Production Technology:
Optimal Capital Structure and Dividend Policy

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Abstract

Does production technology affect optimal capital structure and dividend policies? To address this largely unexamined question, we examine how a firm's technology changes corporate policies in the presence of limited debt enforceability. Without payback guarantees of principles and interests, creditors seek collaterals for their debt contracts. Yet, they have very restricted ways to secure the fund used for wage payments. As a result, equity financing is preferable for wage payments, leading to a lower debt to equity ratio for a labor intensive firm. Moreover, such a demand of equity makes this labor intensive firm to delay or reduce current dividend payouts, resulting in lower dividend payout ratios. Because production technology determines the relative factor demand for labor and fixed capital, a firm's technology plays a critical role in shaping capital structure and dividend policy. Our theoretical model highlights this factor demand channel and predicts a lower debt to equity ratio and conservative dividend policy for a labor intensive firm. Consistent our model predictions, the wage to fixed capital ratios, our measure of labor intensity, are negatively correlated with leverage ratios, debt issuance probability, dividend payout propensity, and payout ratios.

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1 Introduction

How does production technology affect capital structure and payout policies? To address this question, we reexamine the implications of Modigliani and Miller irrelevance theorem (1958; 1961, hereafter MM) in the presence of imperfect debt enforceability. In particular, this paper uncovers an economic reason why the joint decision of employment and capital acquisition is important in corporate policies. Because a firm's technology determines such demand of labor and fixed capital for production, real production technology lies at the core of our analysis. Despite the quantitative dominance of wage payments in a firm's budgeting problem (Table 1), existing literature has largely focused on revenue generations, rather than real production procedure, and its implication on corporate policies.

In contrast to the assumptions of MM (1958; 1961), the payments of interests and principles are not fully guaranteed to creditors. The limitation of liability allows shareholders to simply walk away from a failed company without the payments of its debt obligations. To resolve this issue of imperfect enforceablity in debt contracts, creditors try to secure a firm's property in case of default. The purchase of two major production inputs, however, differs critically in terms of their role as collateral. While creditors could pledge acquired capital stock as collaterals for their loans, they have very restricted ways to secure their money used for wage payments. Accordingly, a firm's equity and debt choices are crucially affected by its production technology, which determines the factor demands for labor and fixed capital. Such need of equity for financing consequently alters the firm's dividend payout incentives as well.

To examine how production technology changes corporate policies, we firstly develop a two-period corporate model. Our model incorporates capital structure and payout choices with Cobb-Douglas production technology and time-to-build feature in production. In each period, the firm has to employ (wealth constrained) workers and to acquire physical capital for its production. Because creditors cannot secure their money for wage payments, debt financing is only available for the acquisition of fixed capital that can be collateralized. The production procedure takes one period to make sales; the wealth constrained workers require an advanced payment of their wage. This firm decides the amount of dividend payout after one-period of production and liquidates at the end of second period.

Table 1: Summary Statistics: Wage and Fixed Capital Investment

Variable	Average	Quartile 1	Median	Quartile 3
Investment/Wage	0.22	0.07	0.13	0.25
Gross Investment/Wage	0.30	0.08	0.16	0.33

This table displays summary statistics for investment to wage ratio and gross investment to wage ratio. The mean, 1st quratile, median and 3rd quartile are calculated from our sample. Investment refers to capital expenditures and gross investment includes acquisitions as well as capital expenditures

Our model directly shows that labor intensive firms, measured by the sales elasticity of labor input, should show lower leverage and dividend payout ratios. The stark difference of pledgebility in the purchase of labor and fixed capital plays the pivotal role in our analysis. Due to the limitations in debt enforceability, a labor intensive firm has to rely more heavily on its own equity for wage payments, leading to lower debt to equity rations. In order to hire next period workers and pay their wages, such labor intensive firm also reduces dividend payouts from current operating profits.

These findings allow us to develop novel empirical predictions on capital structure and dividend policies. The Cobb-Douglas technology in our model implies a higher wage to fixed capital ratio for more labor intensive firms. Accordingly, our model predicts that a labor intensive firm, in terms of wage to fixed capital ratio, tends to show lower leverage and dividend payout ratios altogether. This prediction is naturally extended to the likelihood of debt issuance and dividend payout; a labor intensive firm is less likely to issue debt and shows a lower propensity to pay out dividends.

To analyze our theoretical predictions, we employ the sample of listed U.S. manufacturing firms from 1971 and 2013. Because most of the publicly listed firms in the U.S. market do not report their wage payments and material costs separately, we make a proxy of firm level wage rate by multiplying the number of employees with the industry average wage reported in NIPA Table 6.6. Based on our measure of wage-fixed capital ratio, we conduct industry and firm level analyses on capital structure and dividend policies.

Our main empirical findings are as follows. Most of all, we confirm lower leverage ratios for labor intensive firms. Both of the industry and firm level analyses verify that our wage to fixed capital ratios are negatively related to the book and market leverage ratios. The results are also robust to the inclusion of fixed effects and other firm characteristic variables. This finding is fully consistent with our model prediction that expects lower leverage ratios for labor intensive firms.

Next, we find that labor intensive firms use less active long-term debt financing in our logit model of debt issuance. A higher wage-fixed capital ratio points to a lower probability of long term debt issuance in our estimations. This negative relationship is invariant to the inclusion of other control variables or fixed effects term. These findings support our empirical prediction, which indicates a lower likelihood of debt issuance for labor intensive firms.

Our empirical analysis also confirms a lower probability of dividend payout for a labor intensive firm. In our binary choice model of dividend payout decisions, the wage-fixed capital ratio is negatively related to the propensity of dividend payout. Both firm and industry level analyses confirm this negative tendency. Our results are also stable to the introduction of other control variables and year fixed effect. This lower tendency is exactly in line with our theoretical implication as well.

Finally, we find smaller dividend payout ratios for labor intensive firms. We adopt two measures of payout ratios- the amount of dividend payout to EBITDA and to total assets. Tobit analyses are conducted to take account of left-censoring problem in dividend payout ratios. We confirm that the wage to fixed capital ratio are negatively correlated to both measures of payouts. These results are also robust to the consideration of other firm characteristic variables and year fixed effects. This finding is fully consistent with our theoretical arguments that expect a smaller amount of dividend payout for a labor intensive firm.

This paper contributes to existing literature in a number of aspects. Most of all, we present an economic mechanism about how real production procedure affects corporate policies. Since the seminal works of MM, most corporate finance literature has paid little attention to the role of production technology; a firm's technology matters only if it could change revenue generations. In contrast, our analysis highlights how the joint determination of wage payments and capital acquisition influences optimal capital structure and payout decisions. Because a firm's technology endogenously decides the factor demand for labor and fixed capital, our argument points to production technology as a key economic determinant in corporate policies. To our best knowledge, this is the first study that directly links production technology with corporate decisions, via the channel of relative factor demand for labor and fixed capital.

We add new dimensions to the literature on optimal capital structure policy as well. There have been two major theories in optimal capital structure literature. The trade-off theory (MM 1958) examines the tax benefits of interest payments against expected bankruptcy costs. The pecking order theory (Myers and Majluf 1984) emphasizes the implications of asymmetric information between managers and outside investment on external financing costs. Yet, we highlight the economic effect of limited debt enforceability on capital structure policies. In particular, we explicitly show how production technology matters in capital structure policy due to the imperfections of debt enforcements.

This paper also provides new insights on dividend payout decisions. The prior literature has examined the effect of capital gain and dividend tax differences on payout ratios (Poterba 2004), the signaling effect of dividends (Miller and Rock 1985), the dividend policy as a disciplinary tool on manager (Jensen 1986), and the life-cycle aspect of firm (DeAngelo, DeAngelo, and Stulz 2006). In contrast, we emphasize the need of equity as a key factor in corporate dividend policy by examining the financing of wage payments. Our following empirical analysis verifies that our wage-fixed capital ratio is related to conservative dividend policies, which supports the role of equity demand in payout decisions.

Finally, we shed new lights on the role of collaterals in corporate policies. Prior studies have mainly focused on a firm's asset composition, the fixed capital-book asset ratios, to capture the importance of collateral values in capital structure policies (e.g. Rajan and Zingales 1995), without concrete economic arguments. Yet, this paper argues a new channel between collateral values and capital structure choices by examining a budgeting problem incorporating wage payment and capital acquisition. Moreover, our analysis suggests that the value of collaterals critically influence optimal dividend policy as well.

The next section explains our theoretical arguments in detail. Section 3 focuses on empirical analysis that tests our theoretical predictions. Section 4 concludes.

2 Model

We propose a simple corporate model, where the limitations in liability of shareholders and the time-to-build nature of production play critical roles in determining capital structure and dividend policies.

2.1 Model Set Up

Timing

There are three dates, $t = 0, 1,$ and 2 in our model. We assume that it takes one period of time for production because of time-to build nature in production procedure. Accordingly, the representative firm begins its operation at the first date, $t = 0$ and has two opportunities to complete its production at $t = 1$ and 2. The firm finishes its operation at date $t = 2$ and pays out liquidating dividends.

Production Technology

The firm requires physical capital and labor for production. The firm purchases physical capital at t and liquidates it after one-cycle of production at $t + 1$, where $t = 0$ or 1. The price of physical capital is normalized to 1. For simplicity, we assume no depreciation and no resale discount for physical capital.

The firm hires workers for each cycle of production. The wage rate is constant over time and is denoted as w. We assume that workers are wealth-constrained; they do not have any wealth for consumption without their wage income. These wealth-constrained workers ask advanced payments of wage before each production cycle begins.

