Heterogeneous Effects of Factor Intensity on Creative Destruction

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Abstract

This paper studies creative destruction via a firm dynamics model with lending which is modified to allow for individual factor needs and productivities to better fit macroeconomic data. Using public American public firm data from Compustat I show misallocation regressions that are in line with the literature even with this different public firm environment. In doing this, we see some sector differences after a recession shock that, beyond features described in the existing literature, may be partially driven by their different uses of factors of production and differences in reallocation. Using American data on recent recessions job flows and factor usage as a goal, it uses high and low capital usage firms making new options on loans where firms may take out longer term debt when interest rates are lower in a recession and short term loans in higher interest rate environments. It sometimes leads to unproductive firms getting loans to delay exit. Through this model with variable length debt contracts I can change parameters of productivity distributions, recession shocks, or factor intensity to change length of mean reversion after a recession or depth of the initial drops and recovery to better match a given recession. Productivity transitions helped guide the lending behavior costs in ways that sometimes shut out productive firms from getting their desired debt contracts when the productive firms better creditworthiness led them to over borrow before the macroeconomic shock and then exit. This method of choosing loans size was a useful way for productivity alone to not dominate dynamics but computationally expensive and the model may benefit from more detailed labor or capital markets.

Economic growth is frequently described in terms of technological progress and the efficient allocation of resources, but these outcomes depend critically on the continuous process of selection among heterogeneous firms. A large literature in productivity and firm dynamics shows that reallocation—shifts in employment, capital, and output across producers—accounts for a substantial share of aggregate productivity growth (e.g., Foster, Haltiwanger, and Krizan 2001). In this framework, recessions play a central role: they are moments when unproductive firms are more likely to exit and when new, more efficient firms can gain market share. This "cleansing" mechanism, rooted in Schumpeter's theory of creative destruction, relies on the assumption that exits are driven primarily by low productivity rather than by frictions unrelated to efficiency.

However, whether recessions actually improve allocative efficiency is an empirical question rather than a theoretical certainty. Early work by Caballero and Hammour (1991, 1999) highlights that recessions can amplify distortions. If financially constrained but productive firms fail—not because they are inefficient but because they cannot secure funding—then the cleansing effect

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weakens or even reverses. Their models demonstrate that financing constraints, labor market frictions, and declining firm net worth can collectively distort which firms survive downturns.

Caballero and Hammour (1994, 1999) formalize how recessions can distort the creative-destruction process by embedding production in a three-agent environment—entrepreneurs, workers, and financiers—where creation requires entrepreneurial wealth, hired labor, and external capital. Firms are subject to idiosyncratic profitability shocks, modeled as mean-reverting Ornstein–Uhlenbeck processes, which determine whether continuing operations remain viable. In this setting, destruction occurs either when profitability turns negative or when financing becomes unavailable, while creation depends on entrepreneurial net worth and aggregate financial conditions. Their 1999 extension introduces binding financial and labor-market constraints, showing analytically that recessions can produce cumulative output and productivity losses: even if the destruction margin behaves as in a cleansing model, the creation margin collapses because constrained entrepreneurs cannot open new production units. Using job-flow data and structural VARs, they document that severe downturns exhibit precisely this asymmetric response—creation falls sharply, destruction rises modestly—and quantify substantial welfare losses from recession-induced sclerosis. With only labor constraints, the welfare cost of a two-standard-deviation recession is modest (1.9% of GDP), but when financial constraints bind simultaneously, cumulative losses rise to 4.6%. Their framework highlights that selection operates cleanly only in frictionless environments; when wealth dynamics, credit frictions, and matching frictions bind, recessions can misallocate by eliminating productive but constrained firms and suppressing the entry of high-productivity entrepreneurs.

Foster, Grim, and Haltiwanger's 2013 paper, Reallocation in the Great Recession: Cleansing or Not, analyzes job reallocation in the U.S. during the Great Recession, contrasting it with previous recessions. Using job flow data from the BLS and Census manufacturing data, they find that earlier recessions brought productivity-enhancing reallocation, while the Great Recession had unusually low job creation and was less productivity-enhancing. They use a propensity score weighting to standardize firm characteristics and measure firm productivity to better match the distribution in their business database. Their job flow analysis shows that job creation was historically low after the Great Recession, while job destruction was high. Regression analysis on productivity using unemployment changes, recession dummies, TFP changes, interactions and fixed effects on states or year, alongside Great Recession-specific dummies and interactions, indicates that exits—especially among young firms—drove much of the productivity decline. The authors then perform an accounting decomposition to simulate productivity effects of varying employment distributions. They find that reallocation contributed less to productivity growth during the Great Recession than in previous downturns. They suggest this may be due to regulatory or credit constraints. The data shows that credit costs influenced productivity post-recession. The study emphasizes that the nature of recessions matters: while earlier recessions promoted reallocation, the Great Recession's constraints on creation and capital access hindered productivity

gains typically associated with creative destruction. An emphasis on the financial crisis. I will be using their regression specifications to influence my regressions to come later.

Gamberoni, Giordano, and Lopez-Garcia's 2016 paper applies the Hsieh-Klenow 2009 model to analyze factor misallocation in developed European economies, particularly during the Great Recession. They identify three key trends: Capital misallocation worsened over time in four out of five countries (excluding Germany), while labor allocation remained stable. Capital misallocation increased more in the service sector than in industry. Misallocation for both capital and labor fell across countries in 2009, with further declines in some sectors during 2011-2012, suggesting a potential "cleansing effect" from the recession. The authors use various misallocation measures, including the Hsieh-Klenow (2009) measure, Olley-Pakes (1996) indicator, and Petrin-Sivadasan (2013) marginal productivity wedge. These measures align in showing dispersion in marginal revenue productivity for capital and labor, which grew until 2006, dropped during the 2008-2009 recession, and fell again during the 2012 debt crisis. Regression analyses with country and sector fixed effects reveal that changes in credit costs and demand were the largest drivers of MRPK, while turnover and regulation changes most affected MRPL. The cleansing effect was stronger for labor than for capital, indicated by the reduced dispersion in MRPL. Though the study provides insights into misallocation patterns during the recession, it lacks lagged and cumulative effects, and its findings may be specific to Europe. Broader testing with international data and additional controls could enhance the robustness of these results. Or perhaps looking for an event to use differences in differences on in one of these countries. This result also varies from the Oberfield 2011 paper that said in their Chilean recession that capital changes were bigger over the recession than labor. Measures from this Gamberoni paper like MRPK and MRPL are used in comparing my results.

