Does Firm-Level Productivity Predict Stock Returns?

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Motivation

- Although productivity is an important issue for the Japanese economy, little is known about the relationship between stock returns and firm-level productivity.
- İmrohoroğlu and Tűzel (2014) and Ang et al. (2020) find a negative relationship between returns and total factor productivity (TFP) for US companies.
- No research on the relationship between stock returns and firm-level TFP for Japanese firms, previous studies have looked only at returns and labour productivity.
- Risk factors that may lead to a relationship between future returns and TFP are unclear.

Questions and findings

- Does the firm-level TFP of Japanese manufacturers predict their future stock returns?

  $\Rightarrow$ Yes.

- Is the relationship negative similar to previous US studies?

  $\Rightarrow$ No. High TFP Japanese manufacturing firms have high future stock returns.

- What is the reason behind the predictive power of TFP for future returns?

  $\Rightarrow$ Risks related to intangible expenditure, primarily those for R&D and personnel, explain a substantial fraction of the predictive power of firm-level TFP.

  $\Rightarrow$ Mispricing with limits-to-arbitrage does not explain the relationship.

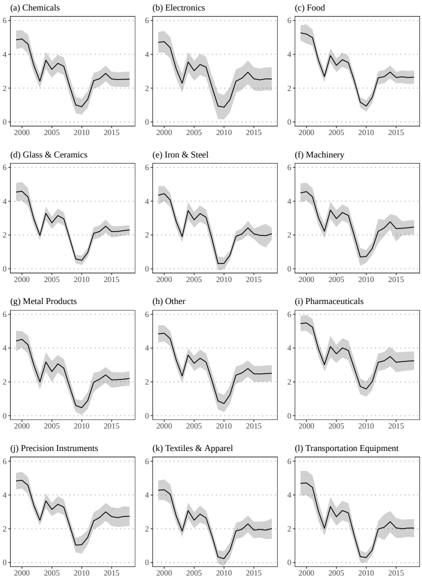
Data

- Manufacturing firms in the TOPIX (large manufacturers) for 12 sectors, March FY-end firms only.
- Panel data constructed from consolidated corporate financial reports.
- Corporate financial data: FY1999 (end March 2000) to FY2018 (end March 2019).
- Stock returns: July 2000 to June 2020.
- Corporate financial data refer to the fiscal year (April to March) and future stock returns refer to the one-year period beginning three months after the end of the fiscal year (July to June).

Estimating firm-level TFP

$$\omega_{i,t} = y_{i,t} - \hat{\alpha}_k \, k_{i,t} - \hat{\alpha}_l \, l_{i,t}$$

- Cobb-Couglas production function used to estimate TFP.
- OLSE biased,use control function approach of Levinsohn and Petrin (2003), Wooldridge (2009).
- Annual recursive estimation to avoid look-ahead bias.
- Coefficient estimates:
  - Capital: mean 0.375 , sd 0.108.
  - Labour: mean 0.498, sd 0.024.
- 20 years of annual firm-level TFP estimates for FY1999 to FY2018.



Annually rebalanced TFP-quintile portfolios

	(Low)	TFP Quintiles			(High)	(High-Low)
	Q1	Q2	Q3	Q4	Q5	Q5-Q1
TFP	2.005	2.415	2.659	2.918	3.373	1.368
Contemp. return (%)	7.467	9.760	12.474	13.490	12.689	5.222
Future return (%)	7.349	9.058	8.638	8.292	7.863	0.514
ln(ME)	9.990	10.548	10.998	11.551	12.371	2.381
ln(B/M)	0.159	0.056	-0.023	-0.186	-0.383	-0.542
ROE (%)	1.697	4.201	5.051	6.172	7.364	5.667
ROE_{t+1} (%)	2.398	4.167	5.297	6.261	6.918	4.521
Net Income/Sales (%)	1.031	2.467	3.422	4.267	5.165	4.134
Net Income/Sales_{t+1} (%)	1.316	2.554	3.570	4.282	4.993	3.678
Net Income/MV (%)	-0.251	2.743	2.921	4.099	3.655	3.905
Net Income/MV_{t+1} (%)	0.192	2.471	3.784	3.680	3.863	3.671
AG (%)	2.185	2.540	2.764	3.701	4.020	1.835
ln(L)	7.548	7.824	8.042	8.361	8.795	1.247
Observations	2,366	2,235	2,229	2,235	2,329	

- High (low) TFP firms tend to be large growth (small value) firms.
- High TFP firms have better operating performance, higher asset growth and more employees than low TFP firms.
- Same as İmrohoroğlu and Tűzel (2014).

