Capital Intensity and the Labor Share of Income: New Theoretical and Empirical Insights

Grazzini Jakob and Rossi Lorenza
University of Pavia

Preliminary Draft, August 2019

Abstract

This paper considers a two sectors heterogeneous firms model where firms' specific technology and capital intensity are endogenously determined through business dynamics. We show that a shock to the relative price of investment goods is followed by the entrance of new firms characterized by higher capital intensity of production and lower labor income share. Remarkably, differently from Karabarbounis and Nieman (2014) and Piketty (2014), a standard Cobb-Douglas production function, where capital and labor are complements, is sufficient to obtain the result. Using ORBIS microdata of US, UK, Germany and France we find strong and robust evidence confirming that new firms enter the market with higher capital intensity and lower labor income share than the average. Remarkably, this evidence holds for those firms entering the market from 1980 to 2007, a period characterized by a strong decline of the relative price of investment goods.

KEYWORDS: Firms Dynamics, Firms Heterogeneity, Labor Income Share, Capital Intensity, Capital Technological Change, ORBIS Microdata

JELCODE: D33, E25, J24, J30

1 Introduction

1. Motivation: In the last 50 years, capital intensity has increased and labor share has decrease in the US. Question: how? Are new firms more capital intensive? or incumbent firms change their capital intensity? We show that entry has a very important role (similar to putty-clay paper)

2. Robustness. Is all of this true also outside the US? We perform the same regressions also on UK, DE, FR and all togheter. The evidence on the importance of the entry year on capital intensity is strong also in Europe. The evidence on labor share is weaker in Europe, however, once we pull all countries togheter we find that entry year influences labor share. Thus, the economic environment in entrance year has a long lasting effect on firms' technology. Morevoer, we conclude that entry-exit process has a crucial role in shaping aggregate technology.

3. Why do entrant have higher capital intensity and lower labor share? We explore the role of decreasing price of investment. Model. Empirical evidence on capital intensity vs prices.

[labour share reduction and capital intensity increase in the US bla bla bla].

In this paper we aim at understanding *how* and *why* did capital intensity increase and labor share decrease. Regarding the first point, we can imagine two channels leading to an increase of aggregate capital intensity: 1) incumbent firms increase their capital intensity as a response to some change in the economic environment, 2) new firms enter the market with a more capital intensive technology. We estimate an empirical model using firm-level data, showing that the main role in increasing aggregate capital intensity and reducing labor share can be attributed to the entry of new, relatively capital intensive firms. [paper on restaurants]

[]

The second part of the paper, analyzes the reasons that led new firms to enter the market with relatively capital intensive technology and relatively low labor share. [we contribute here to the vast literature on the decline of the labor share and find a result compatible with Karabarbounis and Nieman (2014) but...]

The labor income share has long been considered stable according to Kaldor (1957) stylized facts, and therefore attracted little attention from researchers in academics and institutional circles. In recent years however, the evidence suggests that labor income share has seen a secular downward trend, not only in the US but in the majority of the developed and developing countries. For example in the G7 countries it has declined by almost 2 percentage points per decade. Several potential causes of the decline in the labor share have been investigated in the literature. According to Karabarbounis and Nieman (2014) one leading potential explanation is capital technological change, followed by a persistent decline in the relative price of investments that has led firms to substitute labor for capital. A necessary condition to get this result is that labor and capital are strong substitute inputs in the production function, thus requiring an input elasticity of substitution greater than one. Karabarbounis and Nieman (2014) find some evidence in favor of an input elasticity greater than one using cross country macro data. Piketty (2014) documents that the corresponding higher capital share has been associated with higher inequality in the personal distribution of income and also estimates an elasticity of substitution between labor and capital greater than one. These estimates are however at odds with the predominant literature. The majority of the empirical evidence, both macro and micro, reports estimates of the elasticity of substitution lower than one, implying that the two inputs are complements rather than substitutes, at least intrateporally. Because of this, the recent theoretical literature has cast doubts on the relevance of the decline of the relative price of investments and of the consequent capital accumulation as a possible and leading explanation for the declining labor income share. Alternative explanations have been recently found in the rise of superstar firms (Autor et al. 2017) and in the increase in firms markups and thus in the profit shares (Blanchard and Giavazzi 2003, Barkai 2017, De Loecker and Eeckhout 2017).

Starting with a simple model with endogenous business creation, where heterogeneous firms adopt a Cobb-Douglas production function with different capital intensity technology, this paper shows that the capital accumulation mechanism caused by the decline of the relative price of investment is still a key mechanism to explain the decline in the labor income share and the increase in capital intensity. Remarkably, this mechanism is valid in a model characterized by complementarity between capital and labor. In particular, we show that when labor and capital are intertemporal rather than intratemporal substitute, the dynamics of the relative price of investment goods is still fundamental to explain the long run decline of the labor share. To obtain this result we build up a two sectors heterogeneous firms model where firms' specific technology and capital intensity are endogenously determined through business dynamics. We show that in face of a shock to the relative price of investment goods the adoption of a more capital intensive technology by new firms entering the market arises endogenously and it is key to explain the long-run pattern of the labor income share. Remarkably, differently from Karabarbounis and Nieman (2014), Piketty (2014) and Piketty and Zucman (2014) a standard Cobb-Douglas production function sufficient to obtain the result. The second part of the paper tries to empirically validate our the-

