The use of asset growth in empirical asset pricing models

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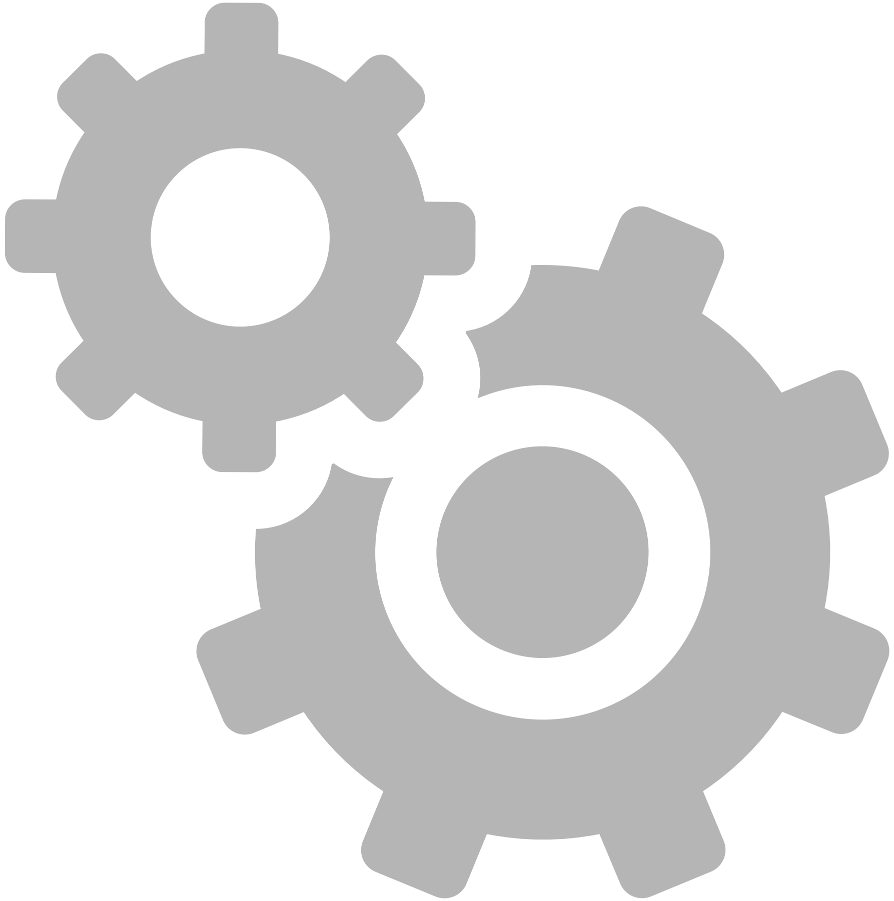

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HXZ and FF5F Models

Hou, Xue, and Zhang (2015) proposed a four-factor model, known as the q-factor model, which builds on the market factor (MKT) and size factor (ME) by adding profitability factor (ROE) and investment factor (I/A), using ROE and total asset growth rate as proxies for profitability and investment factors.

$$E[R_i] - R_f = \beta_{i,MKT}(E[R_M] - R_f) + \beta_{i,ME}E[R_{ME}] + \beta_{i,ROE}E[R_{ROE}] + \beta_{i,I/A}E[R_{I/A}]$$

Fama and French (2015), inspired by the dividend discount model, proposed the five-factor model (FF5F). In addition to retaining the market factor (MKT), size factor (SMB), and value factor (HML), they added the profitability factor (RMW) and investment factor (CMA).

$$\begin{aligned} \mathrm{E}[R_i] - R_f &= \beta_{i,\mathrm{MKT}}(\mathrm{E}[R_M] - R_f) + \beta_{i,\mathrm{SMB}}\mathrm{E}[R_{\mathrm{SMB}}] + \beta_{i,\mathrm{HML}}\mathrm{E}[R_{\mathrm{HML}}] \\ &\quad + \beta_{i,\mathrm{RMW}}\mathrm{E}[R_{\mathrm{RMW}}] + \beta_{i,\mathrm{CMA}}\mathrm{E}[R_{\mathrm{CMA}}] \end{aligned}$$

Existing Problems in Both Models

The investment factors used in the HXZ and FF5F models are not based on traditional corporate investment measures such as capital expenditure or property, plant, and equipment (PPE) growth. Instead, they adopt the asset growth (AG) measure proposed by Cooper et al. (2008), which is the annual percentage growth in the book value of total assets. This measure of corporate investment lacks theoretical justification for its relevance to asset pricing efficiency.