Theoretical advances have attempted to incorporate some of these empirical insights. Osotimehin and Pappada's 2017 paper, Credit Frictions and the Cleansing Effect of Recessions, incorporates credit frictions into a firm dynamics model, suggesting that while recessions can still have a "cleansing effect," these credit frictions weaken it. Firms in the model have varying levels of net worth and both persistent and nonresistant productivity, they produce solely with capital, facing fixed production costs each period. There are higher default thresholds on their firm characteristics if they want to produce much. If they can't cover these costs using existing net worth, they exit and cease production. They may also exit from an inability to have profitable participation from the lending bank. The bank must pay a monitoring cost upon failure to pay. Firms can save net worth or pay dividends. Firms take out debt if their internal net worth is insufficient given their productivity. However, low net worth can limit future production and borrowing capacity, increasing borrowing costs and potentially forcing exit. Productivity has a persistent component which has a tendency to revert to the mean. The model asserts that higher productivity firms, although more sensitive to credit constraints due to larger production needs, are generally more resilient because they build net worth faster. Yet, credit constraints raise the

likelihood of even these high-productivity firms exiting, which dilutes the cleansing effect of recessions (where ideally only lower-productivity firms exit). Osotimehin and Pappada use value function iteration to find steady-state firm dynamics in both frictionless and credit-constrained economies, revealing that net exits rise by 1.53% with credit frictions compared to 1.44% without, while productivity gains drop from 0.48% to 0.43%. Given these decision rules, they test various scenarios in a simulation to follow with constant amount of firms to enter, adjusting distributions of net worth and productivity, showing that stronger correlations between net worth and productivity lead to higher exit rates among low-productivity firms, enhancing the cleansing effect. Alternatively, increasing financial shocks disproportionately affects high-productivity firms, further reducing the cleansing impact by forcing out firms that would otherwise survive, similar to the weaker cleansing observed during the Great Recession. While the model explains how credit frictions dampen productivity-enhancing reallocation, it depends heavily on assumptions about net worth and productivity distributions and omits any microeconomic explanation in labor and demand-side factors. To address differences observed between Europe and the U.S. during the Great Recession, the authors suggest variations in firm net worth or shock severity could be responsible, but they focus on the U.S. Some issues with the results are that they don't have spiky enough initial behavior following the recessions and but the effect is rightly more prolonged than Caballero. The paper serves as a useful theoretical framework to highlight how credit constraints alter reallocation patterns in recessions, but I believe one could do more using a similar framework. It incorporates net worth fluctuations that are idiosyncratic to the firm and it uses the Bernanke Gertler style of financing. It gets misallocation from failed borrowing constraints as well as natural firm exit, the former is the source of misallocation rather than failing to enter profitably.

Motivated by these gaps, my paper proceeds in two steps. First, I revisit the macro-reallocation patterns emphasized in Foster, Grim, and Haltiwanger (2013) using Compustat public firm-level data. By estimating sector-level productivity regressions around recessions, I validate the broad patterns in their study but see substantial heterogeneity across industries. Sectors that differ in capital intensity, labor dependency, and debt usage display markedly different recovery paths. Although the reduced-form effects are sometimes modest, their persistence suggests that firm heterogeneity such as sectoral production structure shapes how recessions translate into changes in efficiency.

Second, I build a modified creative-destruction model that incorporates this type of heterogeneity. Drawing on Osotimehin and Pappadà's (2017) credit friction model, I add two extensions: (1) firms endogenously choose the maturity of their debt contracts, which allows them to time recessions and interest-rate movements, and (2) firms differ structurally in their factor intensities—capital-intensive versus labor-intensive—altering their exposure to credit conditions and aggregate shocks. These features allow the model to generate both sharp short-run adjustments and prolonged recoveries, allowing you to adapt to patterns observed in the empirical results. They also produce asymmetric responses across firm types, helping explain why some firms recover

quickly while others remain constrained long after the recession ends.

The layout of my paper is that in the following section I use a series of regressions motivated by the Foster Grim Haltiwanger paper to learn more about the features of heterogeneity in productivity following recessions using sectoral differences and some alternative productivity measures. Then in section 3 using those facts and the existing literature results I propose and implement my model based on the Osotimehin and Pappada 2017 paper for an improved and flexible firm dynamics model. Section 4 discusses the implications, quality of results, and concludes.

Section 2 - Empirical Analysis

In this paper I aim to see more of these differences in responses to reallocation during recessions using some regressions influenced by Gamberoni, Giordano,Lopez-Garcia 2016 and Foster Grim Haltiwanger 2013. I use a different dataset than the original in Foster Grim Haltiwanger, and a different measure of efficiency. It is important to state that caballero uses only manufacturing firms in his job flows data, the Gamberoni et al one is using european data of 20 countries from Compnet, and The Foster Grim Haltiwanger paper uses census data from its longitudinal business firm data but its TFP measurements are from manuacturing data only. My data is public american firms which skews larger and capital intensive.

The cumulative effects of recessions have not been attempted with such data, and I also examine differences between sectors. There are several measures of efficiency of factor allocation that have been examined in determining effects of creative destruction. A popular favorite is the dispersion in the Hsieh Klenow 2009 marginal revenue products for each factor which was used in Gamberoni, Giordano,Lopez-Garcia 2016 paper as well as other measures. This measure relies on assumptions of common marginal costs, monopolistic competition, and cobb-douglas production which eliminates differences in labor productivity within industry. There are other similar efficiency measures such as the Olley Pakes 1996 measure of factor productivity using productivity relative to the industry. There is also the Petrin Sivadasan 2013 measuring the wedge between marginal product of a factor and marginal cost. Each of these have been used for robustness in papers of misallocation. These are good for focusing on the efficiency of allocation in a specific factor of production, but for the economy or an industry it is more likely accurate to measure it using a more inclusive measure. In my analysis, I choose to use the change in allocative efficiency as defined in a more modern 2020 paper "Productivity and Misallocation in General Equilibrium" by Baqaee Farhi because it captures reallocation effects in a manner consistent with general-equilibrium distortions, making it well-suited for comparing sectors that differ in capital intensity and financing structure. The needed data for its calculation can be easily obtained from the compustat database.

$$d\log Y = \underbrace{\vec{\lambda}' d\log A}_{\text{Technology}} - \underbrace{\vec{\tilde{\lambda}}' d\log \mu - \vec{\tilde{\lambda}}' d\log \Lambda}_{\text{Allocative Efficiency}}.$$

This measure assumes markups are the only distorting wedges and that production functions within an industry are alike. Cost functions can vary among firms. The paper has a decomposition of changes in log output stating that it is equal to the changes in technology and the changes from the reallocation of shares of resources among users. $\vec{\lambda}$ denotes the Domar weights measuring each firm's contribution to aggregate output, $d\log A$ is the change in firms' physical productivity, $\vec{\tilde{\lambda}}$ denotes the distortion-adjusted Domar weights, $d\log \mu$ captures changes in firm-level wedges or markups, and $d\log \Lambda$ reflects changes in the allocation of resources across firms. It has two parts, one of changes is coming from markups and the other of changes in factor shares.