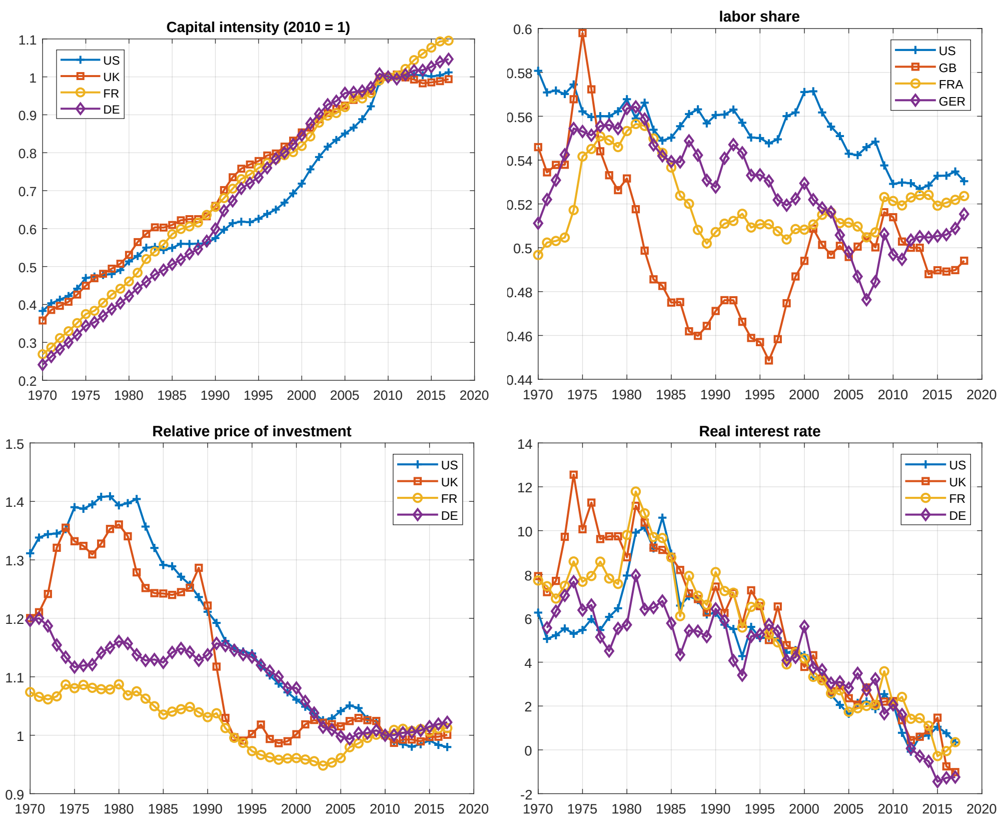

Figure 1: Relative price of investment, long-term real interest rate, aggregate capital intensity and labor share for US, France, Germany and UK.

oretical result using ORBIS microdata for the US and also for UK, France and Germany. We show that the decline of the labor share is significantly affected by the increase in capital intensity, together with an increase in firms mark-up. Importantly, we then regress firms capital intensity on firms date of birth, also controlling for the age of the firms, and we find that, ceteris paribus, new firms enter the market with higher capital intensity than the average. Remarkably, we show that this evidence holds for those firms entering the market from 1980 to 2007, but not for younger firms. As well known, this was a period characterized by a strong decline of the relative price of the investment goods, accompained by an increase in capital intensity, a decline of the real interest rate and a decline of the labor income share in the countries considered (see Figure 1). For the majority of these countries the relative price of investments has in fact remained constant from 2007 on. The subsequent period of a severe crisis also contributed to distort firms choice to accumulate capital and to cause an extraordinary fall of new business. All facts that could have altered the relationship between the adoption of new capital intensive technology and the labor income share in the last few years. Overall, our paper claims that technological changes and declining relative price of investments cannot be discarded a priori through the evidence that capital and labor are intratemporal substitute, since entrance of new firms with more capital intensive technology may be sufficient to obtain a declining labor income share.

Many recent papers have documented trends in the aggregate labor share. Grullon, Larkin and Michaely (2017) show that increased concentration across most U.S. industries has contributed to the labor share decline. Recently, Barkai (2017) and Autor et al. (2017) both report a positive correlation between industry concentration and the decline in the labor share. Our paper does not investigate the role of market concentration, though in the empirical section we control for two different proxies of market concentration given by firms markup and by firms market shares. The paper closely related to ours is the one of Karabarbounis and Neiman (2014). These authors find that the decline in the labor share is a within-industry rather than a cross-industry phenomenon, primarily due to the decline of the relative price of investment goods. Our paper documents that though the increase in profits shares has affected the labor share, increasing capital intensity by new firms is also key to explain the long run pattern of the labor income share. Importantly, though the relative price of investments is key to explain our results, in our model capital and labor are strong complements rather than substitute. Also, differently from Karabarbounis and Nieman (2014), the decline of the labor income share is not followed by a one to one increase of the capital income share, but also by an increase of the profits shares. Recently, Barkai et al. (2017), De Loecker and Eeckhout (2017), claim that profits share has increased by almost thirty percent, whereas capital income share has decreased in the last three decades, thus challenging theories sustaining capital technological change as possible explanation of the decline of the labor share. These studies have been however questioned by a recent paper of Karabarbounis and Nieman (2018). In this paper the two authors provide new support of a decline of the labor share due to an increase in capital income share resulting from capital technological change. They claim that the surge in the profits shares and the decline of the capital income share recently documented by Barkai et al. (2017), are most probably due to a measurement problem of "factoless income", and show that unmeasured capital plausible accounts for all factorless income in the recent decades. Finally, Basu (2019) shows that estimates of large or steeply rising markups has to be considered implausible, thus casting new doubts on the relevance of the increase of the markups and profits shares as the only explanation for the decline of the labor income share.[1]

Our paper is not intended to take a stand on single explanation of the declining labor income share. Our main contribution is to have emphasized the role of firms heterogeneity in production technology and business dynamics that has been neglected by the recent literature. We show that these two ingredients may be key to explain the long run dynamics of the labor share as well as the dynamics of the average capital intensity. Remarkably, our results are obtained assuming that capital and labor are intratemporal complements rather than substitutes. Last but not the least, to date the evidence has been mainly obtained using macro data or sectoral data. In this respect, we make a step ahead in the literature by using firms' level data that allow to investigate the importance of the entrance of new firms for the long run pattern of the factor income shares together with that of capital intensity.

