



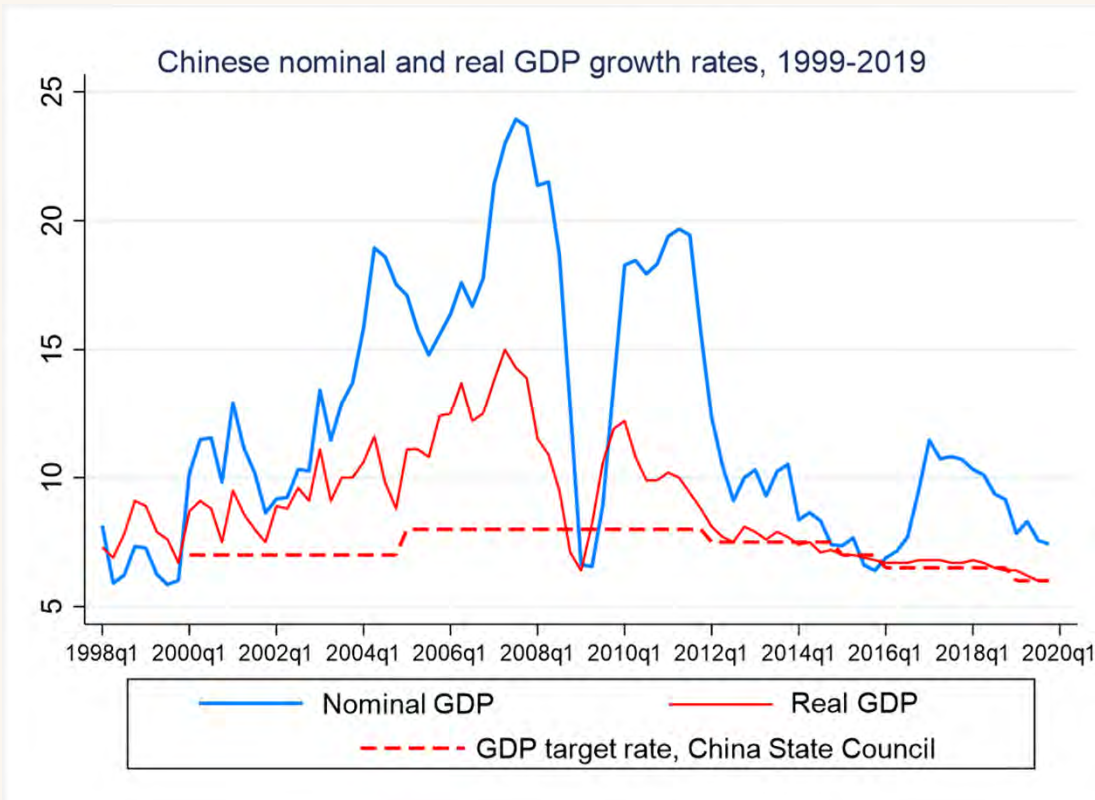
What 31 provinces reveal about growth in China?

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Motivation



- Growth in China is the main engine of the global economy
- Growth statistics have raised more doubts after the explicit GDP doubling target announcement in 2012
- What is flat, offers little hope for econometric analysis
- In this paper, we take advantage of greater statistical variance from a macroeconomic dataset at the level of 31 Chinese provinces

Main results

- We show that provincial data helps to forecast aggregate economic activity
- We reveal that the determinants of growth have changed
 - Before 2010: investment and urban productivity
 - After 2010: credit and government expenditure
- We introduce
 - a new alternative indicator for Chinese growth
 - a method to pinpoint changes in the underlying determinants of Chinese growth that can be updated easily

Contribution to literature

- 1) Reliability of Chinese official statistics and measurement challenges of economic activity
 - Accuracy of Chinese figures debated for decades (Rawski, 2000; Maddison and Wu, 2006; Maddison, 2006; Young, 2006, Perkins and Rawski, 2008; Holz, 2006, 2014; Clark et al. 2017)
 - Missing fluctuations gave rise to alternative indicators: China CAT by Fernald et al. (2019), Conference Board's alternative estimate based on Wu (2014), Li Keqiang –index, Barclay's Index, Bloomberg Index, Capital Economic Index, Lombard Street Index
 - Growth rate estimated using for ex. trade partner export data (Fernald et al., 2019), satellite night-time light intensity (Henderson et al., 2012) or alternative deflators (Kerola, 2019)
- Our contribution: missing fluctuations can be revealed using official provincial macroeconomic data and principal component analysis

