Nowcasting China Real GDP

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February 2013

Abstract

In this paper we nowcast mainland China real GDP estimating a Dynamic Factor Model on a set of mixed frequency indicators to exploit the information content of more timely data in producing early forecasts of GDP figures. Estimating the model via quasi maximum likelihood (Doz et al, (2012), Bańbura and Modugno (2012)) allows to efficiently handle complications arising from the dissemination pattern and transformations of Chinese data types; moreover, model-based *news* can be used to sequentially update GDP nowcasts allowing for a meaningful interpretation of the revision process. We evaluate the model running a pseudo real time forecasting exercise over the period 2008 - 2013 and show how the model efficiently processes new information increasing forecasting accuracy as more data releases are taken into account; this ultimately delivers a forecast which is comparable to the best judgemental forecasts available within financial markets, while significantly outperforming the standard AR benchmark. We also evaluate model performance against institutional forecasters in terms of annual growth rates: we show how model-implied annual rates become extremely accurate at Q4, beating virtually all the surveyed benchmarks, with performance expected to further improve towards the end of the year.

JEL Classification: C33, C53, E37

Keywords: Nowcasting; Forecasting; Factor Model; News.

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1 Introduction

In this paper we undertake the task of nowcasting real GDP for mainland China. Nowcasting is defined as the prediction of the present, the very near future and the very recent past and is therefore particularly relevant for those variables that - like GDP - albeit being critical in evaluating current economic performance, are only available at low frequency, typically quarterly, and are published with significant delay, making also the recent past unknown. In order to produce early estimates of GDP, nowcasting involves exploiting the information content of indicators that, related to GDP, are available both at higher frequency and in a more timely fashion. Such assessments are routinely conducted within major policy institutions that employ either judgement, or simple models (i.e. bridge equations), or a combination of the two to gauge insights on the current status of the economy using information contained in potentially very large sets of relevant economic variables. However, despite being a crucial activity in virtually all central banks, nowcasting is relatively novel to the academic literature and started catalyzing attention only after the work of Evans (2005) and Giannone, Reichlin and Small (2008) when the problem was for the first time formalized within a coherent statistical framework. Subsequent research work has then extended the number of nowcasting applications to an ever growing sample of countries (see Bańbura et al. (2010) and Banbura, Giannone, Modugno and Reichlin (2012) for a survey). Yiu and Chow (2010) apply the model in Giannone, Reichlin and Small (2008) to an heterogeneous set of monthly indicators including information on real economy as well as prices and financial variables to nowcast Chinese GDP and find that the forecasting performance improves upon the random walk benchmark; moreover they find that, presumably due to the adopted convention according to which they are the first variables to be released within a reference month, interest rate-related variables are the single most important block of information when it comes to update current quarter GDP estimates. Following a different approach, Maier (2011) compares the performance of an economic activity index, indicator-model averaging and a static factor model as well as pooled forecasts to predict current and next quarter Chinese GDP finding that factor models generally deliver a superior results; also in this case the underlying set of data contains information on both real and financial variables.

Our approach differs from the above mentioned studies in at least two aspects. On one hand we concentrate our attention only on the real side of the economy and therefore exclude from the set of potential relevant indicators all prices and financial variables. On the other hand, we nowcast Chinese GDP estimating a Dynamic Factor Model using quasi maximum likelihood as in Doz, Giannone and Reichlin (2012) and Banbura and Modugno (2012). Banbura and Modugno (2012) generalize the framework delineated in Doz *et al.* (2012) deriving maximum likelihood estimators for factor models on data set that are characterized by the presence of arbitrary patterns of missing data. Being able to efficiently bypass the problem of missing data translates in practice into maximum likelihood being feasible even when data are are published at different frequency and in a non-synchronous fashion yielding the so called "ragged edge" towards the end of the sample; crucially, the ability of such framework to deal with missing data proves particularly beneficial in the context of Chinese data whose publication schedule hardly delivers a balanced panel at any given vintage. Notably, Banbura and Modugno (2012) also show how, following economic data releases, model-based *news* can be estimated and how these are the principal determinant of forecast revisions. Intuitively, the concept of *news* is related to the fact that it is not the released value *per se* that moves the forecast, rather, it is the "surprise" effect associated to the unexpected component of the economic release the main driver of forecast revision. In the context of nowcast revisions, the unexpected component associated to the news translates into that component of the release due at time $v + 1$ that deviates from what the model predicted it to be based on information available up to time v, where v denotes the release date/time of a particular variable. This formalization implies that together with the nowcast of GDP, the model also produces forecasts for all the input variables, and that - abstracting from data revision - what effectively drives forecast revision is the (opportunely weighted) forecast error associated to each release; therefore, each forecast update can be given in this context a meaningful, model-based, interpretation.

Naturally constrained by data availability, we estimate the model on a relatively small scale data set of monthly and quarterly indicators selected to best represent the Chinese economy and evaluate model performance running a pseudo real time forecasting exercise over the period from Q1 2008 up to Q1 2013. We show how the model significantly gains accuracy when compared to naive AR, and performs remarkably well when institutional and market forecasts are used as benchmarks. Due to lack of seasonally adjusted official GDP data, and contrary to standard nowcasting applications, we use as target variable the year-on-year growth rate of real GDP at quarterly frequency; this is also motivated by the fact that China did non experience negative growth at least since the early Fifties and therefore looking at growth rates cycles is a sensible choice in this setting. Chinese GDP figures are compiled by the National Bureau of Statistics (NBS) and - being released around 20 days after the end of the reference quarter - are incredibly timely when compared with other countries. Official GDP releases comprise quarterly nominal year-to-date (YTD) levels in billion Yuan and two quarterly series of real rates, a year-on-year (YoY) and a YTD YoY rate, both at constant (1990) prices; from Q4 2010, the NBS releases seasonally adjusted QoQ real rate however, due to its short history and to the fact that at every new release the entire series gets revised, this indicator has received relatively little attention. Annual levels and growth rates are also distributed by the NBS within the Statistical Communiqué on the National Economic and Social Development due towards the end of February every year[1].

[1]The NBS (formerly State Statistical Bureau - SSB) starts compiling GDP figures only in 1985 when alternative measures such as National Income and Uses of National Income defined by the Soviet-style Ma-

Although there is a clear effort in producing more accurate data starting form the Nineties, the quality and reliability of Chinese statistics in general and of GDP data in particular, has been repeatedly challenged by scholars and international observers who have raised concerns about the lack of consistency between local and aggregate data suggesting growth figures might have been artificially inflated over the years by local authorities whose status and compensation were intimately linked to economic performance. Arguably due to local officials exaggerating growth performance and figures reporting growth objectives rather than actual achievements, regional figures are more often than not found to be at odds with aggregated national counterparts [Wu and Ozyildirim (2011)]. Yet another concern relates to data revisions and how these are accounted for at different levels of time aggregation; Maier (2011) notes that quarterly figures do not always add up to annual figures[2] presumably because when annual growth figures get revised at a later date, corresponding quarterly numbers for the same year are not updated accordingly; this is particularly true for early releases since the NBS only started officially benchmarking quarterly GDP to verified annual data in 2003 while previous figures have been left untouched (i.e. no adjustment or revision or benchmarking) [Curran and Funke (2006) and references therein]. Finally, the size of revision can be quite substantial; to account for underestimation of the actual size of Chinese economy due to under-representation of the tertiary sector, in 2005 GDP data underwent major revisions with both size of the economy and historical real GDP growth rates between 1993 and 2004 revised upwards by 16.8% and 0.5% respectively [Goldman Sachs Asia Economic Group (2006)].