- Asset growth (AG) does not include off-balance-sheet intangible capital. According to recent evidence from Peters and Taylor (2017), intangible capital is increasingly recognized as an important capital type in recent research and should be included in corporate investment measures.
- When financing is used for investment activities, the book value of asset growth is not affected.
- The growth of current assets and other total asset components cannot be regarded as a manifestation of investment activities. While an increase in current assets may indicate that a company is expanding operations, it may also be a result of stagnation.

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Model Performance Comparison Based on Maximum Squared Sharpe Ratio Test

Alternative Factors

Physical capital investment measures:

- Property, plant, and equipment growth (PPE)
- Capital expenditure (CAPX)

Capital composition measures:

- Total capital annual change (TOTK)
- Physical capital annual change (PHK)
- Intangible capital annual change (INTK)

Physical capital investment measures are all normalized by dividing by lagged fixed assets, while capital composition measures are normalized using lagged total capital.

Table 1

Using Sharpe Ratio Tests to Compare HXZ and FF5F to Models Based on Alternative Investment Factors.

Panel A: Comparing HXZ-like models using maximum Sharpe ratio tests

Baseline model	Statistic	None	CAPX	PPE	TOTK	PHK	INTK
HXZ(AG)	$\Delta(maxSR^2)$	-0.078***	-0.038**	-0.044**	-0.040**	-0.055***	-0.055**
	p-value	(0.002)	(0.041)	(0.012)	(0.020)	(0.005)	(0.015)
None	$\Delta(maxSR^2)$		0.040**	0.034**	0.038**	0.023*	0.024*
	p-value		(0.016)	(0.035)	(0.030)	(0.094)	(0.053)
FF3F	$\Delta(maxSR^2)$	0.026	0.067**	0.060**	0.065**	0.049*	0.050*
	p-value	(0.303)	(0.023)	(0.032)	(0.021)	(0.070)	(0.074)

Panel B: Comparing FF5F-like models using maximum Sharpe ratio

Baseline model	Statistic	None	CAPX	PPE	TOTK	PHK	INTK
FF5F(AG)	$\Delta(maxSR^2)$	-0.037**	-0.034**	-0.038**	-0.037**	-0.033**	-0.039**
	p-value	(0.037)	(0.034)	(0.021)	(0.021)	(0.038)	(0.034)
None	$\Delta(maxSR^2)$		0.002	-0.001	-0.001	0.004	-0.002
	p-value		(0.698)	(0.664)	(0.782)	(0.573)	(0.331)
FF3F	$\Delta(maxSR^2)$	0.025	0.027	0.024	0.024	0.029	0.023
	p-value	(0.124)	(0.144)	(0.162)	(0.162)	(0.112)	(0.153)