- 2) Understanding and analysing the determinants of Chinese growth
 - China has gone through several phases during its transition (Chen and Zha, 2018)
 - Greater awareness should be paid to structural factors as business cycle fluctuations still play a smaller role (Laurenceson, 2013; Laurenceson and Rogers, 2010)
 - Heterogeneity across provinces depends on: greater exposure to international trade (Laurenceson, 2013), inefficient capital allocation and low labour mobility (Démurger et al., 2002), production structures and free labour mobility (Poncet and Barthélemy, 2008), degree of market system development and relative exposure to excess demand pressures (Mehrotra et al., 2010)
- Our contribution: using province-level data we are able to reveal how the determinants of growth have changed during 1999-2019 both with respect to economic variables and across provinces

Provincial and national data

- NBS has little control over provincial bureaus of statistics
 - Historically, a large discrepancy between the sum and growth rates of GPPs and GDP, due to: different compilation methods (Vu, 2010) and incentives to exaggerate output (Holz, 2014)
 - Past years saw many revelations of data falsification at the provincial level
- NBS took over the compilation of GPPs since 2019, provincial data revised extensively especially for 2018 (both up and down)
- Overall, no a priori reason to believe that provincial data would be of better quality, BUT:
 - NBS data revisions suggest that measurement errors can occur in both directions
 - 28,000 observations provide sufficient variation to reduce the probability of deviations from the underlying real growth in one direction or another

Data

- Provincial macroeconomic dataset in quarterly frequency
 - Data sources: NBS, PBoC, Ministry of Finance, Ministry of Human Resources and Social Security, SouFun CREIS
 - 31 provinces, time span 1999Q1 – 2019Q4

	Provincial panel			National data		
	# of obs	Mean	Std.dev.	# of obs	Mean	Std.dev.
Nominal GDP	2,604	11.37	8.71	88	12.15	4.88
Real GDP	2,604	13.47	9.25	88	8.89	2.19
CPI inflation	2,604	2.10	2.28	82	2.03	2.09
Consumption	2,604	9.62	7.50	79	9.57	2.30
Bank loans	2,604	12.90	8.65	74	13.23	5.37
Investments	2,511	15.65	11.66	81	14.02	5.77
Gov't expenditures	2,511	13.95	9.36	82	16.88	16.22
House prices	2,490	4.61	6.00	71	5.11	4.29
Population	2,387	0.82	1.36	87	0.56	1.00
Urban employment	2,387	4.97	6.71	84	3.57	0.67
Productivity	2,542	9.03	11.38	84	5.45	1.72

Using provincial data in three different ways

1. Provincial panel: all variables for 31 provinces
2. Variable specific principal components: each of the variables compressed into one component
3. Full information principal components: full panel compressed into principal components

Proportion of variance explained by variable specific principal components for each variable in provincial panel		Proportion of variance explained by first eight full information principal components for the whole provincial panel		
	Proportion (%)		Proportion (%)	Cumulative (%)
Nominal GDP	56.6 %	Comp1	22.89 %	22.89 %
Real GDP	50.4 %	Comp2	13.16 %	36.05 %
CPI inflation	82.4 %	Comp3	9.74 %	45.80 %
Consumption	37.9 %	Comp4	6.57 %	52.37 %
Bank loans	57.3 %	Comp5	5.63 %	58.00 %
Investments	55.4 %	Comp6	5.29 %	63.29 %
Gov't expenditures	35.6 %	Comp7	4.21 %	67.50 %
House prices	56.5 %	Comp8	3.78 %	71.28 %
Population	39.7 %			
Urban employment	52.0 %			
Productivity	40.6 %			

1. Projecting national GDP growth

Provincial data is highly relevant in projecting national growth, a panel approach

Provincial panel		Whole time span		
Overall R2 0.607, # obs: 2310				
	Coeff	F-stat	Prob>F	Marginal R2
Inflation	-1.411	1331.35	0.000	0.228
Credit	0.122	193.10	0.000	0.033
Investments	0.076	116.70	0.000	0.020
Productivity	0.034	16.05	0.000	0.003
Consumption	-0.034	10.92	0.001	0.002
Gov't expend.	-0.016	3.22	0.073	0.001
Population	-0.082	3.08	0.080	0.001
Urban empl.	0.006	0.19	0.663	0.000
House prices	0.003	0.05	0.823	0.013

- Aggregate growth measured by official **nominal** GDP growth
- Granger causality tests confirm that provincial data is relevant and highly significant in projecting aggregate growth in China
- Nominal GDP today seems to reflect what happened in the provinces 4 quarters ago

Results hold in time series, i.e. after compressing the economic information from provinces into principal components