Notwithstanding the critiques just detailed, we believe GDP statistics remain the main indicator to evaluate Chinese growth performance and - given the increasing relevance of China as an international player - one of the key world economic variables. To support this claim, figure 1 plots the evolution of the factor estimated by the model across all available vintages over the evaluation sample. The red crosses are placed at the last available observation in each vintage and the gray shaded area is the first release of YoY GDP rate. The factor is transformed to have the same mean and standard deviation of GDP. Despite all criticism, what figure 1 implies is that the collection of Chinese data that we select tells overall a very coherent story, with the common factor tracking GDP and its turning points remarkably well over time.

The remainder of the paper is organized as follows: section 2 briefly describes the issue of Lunar calendar and introduces notation for data types and transformations; the model is detailed in section 3 with a dedicated section on the definition of the *news* and the process of forecast

terial Production System (MPS) of accounts are discarded in favor of a system of accounts more compatible to the United Nations SNA standard.

[2] Official annual growth rate for 2009 is 9.1% while calculating the same rate starting from quarterly GDP releases yields 8.4% [Maier (2011)].

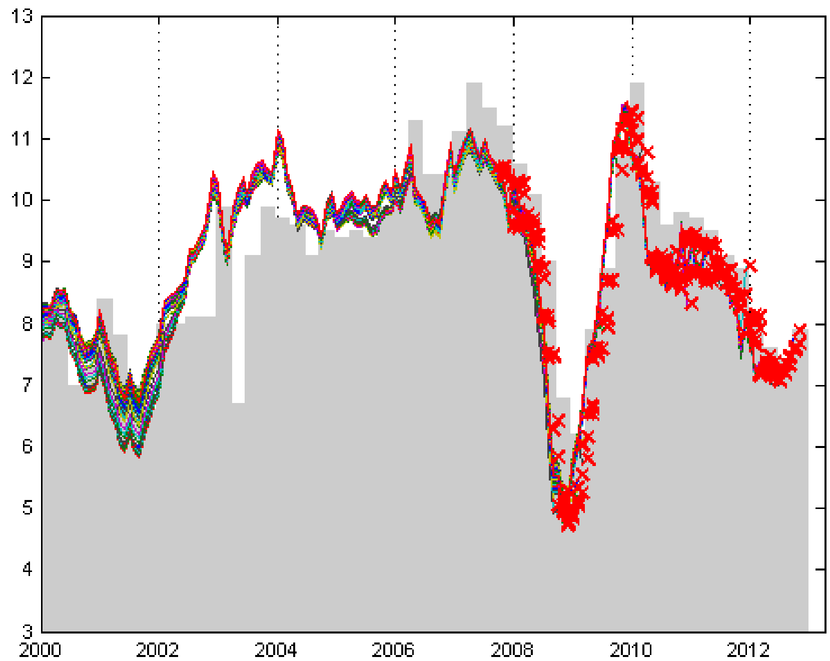

Figure 1: Real time factor for all vintages in the evaluation sample. Red crosses are placed at the last observation in each vintage. The gray shaded area is the first release GDP rate, the factor is transformed to have the same mean and standard deviation of GDP.

revisions. Data selection criteria and description of the data used are in section 4 with a short description of the calendar of economic data releases available at the end of the section. Results are commented in section 5 and section 6 concludes. Additional details on input data and their transformation is reported in Appendix A at the end of the paper.

2 Note on Lunar Calendar and Data Types

One of the major challenges when confronted with the task of forecasting Chinese GDP is being able to cast all relevant information in a framework which is able to accommodate all the peculiarities of Chinese data types. Even abstracting from issues related to availability of relevant indicators, most of which started being published only very recently, the format and characteristics of Chinese data remain fundamentally different from those relative to all other economies; in particular, Chinese data are disseminated in a number of different formats some of which owe their peculiarity to the fact that the most important Chinese holidays have dates that are determined by a lunar calendar and can therefore oscillate between two consecutive (solar) months. Table 1 below summarizes the main characteristics of Chinese data types and the notation adopted throughout the paper.

Other than impacting on data types, adherence to the lunar calendar also influences the calendar of economic data releases; particularly crucial in all these aspects is the occurrence of the the Spring Festival (or Chinese New Year) which is the most important of Chinese holidays and whose date falls between January and February every year. Because of its relevance among Chinese festivities, the Spring Festival has an extraordinary impact on the overall economic activity due to production almost ceasing during the weeks dedicated to its celebration. Due to this phenomenon, not only will seasonality be present when looking at economic indicators in levels, but also when transformations such as month-on-month (MoM) and, most notably, year-on-year (YoY) growth rates are taken into account[3]. Provided that officially seasonally adjusted data are not directly available at source, in an attempt to cope with this issue, the NBS has instead opted for scheduling the calendar of press releases such that figures referring to monthly indicators which are more directly linked to the production side of the economy are released only eleven times in a year, with numbers referring to both January and February being jointly published in March[4]. Furthermore, for these indicators, rather than publishing pure level data, the NBS adopts a year-to-date (YTD) transformation that consists of releasing figures that track the evolution of the indicator from the beginning of each solar year; this way March releases will include information accumulated over the first two months without effectively splitting the contribution specific to either January or February, and

[3]If the Spring Festival falls into two different months over two consecutive years then YoY rates for Jan and Feb are highly distorted.

[4]http://www.stats.gov.cn/english/pressrelease/releasecalendar/t20120109_402787732.htm

Table 1: **Chinese data types**

frequency	type	notation[♮]	example
monthly	level	$Y^M_{i,t}$	
	YTD level[†]	$\tilde{Y}^M_{i,t} = \sum_{j=1}^{t} Y^M_{i,j}$	Imports from Asia
	YTD level[‡]	$\tilde{Y}^M_{i,t} = \sum_{j=1}^{t} Y^M_{i,j}$	Fixed Assets Inv't
	MoM rate	$y^M_{i,t} = Y^M_{i,t} - Y^M_{i,t-1}$	CPI
	YoY rate[§]	$y^{MY}_{i,t} = Y^M_{i,t} - Y^M_{i-1,t}$	real IP
	YTD YoY rate[♭]	$\tilde{y}^{MY}_{i,t} = \tilde{Y}^M_{i,t} - \tilde{Y}^M_{i-1,t}$	real IP
quarterly	level	$Y^Q_{i,s}$	
	YTD level	$\tilde{Y}^Q_{i,s} = \sum_{j=1}^{s} Y^Q_{i,j}$	nominal GDP
	QoQ rate	$y^Q_{i,s} = Y^Q_{i,s} - Y^Q_{i,s-1}$	real GDP
	YoY rate[§]	$y^{QY}_{i,s} = Y^Q_{i,s} - Y^Q_{i-1,s}$	real GDP
	YTD YoY rate[♭]	$\tilde{y}^{QY}_{i,s} = \tilde{Y}^Q_{i,s} - \tilde{Y}^Q_{i-1,s}$	real GDP
annual	level	Y^A_i	nominal GDP
	YoY rate[◇]	$y^A_i = Y^A_i - Y^A_{i-1}$	real GDP

Notes:

[♮] $Y^M_{i,t} = 100 \times \log(X_{i,t})$ where $X_{i,t}$ denotes the actual level registered in month t of year i;
$Y^Q_{i,s} = 100 \times \log(Z_{i,s})$ where $Z_{i,s}$ denotes the actual level registered in quarter s of year i;
time of quarter is conventionally set at third month of quarter; for YTD data $t = 1$ and $s = 1$ refer to January and first quarter of year i respectively.

