty in this section, to focus instead mostly on the combined time period of twenty seven years from 1980 to 2007. Strictly speaking this can be problematic given the change in classification of various sub-industries. As a pre-check, we plotted the three year averages of labor income shares before and after the change in classification for goods and services to rule out any unusual biases. As the plots in Figure B.2 in the online appendix indicates, there does not seem to be any systematic differences.[21] To streamline the discussion, all our results from here on will use compensation based wage data. We will refer to robustness with respect to IPUMS based wage data whenever necessary and are included in Section C of the online appendix.

4.1 MFP Growth Correlations

In Table 7, we present the summary statistics for the combined time period. There are two main conclusions to take away here - first, as we have seen before with the shorter time intervals, the goods producing sector, had higher labor productivity growth and higher MFP growth. In fact MFP growth in services was on average, less than zero. A second observation relates to the gap between real wage growth and labor productivity growth. While wage growth was higher for the goods producing sector, it lagged behind labor productivity growth by approximately a full percentage point. In the private service producing sector, however real wage growth was close in magnitude to labor productivity growth. Given that the service sector is usually a much larger sector for most states, this reinforces the observations of Pessoa and Van Reenen (2013). They note that the gap between labor productivity growth and average wage growth is much smaller when one uses the same deflator (output deflators), looks at mean growth (instead of the median), and uses compensation data rather than wage data. Interestingly, the standard deviations for both variables within each sector are also similar in magnitude. In addition to summary statistics, we can take advantage of the cross-section and also examine the correlation between labor productivity growth, MFP growth, wage growth, and real user cost growth. The statistics are displayed in Table 8. In the goods producing sector, particularly once we drop mining, we see a strong correlation between

[21]The plots also indicate that some states experience larger changes compared to others. However such movements were also apparent when we compared shares within each of the time periods within each sector (i.e 1992-1994 vs 1995-1997 for SIC and 1998-2000 vs 2001-2003 for NAICS).

all four variables. Mainly real wage growth and real user cost growth exhibit a strong correlation. However, the same cannot be said of services. In fact, for services we see something quite different. While real wage growth and labor productivity growth were strongly correlated, real user cost growth and labor productivity growth exhibited a negative correlation. A corollary is the weaker correlation between productivity growth and MFP growth in services relative to the goods sector. We will revisit this issue in a later subsection when we undertake variance decomposition exercises.

A different way to exploit the cross-sectional data is to look at correlations across sectors for these four variables. The statistics are displayed in Table 9. The main observation here is that real wage growth exhibits a clear positive correlation across sectors, and, interestingly, real user cost growth exhibits a weak negative correlation. Given the larger labor share in output for both sectors, overall MFP growth also exhibits a weak positive correlation.

Finally, one can ask, how much of these observations are due to the fact that we use compensation data, and also, if, we stopped the analysis in 2003, as in the earlier section, how would things change? Tables C.1 through C.9 in the online appendix summarize these alternative scenarios. As we have already seen, using IPUMS based wage data yields lower values of wage growth. As a result, the service sector wage growth now lags behind labor productivity growth by approximately half a percentage point. At the same time, the gap increases even further in the goods producing sector. Secondly, the tight positive correlation between real wage growth and labor productivity growth in services is not as strong though the goods sector is unaffected. Not surprisingly, some of the positive correlation for wage growth across sectors is weaker. If instead we use the compensation data but stop the analysis at 2003, the only change is that the weak negative correlation between real user cost growth in service sector and the goods sector now disappears.

4.2 Sectoral Convergence

Moving on from simple correlations, we now examine sectoral convergence. While earlier studies such as the one by Barro and Sala-i-Martin (2004) indicated per-capita income convergence across US states at an annual rate of 2% for over a century, this phenomenon has weakened considerably over the past three decades.[22] To assess the degree of convergence in sectoral productivity growth, we run some cross-sectional regressions. We run regressions with both ALP growth and MFP growth as dependent variables. To capture initial values, we use initial average labor productivity for both types of regressions, since we do not have initial MFP values. The time period covered is 1980-2007. As an additional exercise, we also control for initial sectoral human capital using the fraction of workers with a college degree.[23] Given the well documented phenomenon of skill biased technological change during this period, it would be instructive to see if sectors that had initially high shares of skilled workers fared better during this time period. In keeping with the literature, our baseline regressions are of the following form,

$$g_i = \alpha + \beta \ln y_{i,1980} + \epsilon_i \tag{11}$$

where g_i refers to the growth rate of labor productivity or MFP and $y_{i,1980}$ refers to average labor productivity for 1980. A negative and significant β-coefficient provides evidence of absolute convergence.[24] Table 10 lists the results. Several contrasting results emerge from the table. First, irrespective of whether we look at ALP growth or MFP growth, the estimates suggest that the goods sector irrespective of whether mining is included or not exhibits absolute convergence. However, convergence seems stronger once we drop the mining sector which is not that surprising. The inclusion of mining as we have seen all along can affect the growth rates of states very asymmetrically. Once mining is dropped, the coefficient falls to -0.042 which suggests a convergence rate of 1.68%. This is not that far from Barro's iron law of 2%. Secondly, we also find that initial human capital has a significant effect on explaining both ALP growth and MFP growth. An examination of the magnitude of the point estimate indicates that initial college labor share plays a greater role in explaining MFP growth than ALP growth. Adding human capital does not alter the coefficient of initial productivity. It increases the R-square quite a bit. While these regressions are at best, exploratory, for the non-mining goods sector we can explain almost seventy percent of the variation in MFP growth. The results themselves are not surprising. For instance, Barro

[22] In addition to the recent work of Ganong and Shoag (2013) and references cited therein, Barro and Sala-i-Martin too found a lack of convergence over 1980-2000.

[23] The college share refers to the share of college graduates in the labor force specific to a sector-state in 1980. The variable is computed using the full-time employed labor force from the CPS-IPUMS data.

[24] One can write an entire paper surrounding determinants of convergence across states. This is not our aim here and our exercises should be viewed more as indicative of broad patterns.

and Sala-i-Martin (1991) and Bernard and Jones (1996) provide strong evidence of convergence in manufacturing for the US states for earlier time periods.

In Panel B, we present the results for services. Here we find something entirely different. Both labor productivity and MFP growth show no convincing signs of convergence. The estimated coefficient for initial productivity is, instead, positive and significant for ALP growth, though the significance goes away once human capital is added. For MFP growth, it is not significant to start with. Human capital is, however, significant in both regressions. The magnitude of the estimated coefficient is larger for ALP growth rather than MFP growth. Similarly, the fraction of the variation explained is relatively larger for ALP growth. While not conclusive, these exercises indicate that irrespective of the sector, both ALP and MFP growth are positively associated with initial human capital. However, convergence is only observed for the goods sector. Given the uniformly low growth rates in ALP and MFP in the service sector, one might argue that it unreasonable to expect convergence dynamics.[25] Nevertheless, the fact that we do not observe any convergence in services can be further investigated by individually examining convergence in real wage growth and real user cost growth respectively. We do this in Table 11 where we run regressions with initial values of the relevant factor price and also include the control for initial human capital. One has to be more careful about the interpretation of the initial human capital value now since surely the initial factor price is also a function of initial human capital. When we look at non-mining goods, we see clear signs of wage convergence without the human capital control. Once the human capital control is introduced, we continue to see convergence but the effect of the human capital variable is positive both for user cost and real wage growth. One interpretation of the positive effect of initial human capital is that it might reflect the skill bias of technological change, which in turn increased factor prices. However, things become murky when we look at the service sector, where we know real user cost growth has been negative per our construct for all states. It seems that the real user cost growth exhibits convergence while it is real wage growth that exhibits either a lack of convergence and even divergence. The lack of convergence in wage growth consistent