Variable specific principal components	Whole time span Overall R2 0.840, # obs: 77				Full information principal components	Whole time span Overall R2 0.849			
	Coeff	F-stat	Prob>F	Marginal R2		Coeff	F-stat	Prob>F	Marginal R2
pc(inflation)	43.83	0.000	0.170		Principal comp 6	-0.437	74.39	0.000	0.115
pc(credit)	15.55	0.000	0.025		Principal comp 3	0.486	73.58	0.000	0.267
pc(investments)	15.20	0.000	0.025		Principal comp 2	-0.197	26.52	0.000	0.062
pc(consumption)	4.48	0.038	0.009		Principal comp 4	0.170	12.23	0.001	0.023
pc(productivity)	3.77	0.056	0.007		Principal comp 8	0.237	9.50	0.003	0.029
pc(population)	2.71	0.105	0.008		Principal comp 5	-0.030	0.32	0.574	0.001
pc(gov't exp.)	2.01	0.161	0.004		Principal comp 1	-0.001	0.00	0.990	0.000
pc(urban empl.)	0.59	0.447	0.002		Principal comp 7	-0.004	0.00	0.944	0.000
pc(house prices)	0.06	0.802	0.001						

Provincial data can be used to build up alternative indicators for Chinese growth

$$GDP_t = GDP_{t-4} + X_{t-4} + \varepsilon_t$$

- Three candidates for X:
 1. Using stat.significant full information principal components
 2. Using stat.significant variable specific principal components
 3. Using stat.significant provincial panel variables
- Result: three different estimated time series

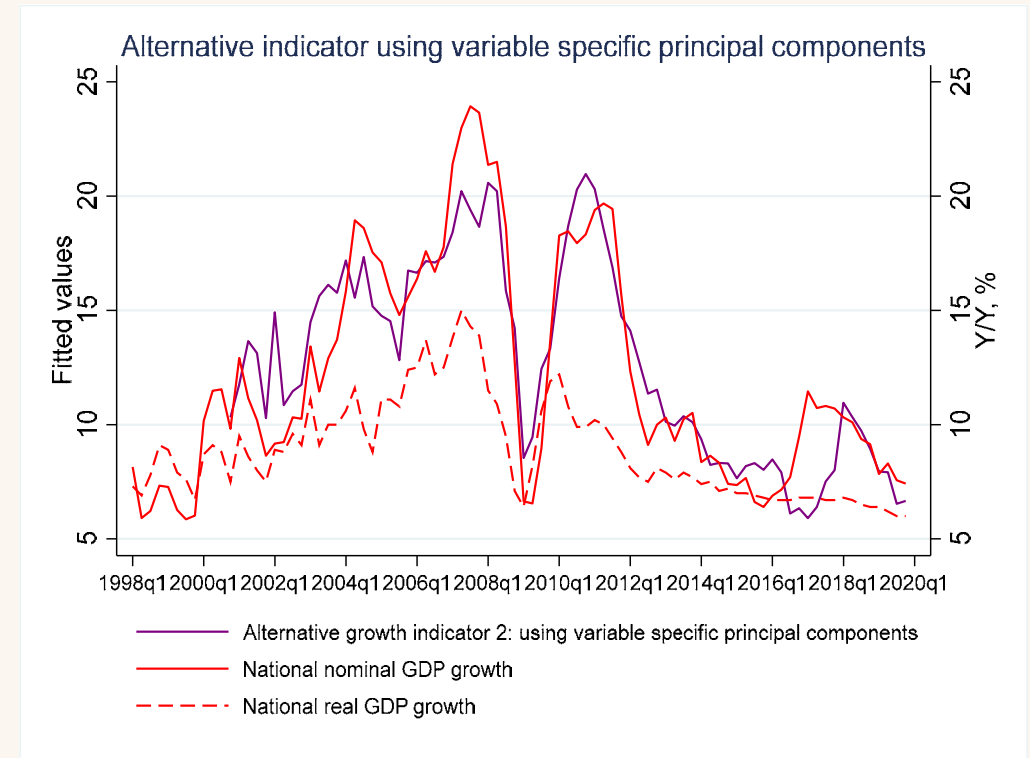
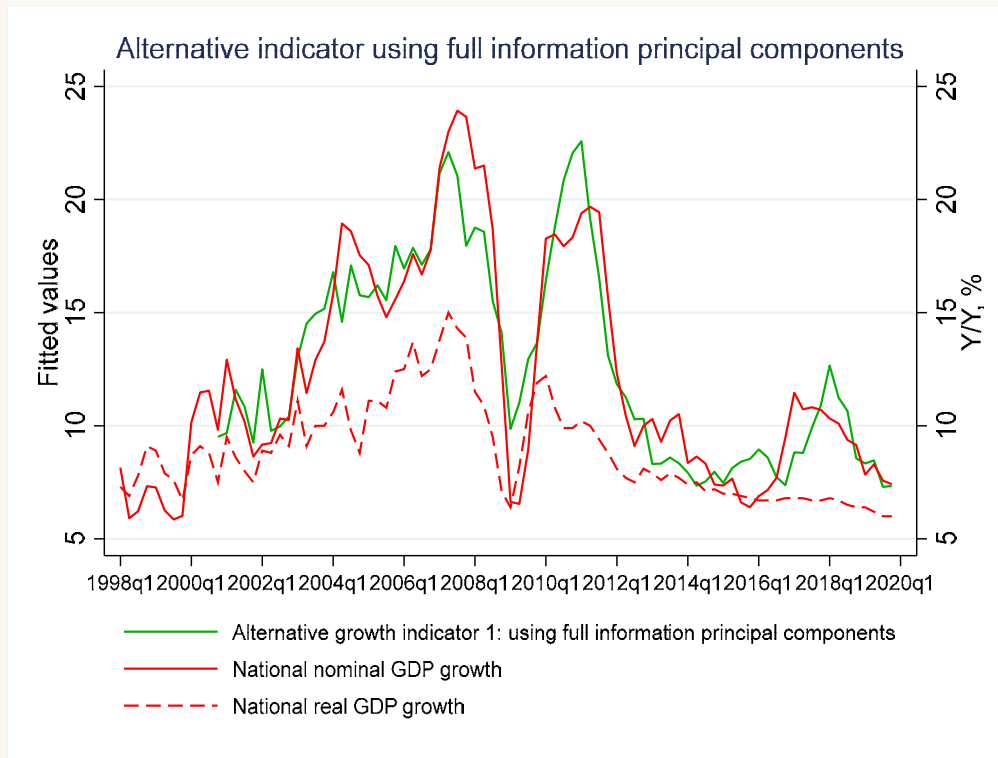
Provincial data can be used to build up alternative indicators for Chinese growth