[†] Year-To-Date: cumulated value from beginning of calendar year

[‡] Jan value not released

[§] denotes growth rate with respect to same period a year before

[♭] denotes growth rate with respect to same cumulated period a year before

[◇] equals YTD YoY rates at end of calendar year thus irrespective of the actual date of the Spring Festival. A notable exception in this setting is the monthly report on industrial production (IP) operations that, although following the timing of releases along the guidelines defined above, remarkably lacks level (i.e. index) data which are not disclosed in favor of both absolute and cumulated growth rates.

3 Econometric Framework

This section describes the model in [GIANNONE REICHLIN SMALL + BANBURA GIANNONE REICHLIN: DYN CITATION] and details the changes that have been implemented to account for the specificity of Chinese data transformations. Estimation by maximum likelihood is carried following [BANBURA MODUGNO: DYN CITATION] who suggest the use of the EM algorithm [CITATION] combined with the Kalman filter to estimate the model parameters and extract model-based news responsible for forecast revisions. [DOZ GIANNONE REICHLIN: DYN CITATION] prove feasibility and consistency of (quasi) maximum likelihood estimators even under model misspecification: cross and serial correlation of the idiosyncratic component does not compromise the quality of estimation. However, because this misspecification can be a potential source of problem when dealing with incomplete cross section at the end of the sample, we also model the dynamic of the idiosyncratic component as in [BANBURA GIANNONE REICHLIN: CITATION].

Let $y_t = [y_{1,t}, y_{2,t}, \ldots, y_{n,t}]'$, $t = 1, \ldots, T$ denote a set of standardized stationary monthly variables. We assume that y_t has a factor structure of the form:

$$y_t = \Lambda f_t + \varepsilon_t \tag{1}$$

where f_t is a vector of r unobserved common factors with zero mean and unit variance, Λ is a matrix of coefficients collecting the factor loadings for the monthly variables and $\varepsilon_t = [\varepsilon_{1,t}, \ldots, \varepsilon_{n,t}]'$ is a n-dimensional vector of idiosyncratic components uncorrelated with f_t at all leads and lags. We further assume that f_t follows a VAR of order p:

$$f_t = A_1 f_{t-1} + \ldots + A_p f_{t-p} + u_t \qquad u_t \sim i.i.d.N(0, Q) \tag{2}$$

where A_i, $i = 1, \ldots, p$ are $r \times r$ matrices of autoregressive coefficients, and that the idiosyncratic components follow an AR(1)

$$\varepsilon_{i,t} = \alpha_i \varepsilon_{i,t-1} + \epsilon_{i,t} \qquad \epsilon_{i,t} \sim i.i.d.N(0, \sigma_i^2) \tag{3}$$

with $E(\epsilon_{i,t}, \epsilon_{j,s}) = 0$ for $i \neq j$. Specifically, y_t will be a collection of monthly data taken either in levels or monthly YoY rates. To incorporate quarterly YoY GDP data in this setting we construct a partially observable monthly YoY GDP series and link it to the monthly variables imposing restrictions on the loadings for the quarterly variables which results in a modification of the approximation in Mariano and Murasawa (2003). In what follows we adopt the convention that time indices for the quarterly variables refer to the third month of each quarter. Let GDP level data for a given quarter be the sum of monthly unobserved contributions and let y_t^{MY} denote the unobserved monthly YoY GDP rate. We assume that y_t^{MY} admits the same factor structure of the monthly variables, that is

$$y_t^{MY} = \Lambda^Q f_t + \varepsilon_t^Q \tag{4}$$

$$\varepsilon_t^Q = \alpha^Q \varepsilon_{t-1}^Q + \epsilon_t^Q \qquad \epsilon_t^Q \sim i.i.d.N(0, \sigma_Q^2) \tag{5}$$

The monthly unobserved YoY rate can then be linked to a partially observed (at every third month of the quarter) quarterly YoY rate using the following:

$$\begin{aligned} y_t^{QY} &= Y_t^Q - Y_{t-12}^Q \\ &= (1 - L^{12}) Y_t^Q \\ &\approx (1 - L^{12})(1 - L - L^2) Y_t^M \\ &= (1 - L - L^2) y_t^{MY} \\ &= y_t^{MY} + y_{t-1}^{MY} + y_{t-2}^{MY} \end{aligned} \tag{6}$$

which implies requiring the quarterly variables loading equally on the current and lagged values of the unobserved monthly factor[5].

News and Impact of Data Releases

Let Ω_v denote a vintage of data available at time v where v denotes the date/time of a particular release. The problem of nowcasting the quarterly YoY rate of GDP is formally defined as the orthogonal projection of y_t^Q onto the information set Ω_v, which is equivalent to evaluating the conditional expectation $E(y_t^Q|\Omega_v)$.

When new data are released, at time $v+i, \quad i = 1, \ldots,$ the projection is updated to account for the new information set, and the forecast is revised accordingly. It is important to notice that v has high frequency and is irregularly spaced due to irregular intervals between consecutive data releases.

[5] $Y_t^Q = 100 \times GDP_t$ and Y_t^M denotes unobserved monthly level of GDP.

In principle as new data flows in, the information set changes in two dimensions: on one hand it becomes larger as it starts including new data, on the other hand, older data might get revised. In what follows and in the empirical application we will abstract from revisions running a pseudo real time forecasting exercise on pseudo vintages constructed applying the calendar of economic data releases to the last available vintage of data. This procedure implies that the only difference between two consecutive data vintages is in their size; specifically $\Omega_v \subseteq \Omega_v$ and $\Omega_{v+1}\ \Omega_v = x_{j,T_j,v+1}, j \in J$ where J is the set of data released at $v+1$[6]. Due to the nature of the evolution of the information set the updated projection can be decomposed as follows:

$$E(y_t^Q|\Omega_{v+1}) = E(y_t^Q|\Omega_v) + E(y_t^Q|I_{v+1}) \tag{7}$$

where $I_{v+1,j} = x_{j,T_{j,v+1}} - E(x_{j,T_{j,v+1}}|\Omega_v)$. Equation (7) states that the new forecast will be equal to the old forecast plus a revision which is a function of the *unexpected component* of the release of $x_{j,T_{j,v+1}}$, which we label "news". Under Gaussianity the model implies that the forecast revision can be further expressed as:

$$E(y_t^Q|\Omega_{v+1}) + E(y_t^Q|\Omega_v) = \sum_{j \in J} b_{j,t,v+j}(x_{j,T_{j,v+1}} - E(x_{j,T_{j,v+1}}|\Omega_v)) \tag{8}$$

where $b_{j,t,v+1}$ are model-based weights reflecting the relevance of the news [BANBURA MODUGNO + BANBURA GIANNONE REICHLIN].

4 Input Data Series

In order to select the list of input variables used to track Chinese GDP we combine different criteria ranging from weight assigned by the NBS, economic sector coverage, use in construction of related economic activity indices and relevance in financial markets. Given the choice, we prefer composite to sector specific indicators [BANBURA 2011 DYN REFERENCE] and aim at covering all relevant aspects of Chinese economy thus including data on production, trade in goods, housing and constructions, transports and communication. Particular attention is given to soft data, mainly surveys, whose relevance is highly related to their very short publication delay. We do not include in the set prices and financial variables.

To assess relevance across financial markets, we look at two market information providers: Bloomberg (`www.bloomberg.com`) and Forex Factory (`www.forexfactory.com`). Bloomberg and

[6] on revisions

Forex Factory both make a list of indicators and report the importance of each variable in terms of market relevance, although the lists do not entirely coincide: while Bloomberg reports a relevance index ranging between 0 and 100 which corresponds to the percentage of subscribers that monitor that variable, Forex Factory classifies the variables according to their expected impact on the currency market into low, medium and high-impact variables. Both these services also collect the views and expectations of market participants on particularly important variables and disseminate results in the form of short-term forecasts in concomitance with the actual release; we use these surveys of professional forecasts as benchmark when evaluating the model performance in terms of target rate. We complement these information accounting for component indices in all coincident and leading indicators published by major institutions (Table 2).