Then in order to determine what a cumulative effect would be after a change in factor reallocation or a recession I regress again using a 3 year change in allocative efficiency. I am more concerned about cumulative effects because the creative destruction process has a period of destruction followed by a creation period and both are important for knowing whether the recession was good or bad for efficiency. NBER says a typical recession lasts 11 months so one year should capture much of the destruction and the time following it should be capturing creation. I then calculate cumulative changes in allocative efficiency for 32 of the sectors for which I had shared data among the required variables. The Foster Grim Haltiwanger regressions use cycle changes which they measure using changes in unemployment, changes in TFP, a recession dummy, and the two way and three way interactions of these. The Gamberoni, Giordano, Lopez-Garcia regression uses changes in sales, regulations, demand uncertainty, changes in costs of credit and a recession dummy. Both of these regressions try to control for factor changes, some kinds of market changes, and the recession. The latter uses some extra conditions on demand and lacks changes in labor. I do not have access to these finer detailed terms of regulations or demand changes and I choose to use a different control cleansing intensity in the regressions from the Osotimehin paper. The cleansing intensity is defined as changes in average productivity divided by the net firm exit rate of the period. I tried TFP initially but it wasn't as strong a fit as when I normalized the TFP changes by net exit rates as was done in Osotimehin Pappadà with their cleaning intensity measure and there were no major deviations in results. It therefore does include selection pressures as well, rather than just changes in TFP.. This helps separate away from the firm distribution in the data. I identically control for unemployment changes using data from the BLS. I didn't have good data for changes in costs of credit for the firms which may have helped better explain capital effects. I had changes in per period debt which I deflated to 1998 prices from the beginning of sample. Then I use a dummy for the recessions in my data as defined by NBER and interacted it with the changes in the factor variables unemployment and debt as was done in Foster Grim Haltiwanger. The regression specification I used then is

$$\Delta\text{Allocative Efficiency}_t = \alpha + \Delta\text{Unemployment }_t\beta + \Delta\text{ Debt }_t\gamma + \Delta\text{Cleansing Intensity }_t\delta$$

$$+\text{Recession }\theta + (\text{Recession * }\Delta\text{ Unemployment }_t)\zeta + (\text{Recession * }\Delta\text{ Debt }_t)\eta + \varepsilon_t$$

I did this one once for the whole compustat economy and then switched to the cumulative changes over 3 years once more and again with each of the sectors. I used the years 1998 to 2015 because it was in common among the compustat data, the BEA data for depreciation, the BLS goods deflator data, and the census firm exit data. I drop data that has no entries for the required variables, ones that give me divide by zero results, and I winsorize the firms with markups outside 2 standard deviations. After this all I had 4740 observations remaining. I started by using the BEA sector definitions which are primarily popular 3 digit NAICS industries and then adjusted the compustat codes and Census firm exit codes to match these as close as possible. There were 32 total sector regressions after these adjustments. The markups used in the allocative efficiency measure were using accounting profits for simplicity. The accounting profits used operating income before depreciation and then subtracted away depreciation using the BEA depreciation figures and property plants and equipment. The allocative efficiency term uses total Compustat economy sales for output so it only represents my dataset. The labor share was using employment expenditures over sales and the capital share the residual. Then to get the firm TFP measure I used in calculating the cleansing intensity I followed the method of Baily, Hulten and Campbell (1992) as it was in the Foster Grim Haltiwanger paper. In the cleansing intensity calculation I use average TFP for the whole economy or for the sector over the net exit rate for the whole economy or for the sector alone in the sector regressions. This TFP metric is defined to be the residual from logged real output subtracted by real logged capital multiplied by its factor share and the real labor expenditures multiplied by its factor share. For real output I used sales and deflated it by the PPI for the relevant industry. Some of these PPI datapoints had to be imputed. I calculated capital using the perpetual inventory method and deflated it by a capital goods deflator from the St. Louis Federal Reserve branch. I deflated the labor expenditures and the average debt by the PPI as well. The recession dummies were 1 in the years 2008 and 2001. My initial aggregate results are as follows in figure 1:

Figure 1

	Unemployment	Debt	Cleansing	Crisis	Crisis x Unemp.	Crisis x Debt
Aggregate	-.056*	.0069	0.000000904	.0195	.1672	-.0627
Aggregate Cumulative	-.0637**	-.1083**	-.00003679*	.0129	.8824**	-.3466** .

	Unemployment	Debt	Cleansing	Crisis	Crisis x Unemp.	Crisis x Debt
Mining	-.0092***	.0002	0.0007	-.0062**	-.0014	.003
Utilities	-.0002	-.0036	.00002928	-.0025	-.0007	.0045
Chemical Mfg	.0049	-.0074	0.0001	.0025	-.0003	.0037
Mineral Mfg	-.0004	.00047	-.0000369	.0002	.0008	-.0014
Food Mfg	.0005	.001	.0000442	.0008	-.0006	-.0033
Metal Mfg	.0073**	.0034	-.0002	-.0006	.0004	0.0018
Apparel Mfg	-.00045	.000007	-.0000024	-.0000216	.000000216	-.00001639
Metal Fabrication	-.0000256	-.0001	.00001984	-.0001	.0001	-.0008
Wood Products	-0000613	.0004	.0003	.0002	.0000277	.0000729
Computer/Electronics	.0036	.006	.0007	.004	.0064*	-.014*
Machine Mfg	.0017***	.0001	.0000339**	.0000729	.0017	-.0016
Paper Mfg	-.0007	-.0004	.0000463	-.0002	.003	-.0069
Electrical & Appliances	.0002*	.0000037	-.0002	-.0002	.0005	.0012
Petroleum/Coal	.0198***	.001	.0003***	-.0017	.0001	.0016
Car Mfg	.0037	-.0001	-.0012	-.0025	-.0084	-.0088
Wholesale	.0000677	-.0000297	-.00000439	-.00000415	.0000106	-.0000515
Air transport	.0039***	-.0001	.00004679	.0003	.0001	-.000015
Misc Mfg	.00005115	-.0000195	.0002**	-.0005**	-.0013**	.0001**
General Merchandise	-.001	.0000105	.0003	.0009	.0013	-.002
Rail transport	.001	-.0006	-.0004	-.000059	-.00000687	-.0000141
Water transport	-.000089	-.0000558	-.0000234	.0000339	.000003	.00009
Other transport	.0003	.00001339	-.0000151	.0006	.0001	-.0000889
Truck transport	-.00008	.000031	-.000001	.000032	.0002	-.0001
Telecommunications	.0124	.0093	-.0001	.0062	-.0035	.0105
Data processing	.0001	-.0002	0.0000053	.0002	.0000469	-.000038
Publishing	.0003***	-.000082**	.0000646	.000055	-.0005**	.0007**
Legal services	.0002	-.0001	0.0000084	-.000076	-.000008	.000008
Tax and Accounting	-.0004	-.000013	-.000018	-.0002	-.0003	.0001
Computer Services	-.0001	-.00000002	-.000015	-.0002	-.00002	-.000066
Admin/Support	.0002**	-.000087*	-.000009	.0003**	-.0007**	.0009**
Ambulance services	.000025	-.000067	-.000007	.000041*	-000011	-.000086
Accommodations	.0005	.0002	.000008	.0008***	-.000015	-.0006**
Food and drink services	.000073	.00008	.000009	.000073	.000008	.000009