The remainder of the paper is organized as follows. Section 1 spells out the model economy and the main mechanism behind the declining labor share. Section 2 presents descriptive analysis and new empirical evidence on firms capital intensity and the labor share of income using ORBIS microdata on the G7 countries. Section 3 concludes. Robustness analysis for the theoretical

[1] He claims that several of the prominent estimates suggest that the markup increased far more than would be necessary to explain the decline in labor's share.

model and for the empirical evidence are left in the Technical Appendix.

2 The model

We consider an RBC model with heterogenous firms and endogenous firm dynamics. The economy is populated by a representative household and by a continuum of heterogeneous firms which are owned by the household.

2.1 Households

The representative household chooses consumption C_t, investment into physical capital I_t and the supply of labor L_t. The per-period utility of the representative household is

$$\log\left(C_t\right) - x\frac{L_t^{1+\phi}}{1+\phi}$$

Precisely C_t is consumption and L_t are labor hours. The representative household maximizes the expected discounted value of her life-time utility, subject to the intertemporal budget constraint

$$C_t + I_t = w_t L_t + R_t K_{t-1} + \Pi_t$$

which states that total expenditure in consumption and investment goods equals total income stemming from labor income. We assume that the household derives income from the return of capital (where R_t is the competitive interest rate) and the from return of being the owner of firms (that is from profits Π_t). The stock of capital evolves according to the following law of motion

$$K_t = \left(1-\delta\right) K_{t-1} + \zeta_t I_t.$$

$\zeta_t = g_I \zeta_{t-1}$ represents investment specific technology progress and also the inverse of the relative price of the investment good. Solving for the household first order conditions:

$$w_t = x C_t L_t^{1+\phi}$$
$$C_t^{-1}\zeta_t^{-1} = C_{t+1}^{-1}\beta\left(1-\delta\right)\zeta_{t+1}^{-1} + R_{t+1}$$

we find the labor supply and the consumption Euler equation.

2.2 Investment Good-Producing Firms

Perfectly competitive firms purchase Y_t^I units of the aggregate final good to transform them into investment goods in efficiency units I_t. The investment good is then sold to households at a unit price P_t^I. The optimal problem of the investment good-producing firms is thus to maximize the profit function

$$P_t^I I_t - P_t Y_t^I$$

subject to their production technology, given by

$$I_t = \zeta_t Y_t^I$$

where ζ_t represents investment specific technology progress. It is not stationary and evolves following a deterministic trend g_I, so that $\zeta_t = g_I \zeta_{t-1}$. First order condition implies

$$\zeta_t = \frac{P_t}{P_t^I} = \zeta$$

is the relative price of the investment goods.

2.3 Consumption Goods-Producing Firms

The production sector is composed of a continuum of firms producing an homogeneous good under perfect competition. Though goods produced are homogeneous firms differentiate in terms of their specific technology. In particular, firm i produces the good y_i using the following Cobb-Douglas technology:

$$y_{i,t} = A_t \left(k_{i,t}^{a_i} l_{i,t}^{1-a_i}\right)^{\rho}$$

where A_t is total factor productivity. The parameter $\rho < 1$ defines a decreasing return to scale production technology, with capital intensity $0 < a_i < 1$ being heterogenous across firms.

We assume that each period the mass of production firms is fixed and equal to 1. However, firms entry and exit are endogenous, so that in each period the decision of entry and exit the market determines the lower and the upper bound of the capital intensity of operative production firms. At the beginning of each period both potential entrants and incumbent firms decide respectively whether to enter the market and whether to remain operative or endogenously default. Both new entrants and incumbent will pay an operating costs $f_t = f w_t$ to start the production period. The cost is paid in units of labor. Because of the presence of this cost, profits shares will be not constant in our model. Further, new entrants will pay also a fixed entry cost $EC_t = EC$.

The entry condition will then imply that potential new entrants will enter the economy if and only if the stream of their discounted profits is greater or at least equal the entry cost. That is, if

$$v_{i,t}(a_i) = \Pi_{i,t}(a_i) + \beta v_{i,t+1}(a_i) \geq EC w_t \tag{1}$$

where

$$\Pi_{i,t} = y_{i,t} - w_t l_{i,t} - R_t k_{i,t} - f_t w_t \tag{2}$$

are period t real profits. In each period condition (1) will endogenously determine the lower cut-off value $\underline{a}$ of capital intensity $a_i \in (a_{\min,}\underline{a}, a_{\max})$ of operating firms. The upper bound and the lower bound are instead fixed exogenously. Further, each period an exogenous fraction η of firms exit the economy so that, though the cut-off values of the α_i will change, the mass of firms will remain constant and equal to 1. Thus, the dynamics of firms follows:

$$N_t = (1-\eta) N_{t-1} + N_t^E \tag{3}$$

Firms maximize profits to find the optimal capital and labor demand. Firms optimal demand for labor and capital is then given by

$$R_t^N = p_{i,t}\rho A_t \left(k_{i,t}^{a_i} l_{i,t}^{1-a_i}\right)^{\rho-1} a_i k_{i,t}^{a_i-1} l_{i,t}^{1-a_i} = p_{i,t}\rho a_i \frac{y_{i,t}}{k_{i,t}} \tag{4}$$

$$W_t = p_{i,t}\rho A_t \left(k_{i,t}^{a_i} l_{i,t}^{1-a_i}\right)^{\rho-1} (1-a_i) k_{i,t}^{a_i} l_{i,t}^{-a_i} = p_{i,t}\rho (1-a_i) \frac{y_{i,t}}{l_{i,t}} \tag{5}$$