Model Performance Comparison of Other Alternative Factors

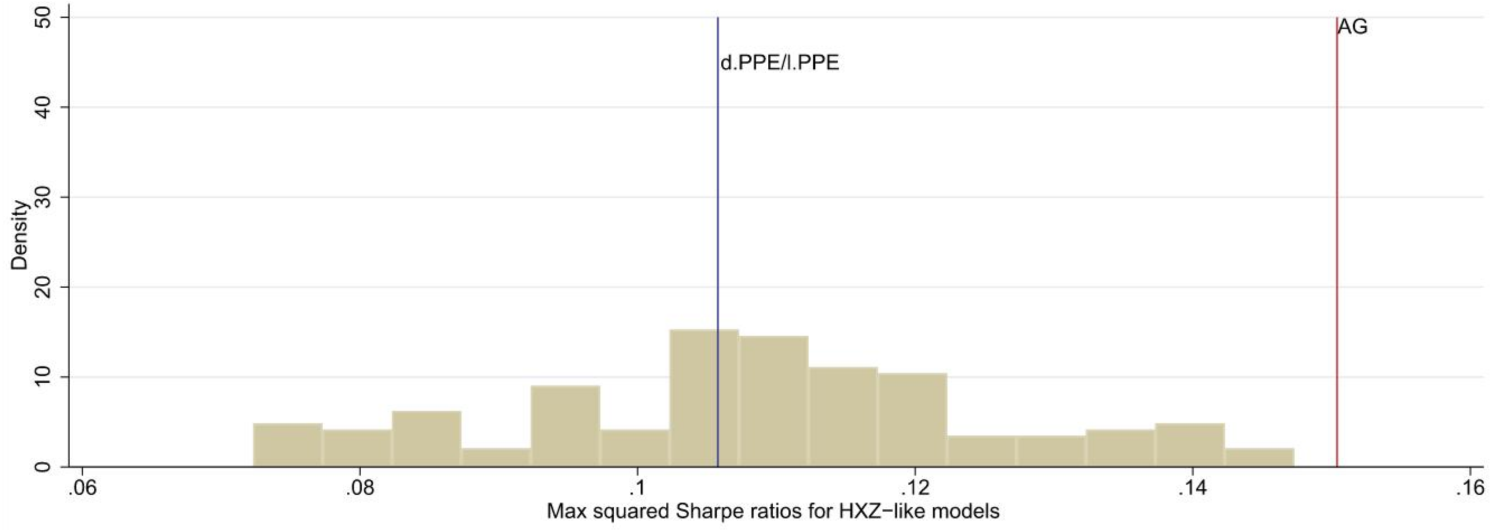
Alternative Factors

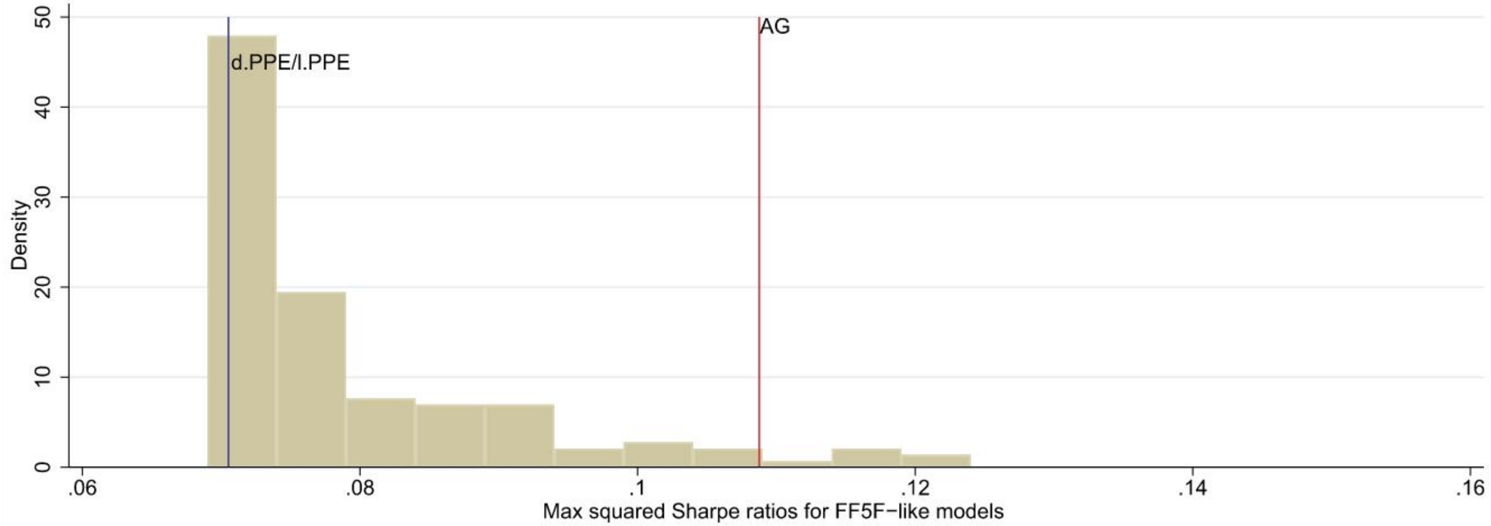
- Physical capital investment measures: CAPX / Total PPE change / Net capital expenditure (CAPX) minus capital from fixed asset sales

- Other investment measures: Inventory change / Goodwill change / Capitalized knowledge capital change / Capitalized organizational capital change

- The subdivision of 3 physical capital investment measures and 4 other investment measures constitutes 3×2×2×2=48 combined factors.