The allocative efficiency metric is percentage changes where .01 is 1 percent and so when you see -.056 as an effect from unemployment this is to be interpreted as a 1 percent change in unemployment leads to a 5.6% fall in it. When I put 1 asterisk I mean a significance of 90 percent and 2 asterisks is 95 percent and 3 is 99 percent. I think my result on allocative efficiency is more positive from the recession than the Baqaee Farhi figures because a good amount of the decline in allocative efficiency occurred at the end of 2007 and my recession indicator from NBER is 2008 only. If the data was higher frequency it may be a smaller effect. When I removed data before the 2001 recession there actually was a sign change in the interaction between changes in average debt and the crisis. So changes in debt during the great recession brought up the efficiency here. This may mean that the firms who perished from lack of credit were actually of a lower level of

productivity. Then when including the other recession it became more of a negative thing for productivity which might be more fitting of the credit constraint view of Barlevy or Osotimehin Pappada. This firm debt incorporation wouldn't be possible in the other datasets. A negative cost of credit effect on MRPK is observed in the Gamberoni et al paper as well. The effects on allocative efficiency were weaker than in the 3 year cumulative version. It could be that much of the effects of these factor changes are more drawn out. If the data was more frequent than annual it would have more accuracy on timing. Unemployment changes dominate effect sizes here and in the regressions for each sector. It seems in normal times unemployment is bad for efficiency but in a recession the sign changes and it becomes a positive and strong force for allocative efficiency. Cleansing intensity was lightly significant and a negative influence from its inclusion of net exit effects. I think that cleansing intensity is a negative influence on cumulative efficiency from the great recession data primarily for that reason. It was shown in the Foster Grim Haltiwanger regressions the great recession had worse destruction and less creation than usual so cumulative negative over the short term. The second figure describes the regression results for each of the sectors that I had complete data for:

There are varied effects per sector but not as much was significant with this dataset. My data does lack enough data for some important things like finance, healthcare or education but I had good manufacturing data which I have in common with the other analysis. The only shocks in the recessions of the 2000s are both more financial crisis so this also affects the results. Aggregate unemployment data used instead of finer data may be an issue on effect sizes.The crisis was significant for mining, machine manufacturing, miscellaneous manufacturing, administrative and support services, and in the accommodation industry. It seems to be more negative for manufacturing and positive for services. The unemployment variable is the most dominant effect again. Notice that some of the more service type industries (which is lacking in other papers) had more significant effects like accommodations, publishing, and administrative. It seems unemployment has a very heterogeneous effect among industries. It is strongly negative for the whole economy outside of recessions but you get positive effects for industries like petroleum, telecommunications, chemical manufacturing, air transport, and metal manufacturing. Many of those are capital intensive. It appears more labor intensive industries had negative effects of unemployment when in a recession. Most of the technology related industries have positive effects from the reallocation with the exception of computer services. It appears that there are positive or near zero effects from changes in debt or the interaction of debt with the crisis on allocative efficiency in more labor intensive industries. Then you see negative effects from the debt changes in some more service like industries and capital intensive things. In the aggregate it is fairly strongly harming efficiency so it must be driven primarily by some of the larger effects in certain sectors. Additionally some of these effects could be lagged at varying rates across firms. Labor intensive firms seem less affected by the recession but are affected by aggregate unemployment trends. And clearly a capital intensive firm would be more harmed by higher borrowing costs and are more credit constrained.

Cleansing intensity also has a varied effect but it isn't very significant. I believe it was weaker due to allocative efficiency focusing on misallocation of productivity. Yet it still outperformed unadjusted TFP. Importantly my sample of large public firms is likely lacking the type of marginal firm which is cleansed or is more deeply influenced by the changes of capital and labor conditions The capital intensive industries also have high adjustment costs and some barriers to entry. So from these relationships I draw a few hypothesis. Crisis and debt constraint effects seem to affect capital firms more. The factor intensive firms are more constrained by their factor intensity and are negatively affected from forced factor reallocation in it. Crisis effects seem to be greater in industries that have more adjustment frictions, barriers to entry, or market power issues. This regression serves more as a reallocation test in a different part of the firm distribution rather than a strict replication. Much of these results line up with the literature even under these conditions, confirming the robustness of older papers results and showing some lesser seen environments. I use some of these facts to help inform how to improve the model to consider those hypotheses. I focus on adjusting the setting to show factor usage diversity and draw out some impulse responses with longer debt contracts.

Section 3 - Model

If firms that have more intensive usage of one factor are harmed more by forced reallocation in it, then market distortions or regulation in that factor would harm them more. Things like credit constraints, increased lending scrutiny, high adjustment costs, or abnormally high interest rates would limit efficiency in capital intensive industries. Labor market regulation, searching frictions, strong job match quality, and unionization all might harm allocative efficiency in labor-intensive industries. An industry could benefit from exits if there is too much capital or labor being used by unproductive firms. Likewise, from entry if productive firms are constrained. Policies protecting incumbent firms can worsen the first issue, and policies making it more difficult to enter worsens the second issue. To get these heterogeneous effects in firms with different dependencies on the factors of production you couldn't only differentiate firms based on productivity or net worth as Caballero Hammour do or Osotimehin Pappada do. If they only get heterogeneous debt contracts based on each of these differences, then it won't generate this desired deviation in sectors. Manufacturing job flows data from Caballero Hammour 1999 suggests creation of jobs should spike downward initially, up and then smoothly slowly curve back down in recovery. The destruction spikes up and down initially, then smoothly falls back to trend. In Gamberoni Giordano Lopez-Garcia the graph for changes in MRPK dispersion over time in Europe shows a steeper decline during the recession than it returns, but the shape isn't very defined since observations are annual. The MRPL dispersion had steeper declines and return after than MRPK reflecting our bigger effects in unemployment from other papers. This European trend of dispersion worsening over time is probably unrelated to the normal business cycle trend, but the responding movements during the

recession are relevant. Allocative efficiency changes in Baqaee Farhi are modest declines from the 2001 recession and then a large improvement following it. Then the great recession had a steep decline and a steep recovery that was lower, and then it stagnated with a slow rise. So an improved model needs to have firms cutting significant labor in downturns and returns allowed to vary in length. To think about how one could structure a firm dynamics model in order to generate these desired effects, I am going to base it upon the Osotimehin Pappada 2017 firm dynamics model of productivity which is highly influenced by older versions like those of Caballero Hammour. It can easily be modified to account for various labor and borrowing frictions.

To do this, I propose some changes to the Osotimehin Pappada model as follows. The model has currently no labor features so its job changes would only be on exits or entry, I add in a single identical unit labor to the problem with the same labor hold-up problem from Caballero to make it less dependent on capital and lessen its effects from shocks. To allow for a less capital dependent firm, the hold-up problem adds a share of production going to workers and so production is reduced by $(1-\gamma)$. Then the capital factor share α is also changed to be lower for labor-intensive firms to add to the heterogeneity. These changes govern the different sectors. I change the capital decision to try to fit the shape of the response so it can be changed to allow for length or depth of shocks. The Bernanke Gertler styled debt contracts can be longer than 1 period. There will be an option to extend the contract for an additional period if they favor the current interest rates. The intermediary still must expect to want to profitably participate next period so its adjusted participation constraint reflects this. I allow the risk-free rate to vary with the aggregate shock to reflect some monetary changes. With varying interest rates in the simulated economy, the firm would be expected to take out longer loans if they expected future rates to be higher. The intermediary will consider the aggregate economy, firm type, firm productivity, and the firm's net worth. Firms may time the macroeconomic circumstances here which allows for more heterogeneity and draw out effects.

The firm environment closely follows Osotimehin and Pappadà (2017) with several modifications. A firm maximizes the present value of dividends subject to a borrowing constraint arising from its interaction with competitive intermediaries. Each firm enters the period with net worth e and a persistent productivity state θ, which evolves stochastically. Aggregate demand Z follows a two-state Markov process identical to that in the original model, and firms also draw an i.i.d. temporary shock ε. Output is given by

$$(1-\gamma)Z(\theta+\varepsilon)k^{\alpha},$$

where α and γ may vary across firm types to capture differences in capital or labor intensity.