Notice that from (5) we can derive the labor share of income firm i, which is:

$$\frac{w_t l_{i,t}}{y_{i,t}} = \rho (1-a_i) \tag{6}$$

Similarly capital share in terms of stationary variables is

$$ks_{i,t} = \frac{R_t k_{i,t}}{y_{i,t}} = \rho a_i \tag{7}$$

Notice that both the labor income share and the capital income share are firms specific and crucially depends on firm i technology. The higher the value of a_i the lower the labor income share and the higher the capital share. Thus, in our model economy firms with higher capital intensity, implied by the higher a_i will be characterized by a lower labor income share. Interestingly, market conditions will affect firms dynamics and average a_i in the economy that is,

$$\overline{ls_t} = \int_0^1 ls_{i,t} di = \rho \int_0^1 (1 - a_i)\, di \tag{8}$$

whereas the aggregate labor income share is instead defined as

$$LS_t = \frac{w_t L_t}{Y_t} \tag{9}$$

notice that $\widetilde{Y}_t$ can be defined also as

$$Y_t = \int_0^1 y_{i,t} di \tag{10}$$

Similarly the average capital income share is

$$\overline{ks_t} = \int_0^1 ks_{i,t} di = \rho \int_0^1 a_i di \tag{11}$$

while the aggregate capital income share is

$$KS_t = \frac{R_t K_t}{Y_t} \tag{12}$$

2.4 Market Clearing

Labor demand will equal the labor supply, so that total hours will be $L_t = \int_0^1 l_{i,t} di$. Total capital is $K_t = \int_0^1 k_{i,t} di$, while total output $Y_t = \int_0^1 y_{i,t} di$. Finally, the implied economy resource constraint is: $Y_t = C_t + I_t$.

2.5 Model Simulation and Long-Run Dynamics

We now study the long-run effects of a 25 percent permanent cut of the relative price of investment goods. In particular, we conduct a very simple steady state analysis imposing the model a relative price of investment equal to 1 before the shock and equal to 0.75 thereafter. We look at the model implied long run movements of all the factor income shares, both the aggregate and the average ones. Also we look at the long run effects on capital intensity, measured as both capital to labor and capital to output ratio, together with other main macroeconomic variables. The model is solved numerically and calibrated at yearly frequencies as follows. The subjective discount rate β is set to 0.96, the parameter of the decreasing return to scale is $\rho = 0.85$. The support of $a_i \in (0.01, 0.5)$. Capital depreciation rate δ is 0.06, while the inverse of Frisch in the labor disutility is set to 2. The fixed operating cost is calibrated to have 5% profits in the steady state, while the entry cost is set to match the US average yearly investment on new firms. Firms' exit probability η is set to 0.10 to match the US evidence at yearly frequency.

Table 1 shows the value of the average and the aggregate labor income share, the average and the aggregate capital income share as well of the of profits share, before and after a 25 percent cut of the relative price of investments goods ζ. Also, it reports the threshold value of the a_i, the two measures of capital intensity, together with the values of real wages, total hours, output and consumption. Columns 1 and 2 show the absolute values, while column 3 shows the associated percentage changes. Finally, the last two columns of Table 1 compare our results with the values of the same variables as reported in Table 4 of the paper of Karabarbounis and Nieman (2014, KN hereafter), that is of a model with homogenous firms and in the absence of firms dynamics. Column 4 of Table 1 reports their results with a Cobb-Douglas production function, while column 5 shows the values obtained with the baseline KN model, that is with a model with CES production function with an elasticity of substitution between labor and capital equal to 1.25.

As shown in Table 1, in our model the 25 percent decline of the relative price of investments is followed by a decrease of both the average and the aggregate value the labor income share and by an increase of the average and aggregate capital income shares in line with what found in KN using a CES production function. Interestingly, while in our model capital and labor are strong complements, they are strong substitute in the KN model. Further, notice that in their model the labor income share moves one to one with the capital income shares, while in our model it is accompanied also by an increase of the profits shares. Last but not the least, our model is able to explain the decline of both the average and aggregate income share, which are substantially in lines with the US Klems sectoral data. These pattern cannot be replicated in a model with homogeneous firms. Finally, notice that thanks to firms heterogeneity and to the business dynamics mechanisms, in our model the threshold value of a increases as the relative price of investments declines, increasing the average a and thus the economy capital intensity, measured as the ratio between K and L, or alternatively as the ratio between K and Y. Also, with respect to the baseline model of KN our model does a good job in explaining the long-run pattern of all the other variables with the only difference that total hours worked increase in our baseline model, while they decrease in their baseline model with a CES due to the hypothesis of substitutability between the two inputs.

The main mechanism behind our results is the following. As soon as the relative price of investment goods declines, the households' supply of capital increases and the return of capital decreases. The average profits of the economy increases as well.[2] Firms with higher capital intensity enter the market, while those with lower a exit, so that both the threshold and the average value of a increase. Since capital and labor are complements the demand for labor increases and the real wages increase as well. However, since firms with high capital intensity use less labor input than the average the increase in labor together with the increase in real wages are not sufficiently high to overcome the increase in production. As a consequence both the average and the aggregate labor income share decline, while the capital share and the profits share increase.

[2]This is due to the presence of the fixed operating costs that allow profits shares to be not constant also in a model with perfect competition.