- Normalizing the 48 factors by total assets / total PPE / total capital creates 144 factors.





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Decomposing Balance Sheet Components into AG Sub-component Alternative Factors

Alternative Factors

Cash (CASH)

Inventory (INVT)

Accounts Receivable (AREC)

Property, Plant, and Equipment (PPE)

Intangible Assets (INTAN)

Other Assets (OTHER)

Current Operating Liabilities (COLIAB)

Non-current Operating Liabilities (NCOLIAB)

Long-term Debt (DBT)

Shareholders' Equity (EQ)

Retained Earnings (RE)

Table 2

Using Sharpe Ratio Tests to Compare HXZ and FF5F to Models Based on Subcomponents of AG.

Panel A1: Comparing HXZ-like models using LHS components of AG

Baseline model	Statistic	None	CASH	INVT	AREC	PPE	INTAN	OTHER
HXZ(AG)	$\Delta(maxSR^2)$	-0.078***	-0.068***	-0.021	-0.018	-0.057***	-0.079***	-0.058***
	p-value	(0.002)	(0.004)	(0.385)	(0.327)	(0.006)	(0.002)	(0.003)
None	$\Delta(maxSR^2)$		0.010	0.057***	0.060***	0.021	-0.000	0.020
	p-value		(0.184)	(0.010)	(0.006)	(0.148)	(0.962)	(0.150)
FF3F	$\Delta(maxSR^2)$	0.026	0.036	0.084***	0.087***	0.048*	0.026	0.047*
	p-value	(0.303)	(0.165)	(0.008)	(0.003)	(0.082)	(0.298)	(0.071)

Panel A2: Comparing FF5F-like models using LHS components of AG

Baseline model	Statistic	None	CASH	INVT	AREC	PPE	INTAN	OTHER
FF5F(AG)	$\Delta(maxSR^2)$	-0.037**	-0.037**	0.000	-0.008	-0.035**	-0.037**	-0.037**
	p-value	(0.037)	(0.049)	(0.996)	(0.597)	(0.031)	(0.032)	(0.024)
None	$\Delta(maxSR^2)$		-0.000	0.037**	0.028*	0.002	-0.001	-0.001
	p-value		(0.919)	(0.032)	(0.072)	(0.731)	(0.473)	(0.671)
FF3F	$\Delta(maxSR^2)$	0.025	0.024	0.062***	0.053**	0.027	0.024	0.024
	p-value	(0.124)	(0.149)	(0.007)	(0.014)	(0.124)	(0.139)	(0.143)

Panel B1: Comparing HXZ-like models using RHS components of AG

Baseline model	Statistic	None	COLIAB	NCOLIAB	DBT	EQ	RE
HXZ(AG)	$\Delta(maxSR^2)$	-0.078***	-0.053***	-0.087***	-0.045*	-0.038*	-0.022
	p-value	(0.002)	(0.004)	(0.001)	(0.065)	(0.060)	(0.339)
None	$\Delta(maxSR^2)$		0.025*	-0.009**	0.033**	0.040**	0.057**
	p-value		(0.065)	(0.034)	(0.026)	(0.014)	(0.012)
FF3F	$\Delta(maxSR^2)$	0.026	0.051**	0.017	0.060**	0.067**	0.083**
	p-value	(0.303)	(0.046)	(0.481)	(0.049)	(0.018)	(0.012)

Panel B2: Comparing FF5F-like models using RHS components of AG

Baseline model	Statistic	None	COLIAB	NCOLIAB	DBT	EQ	RE
FF5F(AG)	$\Delta(maxSR^2)$	-0.037**	-0.039**	-0.039**	0.030	-0.035**	-0.038**
	p-value	(0.037)	(0.024)	(0.021)	(0.223)	(0.025)	(0.026)
None	$\Delta(maxSR^2)$		-0.002***	-0.003	0.067***	0.001	-0.002
	p-value		(0.009)	(0.153)	(0.009)	(0.812)	(0.143)
FF3F	$\Delta(maxSR^2)$	0.025	0.023	0.022	0.091***	0.026	0.023
	p-value	(0.124)	(0.159)	(0.158)	(0.002)	(0.141)	(0.154)

