Towards Recoupling?

Assessing the Impact of a Chinese Hard Landing on Commodity Exporters: Results from Conditional Forecast in a GVAR Model*

Ludovic Gauvin† and Cyril Rebillard‡

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†EconomiX-CNRS & Banque de France; ludovic.gauvin@gmail.com.

‡Banque de France; 39 rue Croix des Petits Champs, 75001 Paris, France; (+33) 1 42 92 66 39; cyril.rebillard@banque-france.fr (corresponding author).

Abstract

China's rapid growth over the past decade has been one of the main drivers of the rise in mineral commodity demand and prices. At a time when concerns about the sustainability of China's growth model are increasingly rising, this paper assesses to what extent a hard landing in China would impact commodity exporters. After reviewing the main arguments pointing to a hard landing scenario – historical rebalancing precedents, overinvestment, unsustainable debt trends, and a growing real estate bubble – we focus on a sample of twenty-five countries, and use a global VAR methodology adapted to conditional forecasting to simulate the impact of a Chinese hard landing. We model metal and oil price separately to account for their different end-use patterns and consumption intensity in China, and we identify two specific transmission channels to commodity exporters: through exports (with both volume and price effects), and through investment (a fall in commodity prices reducing incentives to invest in the mining sector). According to our estimates, Latin American countries would be hardest hit – with a 6 percent cumulated growth loss after five years – followed by Asia (ex. China); advanced economies would be less affected. The "growth gap" between emerging and advanced economies would be considerably reduced, leading to *partial recoupling*.

Keywords: China, hard landing, spillovers, global VAR, conditional forecast, commodities, recoupling
JEL Classification: C32, F44, E32, E17, F47, Q02

1 Introduction

China's rapid growth over the past decade has been one of the main drivers of the rise in mineral commodity demand and prices: over the last ten years, 133 percent of the increase in global copper consumption has been driven by China, 85 percent for coal, 85 percent for iron ore and 108 percent for nickel. This may have benefited commodity exporters, among which Australia and Latin American countries.[1] At a time when concerns have been raised about the sustainability of China's growth (Eichengreen et al. 2012, IMF 2013b), an important issue to address is to what extent an adverse scenario on China's growth could impact commodity exporters. The rebalancing process itself, with China's growth switching progressively from commodity-intensive investment to private consumption, may have sizable consequences on mineral commodity demand and prices, and hence on exporting countries. If this rebalancing were to occur in a disorderly way, that is, a hard landing scenario in which investment would slow sharply, effects on commodity exporters would be amplified accordingly.

The aim of this paper is to assess the potential effect of a Chinese hard landing on main commodity exporters to China. While we also simulate a soft-landing-cum-rebalancing scenario, the reasons we focus on hard landing, in our view a more plausible outcome than soft landing, are fourfold: historical rebalancing precedents, overinvestment,[2] unsustainable debt trends, and a growing real estate bubble. To assess the magnitude of spillovers, we use the Global VAR methodology developed by Dees et al. (2007). More specifically, the procedure proposed by Pesaran et al. (2007) in order to run counterfactual analysis is adapted to conditional forecasting. This allows us to study the impact of a Chinese hard landing on the global economy with a focus on commodity exporters, and commodity prices (which we embed in the GVAR framework by adding two "commodity countries", for metals and oil). In particular, we identify two specific transmission channels of a shock on China's GDP and investment growth to commodity exporters: through exports (with both volume and price effects), and through investment (a fall in commodity prices reducing incentives to invest in the mining sector).

In the hard landing scenario (3 percent growth in China over a five-year forecast horizon, with investment stagnating), we find a strong impact on metal price index, and a milder impact on oil price, consistent with what should be expected (oil being more consumption-related than metals, especially for China; see RGE 2012b). The regions that we show to be most affected are Latin America and Asia (ex-China), for which the cumulated GDP loss after five years are respectively 6 and 4 percent; advanced economies would be less affected (-2 percent after five years). Consequently, the "growth gap" between emerging and advanced economies would be significantly reduced, from 7 percent in the years 2007-09 to less than 2 percent

[1] See Jenkins et al. (2008) for a review of both direct and indirect impacts of the rapid growth of China on Latin America and the Caribbean region.

[2] See Lee et al. (2012) for a cross-country comparison of investment-to-GDP ratios, or Shi & Huang (2014) for evidence of overinvestment in western Chinese provinces.

from 2015 onwards, leading to what could be called *partial recoupling*. In the soft landing scenario, Latin America would again be more affected than Asia or advanced economies, but overall emerging economies' growth would still outperform advanced economies by a sizable 4-percent margin.

The rest of the paper is organized as follows. Section 2 presents China's growth prospects and the main arguments pointing to a hard landing scenario, before turning to some stylized facts and a literature review on the impact of China on commodity markets and exporters. Section 3 details the methodology and data used. Section 4 presents the simulation results in the two scenarios we consider, i.e. hard landing and soft landing, before discussing some of their limits and implications. Section 5 concludes.