	Alternative growth indicators							
	National nominal GDP	National real GDP	Li Keqiang index	Business Climate Index, NBS	Business Climate Index, PBoC	(1) Using stat.sign. full info PCs	(2) Using stat.sign. var spec. PCs	(3) Using stat.sign. provincial vars
National nominal GDP	1.00							
National real GDP	0.84	1.00						
Li Keqiang index	0.56	0.75	1.00					
Business Climate Index, NBS	0.84	0.68	0.49	1.00				
Business Climate Index, PBoC	0.87	0.82	0.65	0.83	1.00			
Alternative growth indicators								
1) Using statistically significant full information principal components*	0.90	0.78	0.50	0.78	0.88	1.00		
2) Using statistically significant variable specific principal components**	0.89	0.82	0.47	0.79	0.89	0.95	1.00	
3) Using statistically significant provincial variables***	0.73	0.65	0.37	0.66	0.79	0.81	0.85	1.00

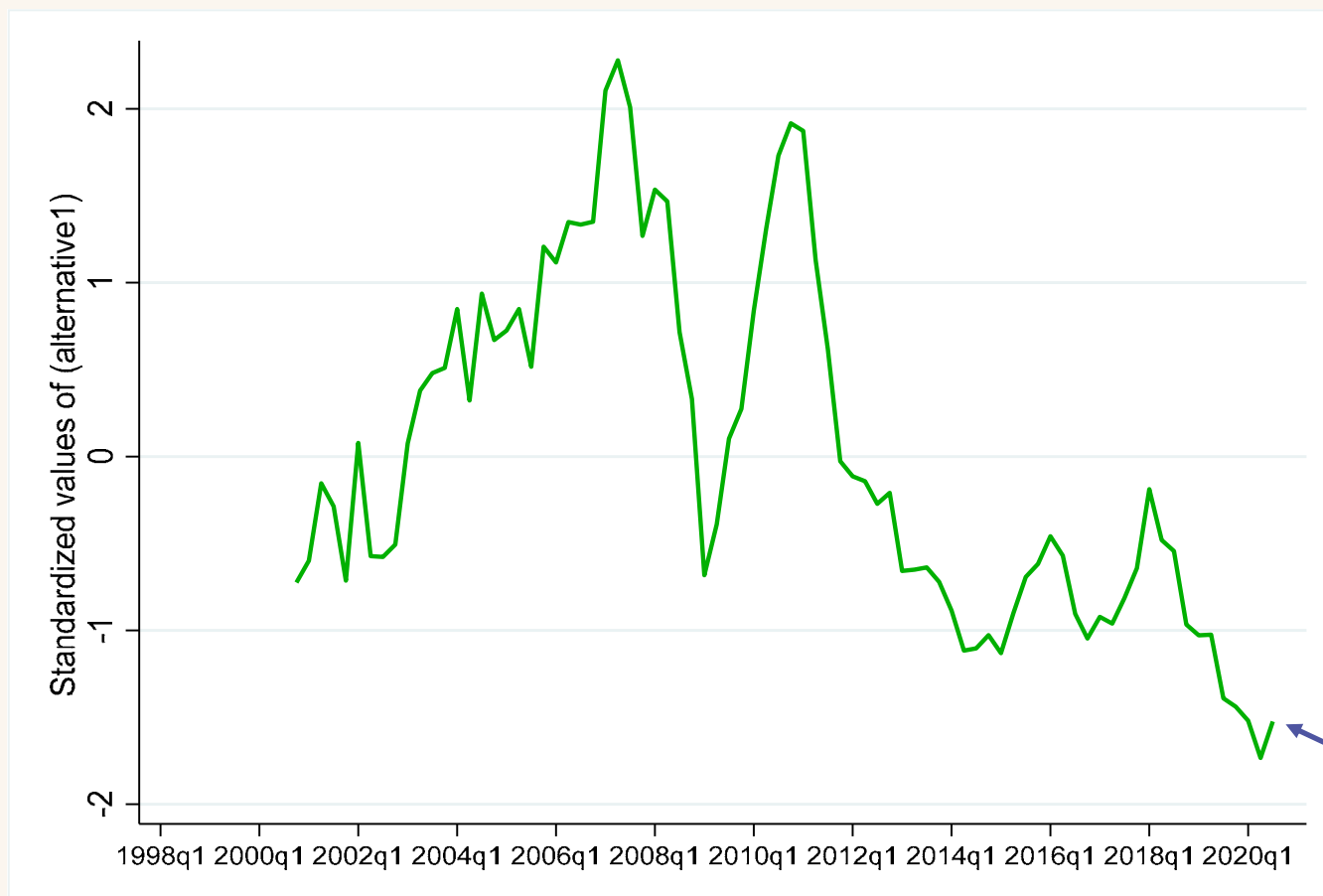
* Full information principal components PC2, PC3, PC4 PC6 and PC8. ** Variable specific principal components: pc(inflation), pc(credit) and pc(investments) *** Provincial variables: inflation, credit, investments, productivity and consumption

All alternative indicators computed by regressing nominal aggregate growth on its own (4 quarter) lagged value and the (4 quarter) lagged values of the statistically significant variables.

Alternative growth indicators reveal fluctuations not present in the official real GDP growth