Cross-sectional Regression Testing the Coverage Ability of INVT and AREC Factors

$$R_{AG,t} = \alpha + \beta_{INV} R_{INV,t} + \beta_{AREC} R_{AREC,t} + \gamma X_t + \epsilon_t \qquad (1)$$

Table 3
Spanning Regressions of AG factor and Subcomponents on Inventory and Accounts Receivable Factors.

Dependent Variable:	R_{AG}	R_{CASH}	R_{PPE}	R_{INTAN}	R_{OTHER}
Panel A: HXZ-Style Models					
α	0.001	-0.000	0.001	-0.000	0.000
	(1.64)	(-0.11)	(1.29)	(-0.36)	(0.86)
R_{MKT}	-0.026*	-0.021	-0.003	0.025	-0.017
	(-1.88)	(-1.51)	(-0.15)	(1.44)	(-1.21)
R_{ME}	0.075**	0.074***	0.105***	0.086***	0.011
	(2.49)	(3.27)	(3.50)	(3.48)	(0.34)
R_{ROE}	0.034	0.013	0.055	0.050	0.035
	(0.79)	(0.52)	(1.50)	(1.22)	(0.84)
R_{INVT}	0.310***	-0.042	0.171**	0.013	0.012
	(6.23)	(-0.82)	(2.57)	(0.23)	(0.26)
R_{AREC}	0.631***	0.280***	0.262***	0.177***	0.338***
	(8.95)	(5.93)	(5.80)	(3.09)	(6.53)
Obs	564	564	564	564	564
R^2	0.648	0.197	0.192	0.109	0.292

Dependent Variable:	R_{AG}	R_{CASH}	R_{PPE}	R_{INTAN}	R_{OTHER}
Panel B: FF5F-Style Models					
α	0.001	-0.000	0.000	-0.000	-0.000
	(1.27)	(-1.10)	(0.43)	(-0.53)	(-0.61)
R_{MKT}	-0.024	-0.016	0.024	0.045***	-0.008
	(-1.36)	(-0.84)	(1.22)	(3.48)	(-0.57)
R_{ME}	0.063***	0.062**	0.071**	0.095***	0.031
	(3.94)	(2.32)	(2.39)	(3.71)	(1.60)
R_{BM}	0.205***	0.119***	0.256***	0.061**	0.129***
	(8.13)	(5.19)	(6.12)	(2.09)	(3.81)
R_{PROF}	-0.012	0.017	0.025	0.136***	0.085***
	(-0.42)	(0.40)	(0.65)	(3.41)	(2.79)
R_{INVT}	0.323***	-0.042	0.265***	0.010	0.006
	(8.76)	(-1.01)	(2.88)	(0.15)	(0.14)
R_{AREC}	0.472***	0.131***	-0.032	0.118***	0.220***
	(9.17)	(2.96)	(-0.38)	(2.68)	(3.85)
Obs	564	564	564	564	564
R^2	0.740	0.236	0.320	0.183	0.331

Conclusion: Inventory and accounts receivable factors jointly capture the pricing information of the AG factor and all other AG sub-component factors for the HXZ and FF5F models.

Cross-sectional Regression Testing Whether INVT Factor Can Be Covered

$$R_{\mathrm{INV},t} = \alpha + \beta_{\mathrm{SUB}} R_{\mathrm{SUB},t} + \gamma X_t + \epsilon_t \qquad (2)$$

Table 4
Spanning Regressions of the Inventory Factor on AG Subcomponents.