[25] In the human capital regressions in Table 10, we have used state-sector initial values. However, one can argue, that what might matter more is the initial state value for all sectors combined. When we substituted that, we found that it still played a significant role in MFP growth but less so for ALP growth.

with finding in the urban economics literature. For example, Berry and Glaesar (2005) document divergence in wages across metropolitan areas for the 1990's. The real user cost growth continues to exhibit convergence. Since labor factor shares are much larger (see Figure B.2 in the online appendix), the lack of wage convergence drives the lack of convergence in MFP growth as well.[26] Finally, unlike the goods producing sector, we see that initial human capital has a negative effect on subsequent user cost growth. A straightforward explanation could be that areas with high human capital attracted more physical capital due to capital skill complementarity leading to a decline in real user cost. However, given the exploratory nature of these regressions, it is premature to jump to conclusions. Nevertheless this highlights the importance of the need to explore further the sectoral variations in both the pace and the nature of technological progress and their interaction with regional endowments.

4.3 Variance Decomposition of Labor Productivity Growth

Having observed that there is little evidence of absolute convergence in the service sector, we now ask a different question. To what extent is the variance in ALP growth due to variation in MFP growth versus variation in factor input growth? Going back at least as far as the cross-country work of Klenow and Rodriguez-Clare (1997, henceforth KRC), a body of research has emerged that attempts to allocate the variance in output per worker growth between growth in factors of production and MFP.[27] Consider equation (4), which can be expressed as

$$\hat{Y} - \hat{L} = (\alpha_L \hat{w} + \alpha_K \hat{r}) + \alpha_K \hat{K} + (\alpha_L - 1)\,\hat{L} \tag{12}$$

Given our underlying assumption of constant returns to scale and the fact that we use factor price growth to estimate MFP growth, equation (12) can be expressed as

$$\hat{y} = \hat{A} + \alpha_K \hat{k} \Rightarrow \hat{y} = \hat{A} + \hat{X}$$

where $\hat{y} = \hat{Y} - \hat{L}$, $\hat{k} = \hat{K} - \hat{L}$, $\alpha_K = 1 - \alpha_L$, and $\hat{X} = \alpha_K \hat{k}$. In terms of variances, this implies,

$$\begin{aligned} \sigma^2_{\hat{y}} &= \sigma^2_{\hat{A}} + \sigma^2_{\hat{X}} + 2\sigma_{\hat{A},\hat{X}} \\ \Rightarrow 1 &= \frac{\sigma^2_{\hat{A}}}{\sigma^2_{\hat{y}}} + \frac{\sigma^2_{\hat{X}}}{\sigma^2_{\hat{y}}} + \frac{2\sigma_{\hat{A},\hat{X}}}{\sigma^2_{\hat{y}}}, \end{aligned} \tag{13}$$

[26] We also find this to be true for CPS-IPUMS data and when we restrict the analysis to 1980-2003. See Tables C.10-C.12 in the online appendix.

[27] Also see Baier et al. (2006).

where $\sigma^2_{\hat{y}}$ is the variance in output per worker growth, $\sigma^2_{\hat{A}}$ is the variance in MFP growth, $\sigma^2_{\hat{X}}$ is the variance in capital intensity growth, and $\sigma_{\hat{A},\hat{X}}$ is the covariance in MFP growth and capital intensity growth. The variance in labor productivity growth can be attributed to variance in MFP growth, weighted capital intensity growth, and the covariance between the growth of the latter two. Such an analysis can provide some insight into how much of labor productivity growth is due to improvements in efficiency or technology vs factor inputs. The presence of the covariance immediately highlights a problem- it is not possible to completely separate the relative contributions of MFP vs factor growth.[28] As a middle ground KRC, advocated the splitting of the covariance equally. Instead, we follow the strategy advocated by Baier et al (2006) and Turner et al (2013), which we briefly summarize below.

Note that equation (13) can also be rewritten as,

$$1 = \frac{\sigma^2_{\hat{A}}}{\sigma^2_{\hat{y}}} + \frac{\sigma^2_{\hat{X}}}{\sigma^2_{\hat{y}}} + \frac{2\rho_{\hat{A},\hat{X}}\sigma_{\hat{A}}\sigma_{\hat{X}}}{\sigma^2_{\hat{y}}},$$

where $\rho_{\hat{A},\hat{X}}$ is the correlation between factor growth and MFP growth, while $\sigma's$ represent the standard deviations. Suppose we believed that all of the correlation was due to MFP growth and not due to variation in factor input growth. In other words, factor accumulation was endogenous to MFP growth. To capture this conjecture, we can first rearrange the above expression as,

$$1 = \frac{\left(\sigma_{\hat{A}} + \sigma_{\hat{X}}\rho_{\hat{A},\hat{X}}\right)^2}{\sigma^2_{\hat{y}}} + \frac{\sigma^2_{\hat{X}}\left(1 - \rho^2_{\hat{A},\hat{X}}\right)}{\sigma^2_{\hat{y}}}.$$

Here the first term captures the fact that variation in MFP growth is not only reflected in the standard variance term but also has an effect through its correlation with factor growth. In other words, it reflects an upper bound for the role of MFP growth. The second fraction reflects the fact that the measured variance in factor growth overstates its true importance. Likewise, we can take the opposite view, that the correlation between the two variables is driven primarily by input growth. We now have,

$$1 = \frac{\left(\sigma_{\hat{X}} + \sigma_{\hat{A}}\rho_{\hat{A},\hat{X}}\right)^2}{\sigma^2_{\hat{y}}} + \frac{\sigma^2_{\hat{A}}\left(1 - \rho^2_{\hat{A},\hat{X}}\right)}{\sigma^2_{\hat{y}}}.$$

Turner et al (2013) propose taking an average of each of the variables' two possible roles. In other words, the share of the variance attributable to MFP growth and factor intensity growth are

[28] Note that one cannot rule out the possibility that any of the first two terms can be greater than one, with the corollary that the covariance is negative.

respectively,

$$\frac{\bar{\sigma}^2_{\hat{A}}}{\sigma^2_{\hat{y}}} = \frac{\left(\sigma_{\hat{A}} + \sigma_{\hat{X}}\rho_{\hat{A},\hat{X}}\right)^2}{2\sigma^2_{\hat{y}}} + \frac{\sigma^2_{\hat{A}}\left(1-\rho^2_{\hat{A},\hat{X}}\right)}{2\sigma^2_{\hat{y}}} \tag{14}$$

and

$$\frac{\bar{\sigma}^2_{\hat{X}}}{\sigma^2_{\hat{y}}} = \frac{\left(\sigma_{\hat{X}} + \sigma_{\hat{A}}\rho_{\hat{A},\hat{X}}\right)^2}{2\sigma^2_{\hat{y}}} + \frac{\sigma^2_{\hat{X}}\left(1-\rho^2_{\hat{A},\hat{X}}\right)}{2\sigma^2_{\hat{y}}} \tag{15}$$