Variable	$\zeta = 1$	$\zeta = 0.75$	% change	% KN CD	% KN CES
$AggLS$ (% points)	0.49	0.47	-2	0	-2.6
$AveLS$ (% points)	0.53	0.50	-3	0	-
$AggKS$ (% points)	0.36	0.377	+1.7	0	+2.6
$AveKS$ (% points)	0.32	0.34	+2	0	-
$AggPS$ (% points)	0.12	0.123	+0.3	0	0
$AvePS$ (% points)	0.10	0.11	+1	0	-
a_i threshold	0.25	0.31	+24	-	-
a_i average	0.375	0.405	+8	-	0
K/L	7.45	12.85	+72	n.a.	n.a
K/Y	3.55	4.94	+39	+51.6	+67.8
Y	1.68	2.25	+34	+18.1	+22.8
L	0.82	0.88	+7.3	0	-1.4
w	1	1.21	+21	+18.1	+19.2
R	0.10	0.08	-20	-22.1	-22.1
C	1.31	1.57	+20	+18.1	+22.1

Table 1: Columns 1-3: Baseline model with heterogeneous firms and with Cobb-Douglas (CD) production function. Columns 4-5: Karabarbounis and Nieman 2014 (KN) with CD and CES production function.

3 Empirical Evidence

In this section we present empirical evidence supporting the entry-exit mechanism to explain the change in capital intensity and labor share. First, we show that labor share correlates with capital intensity, market share and mark-up. To this end we download firm-level data from ORBIS database for firms located in the US, Germany, France and UK with non-negative value-added and cost of employees, as these are the variables we will use to compute firm level labor share. For each selected firm, we collect data on the variables listed in Table 7 in Appendix A from 2010 to 2018. Moreover, we download the NACE sector code of each observed firm. Summary statistics in Table 7 refers to the values recorded for all selected firms in all available years. We use all available years to increase the amount of data points available. We use observed variables to compute labor share, capital intensity, market-share and mark-up. Labor share is computed as the ratio between cost of employees and value added:

$$ls_i = \frac{\text{cost of employees}_i}{\text{value added}_i}$$

where ls_i is the labor share for observation i. Notice that we are stacking observation years together, implying that some firms are observed multiple times, one for every years in which the firm is operating.

We compute *nominal capital intensity* as the ratio between total fixed capital, i.e., tangible capital plus intangible capital, and the number of employees. In other words, we compute capital intensity as the value of capital per employee. Recall that we are observing variables in different years. To correctly compare capital intensity in different year, we deflate the value of capital by the investment deflator. The latter is computed as the ratio between value of investment evaluated at current prices and at constant prices. Using the deflator we then obtain a measure of capital intensity at constant prices. We denote this measure with ci_i:

$$ci_i = \frac{\text{deflated total capital}_i}{\text{number of employees}_i}$$

We do not observe directly market share, however we can use the variable "net sales" as a proxy of the relative market share of firms. In particular, we build a measure of market share by taking the ratio between the net sales of firm i and the total net sales of firms in the same year and same 1 digit sector of firm i. We denote this measure as ms_i.

Finally, we compute the mark-up as the ratio between value of profits and the value of sales

$$m_i = \frac{\text{net sales}_i - \text{cost of goods}_i - \text{other expenses}_i}{\text{net sales}_i} \qquad (13)$$

We clean the data to eliminate inconsistent values, such as negative mark-ups and negative values of tangible and intangible capital, and regress the following equation:

$$ls_i = \text{const.} + \text{dummies} + \alpha\ log(ci_i) + \beta\ ms_i + \gamma\ m_i$$

Results listed in Table 3 show that capital intensity and mark-up have both a negative effect on labor share for all the countries considered. On

Dependent variable: labor share

Country	YoB	age	age^2	log net sales	mark-up	n.obs
US	-0.0077^{***}	0.0000	-0.0109	-0.0206^{***}	-0.2447^{***}	3282
FR	-0.0052^{*}	0.0130	-0.0003	-0.0004^{***}	-1.2537^{***}	1278
UK	-0.0015	0.0068	-0.0002	-0.0246^{***}	-0.9648^{***}	2359
DE	-0.0007	-0.0016	0.0001	-0.0159^{***}	-0.4805^{***}	1108
ALL	-0.0112^{***}	-0.0091^{***}	0.0000	-0.0391^{***}	-0.6755^{***}	8027

Table 2: Regression results using robust standard errors. All regressions include year and sector dummies, last regression also a country dummy.

Dependent variable: labor share

Country	log(cap. int.)	log net sales	mark-up	n.obs
US	-0.0188^{***}	-0.0168^{***}	-0.2126^{***}	3282
	-0.0319^{***}	–	–	3932
FR	-0.0554^{***}	0.0094^{***}	-0.9963^{***}	1278
	-0.0450^{***}	–	–	471850
UK	-0.0415^{**}	-0.0169^{***}	-0.8985^{***}	2359
	-0.0454^{***}	–	–	137913
DE	-0.0581^{***}	-0.0047^{*}	-0.4213^{***}	1108
	-0.0558^{***}	–	–	166719
ALL	-0.0313^{***}	-0.0113^{***}	-0.5162^{***}	8027
	-0.0500^{***}	–	–	780414

Table 3: Regression results using robust standard errors. All regressions include year and sector dummies, last regression also a country dummy.

the other hand, market shares have a positive effect on labor share in the US, but with a lower significance. They are not significant for France, while they show a negative and significant effect for the UK and Germany. When we pool all countries toghether and add a country dummy we find that all regressors have negative and significative effect on labor share.

Capital intensity and date of birth. Our assumption is that labor share has changed over time due to the change in the aggregate production technology, which has evolved to be more capital intensive. According to our argument, the reduction of the relative price of investment could have favored the entry of more capital intensive firms and the exit of more labor intensive firms. As the price of investment decreased, more firms with more capital intensive technology entered the market, reducing the labor share.

In order to empirically evaluate this mechanism, we use that fact that the relative price of investment has constantly decreased over time and we regress capital intensity on firms' date of birth. Results suggest that in fact, firms with more recent date of birth, i.e., created in a time of lower relative price of investment, are relatively more capital intensive, also when controlling for the age of firms.