Main RHS Factor:	R_{INVT}	R_{INVT}	R_{INVT}	R_{INVT}	R_{INVT}	R_{INVT}
Panel A: HXZ-Style Models						
α	0.003***	0.002**	0.003***	0.003***	0.003***	0.002**
	(4.55)	(2.37)	(3.68)	(4.93)	(4.01)	(2.42)
R_{MKT}	-0.087***	-0.029	-0.079***	-0.099***	-0.074***	-0.044**
	(-3.91)	(-1.60)	(-3.75)	(-4.62)	(-3.57)	(-2.19)
R_{ME}	-0.095***	-0.051**	-0.112***	-0.100***	-0.084***	-0.105***
	(-2.87)	(-1.98)	(-3.40)	(-3.29)	(-2.69)	(-3.53)
R_{ROE}	0.010	0.039	0.004	-0.001	0.007	0.028
	(0.19)	(1.04)	(0.09)	(-0.02)	(0.16)	(0.67)
R_{CASH}	0.206**					
	(2.31)					
R_{AREC}		0.487***				
		(8.52)				
R_{PPE}			0.333***			
			(4.47)			
R_{INTAN}				0.203**		
				(2.04)		
R_{OTHER}					0.356***	
					(5.07)	
$R_{AG-INVT}$						0.423***
						(7.13)
Obs	564	564	564	564	564	564
R^2	0.137	0.353	0.208	0.136	0.180	0.304

Main RHS Factor:	R_{INVT}	R_{INVT}	R_{INVT}	R_{INVT}	R_{INVT}	R_{INVT}
Panel B: FF5F-Style Models						
α	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***
	(4.33)	(3.62)	(4.04)	(4.37)	(4.27)	(3.67)
R_{MKT}	-0.059***	-0.037**	-0.060***	-0.061***	-0.056***	-0.043**
	(-3.20)	(-2.15)	(-3.30)	(-3.13)	(-2.91)	(-2.23)
R_{ME}	-0.160***	-0.149***	-0.168***	-0.168***	-0.163***	-0.173***
	(-4.74)	(-4.57)	(-4.97)	(-5.19)	(-4.84)	(-5.44)
R_{BM}	0.241***	0.182***	0.176***	0.231***	0.220***	0.139***
	(7.83)	(4.54)	(4.90)	(7.17)	(6.19)	(3.22)
R_{PROF}	-0.215***	-0.163***	-0.211***	-0.223***	-0.219***	-0.184***
	(-4.53)	(-3.59)	(-4.51)	(-5.47)	(-4.81)	(-4.14)
R_{CASH}	-0.019					
	(-0.27)					
R_{AREC}		0.232***				
		(2.97)				
R_{PPE}			0.199***			
			(2.99)			
R_{INTAN}				0.077		
				(0.68)		
R_{OTHER}					0.099	
					(1.35)	
$R_{AG-INVT}$						0.245***
						(3.23)
Obs	564	564	564	564	564	564
R^2	0.360	0.396	0.393	0.362	0.364	0.397

Conclusion: The pricing information of the inventory factor cannot be covered by any other individual sub-component of the AG factor or by the sum of other sub-components.

Cross-sectional Regression Testing Whether AREC Factor Can Be Covered

$$R_{\text{AREC},t} = \alpha + \beta_{\text{SUB}} R_{\text{SUB},t} + \gamma X_t + \epsilon_t \quad (3)$$

Table 5
Spanning Regressions of the Accounts Receivable Factor on AG Subcomponents.

Main RHS Factor:	R_{AREC}	R_{AREC}	R_{AREC}	R_{AREC}	R_{AREC}	R_{AREC}
Panel A: HXZ-Style Models						
α	0.003***	0.002**	0.003***	0.003***	0.002***	0.001**
	(4.46)	(2.36)	(3.84)	(4.63)	(4.29)	(2.44)
R_{MKT}	-0.109***	-0.086***	-0.116***	-0.141***	-0.093***	-0.061***
	(-4.87)	(-3.85)	(-4.76)	(-5.96)	(-4.34)	(-2.81)
R_{ME}	-0.091***	-0.006	-0.096***	-0.093***	-0.058**	-0.076***
	(-2.90)	(-0.21)	(-3.43)	(-3.08)	(-2.06)	(-2.91)
R_{ROE}	-0.018	-0.009	-0.029	-0.041	-0.029	-0.016
	(-0.32)	(-0.17)	(-0.48)	(-0.71)	(-0.73)	(-0.43)
R_{CASH}	0.557***					
	(8.24)					
R_{INVT}		0.546***				
		(9.44)				
R_{PPE}			0.413***			
			(6.49)			
R_{INTAN}				0.398***		
				(3.91)		
R_{OTHER}					0.692***	
					(13.00)	
$R_{AG-AREC}$						0.615***
						(13.14)
Obs	564	564	564	564	564	564
R^2	0.270	0.371	0.266	0.208	0.348	0.464