This process finally resulted in the selection of the ten indicators listed in table 3. All data are provided by Haver Analytics. Additional details on input data and transformations are reported in Appendix A.

4.1 Calendar Overview

The following chart (Figure 2) sketches the flow of data in a typical month m for all the indicators included in the model. Due to the incidence of the Spring Festival and the effects on data releases discussed earlier, the representation holds for all months except February when the entire NBS block disappears. Each of the releases is placed at the typical release date within the month while the reference period is reported between square brackets. In January, April, July and October GDP relative to the previous quarter adds up to the NBS block and the release date is shifted forward of about 5 days.

5 Results

In order to evaluate the performance of the model in nowcasting Chinese GDP we perform a pseudo real time forecasting exercise over the last five years of data releases. The estimation starts in Q1 2000 which is when the first reading of GDP becomes available[7], while the evaluation span is Q1 2008 to Q1 2013. To mimic the actual flow of data in absence of a real-time database, starting in January 2008, we reconstruct pseudo real-time vintages starting from the most recent set of releases (including data releases up to Jan 18 2013) and replicating the pattern of data availability that is implied by the calendar of economic releases; this process yields over 500 vintages over which the model performance is evaluated. Following every release, forecasts for the current, previous

[7]available at data provider

Table 2: **RAI / CEI / LEI Components**

indicator	TCB	OECD	GS-CEMAC	GSCA	CASS	SICC	HKMA
Industrial Production	✓	✓	✓	✓	✓	✓	✓
Cement Production		✓					
Chemical Fertilizer Production		✓			✓		
Crude Oil Production					✓		
Electricity Production	✓			✓	✓	✓	✓
Steel Production		✓			✓	✓	
Motor Vehicle Production		✓					
Industrial Employment	✓		✓				
Industrial Sales					✓		
Industrial Profits			✓				
Enterprise Deposits		✓					
Retail Sales	✓		✓	✓		✓	✓
Ratio of Sales to Gross Output			✓				
Exports				✓			✓
Total Trade Value			✓				
Freight Traffic at Major Coastal Ports			✓	✓	✓	✓	✓
Passenger Traffic	✓			✓			✓
Investment in Fixed Assets			✓	✓	✓	✓	✓
Realized FDI					✓		
Newly Started Investment Projects			✓				
Total Floor Space Started	✓		✓			✓	
Area of Land Developed			✓				
Money Supply M1					✓	✓	
Money Supply M2		✓	✓				
Interest Rate Spread			✓				
Hang Seng Index (H Shares)			✓				
Total Loans	✓						
Household Income			✓	✓			✓
Government Revenues			✓			✓	
PMI Supplier Deliveries Sub-Index	✓						
PMI Export Orders Sub-Index	✓						
PBoC 5000 Raw Material Supply	✓						
NBS Consumer Expectation Index	✓		✓				

The table lists the components of Real Activity Indices (RAI), Coincident (CEI) and Leading Economic Indicators (LEI) produced by major institutions [The Conference Board (2000), Wu and Ozyildirim (2011), Nilsson and Brunet (2006), OECD (2008), Goldman Sachs Asia Economic Group (2006), Zhang, Liu et al. (2007)].
Notes:
TCB = The Conference Board; GS-CEMAC = Goldman Sachs - Chinese Economic Monitoring & Analysis Center; GSCA = Goldman Sachs China Activity Index (discontinued after merge with CEMAC); CASS = Chinese Academy of Social Sciences; SICC= State Information Center of China; HKMA = Hong Kong Monetary Authority.

Table 3: **Data In**

release	release date	f	source	start	unit	forex factory	bloomberg	other
Industrial Production	mid next m	M	NBS	1992:M1	YoY	M	80.65	
PMI NBS	1^{st} next m	M	CFLP NBS	2005:M1	level	H	83.87	
PMI Markit	1^{st} bus day next m (final)	M	HSBC/ Markit	2004:M4	level	H† M‡	32.25† 70.97‡	
Freight Traffic	beginning 2^{nd} next m	M	NBS	2002:M1	YoY	–	–	GS-CEMAC HKMA - SICC
Exports	10^{th} next m	M	CC	1983:M10	YoY	H§	67.74	
Imports	10^{th} next m	M	CC	1983:M10	YoY	H§	64.52	
Electricity Production	w\ IP	M	NBS	1998:M3	YoY	–	–	GS-CEMAC TCB - CASS
New Constructions	w\ IP	M	NBS	2004:M2	YoY	-	-	SICC - HKMA TCB - OECD GS-CEMAC SICC
Business Climate	10^{th} next m	Q	NBS	2001:Q4	level	-	29.03	
GDP	w\ IP in Jan -Apr-Jul-Oct	Q	NBS	2000:Q1	YoY	H	93.55 6.45◇	

The table lists the variables included in the input set and their main features; arranged per columns are the variable name, typical release date (m=month), frequency (M=Monthly; Q=Quarterly), source, first date at which it is available *in the Haver Analytics Asia Pacific Database (EMERGEPR)*, transformation unit, relevance according to Forex Factory (L=Low; M=Medium; H=High), relevance according to Bloomberg (0=no relevance; 100=max relevance), relevance according to other sources. † flash estimate; ‡ final estimate; § trade balance; ◇ refers to QoQ.

Notes:

CASS = Chinese Academy of Social Sciences; CC = China Customs; CFLP = China Federation of Logistics and Purchasing; GS-CEMAC = Goldman Sachs - Chinese Economic Monitoring & Analysis Center; HSBC = Hong Kong and Shanghai Banking Corporation; HKMA = Hong Kong Monetary Authority; SICC= State Information Center of China; NBS= National Bureau of Statistics; TCB = The Conference Board.

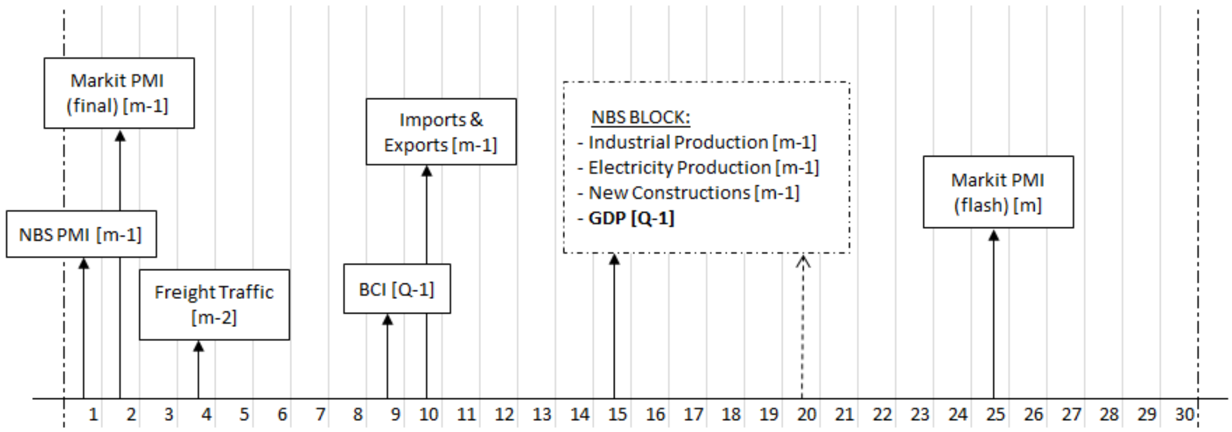

Figure 2: Flow of economic data releases in a standard month m. All indicators are those included in the model and releases are placed at their typical release date with days reported on the x axis; the reference period for each release is reported between square brackets. The scheme applies to all months except February when there are no scheduled NBS releases; GDP adds to the NBS block in January, April, July and October shifting the release date forward.

and following quarter are updated, and throughout this section we will refer to these as nowcast, backcast and forecast respectively. We fit to Chinese data the model discussed in section 3 with one latent monthly YoY common factor and 1 lag in the factor VAR; model parameters are estimated at every January 1st and then kept constant through the year. A remark is in order; to reduce the interference of exceptional readings with the estimation procedure, we set up a threshold for outliers detection which is equal to four times the standard deviation estimated by the model (i.e. $(Var(x_{j,T_{j,v+1}}|\Omega_v))^{1/2}$). In this way we instruct the model not to trust releases which are too far away from what is expected; when and if such threshold is reached, the release is discarded and the associated news is set to zero, moreover, the observation is not accounted for in all subsequent estimations of model parameters.