Risk factor loadings for the TFP-quintile portfolios

- Do Japanese manufacturing stock returns exhibit TFP-related alpha while controlling for a variety of widely-recognized risk factors? Yes.

	Dependent variable: future monthly excess portfolio return					
	(1) Q1	(2) Q2	(3) Q3	(4) Q4	(5) Q5	(6) Q5-Q1
(a) Fama-French 3-Factor						
MKT (Market)	1.179***	1.119***	1.107***	1.076***	1.022***	-0.158***
	(0.026)	(0.027)	(0.024)	(0.023)	(0.025)	(0.028)
SMB (Size)	0.961***	0.750***	0.663***	0.434***	0.230***	-0.731***
	(0.051)	(0.042)	(0.041)	(0.037)	(0.044)	(0.067)
HML (Value)	0.539***	0.456***	0.388***	0.241***	0.110**	-0.429***
	(0.049)	(0.043)	(0.042)	(0.041)	(0.044)	(0.059)
Alpha	-0.109	0.054	0.084	0.172**	0.200**	0.309**
	(0.111)	(0.097)	(0.098)	(0.083)	(0.094)	(0.136)
Adj. R^2	0.925	0.923	0.923	0.927	0.924	0.506
(b) Carhart 4-Factor						
MKT (Market)	1.159***	1.106***	1.090***	1.062***	1.008***	-0.151***
	(0.024)	(0.027)	(0.024)	(0.022)	(0.023)	(0.029)
SMB (Size)	1.018***	0.789***	0.710***	0.474***	0.269***	-0.749***
	(0.046)	(0.040)	(0.035)	(0.036)	(0.045)	(0.067)
HML (Value)	0.509***	0.436***	0.364***	0.220***	0.090**	-0.420***
	(0.051)	(0.044)	(0.046)	(0.041)	(0.042)	(0.061)
UMD (Momentum)	-0.146***	-0.098**	-0.119**	-0.101***	-0.099***	0.047
	(0.051)	(0.042)	(0.050)	(0.036)	(0.033)	(0.045)
Alpha	-0.121	0.046	0.074	0.164**	0.192**	0.313**
	(0.101)	(0.094)	(0.091)	(0.078)	(0.091)	(0.134)
Adj. R^2	0.931	0.926	0.928	0.931	0.928	0.507

Risk factor loadings for the TFP-quintile portfolios

	Dependent variable: future monthly excess portfolio return					
	(1) Q1	(2) Q2	(3) Q3	(4) Q4	(5) Q5	(6) Q5-Q1
(c) Fama-French 5-Factor						
MKT (Market)	1.156***	1.103***	1.092***	1.063***	1.022***	-0.134***
	(0.030)	(0.031)	(0.029)	(0.026)	(0.026)	(0.026)
SMB (Size)	0.913***	0.732***	0.639***	0.419***	0.232***	-0.680***
	(0.048)	(0.046)	(0.043)	(0.038)	(0.044)	(0.063)
HML (Value)	0.442***	0.424***	0.343***	0.212***	0.115**	-0.327***
	(0.049)	(0.050)	(0.041)	(0.044)	(0.048)	(0.067)
RMW (Profitability)	-0.238**	-0.182**	-0.156	-0.143	-0.001	0.237**
	(0.111)	(0.084)	(0.100)	(0.088)	(0.080)	(0.119)
CMA (Investment)	0.053	-0.086	-0.020	-0.058	-0.018	-0.071
	(0.102)	(0.098)	(0.090)	(0.079)	(0.075)	(0.113)
Alpha	-0.059	0.088	0.115	0.199**	0.200**	0.259**
	(0.106)	(0.096)	(0.100)	(0.082)	(0.094)	(0.130)
Adj. R^2	0.931	0.924	0.925	0.928	0.923	0.539
(d) q-factor						
MKT (Market)	1.191***	1.126***	1.115***	1.082***	1.022***	-0.169***
	(0.030)	(0.029)	(0.026)	(0.024)	(0.026)	(0.028)
ME (Size)	0.911***	0.741***	0.653***	0.428***	0.217***	-0.694***
	(0.055)	(0.048)	(0.044)	(0.040)	(0.045)	(0.066)
I/A (Investment)	0.227**	0.051	0.064	0.001	-0.031	-0.259***
	(0.089)	(0.079)	(0.073)	(0.061)	(0.066)	(0.096)
ROE (Profitability)	-0.422***	-0.397***	-0.371***	-0.318***	-0.121	0.301***
	(0.123)	(0.102)	(0.105)	(0.087)	(0.081)	(0.106)
Alpha	-0.015	0.154	0.164	0.231***	0.235**	0.250*
	(0.117)	(0.102)	(0.101)	(0.083)	(0.096)	(0.138)
Adj. R^2	0.912	0.915	0.920	0.929	0.923	0.481