At the start of each period, before observing ε, the firm chooses capital k and borrows $k+c-e$ from an intermediary, with c a fixed cost. Capital depreciates at rate δ. The borrowing rate faced by the firm, $\tilde{r}$, may exceed the risk-free rate r depending on default risk. If the firm defaults, the

intermediary incurs a monitoring cost μk^α. Let $\bar{\varepsilon}$ denote the default threshold; realizations $\varepsilon < \bar{\varepsilon}$ lead to liquidation. The intermediary's participation constraint is

$$(1+\tilde{r})(k+c-e)(1-\Phi(\bar{\varepsilon}))+\int_{-\infty}^{\bar{\varepsilon}} [(1-\gamma)Z(\theta+\varepsilon)k^\alpha + (1-\delta)k - \mu k^\alpha]\, d\Phi(\varepsilon) \geq (1+r)(k+c-e). \quad (1)$$

This equates expected contract returns to the intermediary's risk-free outside option. Because monitoring and liquidation values differ from Osotimehin–Pappadà, and borrowing costs vary across contracts in my environment, it does not collapse to their closed-form expression.

For any (k, θ, Z, e), the participation constraint defines a cutoff net-worth level $e_b(\theta, Z)$ below which no profitable contract is feasible. The default threshold $\bar{\varepsilon}$ is jointly determined with k and e through the equation.

Given the repayment obligation $(1+\tilde{r})(k+c-e)$, next-period net worth satisfies

$$q = \begin{cases} (1-\gamma)Z(\theta+\varepsilon)k^\alpha + (1-\delta)k - (1+\tilde{r})(k+c-e), & \varepsilon > \bar{\varepsilon}, \\ 0, & \varepsilon \leq \bar{\varepsilon}. \end{cases}$$

Using the definition of $\tilde{r}$ from the default condition,

$$(1-\gamma)Z(\theta+\bar{\varepsilon})k^\alpha + (1-\delta)k = (1+\tilde{r})(k+c-e),$$

this simplifies to

$$q = \max\left[(1-\gamma)Zk^\alpha(\varepsilon-\bar{\varepsilon}),\, 0\right].$$

For net worth choices, at the end of the period, after observing θ' and Z', the firm chooses whether to continue by selecting next-period net worth e'. Continuation is feasible only if $e' \geq e_b(\theta', Z')$. The value function is similarly stated

$$V(e, \theta, Z) = \max_{k,\bar{\varepsilon}} \mathbb{E}\left[\max_{e'} \left(q - e' + \beta\, I(e')\, V(e', \theta', Z')\right)\right], \quad (2)$$

where the indicator for admissible continuation is

$$I(e') = \begin{cases} 1, & e' \geq e_b(\theta', Z'), \\ 0, & e' < e_b(\theta', Z'). \end{cases}$$

Following the example of Osotimehin–Pappadà, it is convenient to rewrite the problem in its form,

$$V^1(e, \theta, Z) = \max_{k} \int \left[\max_{e'} \left(q - e' + \beta\, I(e')\, V^0(e', \theta', Z')\right)\right] d\Phi(\varepsilon), \quad (3)$$

with the default threshold implicit in the lender's constraint.

Relative to Osotimehin–Pappadà (2017), two modifications are central. First, the borrowing rate $\tilde{r}$ is contract-specific and carried forward intertemporally, which is necessary for studying debt-maturity choices. Second, firms differ by α and γ, generating heterogeneous responses for capital- versus labor-intensive producers. The default threshold is determined by the choice of k and therefore does not need to be treated as an independent control. As in the baseline model, intermediaries must satisfy the participation constraint each period and do not smooth expected profits across periods.

Finally, the timing of events is as follows: (i) the firm chooses next period's present value of continuation profit maximizing debt contract; (ii) it chooses the associated k; (iii) shocks ε, θ', and Z' are realized; (iv) production occurs and the loan is repaid or the firm is liquidated; (v) the firm selects e' or exits and keeps the remainder as a dividend.

The choices of debt contracts must be made based on the firm's expectations of future net worth, productivity, and aggregate states. In doing this, they compare the expected value of the normal 1 period contract to the value that would come from incorporating the current period's interest rate into the following period's longer contract. In that next period they could take out another extended contract, but it would be with the interest rate that is required using new rates not using the last periods one. This leaves multiple value functions we must calculate in estimation. If it were superior to extend the rate, then we see our continuation value reflecting that expected return rather than the one of a single period contract in equilibrium. So it too must be calculated with that incorporated in the value function of the contract extending decision. Adding to the computational burden which becomes an issue.

Next, just as was done in the original paper, we do a simulation to see how the firms act under an aggregate shock. First, I simulate some periods up until it reaches a steady state distribution of firms. Then I introduce a new path of shocks that reflects this one time aggregate shock effect, followed by the high Z states afterward. There will be a constant amount of potential firms which can enter if they get favorable draws of productivity and starting new worth. Each of these potential firms independently draw their θ and net worth. The net worth is uniformly distributed zero to 9.7 which was what the original author used for the sake of matching his lowest possible dividend threshold. The θ are drawn from the stable distribution that is determined through his specified transition matrix on its AR(1) process with persistence.

$$\ln \theta' = \rho_\theta \ln \theta + (1 - \rho_\theta)\eta_\theta + \varepsilon_\theta, \text{ with } \varepsilon_\theta \sim \mathcal{N}(0, \sigma_\theta). \tag{4}$$

This matrix is discretized with the Tauchen (1986) method. He chooses the variance on this noise component based on getting a desired range of observed firm thetas. This range comes from Del Gatto et al. (2008). It had a mean of .3. The temporary shock ϵ was normally distributed with a variance he chose to match up with the default probability 1% which is found from Carlstrom and Fuerst (1997) estimation. His Z had two states, 1 or .97. The transitions were chosen to reflect a

3 period average time to transition as is seen in the business cycle.

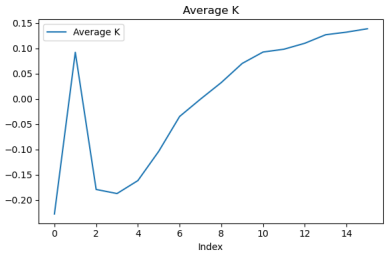
So for each period I start with entries, when the firm considers its entry, it looks to the optimal choice variable for capital and its contract as determined from my value function iteration. Then it looks to its its value function with present value of future profits, and it will enter if it is profitable. Then we must iterate through each of the existing firms. They choose contracts and capital as per the steady state policy and draw their new shocks. They pay back the loan and choose a new net worth. If the intermediary does not want to participate next period on account of low net worth and or productivity, the firm must exit. Likewise, if the firm finds it better to keep their dividends and ignore a low continuation value, then they would exit. I record exiting behavior, entry, average levels of productivity, net worth, and capital usage after a shock on Z. I maintain his calibrations on the parameters with 2 exceptions.