The firm's production function takes a standard Cobb-Douglas form in decreasing returns to scale:

$$Y_t = f(K_{t-1}, L_{t-1}) = \theta_t (K_{t-1})^{\alpha} (L_{t-1})^{\beta}, \alpha + \beta < 1$$

where Y_t is the output of firm at date t and θ_t is the state of production technology Y_t. The physical capital and labor force used to produce Y_t are denoted as K_{t-1} and L_{t-1}, respectively. Without loss of generality, we assume that θ_t does not vary over the firm's production cycles, equal to θ ($\theta_1 = \theta_2 = \theta$). Given α (β), a higher β (a lower α) indicates a more labor intensive firm.

Agency Conflicts and Financing

We assume no agency problem between the manager and shareholders. Yet, the interest of shareholders are not perfectly aligned with that of creditors; the liability of shareholders are limited and the manager (shareholders) has incentives not to repay debt obligations.

The representative firm is able to use both of the (one-period) debt and equity financing. To abate the limitations in debt enforceability, creditors ask the borrower firm to place physical capital as collaterals. As a result, the firm could use debt contract for the acquisition of physical capital. In contrast, creditors hardly secure the money used for wage payments. The firm may have to use equity financing for wage payments regardless of the tax rules in this economy that we discuss later. We also assume that the required returns for shareholders and creditors are identical to $(1 + r)$. The r would be interest rate for debt contract. For simplicity, we assume the firm could borrow principals up to the amount of physical capital:

$$B_t \leq K_t,$$

where B_t is the amount of debt issued for the purchase of physical capital K_t for $t = 0$ and 1.[1]

Without loss of generality, we assume that there is no retention of cash. All of remaining profits are paid out immediately as ordinary dividends at date $t = 1$. All of the second cycle output and the salvage value of physical capital at date $t = 2$ will be distributed to shareholders after the payment of debt obligations.

Taxation

The firm's optimal policy and valuation are influenced by three different types of tax rules. For a simpler analysis, we assume constant tax rates on corporate income, individual in-

[1] Our theoretical results remain unchanged even if the creditors ask collaterals by the coupon payment as well as principals.

terest income, and corporate distributions, denoted by τ_c, τ_i,and τ_d, respectively.[2] The individual interest income tax affects the required return for the shareholders, which becomes $1 + r(1 - \tau_i)$. The inclusion of more detailed tax brackets does not change our results.

The Value of Equity

The shareholder value of firm in this economy can be characterized as follows:

$$\max_{L_t, K_t, B_t} \pi_0 + \frac{\pi_1}{1 + r(1 - \tau_i)} + \frac{\pi_2}{(1 + r(1 - \tau_i))^2} \tag{1}$$

which subjects to

$$\begin{aligned}
\pi_0 &= (1 - \tau_d)\left(-(1 - \tau_c) wL_0 - (K_0 - B_0)\right) \\
\pi_1 &= (1 - \tau_d)\left[(1 - \tau_c)(Y_1 - wL_1 - rB_0) - (K_1 - K_0) + (B_1 - B_0)\right] \\
\pi_2 &= (1 - \tau_d)\left[(1 - \tau_c)(Y_2 - rB_1) + K_1 - B_1\right] \\
Y_t &= \theta (K_{t-1})^{\alpha} (L_{t-1})^{\beta} \text{ for } t = 0 \text{ and } 1 \\
B_t &\leq K_t \text{ for } t = 0 \text{ and } 1
\end{aligned}$$

The firm's initial equity proceed, π_0 consists of wage payments wL_0 and the part of physical capital financed by equity, $K_0 - B_0$.The taxable income at date $t = 1$ is the output Y_1 less labor costs for the second cycle of operations wL_1 and interest expenses rB_0[3]. The firm's net payout to shareholders, π_1, is the sum of net income after tax less net capital expenditure financed by equity $(K_1 - K_0) - (B_1 - B_0)$ .Similarly,.the firm's net payout at date t = 2 is after tax corporate income and the salvage value of physical capital stock after debt payments. The dividend income tax applies for all of the firm's net payout.

[2] This assumption allows the possibility of tax subsidy on negative taxable income. This subsidy region could be closely associated with a firm's capital budgeting problem that only considers incremental cash flows.

[3] In accounting, the wage payments for unsold goods are reported as inventories. Yet, we place the wage payments as operating costs for a simpler analysis. Of course, our results remain unchanged even if we introduce the inventory variable in our model.

2.2 Optimal Policies

The introduction of tax rules provides tax benefits of interest payments. The representative firm has incentives to use debt as much as possible to enjoy the tax benefits of debt.

Proposition 1 *If corporate income tax rate is higher than interest income tax rate.* $\tau_c > \tau_i$, *the firm never uses equity to acquire physical capital.*

Proof. *In Appendix A.* ■

After the consideration of interest tax shields, the cost of debt becomes cheaper than the cost of equity; the firm tries to use less expensive source of financing for the acquisition of capital stock. The condition of $\tau_c > \tau_i$ is quite similar to Miller (1977) except no appearance of dividend tax rate.

Under the assumption of $\tau_c > \tau_i$ the value of equity is simplified as follows:

$$\max_{L_t,K_t} \pi_0 + \frac{\pi_1}{(1+r)} + \frac{\pi_2}{(1+r)^2} \tag{2}$$

which subjects to

$$\begin{aligned}
\pi_0 &= -(1-\tau_d)(1-\tau_c)\,wL_0 \\
\pi_1 &= (1-\tau_d)(1-\tau_c)(Y_1 - wL_1 - rB_0) \\
\pi_2 &= (1-\tau_d)(1-\tau_c)(Y_2 - rB_1) \\
Y_t &= \theta(K_{t-1})^{\alpha}(L_{t-1})^{\beta} \text{ for } t = 0 \text{ and } 1 \\
B_t &= K_t \ \text{ for } t = 0 \text{ and } 1.
\end{aligned}$$

The first order conditions becomes

$$\begin{aligned}
L_0 &: \theta\beta(K_0)^{\alpha} L_0^{\beta-1} = w(1 + r(1-\tau_i)) \\
L_1 &: \theta\beta(K_1)^{\alpha} L_1^{\beta-1} = w(1 + r(1-\tau_i)) \\
K_0 &: \theta\alpha(K_0)^{\alpha-1} L_0^{\beta} = r \\
K_1 &: \theta\alpha(K_1)^{\alpha-1} L_1^{\beta} = r.
\end{aligned}$$

which imply the same level of physical capital and labor demands across the date $t = 0$ and 1; $K_0^* = K_1^* = K^*$ and $L_0^* = L_1^* = L^*$ where the '$*'$ indicates optimal policy.

Because the required returns for equity and debt financing are the same, we can only characterize the range of capital structure and dividend policy. Proposition 2 and 3 describes optimal capital structure and dividend policies.

Proposition 2 *The firm's optimal equity to debt ratio is the ratio between wage payments and physical capital*

$$\frac{E}{B} = \frac{-\pi_1}{B} = \frac{wL^*}{K^*} = \frac{\beta r}{\alpha(1 + r(1 - \tau_i)}.$$

where '$*'$indicates optimal levels. The equity to debt ratio is increasing (decreasing) with respect to the changes in labor intensity β (capital intensity α).

Proof. *In Appendix* ■

Proposition 3 *the firm's dividend payout to output ratio at date $t = 1$ becomes:*

$$\begin{aligned} \frac{\pi_1}{Y} &= (1 - \tau_c)(1 - \tau_d)\frac{(Y - wL - rK)}{Y} \\ &= (1 - \tau_c)(1 - \tau_d)\left(1 - \frac{\beta}{1 + r(1 - \tau_i)} - \alpha\right), \end{aligned}$$

which is increasing (decreasing) with respect to the changes in labor intensity β (capital intensity α).

Proof. *In Appendix* ■

Proposition 2 and 3 clearly indicate that labor intensive firms tend to show lower leverage and dividend payout ratios. This implication remains unchanged whether we use labor intensity or capital intensity parameters.

2.3 Discussion and Empirical Implications

We discuss the implications of our model on corporate policies and build up empirical predictions in this section.

Discussion

Proposition 2 points out that a firm's debt to equity ratio decreases as it becomes more labor intensive. This relationship is directly captured by the sales elasticity of labor in our Cobb-Douglas production technology. As the sales elasticity of labor increases, a firm's wage payments increase more significantly compared to its capital expenditures, which leads to a lower debt to equity ratio in the presence of imperfect debt enforceability.

As a result, a firm's real production procedure becomes no more irrelevant to capital structure policy unlike the prediction of MM (1958). By determining the factor demands for labor and fixed capital, production technology critically affects optimal debt to equity ratio choices. This factor demand channel and its connection with production technology is largely unexamined in existing studies, which have almost exclusively focused on revenue generation process rather than production technology itself.

Proposition 2 also directly show how the limitations in debt enforceability affect optimal capital structure decisions. This emphasis differs markedly from two mainstream theories of capital structure policy. The trade-off theory (MM 1958) balances the benefits of tax deductibility of interest payments against expected bankruptcy costs in optimal capital structure decisions. The pecking order theory (Myers and Majluf 1984) investigate the implications of asymmetric information between managers and outside investment on external financing costs. In contrast, Proposition 2 argues that production technology alter optimal capital structure decisions significantly because of the imperfections in debt enforcements.

Proposition 3 verifies a lower dividend payout ratio for labor intensive firms, measured by the sales elasticity of labor. Because creditors hardly secure wage payments, a firm has to rely more substantially on its own equity to hire workers. Such demand of equity makes the firm cut net dividend payout from its own profit generations, resulting in a lower (ordinary) dividend payout ratio for labor intensive firms.