FMB regressions of future returns on TFP, controls

$$r_{i,t+1} = \gamma_0 + \gamma_1\, \beta_{i,t} + \gamma_2 \ln(ME)_{i,t} + \gamma_3 \ln(B/M)_{i,t} + \gamma_4\, ROE_{i,t} + \gamma_5\, AG_{i,t} + \gamma_6\, TFP_{i,t} + \sum_{j=1}^{11} \chi_j\, DS_j + \epsilon_{i,t+1}$$

- TFP has a positive and significant relationship with future returns in the cross-section, controlling for the Fama-French factors, sectors.
  - Contrary to İmrohoroğlu and Tűzel (2014) who find a negative relationship that is not significant when controlling for Fama-French three factors.

	Dependent variable: future return, $r_{i,t+1}$			
	(1)	(2)	(3)	(4)
β	0.973	0.448	0.769	0.224
	(2.490)	(1.926)	(2.378)	(1.835)
ln(ME)	-0.933	-1.001	-0.876	-0.947
	(0.840)	(0.895)	(0.781)	(0.822)
ln(B/M)	5.235***	5.087***	4.902***	4.718***
	(1.513)	(1.340)	(1.620)	(1.409)
ROE			-0.123**	-0.128***
			(0.046)	(0.043)
AG			-0.013	-0.023
			(0.037)	(0.034)
TFP	3.893***	3.730***	4.068***	3.983***
	(1.083)	(1.188)	(1.103)	(1.138)
Sector dummies	No	Yes	No	Yes
Observations	10,739	10,739	10,580	10,580
Adj. R^2	0.093	0.143	0.101	0.149

A risk-based explanation for the TFP premium?

- The preceding analyses show a positive and significant risk premium for high TFP firms.
- Does this premium represent compensation for investors bearing risk?
- We investigate three types of investment risk that are prominent in the literature:
    1. Bankruptcy risk.
    2. Macroeconomic risk.
    3. Capital and intangibles expenditure risk.
- Conditions:
    i. The risk and firm-level TFP are positively correlated.
    ii. The impact of firm-level TFP on returns increases as the risk increases.

1. Is bankruptcy risk positively related to TFP?

- No.
- Fama MacBeth regressions of TFP on two accounting information-based measures of bankruptcy risk:
  - Altman's (1968) Z-score is a measure of credit strength.
  - Ohlson's (1980) O-score is a measure of credit weakness.

	Dependent variable: total factor productivity, $TFP_{i,t}$	
	(1)	(2)
Z-score	0.106^{***}	
	(0.007)	
O-score		3.49e-04
		(0.001)
Constant	2.300^{***}	2.633^{***}
	(0.253)	(0.243)
Observations	10,843	10,399
Adj. R^2	0.144	0.005

1. Future returns, controls, TFP and bankruptcy risk

- Are future returns more sensitive to TFP as the probability of bankruptcy increases? No.
  - TFP×Z-score should be negative and significant while TFP×O-score should be positive to be consistent with bankruptcy risk explaining the TFP effect.