The nowcast for all years in the evaluation period (2008:2013) is plotted in Figure **??**. The chart compares the nowcasts produced by the DFM, a benchmark AR(1) (red dotted line), and those published within the IMF World Economic Outlook (IMF WEO, yellow diamonds) which are available in terms of quarterly YoY only once a year from 2008 and only track YoY at Q4. The DFM sensibly improves upon the nowcast of the autoregressive model, and this is particularly true during the subsample 2008:2009; although the model nowcasts a deeper than actual slowdown in 2009, it is extremely timely and accurate in predicting the downturn of 2008 and the successive recovery with forecasts for Q4-09 and Q1-10 virtually coinciding with the out-turn. When evaluating the performance against the IMF it is important to keep in mind that while the IMF produces a unique forecast per each quarter, the DFM potentially revises the forecast for current quarter GDP whenever new data are available (equation (7)) improving the forecasting accuracy. This again is particularly visible in the 2008:2009 subsample.

Figure 4 evaluates forecasting accuracy more closely distinguishing between the forecast, nowcast and backcast periods. Principal benchmark is again the AR(1). The x axis is split into three subsamples and days are reported on the x axis. We conventionally set the nowcast period between day 1 and day 90 so that the negative readings refer to the forecast period while the backcast is carried from day 91 onward. The plot averages over days within a reference quarter and the first vertical grid line in each block denotes the beginning of a new evaluation subsample. Each bar on the plot corresponds to the average RMSFE registered after that date; in particular, starting from the first day at which the forecast is performed, which is roughly 90 days before the quarter begins, and taking as a reference the stylized calendar in figure 2, the graph is updated at every new release. The AR forecast, on the other hand, is updated whenever new GDP data are released, which in the case of China between 2008 and 2013, typically happens on the 17th day of the month following the reference quarter. The sequential revision process of DFM forecasts implies that accuracy increases as time goes by and new information is incorporated; notably, the degree of precision reached towards the midst of the nowcasting period is already comparable to the one attained by financial markets participants plotted in concomitance of the GDP release date in figure 4. Bloomberg (BB) and Forex Factory (FF) both collect the views and expectations of market participants on particularly important variables and disseminate results in the form of short-term forecasts in concomitance with the actual release; in particular for Bloomberg, the forecast is the median response to a survey that is systematically conducted before official releases are due and updated until day before the release date.

Table 4 analyzes the contribution to the nowcast of the different data releases splitting the contribution among the three month over which the nowcast is performed. For each variable the table reports the average release day within the specific month, the average MSFE associated to the release, and the (absolute value of) average impact on GDP forecast revisions computed as the product between the average weight assigned by the model and the standard deviation of the *news* in columns 7, 6 and 5 respectively. In terms of overall forecast accuracy Table 4 suggests that most significant reductions in MSFE occur whenever the NBS block of series is released whereas, a closer look at figures relative to the third month in the nowcast period implies that trade variables on average tend to deteriorate the forecast. Interestingly, the evolution of the standard deviation of the news associated to trade variables is somewhat counterintuitive since it becomes more difficult to the model to produce accurate forecast of these variables as we move forward in the nowcast period; also for these two variable is the high forecasting uncertainty rather that the weight that

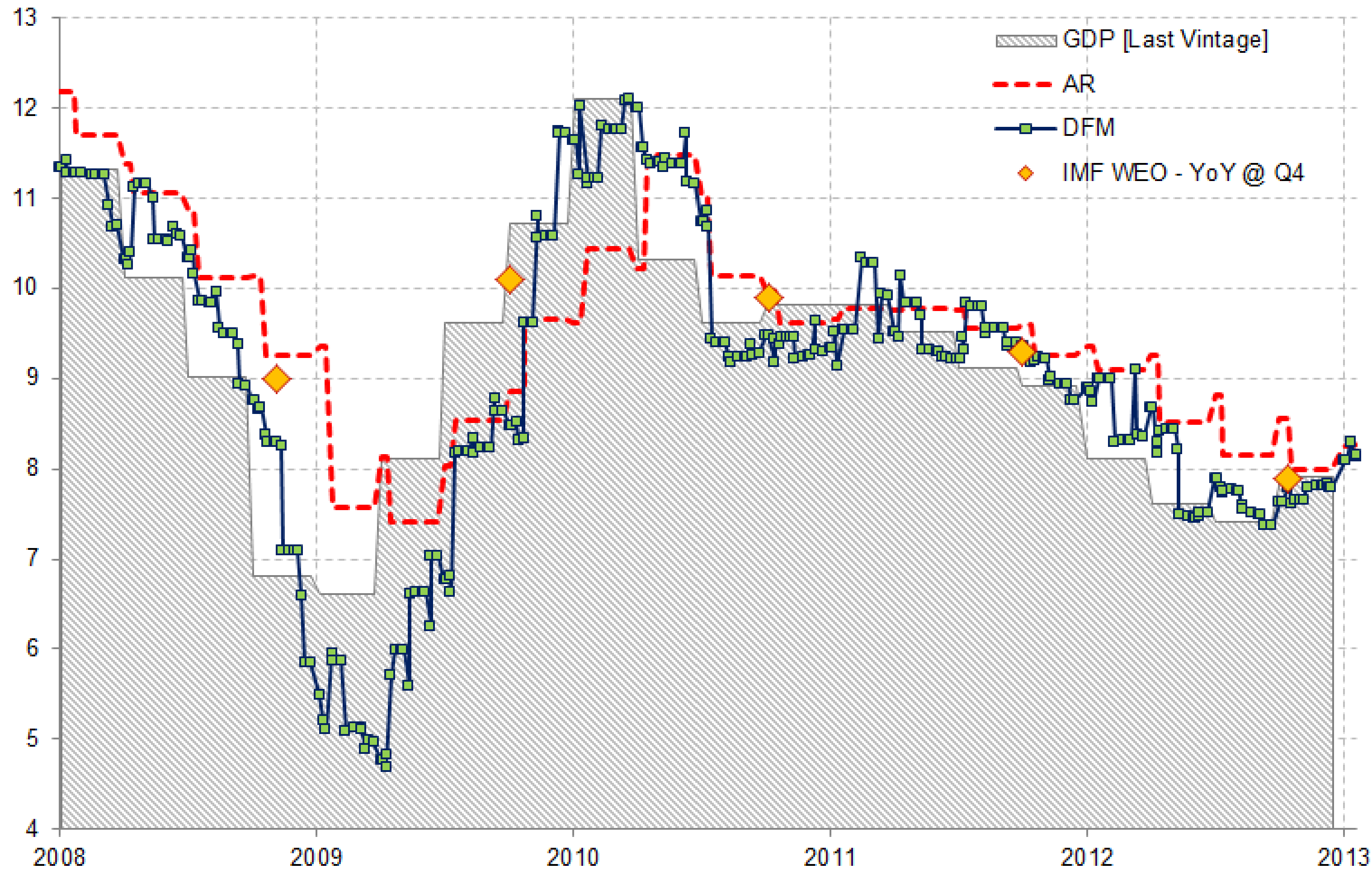

Figure 3: Nowcast of last vintage of quarterly year-on-year Chinese GDP (gray shaded area). The nowcast produced by the model is plotted against the one produced by the AR(1) benchmark (red dotted line) and the forecasts of the IMF which are available once a year from 2008 and only track the YoY at Q4 (yellow diamonds).