where $\frac{\bar{\sigma}^2_{\hat{A}}}{\sigma^2_{\hat{y}}}$ and $\frac{\bar{\sigma}^2_{\hat{X}}}{\sigma^2_{\hat{y}}}$ reflects what they call the average decomposition. In Table 12, we present the pure variance measures, $\sigma^2_{\hat{y}}, \sigma^2_{\hat{A}}$, $\sigma^2_{\hat{X}}$, the correlation between MFP growth and factor intensity growth, $\rho_{\hat{A},\hat{X}}$, and the adjusted variance shares $\bar{\sigma}^2_{\hat{A}}/\sigma^2_{\hat{y}}$, $\bar{\sigma}^2_{\hat{X}}/\sigma^2_{\hat{y}}$. Like before, we do this for the period 1980-2007 and for all goods sectors, non-mining goods sector, and the service sector. Looking at the pure variance terms, we can see that in general that labor productivity growth in the goods sector exhibits much more variation across states than the service sector. This, in itself, is not surprising given what we have already discussed. With respect to the goods producing sectors, we also see that the variation in labor productivity growth is larger when we drop the mining sector, but the variation in factor input growth decreases. The correlation between factor input growth and MFP growth, tends to be virtually zero both for non-mining goods and for services. Finally, the decomposition presents an interesting contrast between goods and services. For goods, most of the variation across states is due to variation in MFP growth. In the case of services on the other hand, we see that the variation is mostly due to factor intensity growth. The latter can probably again be reconciled due to most of this period coinciding with low productivity growth. Since MFP growth was generally depressed in services, any variation in growth in services across states came about mainly due to variations in factor intensity growth.[29]

4.4 Factor Reallocation in Productivity Growth

In Section (4.2), we documented the lack of any convergence in service sector productivity growth rates. One reason for this could be that states, perhaps due to their location, or due to certain tax policies or agglomeration effects, tend to concentrate around certain industries. If underlying industrial productivity growth rates are sufficiently dissimilar this can show up in our measures of

[29]Turner et al (2013) are the only other paper that we are aware of that conducts state-sectoral variance decomposition exercises. Unlike our dissimilar results, they find that variation in input growth is more important in both sectors. However, both the time period in question and the definition of sectors are quite different.

productivity growth aggregated to the sectoral level. One should then also expect factors of production to move to these higher productivity industries. In this section, we examine whether such reallocation has been important over these twenty seven years. In doing so, we follow the framework adopted by Oliner, Sichel and Stiroh (2007) who conducted a similar exercise for the entire US for 1988-2005. They found that labor reallocation was initially a drag on productivity growth but turned around after 2000. They attribute this to growing competitive pressures, flexible labor markets, and restructuring. Productivity growth can be decomposed to sector-specific productivity growth and the contribution of reallocation in input,[30]

$$\widehat{\left(\frac{Y_i}{L_i}\right)} = \sum_j \omega_{j,i} \widehat{\left(\frac{Y_{j,i}}{L_{j,i}}\right)} + \sum_j \omega_{j,i} \hat{L}_{j,i} - \hat{L}_i \tag{16}$$

where j refers to the industry, i to the sector, and $\omega_{j,i} = P_{j,i}Y_{j,i} / \left(\sum_j P_{j,i}Y_{j,i}\right)$ is the share of industrial GDP in sectoral GDP. $\widehat{(Y_i/L_i)}$ is the "direct" sectoral labor productivity growth which is what we have used in the paper so far. $\sum_j \omega_{j,i}\widehat{(Y_{j,i}/L_{j,i})}$ is the industry weighted productivity growth which quantifies the industrial contribution to sectoral productivity growth. Nordhaus (2000) calls this the pure productivity growth effect. $\sum_j \omega_{j,i}\hat{L}_{j,i} - \hat{L}_i$ quantifies the contribution of inter-industry labor reallocation and is calculated as a share weighted industrial labor input growth net of sectoral labor growth using the industry level data.

Similarly, sectoral MFP growth can be decomposed using the following equation

$$\hat{A}_i = \sum_j \omega_{j,i}\hat{A}_{j,i} + [\sum_j \omega_{j,i}\alpha_{j,i}\hat{K}_{j,i} - \alpha_i\hat{K}_i] + [\sum_j \omega_{j,i}(1-\alpha_{j,i})\hat{L}_{j,i} - (1-\alpha_i)\hat{L}_i] \tag{17}$$

where α and $(1-\alpha)$ represent capital income share and labor income share respectively and A represents MFP. $\hat{A}_i$ presents direct sectoral MFP growth computed using dual growth accounting.[31] This direct measure has been the basis of the entire discussion so far in the paper. $\sum_j \omega_{j,i}\hat{A}_{j,i}$ is the industry weighted MFP growth which evaluates the strength of industrial contribution to sectoral MFP growth and hence, represents pure MFP growth effects from industry origins. $[\sum_j \omega_{j,i}(1-\alpha_{j,i})\hat{L}_{j,i} - (1-\alpha_i)\hat{L}_i]$ and $[\sum_j \omega_{j,i}\alpha_{j,i}\hat{K}_{j,i} - \alpha_i\hat{K}_i]$ represent inter-industry labor and capital reallocation respectively. Positive reallocation terms augment sectoral MFP growth. Based on the

[30]The detailed derivations are included in Section D of the online appendix.

[31]Jorgenson, Ho and Stiroh (2005) use a similar equation to decompose aggregate MFP growth. This equation is different from theirs as we use value-added as a basis of industry data. Of course, we also use dual MFP growth measures and not primal ones.

state-level data availability, we use the measures for direct sectoral MFP growth, industry weighted MFP growth, and labor reallocation to back out the information on capital reallocation as a residual. In both, equations (16) and (17), the weights used to construct weighted measures are two period averages. We continue to rely on compensation based MFP growth measures, and merge the SIC and NAICS based measures to allow us to focus on a longer period.

Before delving into results, it is important to emphasize the intuition behind the reallocation terms in both equations (16) and (17). An industry with relatively higher productivity growth generates higher factor price growth and hence, attracts more resources from other industries which results in higher factor input growth and in turn, output growth in that industry. A positive reallocation term indicates such inter-industry factor reallocation that takes place in event of higher productivity growth in an industry. In Tables 13 and 14 we list these results. Like before, we do this for all goods, non-mining goods, and services. In states where factor inputs reallocated to industries with higher productivity growth, we should see the direct measure being higher than the industry weighted measure. However, based on our calculations, there is no evidence of any such systematic reallocation across states. If at all, we see that for the service sector there was negative reallocation of labor in ALP growth, and negative in factor reallocation in MFP growth. The effect is stronger for the former rather than the latter. Though the goods sector experiences overall negative reallocation effect both with respect to ALP growth and MFP growth, the magnitude of this effect declines once we drop the mining industry. However, the overall effects of factor reallocation relative to growth rates as displayed in columns (4) and (7) are marginally stronger in the service sector in comparison to the non-mining goods sector.

5 Concluding Remarks

For the US, the three decades preceding the great recession have been notable for a number of developments. These include rising wage inequality, the moderation of inflation and volatility, generally slow productivity growth. At the regional and, also micro level, researchers have documented a slowdown in labor movements across states, a slowdown in the entry by small firms, and a brake in convergence between states. Our research complements these developments by examining productivity growth trends across the goods and service sectors at the state level. The data presented in our work indicates very different patterns for the two broad sectors, with the former exhibiting convergence whereas the latter exhibiting slow growth and no convergence. While the slow growth in services can be attributed to falling real user cost, the divergence itself seems to be due to variation in wage growth. Furthermore, states with higher initial human capital have experienced higher productivity growth for both sectors. While our work cannot disentangle how much of all this is due to industry specific changes in MFP vs state-specific changes in MFP, it also true that, the differing trajectories of real user cost growth and wage growth, particularly in services, imply that any research on regional economic growth needs to incorporate both the role of human capital, and investment specific technological change in a multi sector setting.