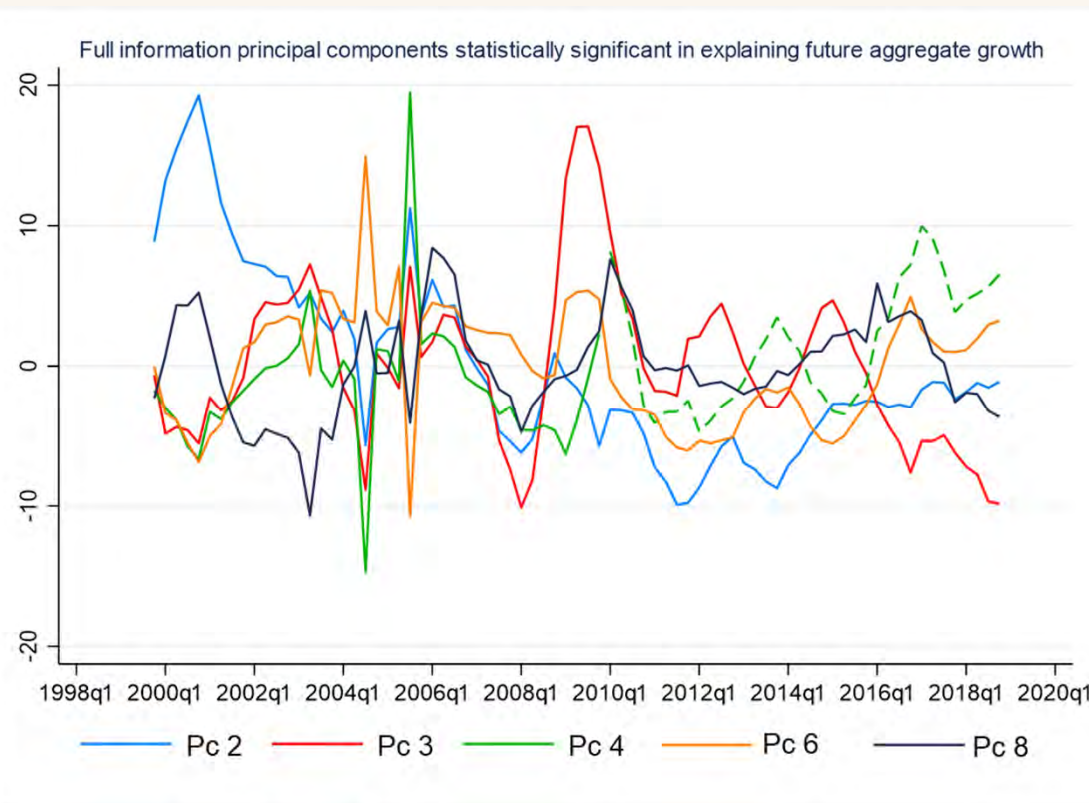


Alternative growth indicator will be published online and updated quarterly



2. Determinants of Chinese growth

A closer look at the full information principal components statistically significant for national GDP growth



- Principal component analysis allows to compress the provincial data into a smaller number of uncorrelated components
- Main drivers of these components can be identified by looking at the factor loadings
- Largest factor loadings:
 - Pc2: Productivity – urban employment
 - Pc3: Credit + investments – inflation – house prices
 - Pc4: House prices – gov't expenditures
 - Pc6: House prices + investments – consumption
 - Pc8: Consumption – gov't expenditures

What is Chinese growth correlated with?

A statistical model of Chinese growth

Principal components with largest factor loadings	Whole time span			
	Coeff.	t	P > t	Marginal R2
National GDP growth (lagged)	0.561	9.19	0.000	0.275
Pc3: Credit + investments - inflation - house prices	0.485	10.90	0.000	0.322
Pc6: House prices + investments - consumption	0.438	9.43	0.000	0.142
Pc2: Productivity - urban employment	0.196	6.20	0.000	0.072
Pc8: Consumption - gov't expenditures	0.238	7.17	0.000	0.030
Pc4: House prices - gov't expenditures	0.169	4.34	0.000	0.026
Number of observations	77			
R-squared	0.834			

Note: Dependent variable: nominal aggregate GDP growth. All four quarter lagged values.

For the full sample, national growth is driven predominantly by:

- Credit in real terms
- Difference between investments and consumption
- Developments in productivity and urban employment

Do the drivers change across time?

More specifically, we want to know whether the determinants of growth have changed after 2010:

- Growth moderated after years of accelerating pace
- Officials became more fixated with numerical growth targets

We explore our provincial data in 3 different ways:

1. Redo previous regression separately before/after

Do the drivers change across time? (1/3)

Principal components with largest factor loadings	Whole time span				Before 2010				After 2010			
	Coeff.	t	P > t	Marginal R2	Coeff.	t	P > t	Marginal R2	Coeff.	t	P > t	Marginal R2
National GDP growth (lagged)	0.561	9.19	0.000	0.275	0.799	3.8	0.001	0.086	0.568	6.73	0.000	0.234
Pc3: Credit + investments - inflation - house prices	0.485	10.90	0.000	0.322	0.699	4.87	0.000	0.122	0.319	5.70	0.000	0.107
Pc6: House prices + investments - consumption	0.438	9.43	0.000	0.142	0.557	4.31	0.000	0.076	0.513	4.19	0.000	0.077
Pc2: Productivity - urban employment	0.196	6.20	0.000	0.072	0.366	2.08	0.047	0.024	0.262	2.07	0.046	0.015
Pc8: Consumption - gov't expenditures	0.238	7.17	0.000	0.030	0.222	1.70	0.100	0.015	0.348	3.04	0.005	0.026
Pc4: House prices - gov't expenditures	0.169	4.34	0.000	0.026	0.124	1.14	0.263	0.005	-0.119	-1.20	0.237	0.004
Number of observations	77				37				40			
R-squared	0.834				0.810				0.879			

Note: Dependent variable: nominal aggregate GDP growth. All four quarter lagged values.

- Most of the growth determinants have higher marginal R2 for the full sample than for each of the subsamples
 → these drivers capture persistent phenomena and changes in fluctuations relevant across the two sub-samples

Do the drivers change across time? (1/3)

Principal components with largest factor loadings	Whole time span				Before 2010				After 2010			
	Coeff.	t	P > t	Marginal R2	Coeff.	t	P > t	Marginal R2	Coeff.	t	P > t	Marginal R2
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Pc6: House prices + investments - consumption	0.438	9.43	0.000	0.142	0.557	4.31	0.000	0.076	0.513	4.19	0.000	0.077
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After 2010:

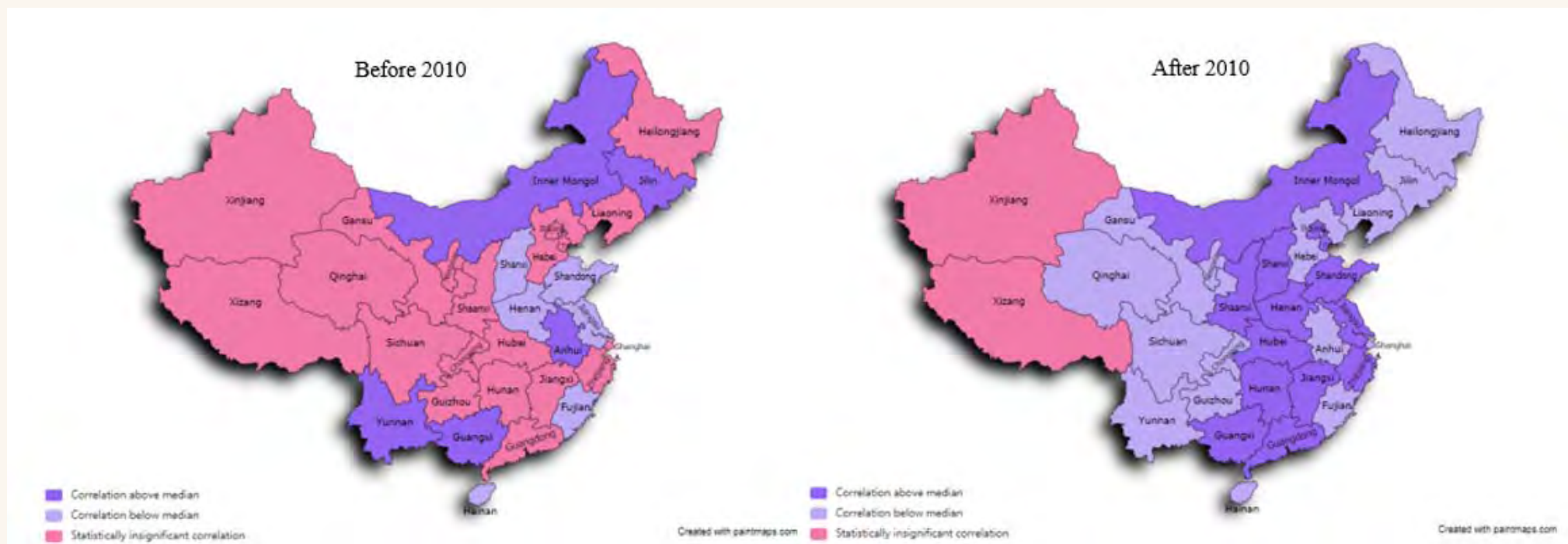
- The impact of (house prices - gov't exp) changes sign
- Credit in real terms and productivity and urban employment matter less to aggregate growth
- Consumption and gov't expenditure gain importance as drivers

What is true for the aggregate may not be true for all provinces: how each province fits into this statistical model?



- For each province we construct its representation of the model using factor loadings and coefficients estimated for the full model and economic variables at province-level
- Result: 31 time series representing our statistical model of Chinese growth for each province
- Are the provincial mappings of the model correlated with aggregate growth?
 - **Pink** provinces: no correlation
 - **Blue** provinces: statistically significant correlation

After 2010, model applies to a larger number of provinces



Do the drivers change across time?

More specifically, we want to know whether the determinants of growth have changed after 2010:

- Growth moderated after years of accelerating pace
- Officials became more fixated with numerical growth targets

We explore our provincial data in 3 different ways:

1. Redo previous regression separately before/after
2. Panel regressions across blue and pink provinces before/after

Do the drivers change across time? (2/3)

	Before 2010				After 2010			
	Provincial model correlated with national growth		Insignificant correlation between provincial model and national growth		Provincial model correlated with national growth		Insignificant correlation between provincial model and national growth	
	Marginal R2		Marginal R2	Marginal R2		Marginal R2		Marginal R2
L4. national GDP	0.811*** (0.048)	0.211	0.852*** (0.070)	0.238	0.658*** (0.034)	0.136	0.785*** (0.091)	0.172
L4. credit	0.071*** (0.016)	0.012	0.085** (0.033)	0.010	0.212*** (0.017)	0.058	0.237*** (0.037)	0.076
L4. consumption	-0.057*** (0.017)	0.006	-0.019 (0.028)	0.000	0.007 (0.015)	0.000	-0.050 (0.046)	0.003
L4. investments	0.089*** (0.014)	0.023	0.047 (0.044)	0.002	0.037*** (0.010)	0.005	0.023 (0.022)	0.002
L4. gov't expenditures	-0.090*** (0.016)	0.016	-0.045 (0.037)	0.002	0.041*** (0.010)	0.004	0.090*** (0.023)	0.029
L4. inflation	-1.383*** (0.092)	0.236	-1.283*** (0.114)	0.240	-1.265*** (0.090)	0.064	-1.427*** (0.196)	0.115
L4. productivity	0.069*** (0.017)	0.009	0.031 (0.026)	0.002	0.014 (0.010)	0.000	-0.031 (0.025)	0.003
L4. population	-0.069 (0.073)	0.000	-0.148 (0.176)	0.001	0.086 (0.076)	0.000	0.083 (0.319)	0.000
L4. urban employment	0.155*** (0.029)	0.017	0.488*** (0.076)	0.070	-0.051*** (0.015)	0.004	-0.109*** (0.032)	0.022
L4. house prices	-0.097*** (0.032)	0.006	-0.109** (0.047)	0.095	0.056*** (0.010)	0.009	0.083* (0.046)	0.103
Constant	4.201*** (0.650)		4.540*** (1.339)		2.426*** (0.292)		1.363* (0.762)	
Observations	888		222		960		240	
R-squared	0.485		0.612		0.743		0.603	