	Dependent variable: future return, $r_{i,t+1}$			
	(1)	(2)	(3)	(4)
β	0.537	0.255	0.707	0.094
	(1.823)	(1.860)	(1.955)	(2.050)
ln(ME)	-0.723	-0.226	-0.753	-0.154
	(0.827)	(0.734)	(0.824)	(0.712)
ln(B/M)	4.747***	4.742***	4.374***	4.070**
	(1.365)	(1.405)	(1.442)	(1.517)
ROE	-0.134***	-0.124**	-0.130***	-0.112**
	(0.046)	(0.046)	(0.045)	(0.044)
AG	-0.015	-0.027	-0.026	-0.036
	(0.035)	(0.034)	(0.038)	(0.036)
TFP	3.153***		3.563***	
	(1.012)		(1.050)	
TFP × Z-score	0.052	0.150		
	(0.096)	(0.111)		
TFP × O-score			0.014	-0.005
			(0.024)	(0.028)
Observations	10,107	10,107	10,053	10,053
Adj. R^2	0.143	0.138	0.142	0.136

2. Are TFP and macroeconomic risk related?

- No.
- DI is the BoJ Tankan diffusion index for business conditions for large manufacturers.
- Q1 to Q5 represent the TFP-quintile portfolio average TFPs.
- Q5-Q1 is the difference between the high and low TFP portfolio productivities.
- Correlations are close to zero.

	Correlation between TFP and DI
Q1	0.001
Q2	0.005
Q3	0.002
Q4	0.000
Q5	-0.001
Q5-Q1	-0.024

2. Macroeconomic risk, TFP and returns

- Average TFP-quintile portfolio future return, positive (negative) DI year defined as expansion (contraction).
- If macroeconomic risk is behind the TFP effect high TFP firms should trade at a premium during recessions.
- However, the table below suggests the opposite.
- Low productivity firms have more volatile returns suggesting they are more susceptible to macroeconomic shocks.

Quintile portfolio future returns (%)	(Low) Q1	Q2	TFP Quintiles Q3	Q4	(High) Q5	(High-Low) Q5-Q1
All states, 20 fiscal years	7.364	9.150	8.571	8.223	7.659	0.294
Expansions, 13 fiscal years	1.427	3.367	3.436	3.482	3.937	2.510
Contractions, 7 fiscal years	18.391	19.889	18.107	17.027	14.570	-3.821

2. Macroeconomic risk, TFP and returns

- If macroeconomic risk explains the TFP premium, the correlation between Q5-Q1 future returns and the DI should be negative.
  - The Q5-Q1 spread represents a strategy that is long high-TFP and short low TFP firms.
- The chart shows Q5-Q1 future returns conditioned on known equity factors and the DI.
  - While the DI and conditioned spread future returns move together in some years, in most they do not and the correlation is close to zero.
- Macroeconomic risk does not explain the TFP premium.

	Obs.	Correlations		
		DI	Q1	Q5
DI	20	1.00		
Q1	20	-0.33	1.00	
Q5	20	-0.09	0.89***	1.00
Q5-Q1	20	0.48**	-0.12	0.35

3. Capital and intangibles expenditure risks

- Hypothesis: high TFP firms undertake greater capital and intangibles expenditure and their future returns are higher to compensate investors for the risks associated with this higher expenditure.
- Both tangible and intangible expenditure involve foregoing current production to increase future production (Corrado et al., 2005).
- Capital expenditure (CE):
  - Increases in capital investment are followed by lower returns (Berk et al., 1999; Baker et al., 2003; Titman et al., 2004).
  - However, the negative relationship doesn't hold for Japanese firms (Titman et al., 2009; Miyagawa and Takizawa, 2017; Kubota and Takehara, 2018).

3. Capital and intangibles expenditure risks

- Intangible capital: computerized information, innovative property and economic competencies (Corrado et al., 2005).

- Intangible expenditure is positively related to productivity (Scherer, 1982; Lin and Lo, 2015; Montresor and Vezzani, 2016) or contributes to the development of organisational capital which is positively related to productivity (Tronconi and Vittucci Marzetti, 2011; Lev and Radhakrishnan, 2005).