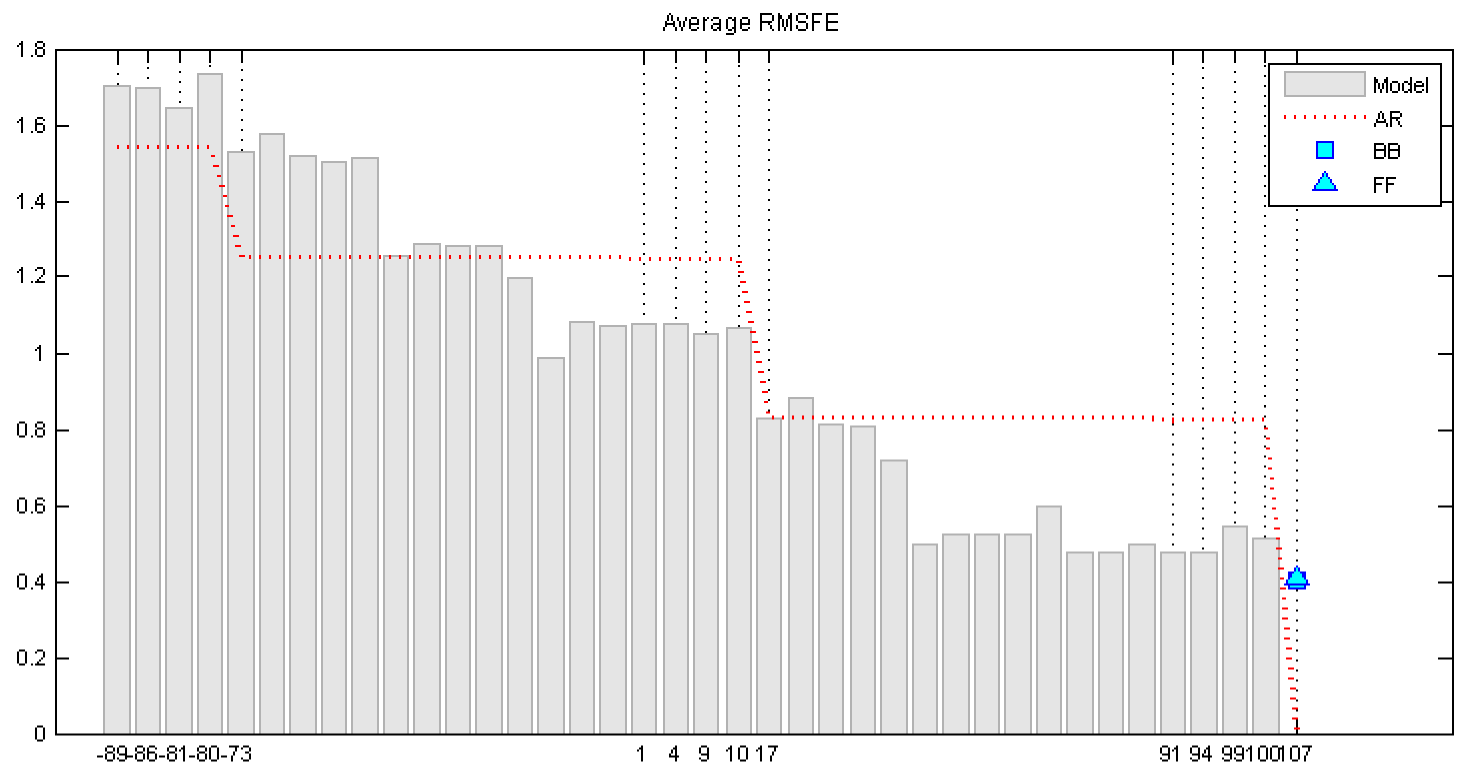

Figure 4: Average RMSFE over the evaluation span split over forecast (-90:-1), nowcast (1:90) and backcast (91:180) periods. Days are reported on the x axis and each bar corresponds to the average RMSFE registered in that day of the evaluation. The graph is updated whenever new data are releases such that the first bar measures the average RMSFE on day one of the forecasting period, which corresponds to the release of the NBS PMI, after that, the next release is freight traffic, which is due on the fourth day of the month, therefore, the second bar in the plot is placed at -86. BB and FF denote Bloomberg and Forex Factory forecasts that become available shortly before the official GDP release.

makes them having a large impact on GDP forecast revisions. Table 4 also confirms the fact that the impact of surveys decays as hard data become available. Among these, IP is confirmed as the single most important indicator to track Chinese GDP.

5.1 Model-Implied Annual Rate

Principal institutional benchmarks forecast Chinese GDP growth in terms of annual rates, therefore, in order to check the accuracy of our results against other forecasters, the model output is transformed from quarterly YoY rates into annual (year i vs year $i-1$) rates according to the following:

$$\begin{aligned} y_t^A &= Y_t^A - Y_{t-1}^A \\ &= (1 - L^{12})Y_t^A \\ &\approx (1 - L^{12})(1 + L^3 + L^6 + L^9)Y_t^{Q4} \\ &= (1 + L^3 + L^6 + L^9)y_t^{Q4} \\ &= y_t^{Q1} + y_t^{Q2} + y_t^{Q3} + y_t^{Q4} \end{aligned} \tag{9}$$

where y_t^A is the annual rate, y_t^{Q1} is the YoY for Q1. It follows from (9) that the annual rate can be constructed as average of quarterly YoY rates relative to the same year which - in practical terms - requires combining model output and GDP out-turn depending on the date (within the year) at which the forecast for the annual rate is made. More specifically, starting on Jan1st and until the end of Q1 the annual rate will be a combination of the nowcast for Q1, forecast at $t+1$ for Q2, at $t+2$ for Q3 and at $t+3$ for Q4; from April 1st until the release of GDP for Q1, the nowcast for Q1 is replaced by its backcast, Q2 is a nowcast and so on; table 5 below summarizes the process for the entire year.