Robust standard errors in parentheses. Variables all in growth rates. Lag 4 quarters. Dependent variable national nominal GDP.

30.1 p=0.01, ** p<0.05, * p<0.1

Investments and productivity replaced by public expenditure, credit and house prices

- Before 2010, correlated provinces were driving on investment and productivity (green boxes)
- After 2010, growth is supported extensively more by public expenditure, credit and house prices (orange boxes)



Do the drivers change across time? (2/3)

	Before 2010				After 2010			
	Provincial model correlated with national growth		Insignificant correlation between provincial model and national growth		Provincial model correlated with national growth		Insignificant correlation between provincial model and national growth	
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25

Reallocation of labour towards cities less prominent after 2010

- Before 2010, growth was supported by urbanization and productivity of the urban workforce
- After 2010, this source of growth seems to have run its course. Now more urban employment is actually reducing growth



Do the drivers change across time?

More specifically, we want to know whether the determinants of growth have changed after 2010:

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- Officials became more fixated with numerical growth targets

We explore our provincial data in 3 different ways:

1. Redo previous regression separately before/after
2. Panel regressions across blue and pink provinces before/after
3. Estimating full info PCs separately before/after

Do the drivers change across time? (3/3)

What we do?

1. Estimate full information principal components across subsamples, identify the main drivers (factor loadings)
2. Test granger causality between estimated principal components and national nominal growth

Before 2010: Granger causality

	Coeff	F-stat	Prob>F	Marginal R2
Pc 2: <i>Urban employment - productivity</i>	0.713	26.13	0.000	0.178
Pc 3: <i>Consumption - gov't expenditures - house prices</i>	0.443	31.64	0.000	0.117
Pc 5: <i>Investments - productivity</i>	0.387	13.80	0.001	0.088
Pc 1: <i>Population - inflation</i>	0.327	6.38	0.018	0.031

of obs: 37

R-squared: 0.843

Note: lagged value of the dependent variable omitted from results. Explanatory variables lagged by 4 quarters.

After 2010: Granger causality

	Coeff	F-stat	Prob>F	Marginal R2
Pc 2: <i>House prices - inflation</i>	0.245	111.77	0.000	0.100
Pc 3: <i>Credit + consumption</i>	0.204	116.10	0.000	0.092
Pc 8: <i>Credit + investments</i>	0.232	43.02	0.000	0.035
Pc 1: <i>Inflation + investments + gov't expenditures</i>	0.282	26.87	0.000	0.032
Pc 5: <i>Inflation + credit - consumption</i>	0.079	10.53	0.003	0.006

of obs: 40

R-squared: 0.971

Note: lagged value of the dependent variable omitted from results. Explanatory variables lagged by 4 quarters.

Do the drivers change across time? (3/3)

What we find?

- Before 2010: growth driven by urban employment and productivity, consumption and investments
 - After 2010: growth driven predominantly by house prices and credit
- ❖ Results again largely confirm our previous analyses
 - ❖ As this third method can be used with little effort, it can be updated regularly to detect changes in underlying determinants of growth

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To conclude

- Which ever way we use the richness of the provincial data, we have relevant information to understand and project Chinese aggregate growth
- We use provincial data to build and publish an alternative indicator for Chinese growth. It detects fluctuations missing from official statistics.
- Over time, growth determinants change both with respect to economic variables and provinces
 - Before 2010, growth was driven more by productivity, urban employment and investments
 - After 2010, growth has become more dependent on government expenditure, credit and house prices
 - Furthermore, these new determinants of growth also apply more homogeneously to a larger group of Chinese provinces
 - One question is, for how long can this go on?



Thank you!

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