- Intangibles expenditure and returns:
  - R&D intensity or expenditure positively related to returns (Lev and Sougiannis, 1996; Bae and Kim, 2003; Hou et al., 2021)
  - Organisational capital and returns are positively related to compensate investors for the risk that senior employees leave (Eisfeldt and Papanikolaou, 2013; Leung et al., 2018).
  - Human capital is positively related to returns (Palacios, 2015), firms with higher labour share have higher returns (Donangelo et al., 2019)

3. TFP on capital and intangibles expenditure

- TFP is positively related to capital (CE) and intangibles expenditures.
  - R&D expenditure (RD) reflects innovative property; personnel expenditure (PE) reflects human capital; selling, general and administrative expenses (SGA) proxy for organisational capital.

	Dependent variable: total factor productivity, $TFP_{i,t}$					
	(1)	(2)	(3)	(4)	(5)	(6)
ln(CE)	0.089***					
	(0.016)					
ln(RD)		0.143***				
		(0.011)				
ln(PE)			0.226***			
			(0.019)			
ln(AD)				0.055***		
				(0.004)		
ln(SGAexRD)					0.075***	
					(0.004)	
ln(SGAexRDPEAD)						0.075
						(0.004)
Constant	1.991***	1.623***	0.751***	2.436***	2.001***	2.039***
	(0.122)	(0.164)	(0.085)	(0.229)	(0.210)	(0.217)
Observations	11,285	11,206	10,969	4,526	11,394	11,394
Adj. R^2	0.099	0.228	0.296	0.048	0.035	0.037

3. Future returns on TFP, capital, intangibles exp.

	Dependent variable: future return, $r_{i,t+1}$					
	(1)	(2)	(3)	(4)	(5)	(6)
β	-0.036	-0.204	-0.134	0.589	0.279	0.220
	(1.791)	(1.769)	(1.823)	(1.970)	(1.829)	(1.833)
ln(ME)	-2.029**	-2.034*	-2.014**	-1.564*	-1.054	-0.993
	(0.950)	(0.993)	(0.874)	(0.859)	(0.839)	(0.837)
ln(B/M)	4.437***	4.318***	4.344***	4.007	4.705***	4.704***
	(1.399)	(1.379)	(1.359)	(2.318)	(1.400)	(1.411)
ROE	-0.124***	-0.119**	-0.110**	-0.277***	-0.127***	-0.128***
	(0.042)	(0.042)	(0.041)	(0.089)	(0.043)	(0.043)
AG	-0.024	-0.014	-0.014	0.054	-0.022	-0.023
	(0.035)	(0.033)	(0.034)	(0.059)	(0.033)	(0.034)
TFP	3.841***	2.366*	1.708	4.929***	3.238**	3.243**
	(1.116)	(1.267)	(1.378)	(1.657)	(1.152)	(1.176)
Dummies:	CI	RD	PE	AD	SGAex RD	SGAex RDPEAD
TFP × dummy2	-0.564	0.783	0.669	-0.324	0.812**	0.899**
	(0.367)	(0.577)	(0.594)	(0.587)	(0.331)	(0.347)
TFP × dummy3	0.792	0.919	0.642	1.132	0.870	0.941*
	(0.459)	(0.570)	(0.516)	(0.676)	(0.506)	(0.489)
TFP × dummy4	1.536**	2.050***	1.885**	1.423*	1.094***	1.082**
	(0.667)	(0.660)	(0.729)	(0.723)	(0.370)	(0.451)
TFP × dummy5	1.679**	2.403***	2.859***	0.405	1.217*	0.995*
	(0.616)	(0.767)	(0.915)	(0.632)	(0.623)	(0.565)
Observations	10,580	10,580	10,580	4,169	10,580	10,580
Adj. R^2	0.160	0.159	0.159	0.236	0.156	0.156

Decomposing the predictive power of TFP

- Hou and Loh (2016) univariate and multivariate (next slide) methods for evaluating competing explanations used to decompose the predictive power of TFP.