Our theory points out that a firm's production technology becomes no more irrelevant to dividend policy as well, in contrast to MM (1961). Production technology matters in dividend policy because it determines the factor demand for labor and fixed capital. The demand of labor decides a firm's wage payments and accordingly the demand of equity, which eventually determines the amount of dividend payouts. Such role of production technology in dividend policy has received little attention in existing literature.

Furthermore, Proposition 3 directly shows how the demand of equity changes optimal dividend payout policies. Most prior studies on payout policy have investigated the effect of capital gain and dividend tax differences on payout ratio (Poterba 2004), the signaling effect of dividends (Miller and Rock 1985), dividend policy as disciplinary tool on manager (Jensen 1986), and life-cycle aspect of dividend policy (DeAngelo, DeAngelo, and Stulz 2006). Yet, the proposition argues the need of equity for wage payment as an economic factor leading to conservative dividend policy.

Propositions 2 and 3 also empathize the joint determination of labor and fixed capital demand on corporate policies, unlike existing studies. Most of the prior studies have seperately analyzed optimal capital acquisition and employment decisions. These studies have mainly focused on the role of external financing conditions either on capital expenditure or layoff decision. Fazzari et al. (1988) and Chodorow-reigh (2014) are the representative studies. Yet, the propositions highlight how the joint determination of labor and capital demands shapes optimal capital structure and dividend policies.

To sum up, we conclude that our theory presents a novel economic mechanism about how real production procedure affects optimal corporate decisions via the channel of factor demands. The relative significance of wage payments and capital acquisition affects critically optimal capital structure and dividend policy in the presence of imperfect debt enforceability. As a result, production technology that determines the factor demand for labor and fixed capital indeed alters optimal capital structure and dividend policies, in contrast to the irrelevance principles of MM (1958; 1961).

Empirical Implications

Our results allow us to develop empirical prediction on how a more labor intensive firm exercises its capital structure and dividend policies This dimension of labor intensity is captured by the sales elasticity of labor in Cobb-Douglas production technology and consequently, the ratio between wage payments and fixed capital. Hence, we are able to use the wage to fixed capital ratio as a proxy for a firm's labor intensity to test our empirical predictions.

Our predictions on capital structure are directly derived from Proposition 2.

Implication 1 (Leverage) Labor intensive firms tend to show lower leverage ratios.

Implication 2 (Debt Issuance) Labor intensive firms are less likely to participate in debt issuance.

If a firm has to rely heavily on labor forces for production, it tends to show a higher wage-fixed capital ratio. Due to the limitation of debt enforceability, this labor intensive firm uses debt less significantly and the observed leverage ratio tends to be low. Accordingly, we expect a negative relationship between the wage to fixed capital ratio and leverage ratios. Moreover, current leverage ratio inherits from the historical activity of debt financing. Hence, a lower level of observed leverage ratio is associated with historically less active participations in debt issuance. Therefore, we can also expect a lower likelihood of debt issuance for a labor intensive firm, measured by the wage to fixed capital ratio.

Our theoretical analysis provides empirical implications on dividend policy as shown in Proposition 3.

Implication 3 (Dividend Payout Propensity) Labor intensive firms are less prone to pay out dividends.

Implication 4 (Payout Ratio) Labor intensive firms tend to show lower dividend payout ratios.

If a firm relies substantially on labor forces as production input, it tends to show a higher wage-fixed capital ratio. Our model argues that this labor intensive firm delays dividend payouts and use current profits for next period wage payments. Therefore, we can predict that a higher wage-fixed capital ratio indicates a lower probability of dividend payouts and a smaller dividend payout ratio altogether.

In addition, our firm level predictions can be naturally extended to industry level predictions, if the variation of wage and fixed capital is substantial across industries. All predictions must remain the same.

3 Empirical Analysis

3.1 Data Description

We now test our model's predictions about the relationships between production technology and corporate policies. To do so, we first employ the sample of all U.S. manufacturing firms (SICs 2000 to 3999) over the 1971 to 2013 period from COMPUSTAT dataset. To obtain industry level wage rates, we use Table 6.6s available in National Income and Product Accounts Tables (NIPA). We rule out the sample firm-year observations without valid information about their total assets, sales, production costs, fixed capital, cash holdings, operating income, and the number of employees. Because almost all firms report their number of employees (97% of our sample), this restriction on employment is not likely to induce sample selection problems. We deflate all series by 1997 dollars. We also eliminate firm-year observations whose deflated asset value is less than 1 million or deflated fixed capital value is less than 0.5 million. We try to minimize the impact of sample attrition for the stability of the estimation results, by requiring our sample firms to provide more than five years of valid information. Our final sample consists of 73,964 firm-year observations.

According to our theory, the wage-fixed capital ratio plays central role in determining capital structure and dividend policies. Because only a small fraction of publicly traded firms report their labor costs, we have to approximate wage payments for the whole sample analysis. We calculate wage payments for a firm-year observation by multiplying the number of employees with industry average wage rate documented in NIPA table 6.6. Industry wage rate is based on two digits of SIC code before the year of 2000 and three digits of NAICS code since 2001 by following NIPA documentations.

The construction of dependent variables is as follows. We measure book leverage using the long term debt to total assets ratio and market leverage using the long term debt to market value of equity ratio. We also define two different measure of payout ratios- the ratio of cash dividends to earnings before interest, taxes, depreciation, and amortization, and the ratio of cash dividends to total assets.

We define a number of firm characteristic variables, which are known to influnce capital structure policies. We construct the return on asset (ROA) as the ratio of earnings before

Table 2: Summary Statistics

Variable	Average	Quartile 1	Median	Quartile 3	S.D.
Wage/Fixed Capital	1.92	0.81	1.42	2.36	1.77
Book Leverage	0.21	0.06	0.20	0.33	0.17
Market Leverage	0.41	0.02	0.16	0.47	0.69
Dividend/EBITDA	0.07	0.00	0.00	0.11	0.12
Dividend/ Total Assets	0.01	0.00	0.00	0.02	0.02

This table displays summary statistics for our wage-fixed capital ratio and other dependent variables. The mean, 1st quratile, median, 3rd quartile and the standard deviations are reported from our sample. All variables are self explanatory.

interest, taxes, depreciation, and amortization to total assets, and market to book ratio (M/B) as the market value divided by the book value of assets. We measure firm size as the natural logarithm of the book value of assets in 1997 dollars. R&D expenditures are divided by total assets. Industry median leverage is calculated based on two-digit SIC codes. We also introduce several control variables for our analysis on dividend policy. RE/TE ratios is by definition the ratio between retained earnings and total common equity. Growth indicates asset growth rate that is the change in total assets divided by the previous year's level.

Our definition of tangibility measure slightly different from the traditional one, in order to take account of the effect of cash management. We define our tangibility measure as the ratio of fixed capital to total assets net out of cash. Our theory expects the importance of internal equity management policy for wage payments, which implies a positive correlation between our wage-fixed capital ratio and cash holding. This positive correlation is empirically verified even though we do not report exact estimation result here. The traditional tangibility measure calculates the ratio of fixed capital to total assets. In this case, our wage-fixed capital ratio and traditional tangibility measure have automatically negative relationship via the composition of book asset values. To be specific, an increase in wage payments indicates a greater amount of cash holding, which raises total asset values, the denominator of traditional tangibility measure. To rule out this cash balance effect on the relationship between our wage-fixed capital and traditional tangibility measure, we subtract cash holdings from total assets in our construction of tangibility measure.

Table 2 summarizes our main variables of interests. The table reports mean, 1st quartile, median, 3rd quartile and standard deviations of each variable. The average and median of wage-fixed capital ratio is 1.92 and 1.42, which indicate the dominance of wage payments in a firm's budgeting problem. For an average firm, the fund needed for wage payments is almost as twice as its current fixed capital stock. This finding is also consistent with the results of Table 1,.which compares the size between annual wage payments and capital acquisitions.

It is also noteworthy that the mean of market leverage ratio is quite greater than that of book leverage in manufacturing firms. These results seem to be related with some manufacturing industries with low market to book ratios such as cigarette and primary metal industries, while we do not report the exact values. The median of market leverage is rather lower than its book leverage counterpart as well.

3.2 Empirical Results: Firm Level

Leverage Ratio

To empirically test our prediction on leverage ratios, we estimate cross-sectional regression models for three different specifications. Table 3 reports the coefficients, t-values (in parenthesis) and other statistics from these models with robust standard errors. The first model investigates a simple correlation between our wage-fixed capital ratio and leverage ratios. The second and third models introduce widely used firm characteristic variables, as proposed in Rajan and Zingales (1995) and Frank and Goyal (2009). The second model excludes tangibility measure that probably provides another dimension of information about the role of fixed capital as collaterals. The third model includes the tangibility measure. We examine both book leverage and market leverage ratios as dependent variables. Our primary interest is in the coefficient on our wage-fixed capital ratio for each empirical model.