Main RHS Factor:	R_{AREC}	R_{AREC}	R_{AREC}	R_{AREC}	R_{AREC}	R_{AREC}
Panel B: FF5F-Style Models						
α	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***
	(4.29)	(3.00)	(3.99)	(4.09)	(4.49)	(3.49)
R_{MKT}	-0.085***	-0.076***	-0.091***	-0.098***	-0.080***	-0.071***
	(-5.10)	(-3.80)	(-5.17)	(-5.75)	(-4.62)	(-3.91)
R_{ME}	-0.068***	-0.015	-0.055**	-0.075***	-0.063***	-0.056**
	(-3.30)	(-0.67)	(-2.43)	(-3.53)	(-2.65)	(-2.42)
R_{BM}	0.208***	0.184***	0.233***	0.220***	0.175***	0.112***
	(7.50)	(5.52)	(8.17)	(7.03)	(5.05)	(2.71)
R_{PROF}	-0.224***	-0.173***	-0.225***	-0.250***	-0.238***	-0.194***
	(-5.55)	(-4.05)	(-5.23)	(-5.89)	(-6.47)	(-4.93)
R_{CASH}	0.229***					
	(3.25)					
R_{INVT}		0.240***				
		(3.20)				
R_{PPE}			0.025			
			(0.37)			
R_{INTAN}				0.228***		
				(2.79)		
R_{OTHER}					0.361***	
					(3.73)	
$R_{AG-AREC}$						0.302***
						(3.53)
Obs	564	564	564	564	564	564
R^2	0.370	0.387	0.352	0.370	0.404	0.403

Conclusion: The pricing information of the accounts receivable factor cannot be covered by any other individual sub-component of the AG factor or by the sum of other sub-components.

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Relationship Between AG and Macroeconomic Factors

Using twelve macroeconomic measures representing productivity, consumption, liquidity, uncertainty, financing costs, production networks, and market sentiment as factors, regression analysis was conducted on portfolios sorted by profitability and AG, INVT, AREC, or PPE growth as test assets.

Result

- All macroeconomic factors have significant pricing power in the cross-section of AG-based assets.
- Three factors representing technology shocks also perform significantly in the cross-section of PPE portfolios.
- Overall, AG, INVT, and AREC portfolios better capture the four factors of financing shocks than PPE portfolios.
- The only factor that can significantly help price AG, INVT, and AREC assets but not affect PPE assets is the stock market sentiment factor (BW).

Conclusion: AG, INVT, and AREC factors reflect financing shocks, while the PPE factor is primarily driven by productivity and technology shocks.

Economic Mechanism of Financing Substitution

- Short-term assets such as inventory and accounts receivable are more collateralizable than long-term assets, allowing them to better substitute debt for equity financing when equity financing costs rise.

- The AG factor, inventory factor, and accounts receivable factor better reflect corporate debt-equity substitution behavior during periods of low stock market sentiment, supporting the important role of short-term assets in financing shocks.

- The AG factor performs excellently when the economy is in a state of excessive extrapolation, but when the degree of extrapolation is low, its performance is inferior to other traditional models.

Contents

Wrap-ups

1

The explanatory power of the AG factor primarily comes from the dynamic changes in inventory and accounts receivable, rather than from investments in long-term assets (such as fixed assets and intangible assets).

2

The pricing ability of the AG factor may be closely related to the substitution mechanism between debt and equity. AG, INVT, and AREC factors better reflect whether companies are subject to collateral constraints.

3

The superior performance of AG, INVT, and AREC factors may stem from their ability to better capture overall financing shocks, especially financing shocks driven by stock market sentiment.

4

The superior performance of the AREC factor only appears during periods of high extrapolation, while during periods of low extrapolation, the HXZ and FF5F models do not significantly outperform traditional models.