Stage	Description		Coefficient					
1	$r_{i,t+1}$ on TFP	TFP	3.983***					
			(1.138)					
			Candidates					
			ln(CE)	ln(RD)	ln(PE)	ln(AD)	ln(SGA exRD)	ln(SGA exRDPEAD)
2	$r_{i,t+1}$ on TFP and Candidate	TFP	4.130***	3.626***	3.261**	5.775***	3.971***	3.965***
			(0.994)	(1.099)	(1.221)	(1.578)	(1.134)	(1.137)
		Candidate	0.752	0.965	1.620*	0.536**	0.595**	0.544**
			(0.659)	(0.564)	(0.894)	(0.244)	(0.258)	(0.245)
3	TFP on Candidate	Candidate	0.089***	0.143***	0.226***	0.055***	0.075***	0.075***
			(0.016)	(0.011)	(0.019)	(0.004)	(0.005)	(0.004)
4	Decompose Stage-1 Coefficient	Explained	0.206	0.525	0.699	0.172	0.096	0.097
		(%)	5.2**	13.2***	17.6***	4.3*	2.4	2.4
			(2.441)	(2.391)	(2.821)	(2.523)	(1.590)	(2.424)
		Residual	3.777	3.458	3.284	3.811	3.887	3.886
		(%)	94.8***	86.8***	82.4***	95.7***	97.6***	97.6***
			(4.593)	(5.662)	(6.233)	(4.714)	(5.012)	(6.564)

Decomposing TFP for all candidates simultaneously

Stage	Description		Coefficient		SE	Coefficient		SE
1	$r_{i,t+1}$ on TFP	TFP	3.983***		(1.138)			
			(1)			(2)		
2	$r_{i,t+1}$ on TFP and Candidates	TFP	3.706***		(0.986)	5.299***		(2.143)
		ln(CE)	0.328		(0.593)	0.092		(0.624)
		ln(RD)	0.766		(0.473)	1.053		(0.854)
		ln(PE)				1.578		(1.284)
		ln(AD)				0.204		(0.430)
		ln(SGAexRD)	0.557**		(0.230)			
		ln(SGAexRDPEAD)				0.599		(0.671)
3	TFP on Candidates	ln(CE)	-0.103		(0.019)	-0.183***		(0.023)
		ln(RD)	0.212***		(0.005)	0.067***		(0.015)
		ln(PE)				0.335***		(0.012)
		ln(AD)				0.025***		(0.005)
		ln(SGAexRD)	0.051***		(0.002)			
		ln(SGAexRDPEAD)				0.015		(0.009)
				Explained (%)			Explained (%)	
4	Decompose Stage-1 Coefficient	ln(CE)	-0.264	-6.6**	(3.056)	-0.858	-21.5***	(2.483)
		ln(RD)	0.470	11.8***	(3.172)	0.355	8.9**	(3.532)
		ln(PE)				1.511	37.9***	(8.960)
		ln(AD)				0.037	0.9	(7.553)
		ln(SGAexRD)	0.063	1.6	(2.319)			
		ln(SGAexRDPEAD)				0.024	0.6	(1.091)
		Residual	3.714	93.2***	(15.904)	2.913	73.1***	(13.147)

Does mispricing explain the TFP premium?

- Does the TFP premium exist because the stocks of high TFP firms are mispriced due to being relatively difficult to arbitrage? No.
  - For mispricing to explain the TFP effect, the coefficients for IVOL, ILLIQ and OPVOL should be positive while those for INST and FRGN should be negative.
  - Our results are the opposite to those of Ang et al. (2020) for US stocks.

	Dependent variable: total factor productivity, $TFP_{i,t}$				
	(1)	(2)	(3)	(4)	(5)
IVOL	-0.006***				
	(0.001)				
ILLIQ		-2.97e-05***			
		(3.26e-06)			
OPVOL			-3.83e-06***		
			(1.67e-07)		
INST				0.006***	
				(0.001)	
FRGN					0.020***
					(0.001)
Constant	2.894***	2.795***	2.949***	2.553***	2.455***
	(0.251)	(0.255)	(0.247)	(0.211)	(0.241)
Observations	11,380	11,390	11,394	11,394	11,394
Adj. R^2	0.025	0.056	0.100	0.026	0.158

Conclusion

- Contrary to the findings of previous U.S. studies, we show that the firm-level TFP of Japanese manufacturers positively predicts their future stock returns in the cross-section when controlling for relevant risk factors.
  - However, the characteristics of high and low TFP Japanese firms are the same as for US firms.
- The premium for highly productive firms compensates investors for risks related to innovation and human and organizational capital formation.
- Investing in R&D and personnel in a way that improves productivity has a substantial positive impact on firms' stock returns.
- Our results provide a strong incentive for Japanese firms to invest in innovation, human and organizational capital.

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