Table 3 confirms the negative correlations between our wage-fixed capital ratio and leverage ratios. This negative relationship is statistically and economically significant. The correlation is also robust to the variation of leverage measures and the inclusion of other firm characteristic variables. For all six models in Table 3, the coefficients on our wage-fixed

Table 3: Wage/Fixed Capital and Leverage

	Book Leverage			Market Leverage		
Wage/FC	-0.016***	-0.012***	-0.011***	-0.045***	-0.027***	-0.023***
	(-46.5)	(-32.8)	(-26.0)	(-35.2)	(-20.7)	(-15.1)
ROA		-0.190***	-0.190***		-0.673***	-0.672***
		(-37.5)	(-37.5)		(-41.3)	(-41.3)
M/B Ratio		-0.036***	-0.036***		-0.160***	-0.160***
		(-71.5)	(-71.6)		(-86.8)	(-86.9)
Size		0.003***	0.003***		0.004***	0.004***
		(12.1)	(12.5)		(3.3)	(3.9)
R&D		-0.502***	-0.501***		-1.333***	-1.328***
		(-40.5)	(-40.5)		(-38.5)	(-38.3)
Industry Med. Lev		0.147***	0.141***		1.454***	1.421***
		(11.9)	(11.2)		(28.1)	(26.9)
Tangibility			0.013***			0.074***
			(2.9)			(4.0)
Intercept	0.245***	0.276***	0.271***	0.495***	0.463***	0.436***
	(270.7)	(76.9)	(69.6)	(127.7)	(33.5)	(29.1)
N	73964	73964	73964	73964	73964	73964
adj-R^2	0.030	0.189	0.189	0.013	0.179	0.179

This table displays the estimation results for cross-sectional models on the relationship between our wage-fixed ratio and leverage ratios. The dependent variables are the book and market leverage ratios. ROA is the ratio of earnings before interest, taxes, depreciation, and amortization to total assets. M/B is the market value of firm divided by the book value of its assets. Size is the natural logarithm of the book value of assets in 1997 dollars. Research and development expenditures are divided by total assets. Industry median leverage is based on two-digit SIC codes. Tangibility is the ratio of fixed capital to total assets net out of cash. The standard errors are robust to heteroskedasticity and the associated t-statistics are reported in parentheses.

capital have significantly negative values. For example, the coefficients are -0.016, -0.012, and -0.011, respectively in our book leverage ratio regressions. In other words, one standard deviation change in our wage-fixed capital ratio is related with 10-14% decrease in book leverage ratio for an average manufacturing firm. The variation of our wage-fixed capital ratio generates a similar quantitative effect on market leverage for an average manufacturing firm. All other coefficients on control variables are in line with previous estimation results such as Frank and Goyal (2009).

The estimation results in Table 3 are fully consistent with our model prediction. Our theory expects lower leverage ratios for labor intensive firms, measure by the wage to fixed capital ratios. Due to the limitations in debt enforceability, a firm relies substantially on equity for wage payments, leading to lower debt to equity ratio for the firms with higher wage payments over the amount of fixed capital. The negative coefficient reported in Table 3 strongly supports our model prediction on leverage ratio.

These findings also argue for the importance of production technology in capital structure policy, which has received little attentions in existing literature. A firm's technology plays a critical role in deriving the demand of labor and capital and eventually determines the ratio between wage payments and fixed capital. We robustly confirm that our wage-fixed capital ratio is negatively associated with leverage ratios. Therefore, our finding is a piece of empirical evidence highlighting the connection between production technology and capital structure policy.

Moreover, Table 3 indicates that our measure of wage-fixed capital has significant explanatory power on leverage ratios even after controlling for the tangibility measure, a widely used proxy of collateral values. Asset tangibility is a balance sheet measure of collateral values, which is defined as the ratio between a firm's fixed capital and its book value of assets. As analyzed in Frank and Goyal (2009), this asset tangibility measure is a reliable firm characteristic that captures the importance of collaterals in financing policies. Table 3 points out that our wage-fixed capital ratio adds additional dimension to the implication of collaterals values on capital structure policies,

The estimation results also imply that the importance of production cost structure on capital structure policy. Since the original work of MM, most literature has almost entirely focused on the implication of profitability measure on corporate financial policies (e.g. Frank and Goyal 2009). The negative coefficients on our wage-fixed capital measure point out that the wage payment, a significant part of production costs, has significant effects on capital structure decisions.

Debt Issuance Policy

To empirically test our prediction on long-term debt issuance policy, we estimate a binary choice model of debt issuance based on logit models. Our empirical strategy is in line with the models of debt issuance in Hovakimian, Opler, and Titman (2001), and Hovakimian,

Hovakimian, and Tehranian (2004). The first model investigates the simple likelihood of debt issuance from our wage-fixed capital ratio. The second and third models introduce widely used firm characteristic variables, as proposed in Hovakimian et al. (2001) and Frank and Goyal (2009). While the second model excludes the tangibility measure, the third model includes it, which provides an additional piece of information for the role of fixed capital as collaterals. The fourth model considers the year fixed effect, which captures a business-cyclical aspect of debt issuance policy as emphasized in Dittmar and Dittmar (2008). Our primary interest still lies at the coefficient of our wage-fixed capital ratio. Table 4 reports the coefficients, z-values (in parenthesis) and other statistics from our binary choice model estimations.

Table 4 documents that a higher wage-fixed capital ratio decreases the likelihood of debt issuance for the manufacturing firms. This negative relationship is robust to the inclusion of other firm characteristics and year fixed effects. For all models in Table 4, the coefficients on our wage-fixed capital indicate strongly negative effects of our wage to fixed capital ratio on the likelihood of debt issuance; these values are -0.140, -0.120, -0.110, and -0.090, respectively. All other coefficients of control variables are generally consistent with existing literature, such as Hovakimain et al. (2001).

The logit model results in Table 4 are well aligned with our empirical predictions. We expect a lower probability of debt issuance for labor intensive firms, measured by the wage to fixed capital ratio. Because current leverage ratio is an accumulation of historical decisions, a higher wage-fixed capita ratio firm tends to rely less significantly on debt issuance. The negative coefficients on wage-fixed capital ratios in our logit models indicate the lower propensity of debt issuance for a labor intensive firm. This result is exactly in line with our second empirical prediction.

The above finding highlights the importance of production technology on debt financing policy again, which is largely unexamined in prior literature. A firm's production technology determines the factor demand of labor and fixed capital, which shapes the ratio between wage and fixed capital. Accordingly, the significant coefficients on our wage-fixed capital ratio imply a considerable role of production technology on debt issuance policy. Such importance of production technology has largely unexamined in existing literature of debt

Table 4: Wage/Fixed Capital and Debt Issuance

	Long Term Debt Issuance			
Wage/FC	-0.140***	-0.123***	-0.112***	-0.095***
	(-22.8)	(-19.0)	(-14.7)	(-12.1)
ROA		-1.199***	-1.199***	-1.686***
		(-16.1)	(-16.1)	(-21.4)
M/B		-0.159***	-0.160***	-0.129***
		(-17.1)	(-17.1)	(-13.5)
Size		0.020***	0.022***	0.076***
		(4.5)	(4.8)	(14.1)
R&D		-3.318***	-3.305***	-3.408***
		(-15.8)	(-15.7)	(-16.0)
Ind. Med. Lev		-0.453**	-0.521***	-0.849***
		(-2.3)	(-2.7)	(-4.3)
Tangibility			0.165**	0.086
			(2.5)	(1.3)
Intercept	-1.029***	-0.631***	-0.696***	-0.593***
	(-75.3)	(-11.5)	(-11.5)	(-6.8)
Year F.E	No	No	No	Yes
N	73964	73964	73964	73964
Psuedo-R^2	0.008	0.022	0.022	0.033

This table displays the estimation results for logit models on the relationship between our wage-fixed ratio and dividend payout propensity. The dependent variable is the binary choice of debt issuance. ROA is the ratio of earnings before interest, taxes, depreciation, and amortization to total assets. M/B is the market value of firm divided by the book value of its assets. Size is the natural logarithm of the book value of assets in 1997 dollars. Research and development expenditures are divided by total assets. Industry median leverage is based on two-digit SIC codes. Tangibility is the ratio of fixed capital to total assets net out of cash. The z-statistics are reported in parentheses.

issuance policy such as Hovakimain et al. (2001) and Hovakimian et al. (2004).

Dividend Payout Propensity

Our model points to a lower propensity of dividend payout for labor intensive firms. To test this empirical prediction, we examine the relationship between our wage-fixed capital ratio and the likelihood of dividend payout by using logit models. Our empirical strategy follows the models of dividend payout propensity in DeAngelo, DeAngelo, and Stultz (2007), which consider profitability, size, asset growth and the life-cycle aspect of a firm altogether

Table 5: Wage/Fixed Capital and Payout Propensity

	Dividend Payout			
Wage/FC	-0.287***	-0.293***	-0.075***	-0.060***
	(-53.0)	(-49.4)	(-10.7)	(-8.1)
ROA			3.647***	3.088***
			(30.2)	(24.5)
Growth			-1.224***	-1.219***
			(-28.5)	(-27.2)
Size			0.027***	0.033***
			(67.8)	(74.5)
RE/TE			2.429***	2.225***
			(78.4)	(71.0)
Intercept	0.382***	1.216***	-2.866***	-2.202***
	(32.0)	(20.3)	(-78.1)	(-28.4)
Year F.E	No	Yes	No	Yes
N	73964	73964	67437	67437
Psuedo-R^2	0.035	0.106	0.353	0.393

This table displays the estimation results for logit models on the relationship between our wage-fixed ratio and dividend payout propensity. The dependent variable is the binary choice of dividend payout. ROA is the ratio of earnings before interest, taxes, depreciation, and amortization to total assets. RE/TE ratio is the ratio of retained earnings to total common equity. Size is the natural logarithm of the book value of assets in 1997 dollars. Growth is the change in total assets divided by the previous year's level. The z-statistics are reported in parentheses.

in payout decisions. To take account of the time trend in dividend policy (Fama and French 2001), we also include the time fixed effect terms in our logit models. The first model investigates a simple relationship between our wage-fixed capital ratio and payout propensity. We additionally account for the trend of dividend policy in our second model. The third model controls a firm's profitability, size, asset growth and life cycle perspective. Our last model expands the third model by introducing the year fixed effect variables. Table 5 documents the coefficients, z-values (in parenthesis) and other statistics from our logit model estimations.