We download firm-level data from ORBIS from 2010 to 2018 for the four countries considered. In particular, we download tangible and intangible fixed asset in thousands of US$, number of employees, NACE sector code and date of incorporation for US firms with date of birth after 1980 and non-negative values of tangible and intangible fixed asset. We use deflated tangible and intangible fixed assets and number of employees to compute capital intensity. Notice that in each year from 2010 to 2018 we observe a value of capital intensity and a year of birth. This allows us to construct the variable *age*, which is simply given by the year of observation minus the date of birth. We exclude firms observed in 2018 because data are not reliable since the sample of firms is not completely updated yet. Also we exclude all the sectors related to government services. Moreover, we include only firms born between 1980 and 2007. This choice is motivated by two facts: i) first in most of the G7 countries the relative price of investments becames relatively stable around 2007; ii) the period of the financial crisis, starting from the end of 2007, was characterized by an unprecedented decline in entry as well as in exit of firms that would distort our empirical results. Also the crisis period was characterized by a decline in the accumulation of capital. We use

Dependent variable: capital intensity				
age	–	–	-73.46^{**}	-89.81^{**}
age^2	–	–	4.83^{***}	4.88^{***}
year of birth	11.92	10.62	109.61^{***}	94.72^{***}
year dummy	NO	YES	NO	YES
sector dummy	YES	YES	YES	YES
n. obs: 19783				

Table 4: Significance computed using robust standard errors.

the selected data to regress the following equation:

$$\text{capital intensity} = \text{const.} + \text{dummies} + \text{age} + \text{age}^2 + \text{year of birth} \qquad (14)$$

Table 3 shows the results of our regression for the US, while Figure 2 summarizes the results for the other countries. First of all, from Table 3 notice that for the US firms with a more recent year of birth tend to use more capital intensive production technology. This is effect is stronger when we take into account age. In fact, empirical evidence points toward a life cycle effect on firms' capital intensity. The positive coefficient of the age^2 term suggests that older firms tend to be more capital intensive. The life cycle effect is counter balancing the effect of the date of birth, explaining the lower value and lower significance of the coefficient of year of birth when the life cycle is not taken into account. Though the year of birth remains an important explanation for the increase in capital intensity.

Robustness. To have a better understanding of the mechanism under investigation, we extend our analysis to include also Germany, France and United Kingdom. We regress equation (14): i) for each country separately; ii) by pooling all countries together, and regressing year by year. Results are shown in Figure 2. In particular, the left panel of Figure 2 shows the coefficient of year of birth and its relative confidence interval in the regression of Eq. 15 for each country, while the right panel of Figures 2 shows the coefficient of year of birth by year, pooling all countries together.

Our regressions suggest that in all considered countries the capital intensity tends to be higher in more recent firms, controlling for the age of the firms and using both sector and year dummies. As shown in left panel of Figure 2, the only country showing a weaker effect of the year of birth on capital intensity is Great Britain. The right panel of Figures 2 shows the results

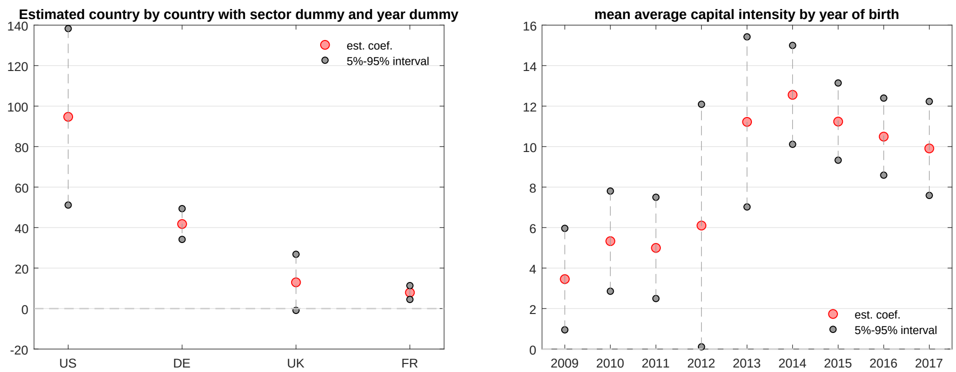

Figure 2: **Left**: Estimated coefficients coountry by country. **Right**: Estimated coefficients all countries year by year

Dependent variable: capital intensity (all countries)

age	18.67***	14.25***	−4.34	−2.12
age^2	0.03	0.08	0.20**	0.24***
year of birth	36.42***	29.25***	16.14***	19.94***
sector dummy	NO	YES	YES	YES
country dummy	NO	NO	YES	YES
year dummy	NO	NO	NO	YES
n. obs: 2,361,873				

Table 5: Significance computed using robust standard errors

when we pool all countries together and regress Eq. 14 year by year, controlling for the age of firms and using sector and country dummies. Clearly, the regression year by year can not take into account the age variable. Also in this case our regressions suggest the capital intensity tends to be higher in more recent firms. Finally, we regress Eq. 14 pooling countries and years. Results are shown in Table 5. Is shows the robustness of our results with the regression coefficient of the year of birth being highly significant for all the specifications considered.

Investigating the role of the relative price of investment and of the real interest rate. To better understand the role played in each country by the relative price of investment and by the real interest rate we now regress capital intensity on the relative price of investment and on the country 10-year treasury bills real interest rate in the year of birth of each firm considered. We also control for the age and the squared value of the age of each firm. Table 5 reports the regression results. Our regression show that for the US both the relative price of investment and the real interest rate have a negative and significant sign, meaning that the lower the real rate and the relative price of investment in the year of birth of the firm the higher its capital intensity. For Germany, at least considering firms established from the year 1990 onwards, the relative price of investment has also a negative and significant sign, while the effect of the real rate is positive and significant, though very low. This result can be explaied by the fact that in the period that follows the post Germany reunification the real interest rates started increasing to fight the higher rate of inflation, while the relative price of investment kept on decreasing permanently. For France the real interest rate has instead a negative and significant effect on capital intensity, while the relative price of investment has a positive and significant effect. In the UK, both the two variables have instead a negative and significant effect also when considering firms established from 1990 onwards.