Note that because further ahead forecasts are progressively substituted with more short-term ones and, eventually, with the actual releases, we are by construction bounded to the actual annual rate which is constructed as the average of the four out-turns when no revisions occur. Moreover, given the results shown in the previous subsections, we expect precision to increase as we move forward within the year. Particularly crucial in this process is the presence of revisions to previously released GDP data when these happen within the year under evaluation. In principle, if the model forecasts are the result of a true real time exercise, revisions are taken into account as soon as they occur within the year, however, results displayed so far are extracted from a pseudo real time scenario in which we target the last available release of GDP, meaning that, potentially, we are

Table 4: **Impact and News of Data Releases**

		Release Day	MSFE	News	Weight	Impact
month 1	NBS PMI	1	1.382	2.958	0.004	0.012
	Freight Traffic	4	1.382	4.864	0.000	0.001
	Business Condition Index	9	1.354	4.665	0.030	0.142
	Exports	10	1.393	11.061	0.020	0.226
	Imports	10	1.390	12.191	0.013	0.163
	Industrial Production	17	1.240	1.402	0.202	0.283
	Electricity Production	17	1.204	3.491	0.021	0.075
	New Constructions	17	1.203	24.698	0.000	0.005
	GDP	17	0.964	0.648	0.599	0.388
	Markit PMI	22	1.047	1.958	0.032	0.062
month 2	NBS PMI	1	0.935	1.697	0.004	0.007
	Freight Traffic	4	0.965	5.098	0.000	0.001
	Business Condition Index	–	–	–	–	–
	Exports	10	0.934	9.773	0.017	0.165
	Imports	10	0.951	14.796	0.011	0.167
	Industrial Production	13	0.687	1.694	0.282	0.477
	Electricity Production	13	0.677	4.346	0.032	0.139
	New Constructions	13	0.677	22.963	0.000	0.007
	GDP	–	–	–	–	–
	Markit PMI	22	0.700	1.762	0.023	0.041
month 3	NBS PMI	1	0.698	1.507	0.003	0.005
	Freight Traffic	4	0.700	5.105	0.000	0.002
	Business Condition Index	–	–	–	–	–
	Exports	10	0.783	15.030	0.012	0.185
	Imports	10	0.818	18.318	0.008	0.142
	Industrial Production	13	0.652	1.684	0.238	0.400
	Electricity Production	13	0.613	4.549	0.020	0.092
	New Constructions	13	0.573	26.620	0.000	0.006
	GDP	–	–	–	–	–
	Markit PMI	22	0.683	1.125	0.012	0.013

The table zooms over nowcast results splitting the contribution of each data release among the three months over which the nowcast is performed. Arranged in columns are the average release day, the average MSFE associated to the release, the standard deviation of the news, the average weight assigned by the model to each release, and the average impact - computed as the product of the average weight and the standard deviation of the news - measuring the average GDP forecast revision due to that release.

Table 5: **Components of Annual Rate**

time of year	Q1 YoY	Q2 YoY	Q3 YoY	Q4 YoY
Jan 1st	NC	FC1	FC2	FC3
Apr 1st	BC	NC	FC1	FC2
Q1 release	Q1	NC	FC1	FC2
Jul 1st	Q1	BC	NC	FC1
Q2 release	Q1	Q2	NC	FC1
Oct 1st	Q1	Q2	BC	NC
Q3 release	Q1	Q2	Q3	NC

Change in the composition of the items used to construct annual rates from YoY rates. BC = backcast; NC = nowcast, FC1 = forecast @ t+1; FC2 = forecast @ t+2; FC3 = forecast @ t+3.

incorporating information before it becomes available to the other forecasters. In order to address this issue, we build the model-implied annual rates using first release data only, which, if anything, puts us in a less favorable position with respect to other forecasters which presumably gradually incorporate revision in the updates of the forecast that are published over the year. The potential mismatch in terms of available information set arising from the lack of a real time database is, however, of minor concern in this particular setting since over the evaluation sample (2008:2013) GDP were revised very little; in fact, since Q3 2009, YoY GDP data haev never been revised.

The annual rates implied by the DFM are compared with the forecast for annual rates distributed by major international institutions; in detail we evaluate our performance against the IMF World Economic Outlook[8] (IMF_WEO), the OECD Economic Outlook[9] (OECD_EO), the European Commission Economic Forecast[10] (EC_EF) and the World Bank Global Economic Perspectives[11] (WB_GEP).

Figure 5 plots the forecast of Chinese annual GDP growth rate implied by the DFM against preliminary and final official rates extracted from the IMF World Economic Outlook, and the four benchmarks. As expected, partly by construction, and partly due to the results in figure 4, the model-implied forecast for annual rate becomes increasingly precise throughout the year. Moreover, it is worth noticing, that while being consistent with all other benchmarks, it connects the dots of

[8] http://www.imf.org/external/ns/cs.aspx?id=29

[9] http://www.oecd.org/eco/economicoutlook.htm

[10] http://ec.europa.eu/economy_finance/publications/european_economy/forecasts_en.htm

[11] http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTDECPROSPECTS/0,,contentMDK:23091814~pagePK:64165401~piPK:64165026~theSitePK:476883,00.html

the best available institutional forecasters among those surveyed here; even the partial overshooting observed when evaluating the nowcast of the YoY rate for Q1 and Q2 2009 is still in line with the view expressed by our benchmarks. Table 6 compares pairwise forecasting accuracy between each institutional forecaster and the DFM both overall and split over each quarter within a calendar year. Per each column, italic figures correspond to the DFM RMSFE calculated at the same time as the institutional forecast. The numbers in table 6 confirm the intuition above, and thus that throughout the year the accuracy of the DFM improves up to the point where, at Q4, generally produces better forecasts that virtually any of the benchmarks selected; moreover, due to properties delineated above, the accuracy of the DFM will continue to further improve until official annual rates get released.

Table 6: **Annual Rate Forecast**

	overall		Q1		Q2		Q3		Q4	
IMF WEO	0.85	*1.45*	1.04	*1.71*	0.96	*1.79*	0.71	*1.11*	0.42	*0.40*
OECD EO	0.40	*0.55*	–	–	0.53	*0.80*	–	–	0.27	*0.23*
EC EF	0.93	*1.19*	–	–	1.42	*1.83*	0.10	*0.41*	0.33	*0.36*
WB GEP	0.99	*0.64*	1.01	*0.98*	0.52	*0.59*	–	–	1.28	*0.30*

The table compares forecasting accuracy of the DFM and principal institutional benchmarks relative to the forecast of the annual GDP growth rate. Pairwise accuracy is calculated by mean of RMSFE computed over the intersection of the set of institutional forecasts and the model-implied annual rate. Institutional forecasters are ordered in rows, while in columns the accuracy is evaluated overall and at each quarter within a calendar year. *Italic* figures denote RMSFE of the DFM computed at the same time as the institutional forecast

6 Conclusions

[TO BE ADDED]