Table 5 shows that our wage-fixed capital ratio indicates a lower propensity of dividend payout for the U.S. manufacturing firms. This negative relationship is robust to the inclusion of other firm characteristics and year fixed effects. All empirical models show strongly negative coefficients on our wage fixed capital ratio. These coefficients are -0.287, -0.293,

-0.075, and -0.060, respectively for each model. The coefficients on other control variables are consistent with those of DeAngelo et al. (2007).

The results of Table 5 are in line with our empirical prediction. We expect a lower dividend payout propensity for labor intensive firms, measured by the wage to fixed capital ratios. Due to the limitations in debt financing for wage payments, a firm tends to delay current dividend payout and use its own equity for wage payments. Therefore, our model predicts a negative relationship between the wage-fixed capital ratio and dividend payout propensity. The logit model results in Table 5 exactly confirm our predictions.

Our findings emphasize the importance of production technology on dividend policy, which is largely unexamined in prior studies. Table 5 indicates that a firm with substantial wage payments is less likely to payout dividends, even after controlling for profit, size, growth and life-cycle stages. This finding suggests that corporate dividend policies are significantly affected by production technology, which determines the factor demand of labor and fixed capital. On the contrary, prior studies mainly highlighted the signaling effects (Miller and Rock 1985), a manager-shareholder conflict (Jensen 1986), or the life cycle aspect of firm (DeAngelo et al. 2007) in dividend payout policies.

The table also provides empirical evidence arguing for the role of financial frictions on dividend payout policy. Our model clearly argues that the limitations in debt enforceability drive the demand of equity for wage payments. Such demand of equity also affects optimal dividend payout policies, which is empirically confirmed in Table 5. Our findings are in line with the prediction of Bolton et al. (2011) that highlights the relationship between a firm's payout policy and external financing frictions.

Payout Ratio

Our theoretical analysis implies a smaller amount of dividends payout from current profits for labor intensive firms. To test this empirical implication, we examine the relationship between our wage-fixed capital measure and dividend payout ratios. To deal with left censoring problem in payout ratio reported in Table 2, we adopt Tobit models for our estimations. The first model simply investigates the correlation between our wage-fixed capital ratio and payout ratios. In our second model, we include other firm characteristic

Table 6: Wage/Fixed Capital and Payout Ratio

	Dividend/Ebitda			Dividend/Total Assets		
Wage/FC	-0.030***	-0.009***	-0.004***	-0.005***	-0.001***	-0.001***
	(-50.2)	(-15.7)	(-6.9)	(-52.7)	(-17.3)	(-7.3)
ROA		0.254***	0.096***		0.091***	0.066***
		(23.1)	(8.7)		(61.8)	(45.5)
M/B		-0.015***	0.001		-0.000***	0.002***
		(-15.0)	(0.8)		(-3.3)	(16.4)
Size		0.019***	0.033***		0.003***	0.005***
		(48.1)	(68.9)		(48.9)	(75.4)
RE/TE		0.157***	0.132***		0.020***	0.016***
		(73.7)	(63.6)		(71.4)	(59.4)
Growth		-0.094***	-0.101***		-0.018***	-0.019***
		(-26.9)	(-29.0)		(-36.2)	(-39.6)
Leverage		-0.185***	-0.219***		-0.025***	-0.031***
		(-30.4)	(-36.2)		(-31.1)	(-38.5)
R&D		-0.907***	-0.934***		-0.125***	-0.129***
		(-39.3)	(-40.9)		(-41.1)	(-43.2)
Intercept	0.027***	-0.104***	-0.063***	0.005***	-0.020***	-0.014***
	(20.2)	(-29.0)	(-10.8)	(26.6)	(-42.4)	(-18.9)
Year F.E	No	No	Yes	No	No	Yes
N	73933	67414	67414	73936	67417	67417
Psuedo-R^2	0.068	0.770	0.872	-0.035	-0.379	-0.435

This table displays the estimation results for Tobit models on payout ratios. The dependent variables are self-explanatory. ROA is the ratio of earnings before interest, taxes, depreciation, and amortization to total assets. M/B is the market value of firm divided by the book value of its assets. RE/TE is retained earnings divided by total common equity. Size is the natural logarithm of the book value of assets in 1997 dollars. Growth is asset growth. Leverage is book leverage. The z-statistics are reported in parentheses.

variables. The set of control variables used here is quite similar to the set of Bliss, Cheng and Denis (2014) that investigate payout reductions during financial crisis. The control variables consists of the return on asset, market to book ratio, size, ratio of retained earnings to total equity, asset growth and R&D expenditures. To account for the time trend in dividend policy (Fama and French 2001), we also consider the time fixed effect in our third model. For robustness, we use two different measures of dividend payout ratios- the amount of dividends divided by EBITDA and total assets.

Table 6 reports the estimation results of our Tobit models. The table clearly indicates that our wage fixed capital ratio is negatively related to payout ratios in the U.S. manufacturing firms. This correlation is robust to the inclusion of control variables and the change of payout measures. In all six empirical models, the coefficients on our wage-fixed capital ratio are significantly negative at 99% confidence level.

Our estimation results in Table 6 are consistent with our theoretical prediction. Our model expects a lower dividend payout ratios for labor intensive firms, measured by the wage to fixed capital ratios. Due to the limitations of debt financing for wage payments, a firm with greater wage payments relies heavily on equity. Hence this firm has more incentives to reduce its current period payout to finance wage payments, resulting in a lower current payout ratio. Our Tobit model results directly confirm our model implications.

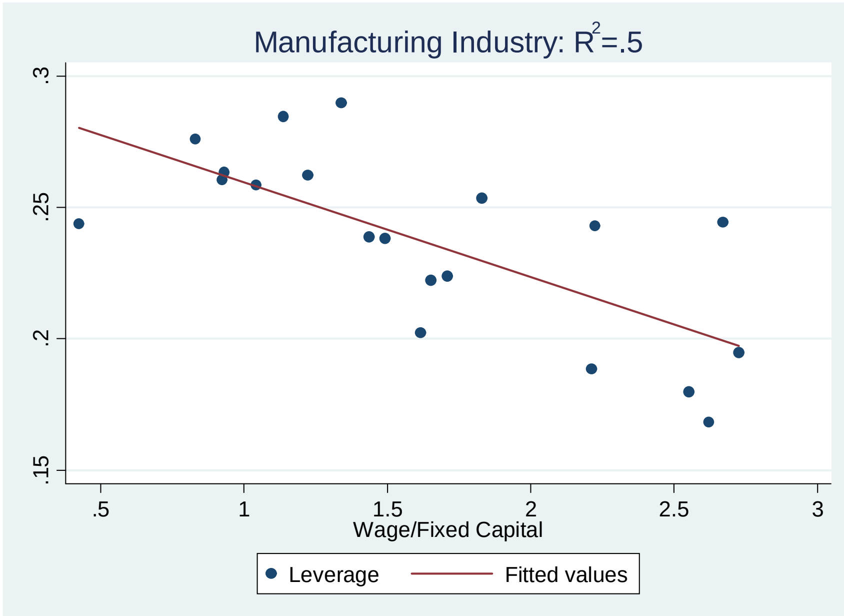
Our results strengthen the importance of production technology on dividend policy again, unlike existing studies. Table 6 points out that a labor intensive firm tends to reduce the amount of dividend payout if all other things being equal. In conjunction with the result of Table 5, this finding suggests that a firm's technology affects dividend policy critically by changing the factor demand of wage and fixed capital. This emphasis on production technology differs markedly from existing studies focusing on signaling effects and agency problems in dividend policies.

Similar to the results of Table 5, our finding also provides empirical evidence suggesting a significant role of imperfect financial market on dividend policy. Due to the limitations in debt financing, equity is more valuable for the firms with large wage payments, leading to a reduction in current dividend payout. This finding is consistent with the implications of Bolton et al. (2011) highlighting the effect of financial constraints on payout policies.

3.3 Empirical Results: Industry Level

The predictions of our model can be naturally extended to industry level analyses, if our wage-fixed capital ratio varies considerably across industries. This section empirically investigates how our wage-fixed capital ratio affects leverage ratios and dividend payout propensity of the U.S. manufacturing industries.

Figure 1: Wage/Fixed Capital and Leverage - Industry



This figure displays the scatter plot and fitted value between the industry average book leverage ratio and wage fixed capital ratio for the 20 U.S. manufacturing sector.

Leverage Ratio: Industry

Before entering comprehensive industry level analysis, we firstly investigate a simple relationship between our wage-fixed capital ratio and leverage ratios. Figure 1 shows the scatter plot and fitted value of book leverage ratio along with wage-fixed capital ratio for 20 manufacturing industries. All variables are averaged over each industry.

Figure 1 shows two interesting results. First of all, the industry leverage ratio has clearly negative relationship with our wage-fixed capital ratio, as expected in our model. Even a half of industry level leverage variation is explained by our wage-fixed capital ratio. Moreover, this figure indicates a substantial variation in the industry wage-fixed capital ratio from 0.4 to 2.6. This substantial variation allows us to conduct industry level analyses.