4 Importance of entry on capital intensity

Using the estimated empirical model it is possible to determine the relative importance of age and entry-exit mechanism on the change of aggregate capital intensity. To do so, we formalize an extremely simple entry exit model with a constant number of firms N. Assume that in $t = 0$, there are N firms all born in $t = 0$. In period $t = 1$, a share η of random firms is replaced by new firms. This implies that $1 - \eta$ of firms are 1 period old, and η of firms are born in period 1. Generalizing, for each period $\tau \geq 0$, it is possible to determine the distribution of age and the distribution of year of birth: a share $(1-\eta)^\tau$ were established in period 0, a share $\eta(1-\eta)^{\tau-1}$ were established in period 1, ..., η were established in period τ. The average age in the population of firms in period τ:

$$\bar{a}_\tau = \tau(1-\eta)^\tau + \sum_{i=1}^{\tau}(\tau - i)\eta(1-\eta)^{\tau-i}$$

Dependent variable: log Capital intensity				
	age	**age^2**	**rr_{YoB}**	**p_{YoB}**
	0.027***	0.00*	−0.12***	−1.07**
US	0.028***	0.00	−0.13***	–
	0.0052	0.01***	–	−2.93***
n. of obs. 18284				
	−0.07***	0.00***	0.03***	−0.98***
DE†	−0.08***	0.00***	0.02***	–
	−0.07***	0.00***	–	−0.63***
n. of obs. 778436				
	−0.00	0.00***	−0.04***	1.43***
FR	−0.02***	0.00***	−0.04***	–
	−0.02***	0.00***	–	0.66***
n.of.obs. 709145				
	−0.05***	0.00***	−0.01**	−0.45***
UK†	−0.04***	0.00***	−0.01**	–
	−0.05***	0.00***	–	−0.42***
n. of obs. 221981				

All estimations include year and sector dummies.

† Only firms born after 1990

Table 6: Estimation of capital intensity on long term real interest rate and relative price of investment in the year of birth.

where i is the year of birth. The average year of birth is:

$$\bar{y}_\tau = \sum_{i=0}^{\tau} i\eta(1-\eta)^{\tau-i}$$

Assume that the average capital intensity of firms born in $i = 0$ is 1. Then, according to the empirical model, we can write the the average change of capital intensity between $i = 0$ and $i = \tau$ as

$$\Delta_{0,\tau} ci = a \cdot \bar{a}_\tau + b \cdot \bar{a}_\tau^2 + c \cdot \bar{y}_\tau$$

which allows us to express the relative contribution of the entry of new firms to the change of capital intensity as

$$\frac{c \cdot \bar{y}_\tau}{a \cdot \bar{a}_\tau + b \cdot \bar{a}_\tau^2 + c \cdot \bar{y}_\tau}$$

According to all of the estimations above, the coefficient a is nost significantly different from zero. We can therefore rewrite the relative contribution of the entry of new firms to the change of capital intensity as

$$\frac{c \cdot \bar{y}_\tau}{b \cdot \bar{a}_\tau^2 + c \cdot \bar{y}_\tau}$$

Setting $\tau = 27$, which is $2007 - 1980$ and the coefficients b and c according to the values in the lasyt column of Table 5, the relative contribution of entry to the change in the logarithm of capital intensity is 95%. According to our estimation, the increase of average capital intensity due to the entry of new, relatively capital intensive, firms is very important to explain the overall change in capital intensity. **Forse ho sbagliato qualcosa... le imprese che entrano hanno una capital intensity più alta, di cui devo tenere conto quando determino l'effetto di age... Infatti age converge (in media le imprese avranno 9 anni) mentre year of birth medio aumenta all'aumentare di τ. Questo mi sembra crei dei preblemi nella interpretazione delle stime. Tra 100 anno vale solo year of birth? No!**

5 Conclusions

In this paper we consider a two sectors heterogeneous firms model where firms' specific technology and capital intensity are endogenously determined through business dynamics. Our model suggests that after a shock that permanently changes the relative price of investment goods, the entrance of new firms is characterized by higher capital intensity of production and lower labor income share. Remarkably and differently from Karabarbounis and Nieman (2014) and Piketty (2014), our results are obtained with a standard Cobb-Douglas production function technology. This represents the first contribution of our paper, since differently from these authors our theoretical model is in accordance with the majority of the empirical evidence, both macro and micro, reporting estimates of the elasticity of substitution to be lower than one, and thus implying that capital and labor are complements inputs rather than substitutes. In the second part of the paper we test the relevance of our results using ORBIS microdata of US, UK, Germany and France. With these data we find strong and robust evidence confirming that new firms enter the market with higher capital intensity and lower labor income share than the average. Remarkably, this evidence holds for those firms entering the market from 1980 to 2007, a period charaterzed by a strong decline of the relative price of investment goods. Though, our paper is not intended to take a stand on single explanation of the declining labor income share. Our main contribution is to have emphasized the role of firms heterogeneity in production technology and business dynamics that has been neglected by the recent literature. According to our results they seems to be important to explain the long run dynamics of the labor share as well as the dynamics of the average capital intensity. Also, to the best of our knowledge our paper makes a step ahead in the literature by using firms' level data that allow to investigate the importance of the entrance of new firms for the long run pattern of the factor income shares together with that of capital intensity.

6 References

Autor, D., Dorn, D., Katz, L. F., Patterson, C., and Van Reenen, J. (2017) 'The fall of the labor share and the rise of superstar firms', NBER Working Paper No. 23396.