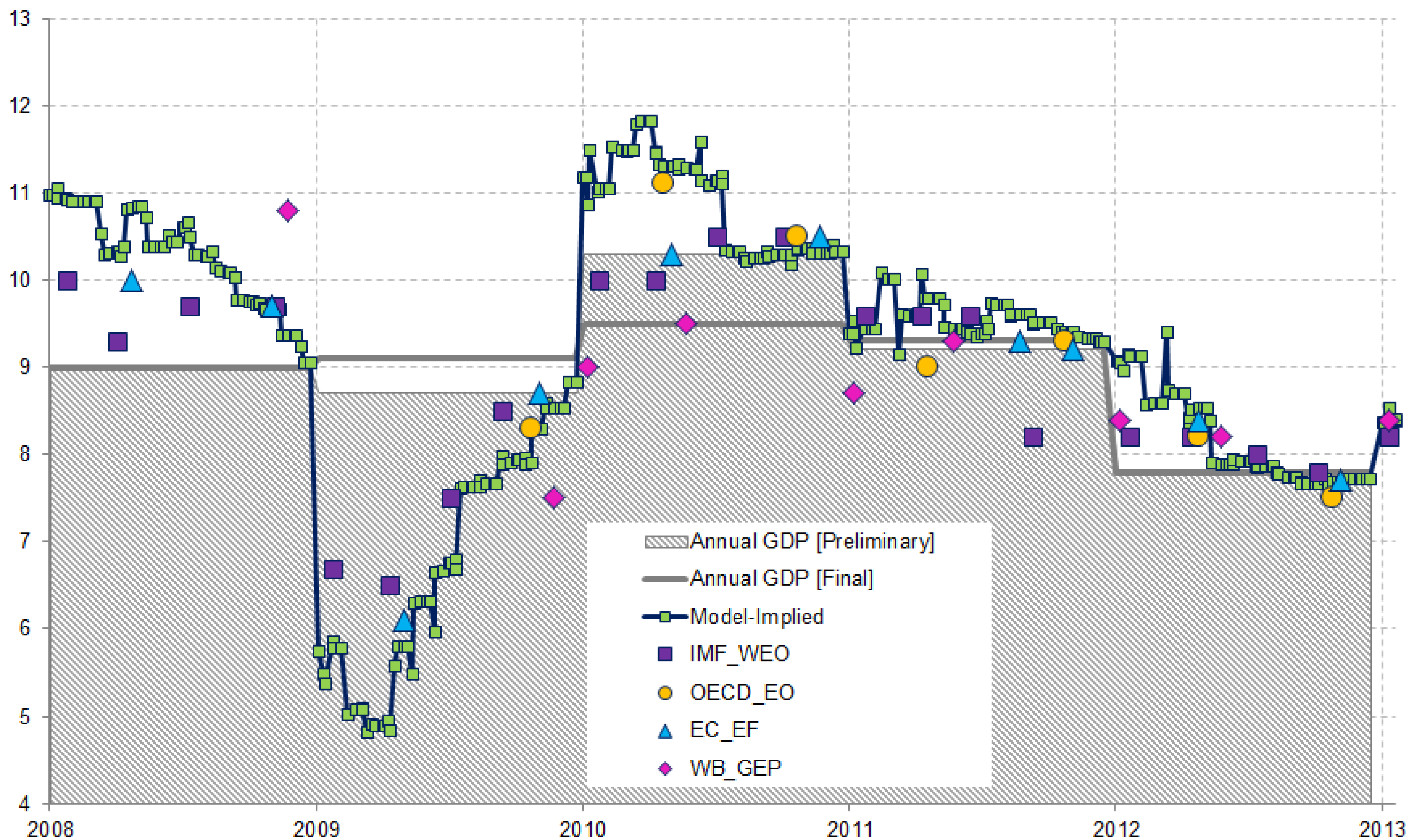

Figure 5: Forecast of annual GDP growth rate implied by DFM against preliminary and final official annual rates. Institutional benchmarks are the IMF World Economic Outlook, the OECD Economic Outlook, the European Commission European Forecast and the World Bank Global Economic Perspectives.

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A Input Data

A.1 Hard Data

Industrial Production Chinese Industrial Production is released by the NBS as Gross Value Added of Industry around 10-15 days after the end of the reference month. Together with the report on Industrial Production Operation, the press release typically comprises also reports on Total Retail Sales of Consumer Goods, Investment in Real Estate Development and Investment in Fixed Assets; when GDP is also due for release (January, April, July and October) these are all released together following the GDP release schedule. For IP the NBS releases:

- NSA YoY rate at constant (1990) prices
- NSA YTD YoY rate at constant (1990) prices
- SA MoM rate at constant (1990) prices
- NSA level in 100 million CNY.

Note that because an index of Industrial Production is not available at source, we have to choose our indicator relying on the data transformations officially distributed by the NBS; using the criteria defined at the beginning of this section and summarized in tables 2 and 3 we decide to input the model with the monthly year-on-year rate (i.e. first item in the above list).

Originally the IP series used to account for two distinct values for January and February, however, due to the high incidence of the Spring Festival on the seasonal pattern of the data, starting in 2007 the NBS decided to discontinue the release for both the January YoY and YTD YoY rates leaving other IP releases unchanged. This initial measure was however followed up in 2012 with the additional removal of the February YoY rate from the IP monthly report; therefore, at every new year, the first information on Chinese industrial production becomes available only in mid March in the form of a growth rate measuring the value added of industry cumulated in January *and* February compared with the year before. The break in the data dissemination pattern also affects other variables in our sample and thus heavily challenges the task of producing an accurate forecast of Chinese GDP whenever Q1 figures are involved due to the scarcity of information we are left with over that specific time window. In order to address this issue, the IP series used throughout the evaluation consists in a combination of YoY amd YTD YoY data, in particular, for the entire history there are no January releases, the YTD YoY for January and February is placed at February, the YoY rate is used from March onward. IP series is not subject to revision.

Electricity Production Is released by the NBS within the monthly report on Industrial Production Operation and it is not subject to revision. The official release unit is 100 million kWh and the variable is used in monthly YoY growth rates. Contrary to IP, electricity production figures also account for a February release via the China Monthly Statistics bulletin produced and published by the China Economic Monitoring and Analysis Center (CEMAC) of the NBS. Not subject to revision.

Imports & Exports Import and Export data are collected and distributed by the Chinese Customs (CC) within the first 10 days of the month for the previous month. Data are collected and distributed in hundred million of current USD. Using nominal figures denominated in a foreign currency represents a big change with respect to our standard policy in terms of input selection; however, in support of our choice, on one hand we have volume data only available from 2005 while nominal figures are available since the early Eighties; on the other hand, all major financial commentators worldwide (Bloomberg, FT, WSJ among others) also monitor the USD-based variables. Both imports and exports data are subject to revision and enter the model in monthly YoY.

Freight Traffic To measure freight traffic we use the volume of freight handled at major coastal ports (Total Volume of Freight Throughput in Major Coastal Port above Designated Size) released by the NBS within the statistics on Total Volume of Transportation. Numbers are released with a two-months delay every month. Official release units are 100 million tons from which we construct monthly YoY rates[12].

New Constructions It is released by the NBS within the report on Investment in Real Estate Development that discloses information on completion of real estate investments and the sources of funding, sales of commercial buildings and the national real estate climate index[13]. Data on real estate sector are released together with IP around the middle of the month and refer to the previous month; there is no release for January numbers. Newly Started Constructions are measured in YTD millions of square meters and figures are not subject to revision. The variable is used in monthly YoY growth rates computed using monthly levels obtained via "decumulation" of the YTD level figures.

[12] The NBS also releases official YoY, and YTD levels/YoY rates, however due to data availability we compute rates using level data.

[13] Data relative to Real Estate and Construction are originally collected by the Chinese Index Academy (CIA) and then disseminated by the NBS.

A.2 Soft Data

NBS/CFLP Manufacturing PMI The NBS manufacturing PMI is compiled by the China Federation of Logistic and Purchasing (CFLP) and China Logistics Information Center (CLIC) based on data collected by the NBS. The indicator was started on January 2005 and it is constructed from a sample of 700 manufacturing firms all over China. Data are not subject to revision and are released on the first of the following month regardless of it being a working day or not. Enters the model in levels.

HSBC/Markit Manufacturing PMI The HSBC China Report on Manufacturing is based on data compiled from monthly replies to questionnaires sent to purchasing executives in over 400 manufacturing companies. The panel of respondents is stratified geographically and by Standard Industrial Classification (SIC) group and is based on industry contribution to Chinese GDP. It was started in April 2004 and is released by HSBC/Markit Economics typically on the first working day of the following month as a final estimate. Starting from February 2007 it is also available as a flash estimate and released around the 20th of the reference month, typically on the second last Thursday. We feed the model with both the flash and the final estimates and treat the latter as a revision to the former. Both enter the model in levels.

Business Climate Index The Business Climate Index is compiled on the basis of a business climate survey where entrepreneurs are asked to evaluate current and future business performance. Current Business Climate and Future Business Climate-related responses are then combined to produce the final index using weights equal to 40% and 60% respectively. The Index ranges from 0 to 200 with 100 being the critical value so that readings above 100 imply the economic performance is picking up or improving. The sample of 16,000 units is selected at the national level and includes all large and some medium and small-sized enterprises. The variable is releases within the first ten days of the month following the reference quarter and is generally not subject to revision. Enters the model in levels.