Table 7 presents more concrete industry level estimation results. We adopt three cross-sectional models to examine the relationship between industry average leverage and wage-fixed capital ratio. The details of our empirical model are similar to those of cross-sectional

Table 7: Wage/Fixed Capital and Leverage - Industry

	Book Leverage			Market Leverage		
Wage/FC	-0.034***	-0.024***	-0.033***	-0.097***	-0.066***	-0.077***
	(-16.8)	(-10.7)	(-9.3)	(-7.8)	(-5.8)	(-4.1)
ROA		-0.009	-0.034		-0.168	-0.195
		(-0.2)	(-0.9)		(-0.8)	(-1.0)
M/B Ratio		-0.025***	-0.028***		-0.303***	-0.306***
		(-7.4)	(-8.1)		(-17.5)	(-17.1)
Size		-0.000	-0.001		-0.017***	-0.018***
		(-0.2)	(-1.1)		(-2.7)	(-2.8)
R&D		-0.542***	-0.501***		-1.109***	-1.065**
		(-6.6)	(-6.1)		(-2.6)	(-2.5)
Tangibility			-0.072***			-0.079
			(-3.4)			(-0.7)
Intercept	0.293***	0.314***	0.365***	0.656***	1.040***	1.096***
	(80.7)	(31.9)	(20.4)	(29.7)	(20.5)	(11.8)
N	860	860	860	860	860	860
adj-R^2	0.247	0.415	0.422	0.065	0.482	0.481

This table displays the industry estimation results for cross-sectional models on the relationship between our wage-fixed ratio and leverage ratios. The dependent variables are the book and market leverage ratios. ROA is the ratio of earnings before interest, taxes, depreciation, and amortization to total assets. M/B is the market value of firm divided by the book value of its assets. Size is the natural logarithm of the book value of assets in 1997 dollars. Research and development expenditures are divided by total assets. Industry median leverage is based on two-digit SIC codes. Tangibility is the ratio of fixed capital to total assets net out of cash. The estimation is based on yearly average values. The standard errors are robust to heteroskedasticity and the associated t-statistics are reported in parentheses.

models used in our firm level analysis. The first model investigates a simple relation between industry mean leverage ratio and our wage-fixed capital ratio. The second and third models introduce widely used control variables. The second model excludes tangibility measure that probably provides information about the role of fixed capital as collaterals. In contrast, the third model also includes the tangibility measure. All variables are averaged over each year for 20 manufacturing industries. We examine both of the book leverage and market leverage ratios as dependent variables. Table 7 reports the coefficients, t-values (in parenthesis) and other statistics from these models with robust standard errors.

Table 7 confirms that the industry level wage to fixed capital ratio is negatively related to leverage ratio, consistent with our predictions. Such negative relationship is robust to the variation of leverage ratio measures and the inclusion of other industry characteristic variables. For all six models in Table 7, the coefficients on our wage-fixed capital turn out significantly negative. For example, the coefficients are -0.034, -0.024, and 0.033, respectively for our cross-sectional models using book leverage ratios. The results on market leverage ratios are similar to those of book leverage ratios.

These findings present another piece of evidence suggesting the importance of production technology in capital structure policy. Given the substantial variations in industry level wage-fixed capital ratio, we can presume that each industry has different mixture of labor and capital for production. . We find lower leverage ratios for more labor intensive industries, in terms of the ratio between wage and fixed capital. Considering the fact that production technology plays a pivotal role in shaping labor and fixed capital demands, our findings confirms the significance of production technology in capital structure policy again.

Our analysis also provides a new economic determinant in industry leverage ratio variations. As emphasized in Frank and Goyal (2009), industry leverage ratio plays an important role in cross-sectional variation of firm leverage ratios. To characterize industry level capital structure policies, prior studies have largely focused on industry competition structure (e.g. Brander and Lewis 1986; Maksimovic and Zechner 1991). This finding suggests that industry production technology could be another important factor in leverage ratio variations across manufacturing industries.

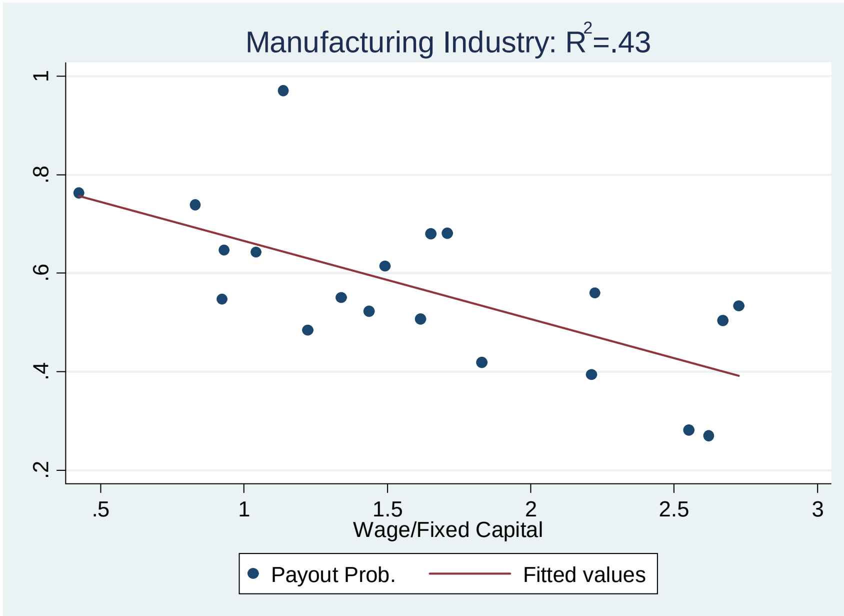
Payout Propensity: Industry

Our firm level prediction can be extended to a lower propensity of dividend payout for more labor intensive industries. Before conducting rigorous industry level analysis, we firstly depict the relationship between our wage to fixed capital ratio and dividend payout propensity for 20 manufacturing industries.

Figure 2 depicts the scatter plot and fitted value between our wage-fixed capital ratio and dividend payout propensity for 20 manufacturing industries. The payout propensity is defined as the number of dividend payout firms divided by the total number of firms for each industry.

The figure shows that the fraction of dividend paying firms is negatively correlated

Figure 2: Wage/Fixed Capital and Payout Propensity - Industry



This figure displays the scatter plot and fitted value between the fraction of dividend paying out firm and our wage fixed capital ratio for the 20 U.S. manufacturing sector. The calculation is based on the average value for the whole sample.

with our wage-fixed capital ratio, consistent with our empirical prediction . R^2 is around 0.43 pointing to a significant explanatory power of our wage-fixed capital ratio in dividend payout tendency variations. The figure points to a lower propensity of dividend payouts for labor intensive industries.

Table 8 reports more concrete industry analysis results. The table investigates the relationship between industry wage-fixed capital ratio and dividend payout propensity by using annually averaged variables. Unlike our firm level analysis in Table 5, we use cross-sectional regression models; there are at least some firms paying out dividends for the manufacturing industries, which prohibits the use of binary choice models. All other empirical strategies are similar to those of the firm level analysis in Table 5. The first model investigates a simple relationship between our wage-fixed capital ratio and the fraction of dividend paying out firms. We additionally control the time trend of dividend policy in our second model. The third model takes account of a firm's profitability, size, asset growth and life cycle aspect. The last model additionally introduces the time fixed effect as the independent

Table 8: Wage/Fixed Capital and Payout Propensity - Inudstry

	Dividend Payout Probability			
Wage/FC	-0.129***	-0.131***	-0.025***	-0.019***
	(-15.1)	(-19.9)	(-3.5)	(-3.5)
ROA			1.332***	0.850***
			(9.3)	(7.2)
Growth			-0.094*	-0.120**
			(-1.8)	(-2.5)
Size			0.005***	0.008***
			(10.5)	(20.8)
RE/TE			0.253***	0.119***
			(14.0)	(7.1)
Intercept	0.767***	0.891***	0.104***	0.140***
	(50.6)	(27.1)	(3.2)	(4.4)
Year F.E.	No	Yes	No	Yes
N	860	860	840	840
Adj-R^2	0.210	0.536	0.699	0.816

This table displays the industry estimation results for cross-sectional models on the relationship between our wage-fixed ratio and dividend payout propensity. The dependent variable is the fraction of dividend paying out firm. ROA is the ratio of earnings before interest, taxes, depreciation, and amortization to total assets. RE/TE ratio is the ratio of retained earnings to total common equity. Size is the natural logarithm of the book value of assets in 1997 dollars. Growth is the change in total assets divided by the previous year's level. The standard errors are robust to heteroskedasticity and the associated t-statistics are reported in parentheses.

variable. Table 8 documents the coefficients, t-values (in parenthesis) and other statistics from these models.

Table 8 points out that our wage-fixed capital ratio is closely associated with a lower propensity of dividend payout in the U.S. manufacturing industry. This negative relationship is robust to the inclusion of other industry characteristics and year fixed effects. All empirical models show strongly negative coefficients on our wage fixed capital ratios; these coefficients are -0.129, -0.131, -0.025, and -0.019 respectively. The coefficients on all other industry characteristic variables show consistent signs with our firm level analysis in Table 5.

This result is fully consistent with our model prediction. We expect a lower dividend payout propensity for labor intensive industries. Due to the demand of equity for wage payments, labor intensive industries tend to delay dividend payout if all other things are equal. Because our industry wage-fixed capital ratio captures the relative demand of labor and capital for production, such significant negative relationship confirms the effect of production technology on dividend payout policy.

This empirical finding also proposes another important economic determinant in industry payout policy. Most prior literature on payout policy has paid little attention to the effects of industry characteristics on dividend policy except R&D expenditures. In contrast, our finding clearly shows that industry production procedure could play an important role in shaping industry level dividend payout decisions.

3.4 Empirical Results: Robustness

In this section, we conduct sub-sample period analyese to address potential concerns about the stability of our findings.