Barkai, S. (2017). 'Declining labor and capital shares', Working Paper, London Business School.

De Loecker, J. and Eeckhout, J. (2017). 'The rise of market power and the macroeconomic implications', NBER Working Paper No. 23687

Basu Susanto, (2019), Are Price-Cost Markups Rising in the United States? A Discussion of the Evidence, *Journal of Economic Perspectives*, 33(3), pp. 3–22

Grullon, Gustavo, Yelena Larkin, and Roni Michaely. 2016. "Are U.S. Industries Becoming More Concentrated?"

Kaldor, N. (1957). 'A model of economic growth,' *Economic Journal*, vol. 67, pp. 591-624.

Karabarbounis, L. and Neiman, B. (2014). 'The global decline of the labor share', *Quarterly Journal of Economics*, vol. 129(1), pp. 61-103.

Karabarbounis, L. and Neiman, B. (2018). Accounting for Factorless Income, NBER Working Paper No. 24404

Piketty, T. (2014). Capital in the twenty-first century, Cambridge, MA: The Belknap Press of Harvard University Press.

Piketty, Thomas, and Gabriel Zucman. 2014. "Capital is Back: Wealth-Income Ratios in Rich Countries 1700–2010." Quarterly Journal of Economics, 129(3): 1255–1310.

A Data

For estimating the equations regarding the labor share we dowload firm level data for US, Germany, France and United Kingdom from ORBIS, selecting firms with non-negative value added and cost of employees. Table 7 summarizes the main descriptive statistics.

Country	Variable	Obs.	Mean	Median	Std. Dev.	Min	Max
	Tangible Fixed Assets (1000$)	8056	1.3715e+06	81087	5.6272e+06	-264351	116655000
	Intangible Fixed Assets (1000$)	8053	1.0150e+06	57292	3.9151e+06	0	112083000
US	Added Value (1000$)	8155	8.8373e+05	103406	3.6646e+06	0	87193000
	Number of employees	6816	1.1494e+04	1.7195e+03	6.8042e+04	1	2300000
	Cost of employees (1000$)	8155	3.0073e+05	11916	1.6856e+06	0	37235000
	Net Sales (1000$)	8020	2.8643e+06	4.9153e+05	1.5409e+07	0	514405000
	Costs of goods sold (1000$)	8083	1.3870e+06	141470	1.0277e+07	-80086000	374601000
	Other operating expenses (1000$)	8151	1.1897e+06	204472	4.7932e+06	-428475	117847000
	Tangible Fixed Assets (1000$)	2151511	3.4528e+03	67	1.9385e+05	-3801	77154539
	Intangible Fixed Assets (1000$)	2151511	2.5391e+03	12	2.1523e+05	-2678	80845453
	Added Value (1000$)	2151528	1.1494e+04	502	1.2845e+05	0	17271848
FR	Number of employees	797580	995240	10	2.7892e+03	1	460663
	Cost of employees (1000$)	2151528	2.8695e+03	376	78640e+04	0	17271848
	Net Sales (1000$)	3260	1.8597e+06	99514	7.4961e+06	8	106600271
	Costs of goods sold (1000$)	3210	9.4112e+05	44363	4.7861e+06	-4626	85520057
	Other operating expenses (1000$)	3317	8.0470e+05	39223	3.0369e+06	-156983	29894750
	Tangible Fixed Assets (1000$)	248145	6.9613e+04	1917	1.1907e+06	0	107428000
	Intangible Fixed Assets (1000$)	247979	3.2462e+04	0	8.2676e+05	-174953	159145263
	Added Value (1000$)	249952	5.0640e+04	6332	6.2936e+05	0	155436044
UK	Number of employees	237759	558.8620	92	6.3954e+03	1	648254
	Cost of employees (1000$)	249953	2.6629e+04	4248	3.9396e+05	0	155451308
	Net Sales (1000$)	5820	1.9076e+06	135788	9.6210e+06	0	232694000
	Costs of goods sold (1000$)	219281	1.1418e+05	15057	1.8280e+06	-3792	218753899
	Other operating expenses (1000$)	247617	5.2696e+04	4923	6.4832e+05	-991361	43491000
	Tangible Fixed Assets (1000$)	340623	2.9722e+04	994	6.6648e+05	-3	92085526
	Intangible Fixed Assets (1000$)	340632	1.1352e+04	12	4.7483e+05	-95	76364668
	Added Value (1000$)	346832	2.8231e+04	4598	4.5373e+05	0	50724375
DE	Number of employees	258713	404.5370	84	5.0293e+03	1	547459
	Cost of employees (1000$)	346832	1.8549e+04	3076	2.8442e+05	0	44745567
	Net Sales (1000$)	2680	3.3459e+06	1.1617e+05	1.5388e+07	0	196869822
	Costs of goods sold (1000$)	7965	1.0682e+06	65217	6.9630e+06	-2241	152026540
	Other operating expenses (1000$)	8869	3.7479e+05	19773	2.4350e+06	-196597	54855372

Table 7: Labor share sample: summary statistics

Table 8 describes the identification strategy. We observe capital intensity of firms with same year of birth but different age because we have different years of observation (e.g., firms a and b in Table 8). This allows us to identify the effetct of the year of birth on capital intensity isolating the effect age. Moreover, we obseerve firms with the same age, but different year of birth. This allows us to identify the effect of the year of birth on capital intensity, isolating the effect of age.

Firm	**Year of birth**	**Year of obs.**	**Age**	**Identification**	**Explanation**
a	1990	2009	19	age	Changes in cap. intensity depend only on age
b	1990	2010	20		
c	1990	2009	19	year of birth	Changes in cap. intensity depend only on year of birth
d	1991	2010	19		

Table 8: Identification strategy of year of birth and age of firms.