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Tables

Table 1: **Productivity Growth in the Goods Producing Sector (1980-1997)**

	Goods				Goods (No Mining)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Mean	SD	Min	Max	Mean	SD	Min	Max
ALPG	2.87	1.10	0.25	5.82	2.78	1.39	-0.34	8.68
			(MT)	(NM)			(MT)	(NM)
MFPG	2.24	1.47	-0.13	6.65	1.34	0.83	-0.38	3.63
			(WA)	(WY)			(NV)	(NH)
RWG	1.69	0.86	-0.32	3.98	1.37	0.92	-0.70	3.99
			(MD)	(NH)			(MT)	(NH)
RUCG	2.90	2.36	0.06	9.38	1.26	0.77	-0.40	3.77
			(WA)	(NM)			(VA)	(NM)

Note: The number of states included is 48. The growth rates refer to average annual growth rates in percentage points. The data reflects unweighted means. ALPG=Average labor productivity growth rate, MFPG=Multi-factor productivity growth rate, RWG=Real wage growth rate, RUCG=Real user cost growth rate.

Table 2: **Productivity Growth in the Goods Producing Sector (1998-2007)**

	Goods				Goods (No Mining)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Mean	SD	Min	Max	Mean	SD	Min	Max
ALPG	2.40	2.21	-1.92	11.07	2.86	2.04	-1.03	11.15
			(WY)	(OR)			(NV)	(OR)
MFPG	-0.20	3.13	-11.77	6.97	1.05	2.11	-2.32	8.55
			(WY)	(OR)			(NV)	(NM)
RWG	0.85	2.09	-4.74	6.44	1.35	1.79	-2.00	6.45
			(WY)	(OR)			(NV)	(OR)
RUCG	-1.72	4.77	-16.95	10.81	0.33	2.73	-4.44	9.92
			(WY)	(VT)			(LA)	(NM)

Note: Refer to Table 1

Table 3: **Productivity Growth in the Service Producing Sector**

	(1980-1997)				(1998-2007)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Mean	SD	Min	Max	Mean	SD	Min	Max
ALPG	0.74	0.61	-0.26	2.24	1.73	0.49	0.66	2.82
			(OK)	(CT)			(MI)	(SD)
MFPG	-0.01	0.27	-0.67	0.69	-0.99	0.68	-2.17	0.67
			(MT)	(NC)			(SC)	(AR)
RWG	0.49	0.47	-0.80	1.69	0.65	1.04	-1.39	2.96
			(MT)	(CT)			(SC)	(AR)
RUCG	-0.82	0.25	-1.65	0.09	-3.50	0.24	-3.91	-3.02
			(DE)	(WY)			(MD)	(KS)

Note: Refer to Table 1

Table 4: **Productivity Growth with Compensation Data**

	CPS-IPUMS Data			Compensation Data		
	ALPG	RWG	MFPG	ALPG	RWG	MFPG
	(1)	(2)	(3)	(4)	(5)	(6)
			(1980-1997)			
Goods	2.87	1.69	2.24	2.92	2.01	2.49
Goods (No Mining)	2.78	1.37	1.34	2.83	1.69	1.59
Services	0.74	0.49	-0.01	0.76	0.71	0.12
			(1998-2007)			
Goods	2.40	0.85	-0.20	2.41	1.58	0.36
Goods (No Mining)	2.86	1.35	1.05	2.87	2.08	1.61
Services	1.73	0.65	-0.99	1.75	1.44	-0.52

Note: Refer to Table 1. The numbers reflect the unweighted means. Columns (1) through (3) display values already reported in previous tables.

Table 5: **Mid-2000's Productivity Slowdown**

	ALPG	RWG	RUCG	MFPG
	(1)	(2)	(3)	(4)
		(1998-2003)		
Goods	3.22	3.38	-0.37	2.25
Goods (No Mining)	3.45	3.83	1.05	3.15
Services	2.13	1.93	-1.96	0.38
		(2003-2007)		
Goods	1.39	-0.68	-3.41	-1.99
Goods (No Mining)	2.17	-0.10	-0.57	-0.30
Services	1.27	0.83	-5.41	-1.64

Note: Refer to Table 1. The numbers reflect the unweighted means. The real wage growth and MFP growth measures are derived from the compensation data of the BEA.

Table 6: **Productivity Growth in the Non-Real Estate Service Sector**

	(1998-2007)	(1998-2003)	(2003-2007)
ALPG	1.81	2.28	1.22
MFPG	0.47	1.04	-0.23
RWG	1.44	1.96	0.79
RUCG	-1.99	-1.36	-2.79

Note: Refer to Table 1. The numbers reflect the unweighted means. The real wage growth and MFP growth measures are derived from the compensation data of the BEA.

Table 7: **Productivity Growth During 1980-2007**

	Goods				NM-Goods				Services			
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
ALPG	2.75	1.17	-0.22	6.51	2.84	1.37	-0.42	7.09	1.10	0.43	0.29	2.09
			(MT)	(OR)			(MT)	(NM)			(MI)	(CT)
RWG	1.86	1.05	-0.40	4.65	1.82	1.19	-0.98	4.67	0.96	0.39	0.19	1.80
			(MT)	(NH)			(MT)	(NH)			(WV)	(MA)
RUCG	1.30	1.41	-1.24	5.38	0.94	1.33	-1.17	5.90	-1.75	0.21	-2.33	-1.11
			(CO)	(VT)			(MT)	(NM)			(DE)	(WY)
MFPG	1.75	1.04	0.16	4.50	1.60	1.24	-0.95	4.91	-0.10	0.26	-0.86	0.42
			(WA)	(NH)			(MT)	(NM)			(DE)	(VA)

Note: Refer to Table 1. The real wage growth and MFP growth measures are based on the compensation data of the BEA.

Table 8: **Within Sector Growth Correlations (1980-2007)**

	Goods				NM-Goods				Services			
	ALPG	RWG	RUCG	MFPG	ALPG	RWG	RUCG	MFPG	ALPG	RWG	RUCG	MFPG
ALPG	1				1				1			
RWG	0.890	1			0.875	1			0.871	1		
RUCG	0.472	0.499	1		0.855	0.792	1		-0.417	-0.326	1	
MFPG	0.785	0.874	0.811	1	0.904	0.975	0.895	1	0.550	0.813	0.167	1

Note: Refer to Table 1. The real wage growth and MFP growth measures are based on the compensation data of the BEA.

Table 9: **Between Sector Growth Correlations (1980-2007)**

(a) Panel A

	ALPG			MFPG		
	Goods	NM-Goods	Services	Goods	NM-Goods	Services
Goods	1			1		
NM-Goods	0.900	1		0.904	1	
Services	0.107	0.044	1	0.113	0.223	1

(b) Panel B

	RWG			RUCG		
	Goods	NM-Goods	Services	Goods	NM-Goods	Services
Goods	1			1		
NM-Goods	0.967	1		0.803	1	
Services	0.445	0.459	1	-0.111	-0.206	1

Note: Refer to Table 1. The real wage growth and MFP growth measures are based on the compensation data of the BEA.