Leverage Ratio: Period by Period

To check the robustness of our prediction on leverage ratios, we choose the third model of Table 3 that contains the largest set of control variables such as profitability, firm size, R&D expenditure, industry median leverage and asset tangibility. By confirming significant negative relationships with the largest set of control variable, we could assure the stability of our empirical results. The time periods we cover here are 1970s (1971 - 1980), 1980s (1981 - 1990), 1990s (1991 - 2000), and 2000s (2001 - 2010). We conduct our cross-sectional regressions for both of the book and market leverage ratios. Table 9 reports the coefficients, t-values (in parenthesis) and other statistics from our empirical models with robust standard errors

The estimation results in Table 9 verify that the negative coefficient from the whole sample analysis is not a mere coincidence. For all of the four time periods, our wage-fixed capital ratio are negatively correlated with leverage ratios. This negative relationship is robust to the variation of leverage measures as well. For all eight cross-sectional regressions, the coefficients are negative at the 99% level of significance. These estimation results

Table 9: Robustness: Wage/Fixed Capital and Leverage

	Book Leverage				Market Leverage			
	1970s	1980s	1990s	2000s	1970s	1980s	1990s	2000s
Wage/FC	-0.015***	-0.011***	-0.006***	-0.005***	-0.039***	-0.025***	-0.014***	-0.007***
	(-11.0)	(-8.9)	(-7.0)	(-7.6)	(-5.4)	(-4.9)	(-4.7)	(-2.8)
ROA	-0.542***	-0.298***	-0.213***	-0.105***	-2.568***	-0.961***	-0.566***	-0.407***
	(-31.3)	(-25.0)	(-22.5)	(-10.9)	(-28.0)	(-23.2)	(-21.7)	(-14.9)
M/B	-0.040***	-0.043***	-0.033***	-0.029***	-0.238***	-0.195***	-0.125***	-0.126***
	(-22.9)	(-29.9)	(-41.9)	(-31.5)	(-22.0)	(-36.4)	(-47.2)	(-39.5)
Size	0.002***	-0.004***	0.010***	0.015***	0.026***	0.007***	0.025***	0.028***
	(2.9)	(-6.8)	(16.3)	(22.3)	(7.3)	(2.7)	(11.4)	(10.3)
R&D	-0.076	-0.573***	-0.529***	-0.328***	-1.567***	-1.787***	-1.068***	-0.899***
	(-1.6)	(-18.4)	(-25.8)	(-14.5)	(-7.7)	(-19.2)	(-20.4)	(-15.3)
Ind. Lev	0.002	-0.023	0.164***	0.393***	1.066***	0.958***	1.153***	1.937***
	(0.1)	(-0.9)	(6.5)	(13.7)	(7.8)	(9.6)	(12.1)	(15.2)
Tangibility	-0.037***	0.005	0.038***	0.053***	-0.056	-0.027	0.040	0.300***
	(-3.4)	(0.5)	(4.5)	(6.0)	(-0.9)	(-0.6)	(1.3)	(7.5)
Intercept	0.390***	0.373***	0.227***	0.089***	1.011***	0.622***	0.294***	-0.010
	(46.1)	(45.7)	(29.2)	(10.4)	(23.0)	(19.4)	(10.8)	(-0.3)
N	14376	18067	19809	16674	14376	18067	19809	16674
adj-R^2	0.231	0.179	0.222	0.207	0.226	0.195	0.173	0.171

This table displays the results of robustness checks for cross-sectional models on the relationship between our wage-fixed ratio and leverage ratios. Four different time periods are analyzed in this table; 1970s (1971 - 1980), 1980s (1981 - 1990), 1990s (1991 - 2000), and 2000s (2001 - 2010). The dependent variables are the book and market leverage ratios. The model specification is exactly identical to the third model of Table 3. The standard errors are robust to heteroskedasticity and the associated t-statistics are reported in parentheses.

confirm the validity of our empirical prediction on the relationship between our wage-fixed capital ratio and leverage ratios.

It is also noteworthy that some coefficients on other control variables are not stable over the sub-samples. For instance, the industry median leverage ratio has negative correlation with book leverage ratios in 1980s. The tangibility measure also shows negative correlation with market leverage ratio during 1970s and 1980s. Unlike such control variables, our wage-fixed capital measure shows stably negative associations with both of the book and leverage ratios.

Table 10: Robustness: Wage/Fixed Capital and Debt Issuance

	Long Term Debt Issuance			
	1970s	1980s	1990s	2000s
Wage/FC	-0.156***	-0.112***	-0.101***	-0.039***
	(-6.4)	(-6.0)	(-6.4)	(-2.9)
ROA	-2.561***	-1.602***	-2.148***	-1.853***
	(-10.9)	(-10.5)	(-15.3)	(-11.5)
M/B	-0.053*	0.037*	-0.070***	-0.008
	(-1.8)	(1.8)	(-4.5)	(-0.5)
Size	-0.030**	0.015	0.131***	0.162***
	(-2.4)	(1.5)	(12.8)	(13.3)
R&D	1.926**	-3.947***	-4.717***	-3.903***
	(2.4)	(-8.3)	(-12.7)	(-9.5)
Ind. Lev	-0.784*	-1.106***	0.527	0.200
	(-1.8)	(-2.9)	(1.4)	(0.4)
Tangibility	0.278	0.145	-0.076	0.188
	(1.6)	(1.0)	(-0.6)	(1.3)
Intercept	-0.188	-0.572***	-1.298***	-2.220***
	(-1.3)	(-4.6)	(-10.8)	(-15.1)
N	14356	18065	19809	16674
Psuedo-R^2	0.015	0.012	0.037	0.028

This table displays the results of robustness checks for logit models on the relationship between our wage-fixed ratio and dividend payout propensity. Four different time periods are analyzed in this table; 1970s (1971 - 1980), 1980s (1981 - 1990), 1990s (1991 - 2000), and 2000s (2001 - 2010). The dependent variable is the binary choice of debt issuance. The model specification is identical to the third model of Table 4. The z-statistics are reported in parentheses.

Debt Issuance Policy: Period by Period

To verify the robustness of our empirical prediction on debt issuance policies, we adopt the third model used in our whole sample analysis, which contains a number of control variables without the year fixed effects. The inclusion of a large set of control variables strengthens the robustness of our results. Because we investigate the logit models in a short time period, the year fixed effect term is not considered. The time periods we analyze here are 1970s (1971 - 1980), 1980s (1981 - 1990), 1990s (1991 - 2000), and 2000s (2001 - 2010). Table 10 reports the coefficients, z-values (in parenthesis), the number of observations and pseudo R^2.

The estimation results in Table 10 are in line with our whole sample analysis documented in Table 4. For all empirical models, a higher wage-fixed capital ratio indicates a lower probability of debt issuance as our theory expects. All coefficients on our wage-fixed capital ratio are significantly negative; these coefficients are -0.156, -0.112, -0.101, and -0.039, respectively. These stably negative coefficients reinforce the importance of production technology on debt issuance, which determines the factor demand of labor and fixed capital.

Notably, some control variables show incoherent correlations with the choice debt issuance choice across sub-sample periods. For example, a firm's size does not have significant implications on long-term debt issuance policy in 1980s. R&D expenditure rather increases the likelihood of debt issuance in the period of 1970s. Tangibility measure does not have any significant effects on long term debt issuance. Unlike these firm characteristic variables, our wage-fixed capital measure has coherent relationship with long term debt issuance over the all sub-sample periods.

Dividend Payout Propensity: Period by Period

We next investigate the robustness of our empirical prediction on dividend payout propensity. By following our whole sample analysis, we adopt the model of DeAngelo et al. (2007), which includes the profitability, asset growth, size and life-cycle stages of firm. The introduction of various control variables reinforces the stability of our results. Because we examine the logit models in a short time period, the year fixed effect term is not included. The time periods we analyze here are 1970s (1971 - 1980), 1980s (1981 - 1990), 1990s (1991 - 2000), and 2000s (2001 - 2010). Table 11 reports the coefficients, z-values (in parenthesis), the number of observations and pseudo-R^2.

The estimation results in Table 11 are consistent with our whole sample analysis reported in Table 5. A higher wage-fixed capital ratio indicates a lower propensity of dividend payout for all sub-sample periods, as predicted in our theoretical analysis. All coefficients on our wage-fixed capital ratio have significantly negative values, -0.094, -0.034., -0.076, and -0.071, respectively. These logit model results confirm the stability of our whole sample estimation result on the relationship between the wage-fixed capital ratio and dividend payout propensity. Because a firm's technology critically affects its wage to fixed capital

Table 11: Robustness: Wage/Fixed Capital and Payout Propensity

	Dividend Payout			
	1970s	1980s	1990s	2000s
Wage/FC	-0.094***	-0.034**	-0.076***	-0.071***
	(-4.4)	(-2.0)	(-4.9)	(-5.3)
ROA	5.888***	3.889***	1.364***	2.049***
	(17.1)	(15.6)	(5.7)	(7.9)
Growth	-1.017***	-1.162***	-1.284***	-1.141***
	(-6.8)	(-13.2)	(-15.3)	(-14.1)
Size	0.030***	0.036***	0.036***	0.027***
	(29.4)	(40.1)	(40.8)	(30.4)
RE/TE	3.707***	3.057***	2.367***	1.813***
	(32.2)	(39.0)	(39.8)	(34.7)
Intercept	-3.098***	-3.592***	-3.492***	-2.887***
	(-29.3)	(-43.5)	(-44.2)	(-37.7)
N	12255	16609	18051	15639
Psuedo-R^2	0.325	0.387	0.367	0.339

This table displays the results of robustness checks for logit models on the relationship between our wage-fixed ratio and dividend payout propensity. Four different time periods are analyzed in this table; 1970s (1971 - 1980), 1980s (1981 - 1990), 1990s (1991 - 2000), and 2000s (2001 - 2010). The dependent variable is the binary choice of dividend payout. The model specification is identical to the third model of Table 5. The z-statistics are reported in parentheses.

ratio, this robustness result provides additional evidence arguing for a significant role of production technology on dividend policy.