Parameter	**Symbol**	**Value**
Discount factor	β	0.956
Risk-free rate high	r	0.04
Risk-free rate low		0.01
Depreciation rate	δ	0.07
Returns to scale capital intensive	α	0.70
Returns to scale labor intensive		0.65
Aggregate productivity high	Z	1
Aggregate productivity low		.97
Persistent productivity, mean	η_θ	-1.2591
Persistent productivity, volatility	σ_θ	0.1498
Persistent productivity, persistence	ρ_θ	0.9
Fixed cost	c	4.5
Idiosyncratic volatility	σ	0.3
Monitoring cost	μ	0.25
Entrants net worth upper bound	$\bar{e}_{\text{entry}}$	9.7
Labor intensive firm labor reduction	γ	.15
Capital intensive firm labor reduction		.1

I chose to allow the risk-free rate to fall in the recession state to 1 percent, reflecting stimulative monetary policy. My c variable had to be much larger than his because my labor payments reduced output and contracts made it more appealing to stay. I would have had far lower exiting rates if not doing so, which was the whole purpose of its calibration. His returns to scale was chosen because of a Hennessy Whited (2007) paper findings. I left his .7 for the capital intensive firm and reduced it slightly by .05 for the labor firm. I chose a difference of .1 and in .15 in the labor holdup production reduction parameter to have a similar sized distortion in the α parameter. The amount of capital or productivity will change which effect dominates. The productivity parameters were meant to fit results of two separate papers that looked at the ranges in TFP in the Italian and American economies. The monitoring costs were chosen to representing about 10% of the firm's capital based on a paper by Andrade and Kaplan (1998).

Section 4 - Results

Some of the factor productivity measures I will use to relate my results would be from the Gamberoni et al. paper as seen in these figures of some popular European economies. The graphs on marginal revenue products of capital and labor. I am able to record changes in average firm capital. The firms in my version when in existence have a single unit of labor, and it isn't a choice, so labor decisions here would just match the net exiting rates. In 2008, they see this spike downwards and a quick return to previous trends. But capital was slower to return. The second set of graphs come from the Caballero papers. These were observed job flows on manufacturing firms, not actual firms created or destroyed. Creation falls during the drop and then spikes higher than usual before it slowly returns to trend. The firm destruction spikes high during the drop. Then we see a bit of lower losses in the years to come as new firms enter, and afterward back to trend. In the Papadas Osotimehin paper average persistent productivity following a recession shock improves and then returns to steady state slowly. The improvement being from knocking out low performing or unlucky firms, as they can't produce enough to satisfy intermediary participation and give a high enough continuation value. So their prediction was a spike that slowly declines. In its entry exit data you see the initial spike and quick return to normal on each. This differs from the other creation and destruction data from Caballero. These impulse responses are nearly mirrored, which is not the case in the other paper results. For Caballero the creation rate does rise and, though falling after, it remains high until another recession. In general, it should have more drawn out effects with the entry lagging exits. They also overstate entry and understate exits. The following are the responses to aggregate economy shocks in my paper.



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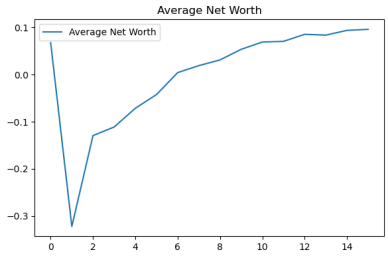

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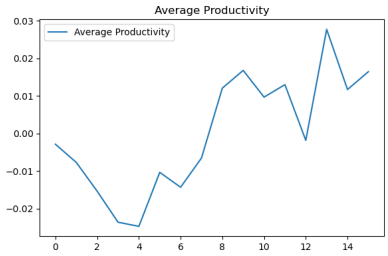

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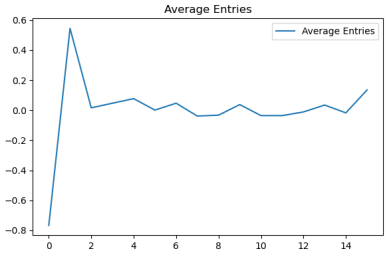

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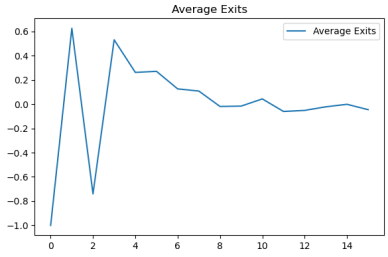

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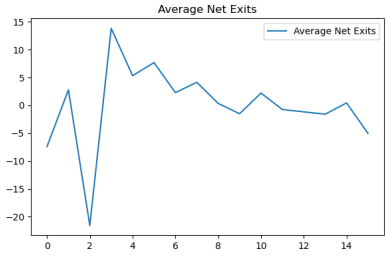

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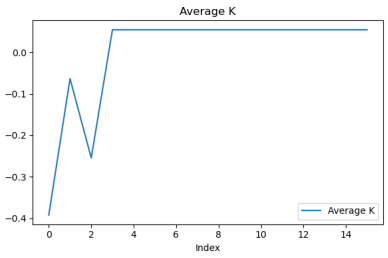
Capital intensive firm's response to aggregate shock



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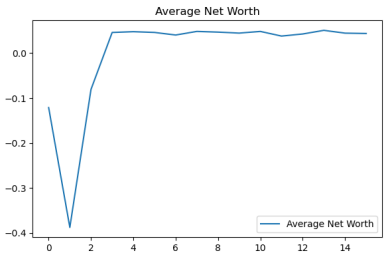

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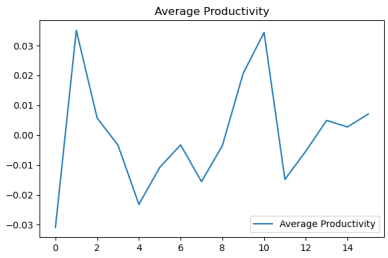

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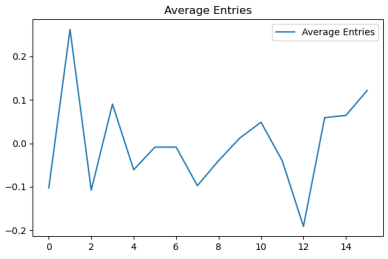

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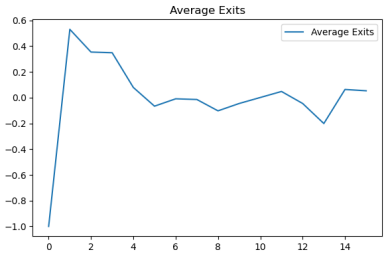

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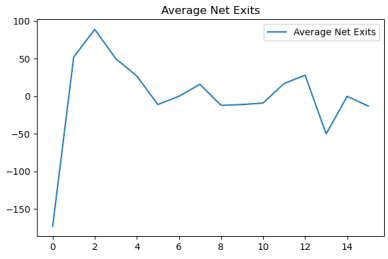

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Labor intensive firm's response to aggregate shock

One first note about my graphics in these figures is that due to the large amount of computation required for my model, I was required to make some sacrifices to make it feasible. By reducing the state spaces available in my grids for capital, productivity and net worth I expect that there are larger changes from period to period and so it will be much less smooth than it ought to be. I have 4 states for both productivity variables, capital, and net worth. The transitions maintain the original designs probabilities. Due to low options of states offered, you see it to be fairly unlikely to change persistent productivity as time progresses. Also with fewer different temporary shocks, it became much more likely to have extreme shocks. Similarly, it would take significantly more compute to consider multiple lengths of a debt contract. Because of these changes the choices of the firms may look choppy in the simulation but assuming there were more states one should expect the graphs to be smoother after the first couple periods of the shock.