Table 10: **Sectoral Convergence of Labor and Multi-Factor Productivity Growth**

(a) Panel A

	Goods				Non-Mining Goods			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ALPG	ALPG	MFPG	MFPG	ALPG	ALPG	MFPG	MFPG
Ln SGDP pw, 1980	-0.023***	-0.026***	-0.021***	-0.024***	-0.042***	-0.046***	-0.043***	-0.047***
	(0.004)	(0.006)	(0.006)	(0.006)	(0.008)	(0.008)	(0.007)	(0.005)
College Share, 1980		0.052		0.054*		0.087***		0.126***
		(0.036)		(0.031)		(0.029)		(0.020)
N	48	48	48	48	48	48	48	48
R-sq	0.21	0.25	0.22	0.27	0.39	0.46	0.48	0.68

(b) Panel B

	Services			
	(1)	(2)	(3)	(4)
	ALPG	ALPG	MFPG	MFPG
Ln SGDP pw, 1980	0.014**	0.010	0.001	-0.002
	(0.006)	(0.006)	(0.005)	(0.005)
College Share, 1980		0.043***		0.029***
		(0.012)		(0.007)
N	48	48	48	48
R-sq	0.10	0.27	0.00	0.22

Note: The convergence analysis refers to the period of 1980-2007. The MFP growth measures are based on the compensation data of the BEA. The numbers in the parentheses refer to robust standard-errors. The college share refers to the share of college graduates in the labor force specific to a sector-state in 1980. The variable is computed using the full-time employed labor force from the CPS-IPUMS data. *** indicates $p < 0.01$, ** indicates $p < 0.05$ and * indicates $p < 0.1$.

Table 11: **Sectoral Convergence of Real Wage and Real User Cost Growth**

(a) Panel A

	Goods				Non-Mining Goods			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	RWG	RWG	RUCG	RUCG	RWG	RWG	RUCG	RUCG
Ln Real Wage, 1980	-0.009	-0.016*			-0.037***	-0.047***		
	(0.007)	(0.009)			(0.007)	(0.005)		
College Share, 1980		0.072		-0.008		0.149***		0.061***
		(0.043)		(0.043)		(0.024)		(0.022)
Ln Real User Cost, 1980			-0.016**	-0.016*			-0.074***	-0.075***
			(0.008)	(0.008)			(0.011)	(0.011)
N	48	48	48	48	48	48	48	48
R-sq	0.03	0.10	0.15	0.15	0.39	0.66	0.49	0.53

(b) Panel B

	Services			
	(1)	(2)	(3)	(4)
	RWG	RWG	RUCG	RUCG
Ln Real Wage, 1980	0.011*	0.006		
	(0.006)	(0.005)		
College Share, 1980		0.050***		-0.011**
		(0.012)		(0.005)
Ln Real User Cost, 1980			-0.031***	-0.032***
			(0.010)	(0.010)
N	48	48	48	48
R-sq	0.08	0.36	0.25	0.30

Note: The convergence analysis refers to the period of 1980-2007. The real wage growth measures are based on the compensation data of the BEA. The numbers in the parentheses refer to robust standard-errors. The college share refers to the share of college graduates in the labor force specific to a sector-state in 1980. The variable is computed using the full-time employed labor force from the CPS-IPUMS data. *** indicates $p< 0.01$, ** indicates $p < 0.05$ and * indicates $p <0.1$.

Table 12: **Variance Decomposition of Labor Productivity Growth**

	Goods	Goods (Non-Mining)	Services
Var ($\hat{y}$)	1.37	1.87	0.18
Var ($\hat{A}$)	1.07	1.53	0.07
Var ($\hat{X}$)	0.54	0.34	0.13
Covar ($\hat{A}, \hat{X}$)	-0.12	0.001	-0.01
Std. Dev. ($\hat{A}$)	1.04	1.24	0.26
Std. Dev. ($\hat{X}$)	0.74	0.59	0.36
Corr. Coeff.($\hat{A}, \hat{X}$)	-0.16	0.001	-0.07
Average Share of $\hat{A}$	0.69	0.82	0.35
Average Share of $\hat{X}$	0.31	0.18	0.68
N	48	48	48

Note: $\hat{y}$, $\hat{A}$ and $\hat{X}$ refer to labor productivity growth, MFP growth and capital intensity growth respectively. The MFP growth measures are derived from the compensation data of the BEA. The variance decomposition analysis refers to the period of 1980-2007. Average shares of $\hat{A}$ and $\hat{X}$ are calculated using equations (14) and (15) respectively.

Table 13: **Labor Productivity Growth and Labor Reallocation (1980-2007)**

	Goods			Goods (No Mining)			Services		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Industry Weighted	3.03	0.46	6.75	3.04	-0.18	7.69	1.36	0.60	2.37
	(1.16)	(MT)	(OR)	(1.40)	(MT)	(NM)	(0.41)	(MI)	(CT)
Labor Reallocation	-0.28	-1.50	0.02	-0.20	-0.60	0.12	-0.26	-0.43	0.65
	(0.26)	(NM)	(OK)	(0.13)	(NM)	(ND)	(0.17)	(LA)	(DE)
Direct Sectoral	2.75	-0.22	6.51	2.84	-0.42	7.09	1.10	0.29	2.09
	(1.17)	(MT)	(OR)	(1.37)	(MT)	(NM)	(0.43)	(MI)	(CT)

Note: The numbers are in percentage. The data reflects unweighted means. The numbers in the parentheses present the standard deviations. The number of states included is 48.

Table 14: **Multi-Factor Productivity Growth and Reallocation (1980-2007)**

	Goods			Goods (No Mining)			Services		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Industry Weighted	1.81	0.24	4.44	1.64	-0.92	4.93	-0.05	-0.88	0.49
	(1.02)	(WA)	(NH)	(1.23)	(MT)	(NM)	(0.27)	(DE)	(GA)
Labor Reallocation	-0.09	-0.34	0.06	-0.07	-0.35	0.02	-0.08	-0.18	0.03
	(0.07)	(DE)	(WY)	(0.06)	(DE)	(IL)	(0.04)	(NY)	(NV)
Capital Reallocation	0.03	-0.15	0.15	0.03	-0.03	0.09	0.03	-0.08	0.08
	(0.04)	(WY)	(VT)	(0.02)	(WY)	(NH)	(0.02)	(WY)	(MS)
Direct Sectoral	1.75	0.16	4.50	1.60	-0.95	4.91	-0.10	-0.86	0.42
	(1.04)	(WA)	(NH)	(1.24)	(MT)	(NM)	(0.26)	(DE)	(VA)

Note: The numbers are in percentage. The data reflects unweighted means. The numbers in the parentheses present the standard deviations. The number of states included is 48.

Figure 1: **Average Labor Productivity (ALP) Growth in Goods vs. Services (1980-2007)**