Payout Ratio: Period by Period

We also examine the robustness of our empirical prediction on dividend payout ratios. We use the Tobit model to control left-censoring problem of dividend payout ratios, identical to the approach of our whole sample analysis. Our benchmark model includes various control variables, which reinforces the robustness of our results. The control variables consist of the return on asset, market to book ratio, size, retained earnings to total equity ratio, asset growth and R&D expenditures. The time periods we analyze here are 1970s (1971 - 1980), 1980s (1981 - 1990), 1990s (1991 - 2000), and 2000s (2001 - 2010). Table 12 reports the coefficients, z-values (in parenthesis), the number of observations and pseudo-R^2 in

Table 12: Robustness: Wage/Fixed Capital and Payout Ratio

	Dividend/Ebitda				Dividend/Total Assets			
	1970s	1980s	1990s	2000s	1970s	1980s	1990s	2000s
Wage/FC	-0.005***	-0.004***	-0.005***	-0.006***	-0.001***	-0.001***	-0.001***	-0.001***
	(-6.1)	(-3.5)	(-3.9)	(-4.1)	(-6.6)	(-5.3)	(-4.3)	(-3.5)
ROA	-0.161***	0.000	0.101***	0.275***	0.060***	0.062***	0.054***	0.063***
	(-11.3)	(0.0)	(4.0)	(7.5)	(29.0)	(26.7)	(15.5)	(13.9)
M/B	0.009***	-0.004	-0.006***	-0.009***	0.004***	0.002***	0.002***	0.002***
	(5.6)	(-1.6)	(-3.0)	(-2.8)	(17.8)	(7.0)	(5.5)	(4.5)
Size	0.018***	0.031***	0.039***	0.041***	0.003***	0.004***	0.006***	0.005***
	(29.0)	(36.0)	(36.7)	(26.9)	(34.1)	(41.0)	(38.8)	(26.8)
RE/TE	0.156***	0.179***	0.150***	0.152***	0.020***	0.021***	0.020***	0.018***
	(33.2)	(35.3)	(35.1)	(29.4)	(29.7)	(35.1)	(34.6)	(28.7)
Growth	-0.035***	-0.075***	-0.118***	-0.127***	-0.013***	-0.014***	-0.021***	-0.021***
	(-5.3)	(-11.7)	(-16.5)	(-13.7)	(-12.5)	(-17.7)	(-21.1)	(-17.9)
Leverage	-0.248***	-0.281***	-0.251***	-0.142***	-0.042***	-0.040***	-0.033***	-0.015***
	(-30.4)	(-25.9)	(-20.1)	(-7.8)	(-35.4)	(-30.4)	(-18.9)	(-6.5)
R&D	-0.459***	-0.934***	-1.090***	-1.170***	-0.102***	-0.122***	-0.155***	-0.138***
	(-11.6)	(-21.9)	(-25.5)	(-16.2)	(-17.8)	(-24.2)	(-26.3)	(-15.6)
Intercept	0.006	-0.102***	-0.210***	-0.337***	-0.011***	-0.021***	-0.038***	-0.049***
	(1.1)	(-14.1)	(-25.9)	(-27.3)	(-13.4)	(-23.5)	(-33.9)	(-31.9)
N	12238	16604	18043	15628	12239	16605	18044	15628
Psuedo-R^2	-0.704	1.156	0.710	0.491	-0.217	-0.358	-0.627	-0.771

This table displays the results of robustness checks for Tobit models on payout ratios. Four different time periods are analyzed in this table; 1970s (1971 - 1980), 1980s (1981 - 1990), 1990s (1991 - 2000), and 2000s (2001 - 2010). The dependent variables are self explanatory. The model specification is identical to the third model of Table 6. The z-statistics are reported in parentheses.

our Tobit model estimations. Similar to our whole sample analysis, Table 12 analyzes two different measures of payouts- dividends to EBITDA and dividends to total asset ratios.

The estimation results in Table 12 are well aligned with our whole sample analysis results. A higher wage-fixed capital ratio indicates a smaller amount of dividend payouts as predicted in our theoretical analysis. The coefficients on our wage-fixed capital ratios are negative at the confidence level of 1% for all sub-sample periods. This negative relationship is robust to the change of payout measures as well. Our results also imply that production technology, which shapes the demand of labor and fixed capital, plays a considerable role in shaping dividend policy.

It is also noteworthy that the coefficients on other control variables are not stable over the sub-sample periods. Unlike our wage-fixed capital ratio measure showing stably negative relations, the coefficients on return on asset and market to book value variables even change their signs over the sub-sample period. These instabilities are observed for both of the payout ratio measures.

Summary

The above examinations verify the robustness of our empirical test results over the sub-sample periods. All coefficients are statistically significant negative, which are consistent with our whole sample results. These findings strengthen the validity of our empirical predictions on corporate policies in the U.S. manufacturing sector.

Interestingly, some of widely used firm characteristic variables such as R&D expenditures, the return on asset, and tangibility measure did not show robust relationship with corporate capital structure and dividend policies. For some time intervals, these characteristics showed no statistically significant effects or even inverse relationships, contradictory to the results of prior studies.

4 Concluding Remarks

This paper argued that a firm's production technology critically affects optimal capital structure and dividend policy by endogenously shaping the factor demand for labor and fixed capital. Limitations in debt enforceability play an important role in our theoretical analysis. Unlike the acquisition of fixed capital, the fund used for wage payments is hardly securable by creditors, which limits the use of debt financing to hire workers. Hence, a labor intensive firm tends to show lower leverage ratios and potentially rely less on debt issuance. Moreover, this labor intensive firm tries to use equity to finance wage payments, leading to delays or reductions in dividend payouts.

We tested our empirical predictions for the sample U.S. manufacturing firms. For this purpose, we firstly developed a natural measure of labor intensities, the wage to fixed capital ratio based on our theoretical arguments. Then we investigated how our measure of labor intensity is related to leverage ratio, debt issuance decision, dividend payout propensity, and dividend payout ratios. All of the estimation results are consistent with our empirical predictions. A labor intensive firm indeed shows lower leverage and payout ratios as well as smaller likelihood of long term debt issuance and dividend payouts.

Our results propose production technology as a key economic determinant in capital structure and payout policies, in contrast to the irrelevance principles of MM (1958; 1961) and subsequent studies. Production technology matters significantly in optimal corporate policies even if it does not change a firm's revenue generations. Our findings provide novel insights to the understanding of optimal capital structure and dividend policies, considering the fact that existing literature has almost exclusively focused on revenue generations rather than production technology itself.

This analysis on production technology opens a new venue for studying the implications of production cost structure on corporate policies. A firm may need a substantial amount of intermediary goods its production, which is also hardly pledgeable. Hence, corporate polices may have close connection with the acquisition of intermediary goods. Furthermore, because the financing of intermediary goods are also closely related to the working capital management, it is worthwhile studying the interactions between traditional corporate policy and working capital management. These topics are beyond the scope of this paper and are left to future research.

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Appendix

A Proof of Propositions

Proof of Proposition 1

Firs of all we prove that there is no equity financing for initial capital purchase , $K_0 = B_0$. Suppose that there exists the firm's optimal policies where $K_0 > B_0$.In such case, there is a small ε, where $K_0 > B_0 + \varepsilon$ and $\varepsilon > 0$. Then we could find another policy where the firm issues additional debt and decreases equity financing by the same amount ε at date $t = 0$. The net valuation effect under the new financing policy is

$$(1-\tau_d)\,\varepsilon - \frac{(1-\tau_d)\,[1+(1-\tau_c)\,r]}{1+r\,(1-\tau_i)}\varepsilon,$$

and so as far as $\tau_c > \tau_i$, this net valuation effect is greater than zero:

$$\begin{aligned} (1-\tau_d) &> \frac{(1-\tau_d)\,[1+(1-\tau_c)\,r]}{1+r\,(1-\tau_i)} \\ 1 &> \frac{[1+(1-\tau_c)\,r]}{1+r\,(1-\tau_i)}. \end{aligned}$$

Hence, there is no optimal policy where $K_0 > B_0$.
Similarly, suppose that $K_1 > B_1$. You find $\delta > 0$, where $K_1 > B_1 + \delta$. If the firm issues additional debt at date $t = 1$ and decreases equity financing by the same amount δ, the net valuation effect of the new financing policy is:

$$(1-\tau_d)\,\delta - \frac{(1-\tau_d)\,[1+(1-\tau_c)\,r]}{1+r\,(1-\tau_i)}\delta$$

whose value is greater than zero as long as $\tau_c > \tau_i$.Therefore, there is no equity financing for the purchase of capital stock at date $t = 1$, either. .

Proof of Proposition 2 and 3

Based on the first order conditions with respect to labor and physical capital, we know

$$
\begin{aligned}
\frac{w\,(1+r(1-t_i))\,L}{rK^*} &= \frac{\beta\,(1-\tau_c)\,Y^*}{\alpha Y^*} \\
\frac{wL^*}{K^*} &= \frac{r\,(1-\tau_c)}{w\,(1+r(1-t_i))}\frac{\beta}{\alpha}.
\end{aligned}
$$

Because all wage payments are financed by equity and all physical capital is finananced by debt, the firm's equity to debt ratio becomes wL^*/K^*. This ratio increases (decreases) with respect to the variation of labor intensity β (capital intensity α).
Moreover, the firm's dividend payout to sales ratio at date $t = 1$ is

$$
\begin{aligned}
\frac{E_1}{Y_1} &= \frac{(1-\tau_d)\,(1-\tau_c)\,(Y^* - wL^* - rK^*)}{Y^*} \\
&= 1 - \beta/\,(1+r(1-t_i)) - \alpha.
\end{aligned}
$$

Accordingly, as the labor intensity β (capital intensity α) increases (decreases) the dividend payout to sales ratio diminishes.