I used 2000 potential entrants per period to try to get meaningful averages. I then ran 5 separate simulations and averaged the results so that it would be less probability dependent and to take away from my issues associated with a small state space. The graphs are percentage deviations from the trend statistics. As in .01 representing one percent, 1 being 100%. Period zero is a high aggregate state that includes the firm behavior knowing the negative shock is now happening, so they may leave preemptively before producing in that shocked economy. The period one is when the shock occurs. And you see extra activity following that period due to extended contracts ending at that time from the shock and twin peaks. This would be more drawn out if they could take out longer contracts and lose that quality. Other things that could extend the mean reversion would be persistence parameter changes or longer recessions. First, I will go

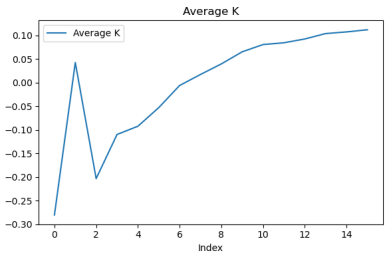
through the capital and labor averages among firms following the aggregate shocks.

The amount of capital I tried to keep similarly utilized among productivity's as in the original paper. You can see following the shock in the labor-intensive firms, they max out their usage at times. However, the graphs were similar to what is expected from the Gamberoni results. They record low marginal products of capital initially, then a fairly quick return to trend. So large decline in marginal productivity of capital, and then we see some increases slower to normal. In their graph there were some differences among different economies in speed of the return to trend, and you can see the bigger lag in my capital intensive firms, so I can show both behaviors. We can see the initial spike in capital usage is much larger for capital intensive firms. The labor-intensive firm does not see a very large spike in capital usage as compared to normal conditions. It took longer to return to the normal usage and following the return it didn't remain far above the average usage, following that I would predict that it would slowly return to steady. The labor case had more potential combinations of states which supported optimally using a contract. Likely from their less volatile changes in production and this appeals to the lender's profitability. Capital intensive firms benefit more from lower interest rates because they have a greater potential profit from adding capital. The intermediary is more heavily burdened with the cost of interest rate risk in extending them loans and thus it may choose to focus offering short term loans due to this interest rate risk.

In my model labor is distributed 1 per firm so net exits matches my labor usage. Note that a negative net exit would mean higher entry. These changes were sharp as you can see, so each period brings a large block of similar firms dropping out or entering at once. This led to high changes in percentage terms, especially in labor firms. In the Gamberoni depiction of MRPL we see it doesn't really grow over time it just dropped and returned to the steady state, some nations more quick than others. There are longer returns to average in capital intensive firms because of their more frequent usage of the extended contracts. Higher creation would indicate a drop in MRPL. These terms can raise from lower factor usage, new technology, or factor complementarity. With capital intensive firms we see that no one wants to exit knowing the recession is coming because they will take advantage of lower interest rates. Then recession knocks out some firms and in the period following recession we see big entries. And then after this contract ends the firms which could only exist in the suppressed rates exit. This is as expected and it represents the more delayed return economies. In labor intensive firms it was more immediate and powerful. They are less likely to remain knowing a recession is coming. When it hits the worst of it is extended until their extended contracts end in period 2. The return is then fairly quick. The labor-intensive firms appear to not be as dynamic because their capital usage trends aren't as significantly changing. Entries are more drawn out and later for labor firms which better reflects the data. Exits have single hump due to less extended contracts. This seems similar to the conclusions I drew from the Caballero model. The labor-intensive firm reflects the expected shock effects more similarly, which makes sense because that would be more firms in America and his graph represents job flows. An

important new feature seen here is the delayed contracts delaying exits in a way that in a simple setting with two choices is showing two peaks but would smooth out and look like a normal delay with more states. So unproductive firms are being extended loans to delay exit similar to how zombie firms work which is drawing down early productivity. Things like lower monitoring costs, low reserve requirements, and barriers to entry would allow for more of such lending.

Aside from the choppiness of the actions due to a much smaller state space the general trends of these graphs are similar to the desired comparisons seen in these other empirical data sets. But their data is over all the firms in an economy and not a single type. If you wanted more or less quick behavior you can adjust the prevalence of each type of factor intensity or productivity/net worth distributions. This issue of state space may be a large part of the reason my impacts are so large if you considered it in percentages as compared to the original paper results. It causes a significant part of firms to drop out of the market when it should be a narrower range. Currently exits are high as compared to the author's 12 percent that was calibrated to the US economy. It can be improved by adjusting my fixed costs, or factor parameters, or adding more simulations to average among, and with a greater state space size. From my previous regressions of various sectors I saw better crisis effects and debt related effects on efficiency among capital firms. The labor firms efficiency changes were more driven by unemployment than crisis or borrowing. The unemployment would be most similar to net exits in my model. My productivity transitions were delayed and in the capital model it would require a longer timeline to see the return to the mean. Labor seeing a bigger swing in its returns and we see the delayed second peak at a similar time that we see capital reach its only peak. I believe my high exits and low extended contract uptake is causing too many good firms to leave, and it muted some of the positive effect size on productivity improvements. The initial exits when entry comes it did bring productivity up and even more so for labor intensive firms. Due to the lower net exits, the cleansing intensity (change in TFP over net exits) of capital firms was better here. The labor industries were less dynamic. So the productivity changes were coming more from changes in labor intensive firms but the capital intensive firms did time the market more and saw more drastic firm behavioral changes, including the delayed entry effect. Some other implications of the current model are that labor firms with their less volatile production could easier receive long term loans but they wouldn't always like to use them. The firms with high net worth and productivity were highly likely to benefit from a locked in lower interest rate. Regression to the mean was kind of strong in this productivity process from the sharp changes in temporary productivity shocks, so productive firms with high capital requirements would experience stronger credit crunches on the long loans post the recession. In this model, the repeated short term loans are more representative of a variable rate loan. Similarly a low productivity firm could get more longer and fixed loans because intermediaries make more money from them. Due to the expectation of things returning to higher production after a recession you weighed continuation values greater and we saw more entrances.