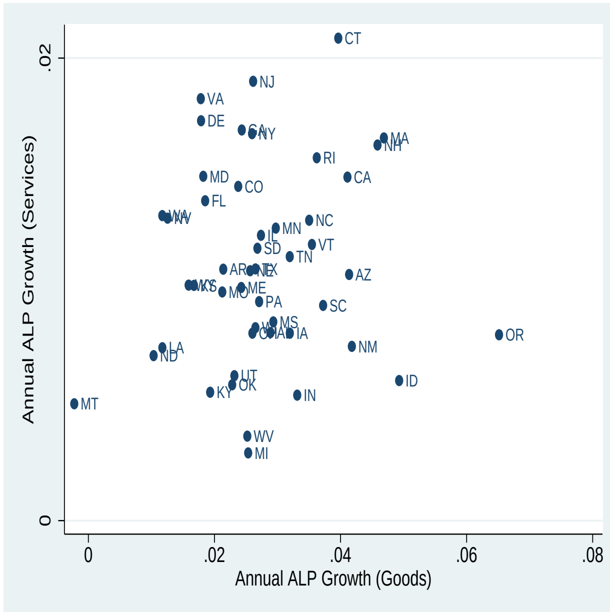
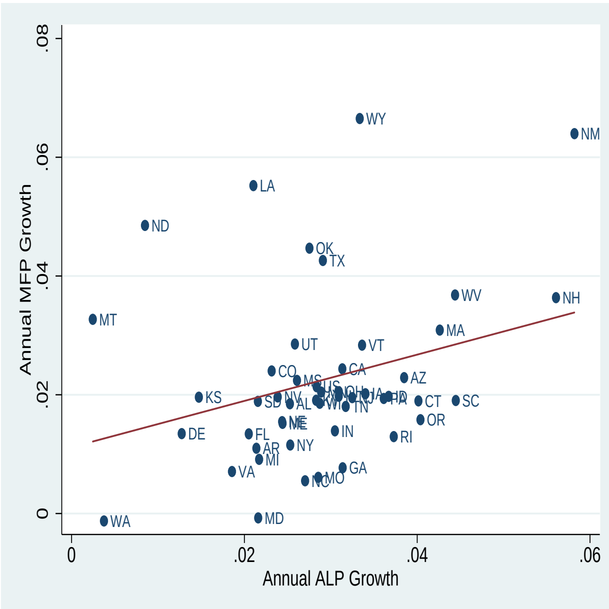
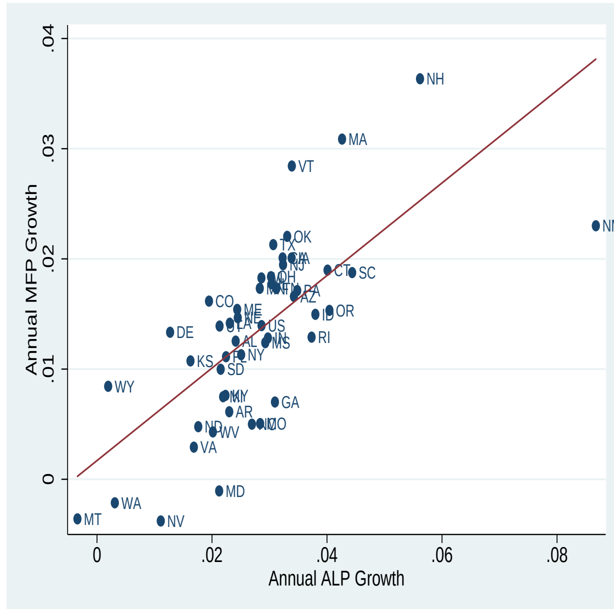


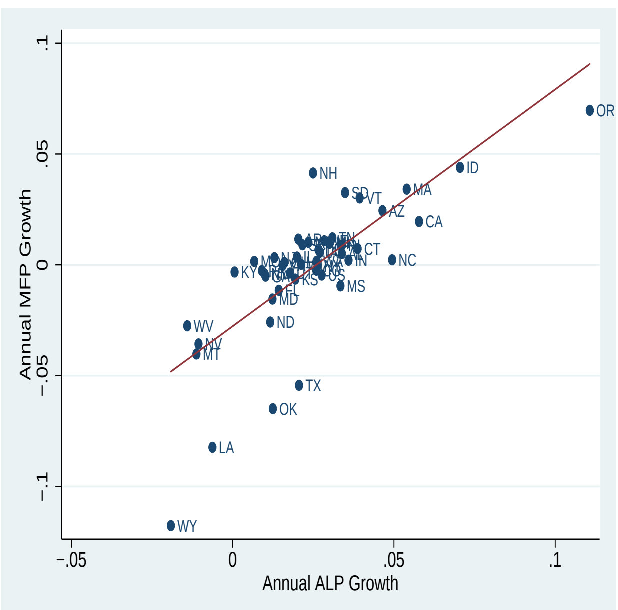
Figure 2: **Labor Productivity and Multi-Factor Productivity Growth (Goods)**



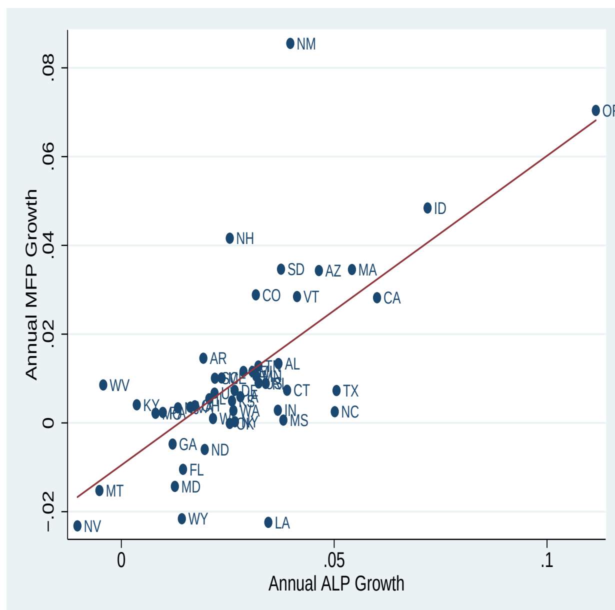
(a) Goods (1980-1997)



(b) Goods (No Mining) (1980-1997)



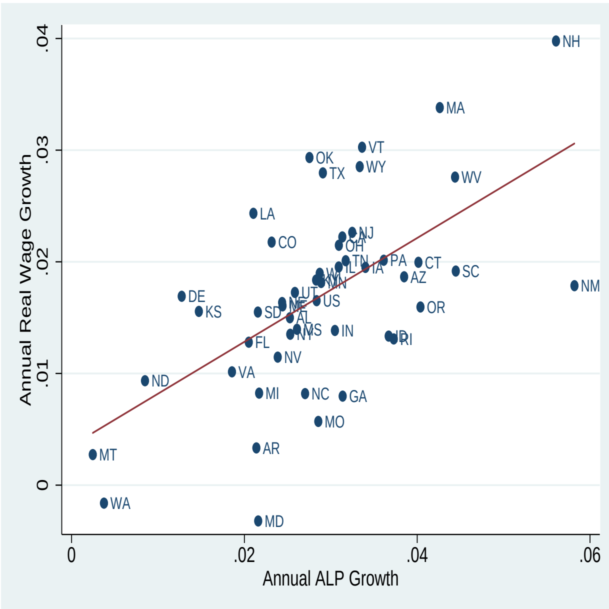
(c) Goods (1998-2007)



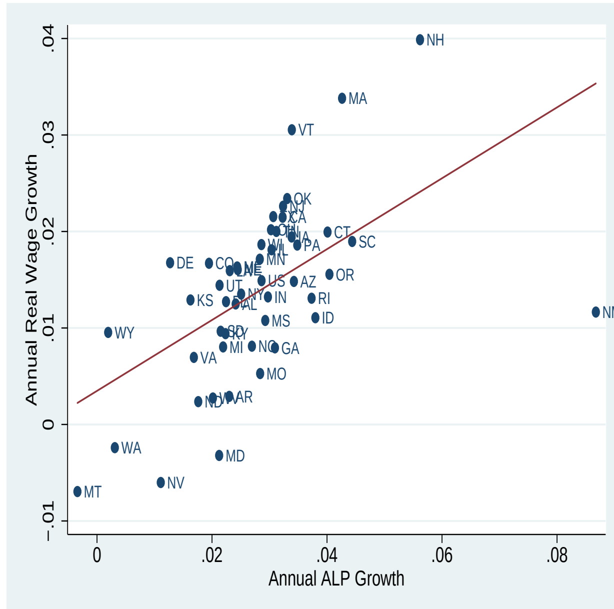
(d) Goods (No Mining) (1998-2007)

Note: The line across the plot represents the regression line.