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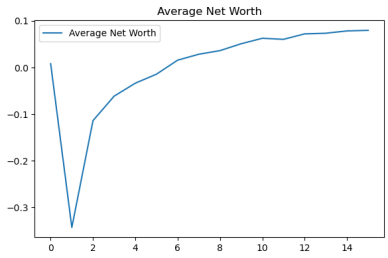

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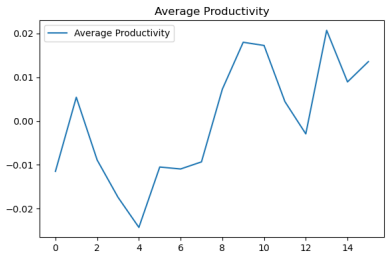

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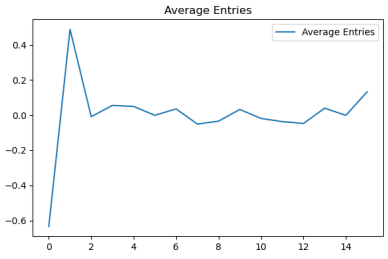

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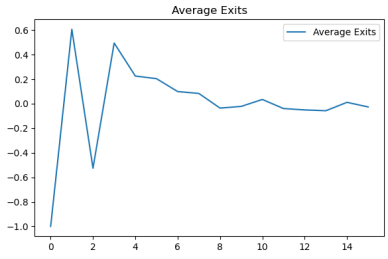

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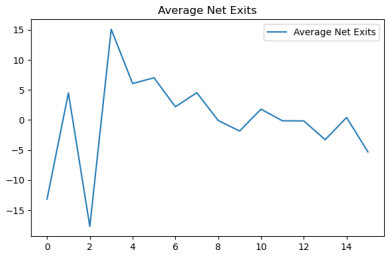

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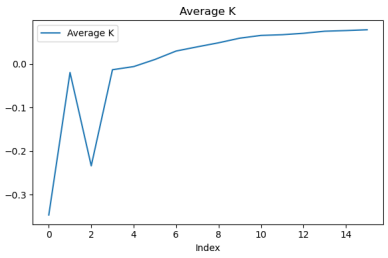
Aggregate economy response to aggregate shock 70% capital firms



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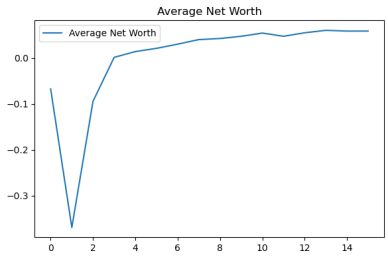

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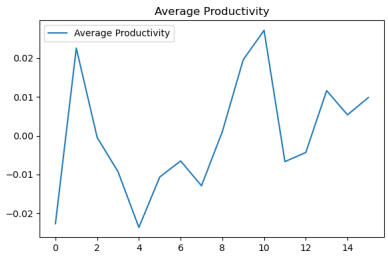

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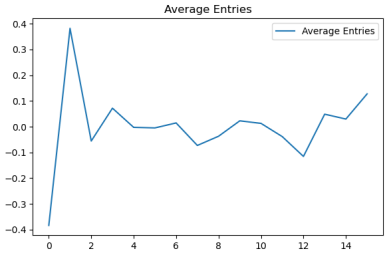

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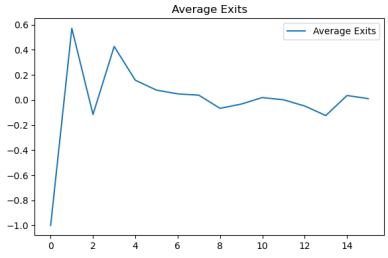

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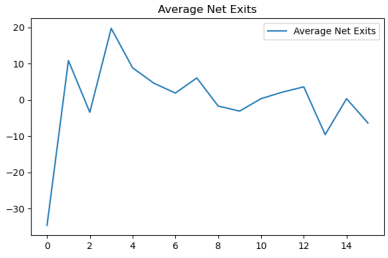

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Aggregate economy response to aggregate shock 70% labor firms

Following this examination I decided to use these two firm type datasets to calculate roughly what it would look like in aggregate and to smooth out impulses. I did it once with 70% capital, 30% labor. Once with 70% labor, 30% capital, which is probably more likely in many developed countries. Looking at the labor dominant economy we see better fits with caballero data on entries with exits a bit more drawn out than desired but this double peak disappears if they could

do longer debt contracts. The net exits and capital behavior seems to closer match the data of Gamberoni. Again, if we bring down exit rates through a different calibration we would see larger productivity gains and a less drastic net exit behavior which could be further calibrated as desired to match any desired country's economy. In these mixed sector economies we see the trends much clearer and accurate than before and these parameters in the model can be adapted to strengthen peaks or lengthen recovery.

Some additions that would be worth exploring with this model would be more complete labor markets than a simple bargaining portion going to labor as it has been ignored in much of the literature. It could then be shocked and maybe that works better for certain recessions or interacts interestingly. One could find different parameterizations or focus on some of the parameters unique to the paper to calibrate closer to a specific economy and recession to say more which effects dominate where. I could try to opitimize my calculations of value function iteration to allow for larger state spaces and longer contracts. With better optimized estimation it maybe possible to show it with even longer debt contracts but I predict this just removes any double peaks we see and draws out the return to mean. I could closer examine the net worth shock idea that was in the original paper to further calibrate it towards recessions more tied to asset prices. One could maybe re purpose this model to add elements of contagion between firm failures like represent various industry connections with intermediate goods. Building on my findings of representing drawn out firm failures, maybe one could add some features to this model to see the effects of bailing out a critical firms or zombie firms and the resulting firm behavior.

Conclusion

In an effort to better understand heterogeneity in productivity after reallocation, I used Compustat firm data to estimate what was driving different sector's net results after a recession. My regressions were based on previous empirical papers that were concerned with reallocation effects of the great recession. My paper uses finer data from public firms and some alternative measures to measure misallocation rather than productivity and it mostly confirms the previous results. I saw that when an industry is more intensively using one factor it will be more negatively affected by frictions concerning that factor. That various inputs have separate or different shocks at times, and it may help explain disparate effects under each given recession. I adjusted a modern firm dynamics model to accommodate this idea through comparing firms with strengths in capital vs labor. I put in a longer duration Bernanke Gertler style debt contract and varying interest rates to more accurately describe monetary policy effects and dynamic firm behavior to see if it captures some of the creation variety. This debt adaptation may be useful in other contexts because it is a popular mechanism. It was able to potentially accommodate the proper firm creation following a recession, and through properly weighting the firm types of the aggregate economy or averaging responses we could see a better fit. It can allow for more prolonged effects as well as sharp

spikes of changes and those features can be more tightly adjusted through it. It can help more specifically explain the transmission of monetary policy and the debt taking behaviors of firms. The model predicts greater productivity gains coming from destabilizing labor-intensive industry, but it isn't as efficient in doing so as in capital-intensive firms. It shows a new source worsening credit frictions coming from an intermediaries desire to not take on changing interest rate risks. This friction is worsened for volatile industries and may suppress firm entry for certain sectors. A more dynamic labor hiring decision could be useful for explaining different types of shocks and the entanglement of the crisis effects with unemployment as it is underexplored in the literature. Using a sort of input output compatible framework or some mechanism with intermediate goods or financing coming from abroad you could describe international influences that might trigger firm exit and cascading effects from failures or industry related shocks. This could also be good to explain systemically important firms, zombie firms, financial liberalization, or trade. There could be shocks abroad or tariffs that drive up input prices and force a firm to exit or debt mismatch problems that make them susceptible to exchange rate fluctuations. This type of model can accommodate more features than it presently does, and this allows for more precise analysis of crisis and firm productivity. These modeling ideas could present new and potentially important avenues for explaining creative destruction. Shocks that could be measured to determine their relative influence and impact size to better motivate policies of recession fiscal and monetary policy.

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