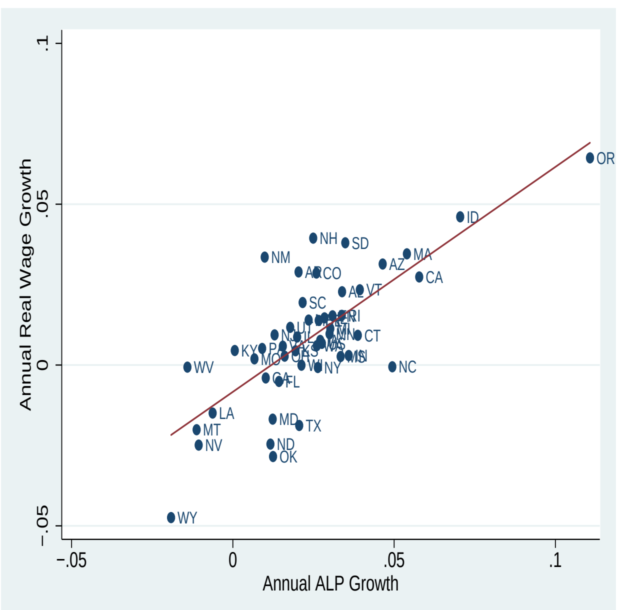
Figure 3: **Labor Productivity and Real Wage Growth (Goods)**



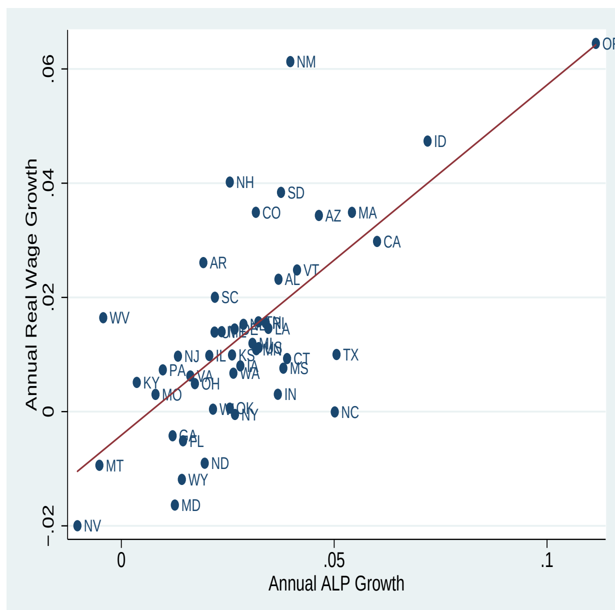
(a) Goods (1980-1997)



(b) Goods (No Mining) (1980-1997)



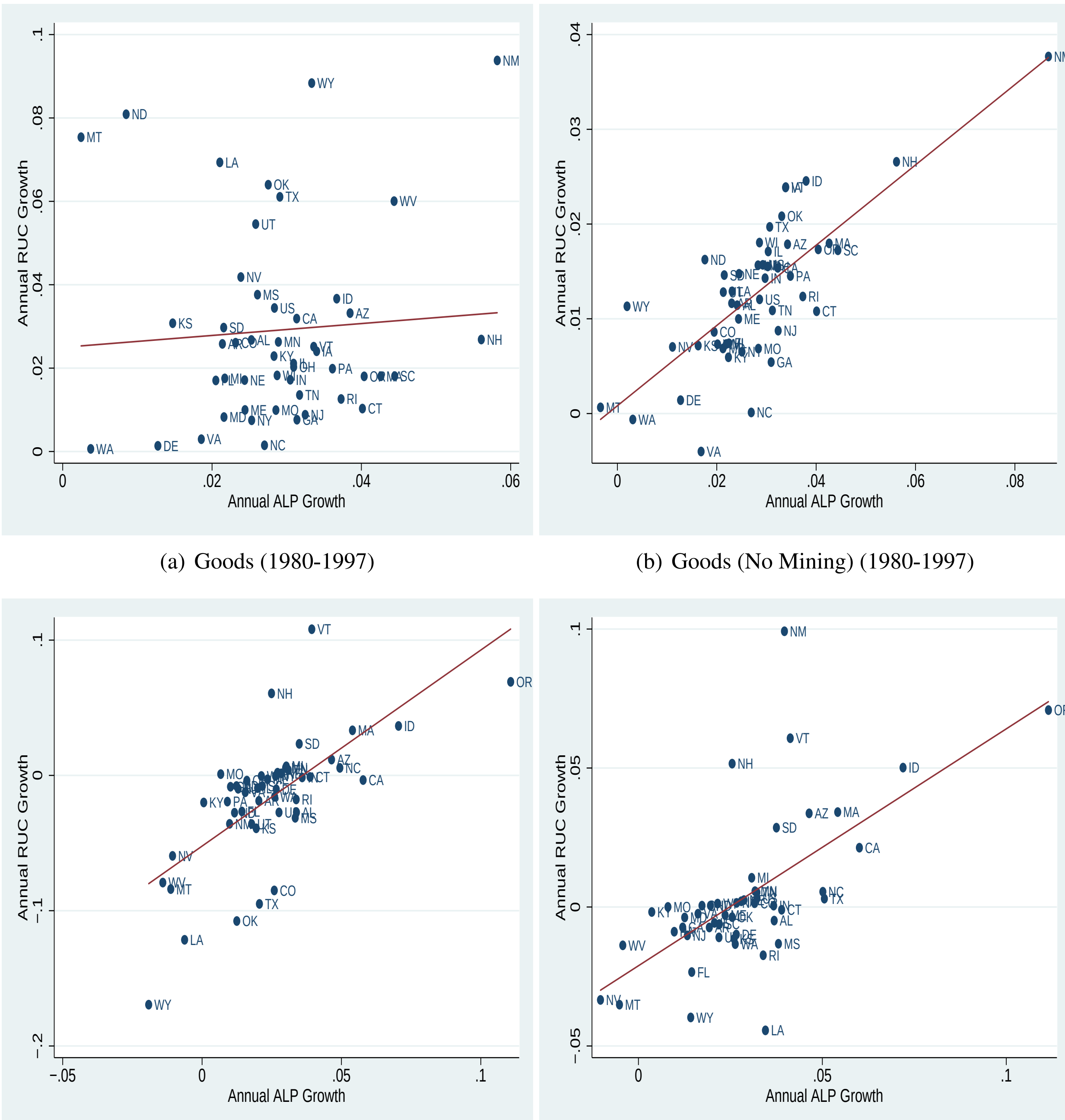
(c) Goods (1998-2007)



(d) Goods (No Mining) (1998-2007)

Note: The line across the plot represents the regression line.

Figure 4: **Labor Productivity and Real User Cost Growth (Goods)**



(a) Goods (1980-1997)

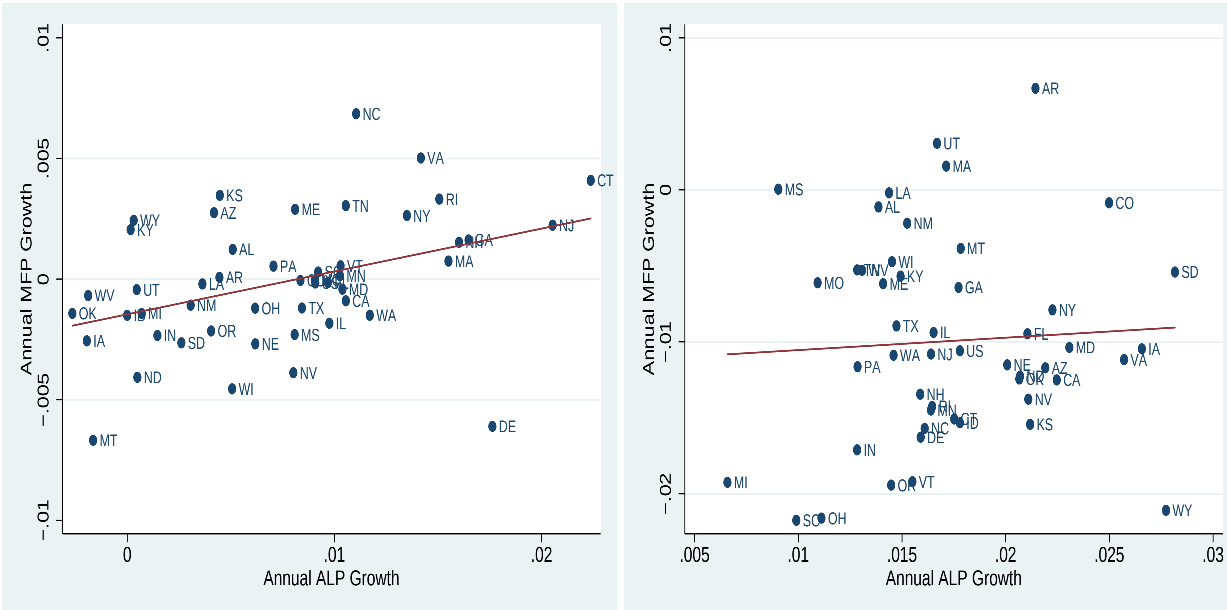
(b) Goods (No Mining) (1980-1997)

(c) Goods (1998-2007)

(d) Goods (No Mining) (1998-2007)

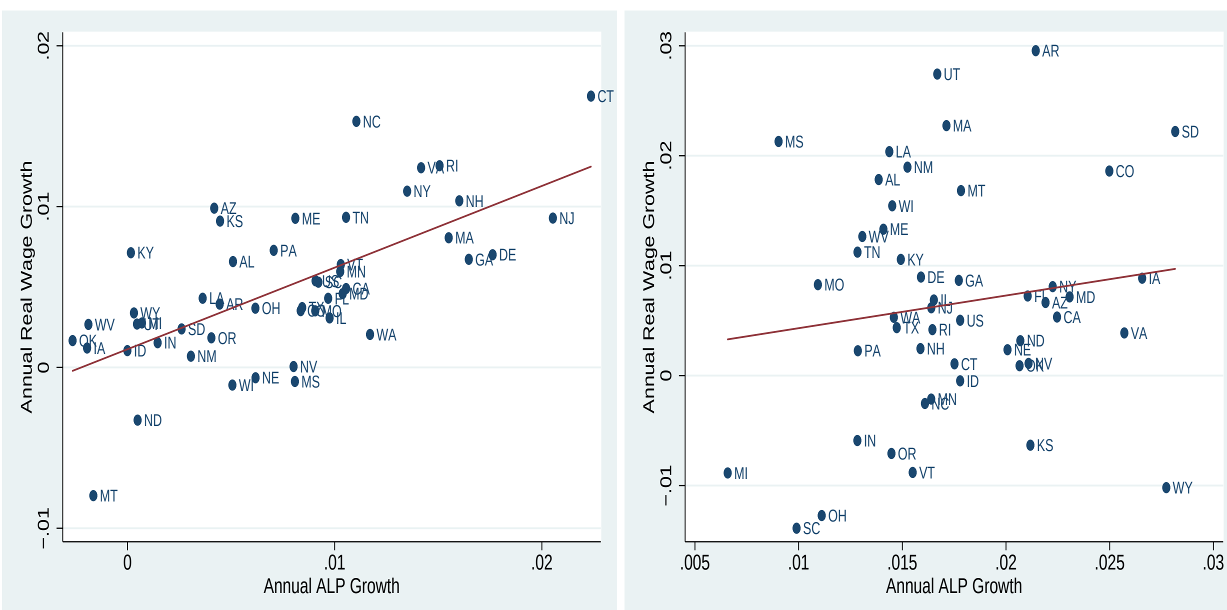
Note: The line across the plot represents the regression line.

Figure 5: **Labor Productivity and Multi-Factor Productivity Growth (Services)**



(a) Services (1980-1997) (b) Services (1998-2007)

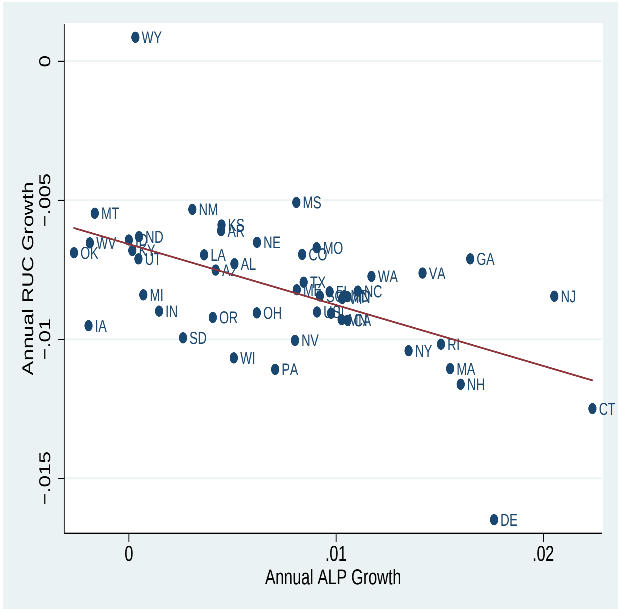
Figure 6: **Labor Productivity and Real Wage Growth (Services)**



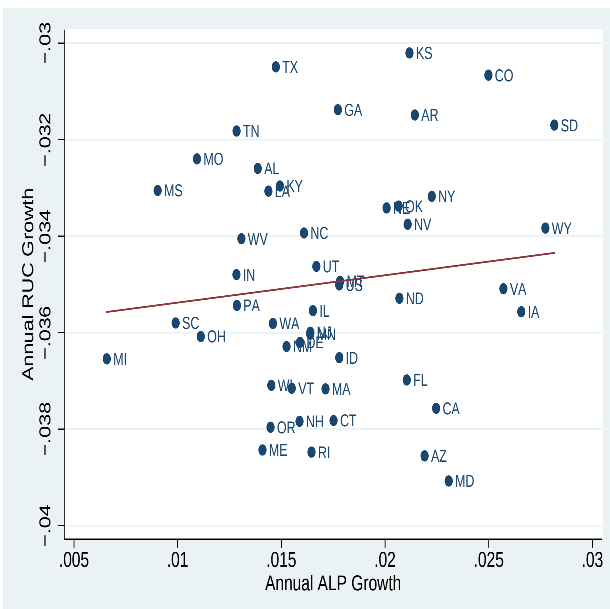
(a) Services (1980-1997) (b) Services (1998-2007)

Note: The line across the plot represents the regression line.

Figure 7: **Labor Productivity and Real User Cost Growth (Services)**



(a) Services (1980-1997)



(b) Services (1998-2007)

Note: The line across the plot represents the regression line.