2 Motivations and literature review

2.1 China's growth prospects: towards a hard landing?[3]

China has enjoyed high growth over the past thirty years. Until 2007, this success was mainly driven by exports and investment; however imbalances, both external (a large current account surplus) and internal (high investment-to-GDP ratio, low consumption-to-GDP ratio) also worsened at the same time. As argued by Huang & Wang (2010), Huang & Tao (2011), and Dorrucci et al. (2013), imbalances are an inherent feature of the Chinese growth model, and both growth and imbalances mainly derive from three key factor price distortions, regarding the exchange rate, wages, and interest rates.

First, an undervalued exchange rate has enabled China to reap considerable benefits from its accession to WTO from end 2001 onwards (Rodrik 2008, Goldstein & Lardy 2009). Strong price competitiveness has boosted manufactured exports and allowed China to strongly increase its global market shares. Exports dynamism also supported related investment in the manufacturing sector, while strong FDI inflows also facilitated technology transfers that helped boost domestic productivity (Yao & Wei, 2007). At the same time, the undervalued exchange rate weighted on household consumption by slowing their purchasing power gains.

Second, low wages have been another key factor to boost export price competitiveness. Along with the undervalued exchange rate, they have arguably been one of the reasons for China to become the "world's factory". Indeed, while still dynamic when compared to other countries, wages have progressively lost ground in relation to nominal GDP growth throughout the 2000s, revealing an increasingly unequal sharing of the value added. This has been a consequence of abundant rural labor supply and of the hukou system, which regulates internal migrations from rural to urban areas, but also of the lack (and poor enforcement) of workers' rights. Lower income growth in relation to nominal GDP growth (rather than rising households'

[3] See Rebillard (forthcoming) for more details.

savings), by constraining households' purchasing power gains, has been the main factor behind the decrease of the ratio between private consumption and GDP (Aziz & Cui, 2007).

Third, very low interest rates have helped support strong investment growth. Financial repression is indeed a key feature of the Chinese growth model (Johansson, 2012). One of its particular characteristics is the system of administered benchmark interest rates, the higher one being (until recently) a floor for lending rates, and the lower one being a ceiling for the remuneration of deposits (Feyzioglu et al., 2009). As such, it has been guaranteeing a net interest rate margin for banks.[4] Since both benchmark rates were set at very low levels, households' interest earnings have been compressed (thus providing an additional explanation to the decrease in the private-consumption-to-GDP ratio), while cheap funding was available for investment.

The 2008-09 *Great Recession* and its aftermath had significant implications for China's growth model. Except during a brief rebound immediately following the international crisis, exports were no longer able to support China's growth. On one hand, the prolonged sluggishness in advanced economies' activity hampered China's external demand. On the other hand, an appreciating yuan and faster rises in wages (partly related to labor shortages, especially within the coastal areas, although whether this can be explained by China reaching the Lewis Turning Point is not clear) implied some loss of price competitiveness.[5]

China thus had to rely more heavily on investment to maintain high growth rates, starting with a huge stimulus in 2009; while driving investment-to-GDP ratio to record highs (46.1 percent in 2012), this allowed China to maintain fairly high growth rates. This also had important consequences on China's imbalances: external imbalances (the current account surplus, which is the difference between national savings and investment) were sharply reduced, while at the same time internal imbalances worsened (Ahuja et al., 2012). As argued by Lemoine & Ünal (2012), these internal imbalances are reflected in the imbalanced geographical structure of China's external trade: the decrease in the Chinese trade surplus between 2007 and 2012 was mainly due to a sharp increase in the trade deficit vis-à-vis commodity exporters, the investment surge being itself highly commodity-intensive (see figure A.1).

Although the Chinese authorities seem committed to rebalance the economy towards greater private consumption, they have not been successful so far (see figure A.2): while some progress was achieved in 2011, as investment slowed down, these progresses were reversed in 2012 as the Government pushed up investment once again to prevent growth from slowing below the official 7.5 percent target.[6] According to Dorrucci et al. (2013), the persistence of internal imbalances can be attributed to the lack of a "critical

[4] From small levels in 1995, when it was set in place, this interest rate margin has been progressively widened and culminated at 360 basis points between 1999 and 2002; it was still representing some 240 basis points as recently as May 2012.

[5] It has been argued that as China progressively upgrades its exports, it may be now less sensitive to price competitiveness. Poncet & Starosta de Waldemar (2013) cast doubts on the extent of China's exports upgrading.

[6] In fact, slowing investment progressively affected corporate profits and hence employees' wages, leading to a (delayed) slowdown in private consumption.

mass" of reforms so far; indeed, while some progress has been made to reduce some of the distortions mentioned earlier (exchange rate, wages), the fundamental characteristics of the historical Chinese growth model, especially financial repression, remain largely unchanged.

This growth model now seems to have reached its limits, as shown by the continuous growth deceleration that China has been experiencing since the beginning of 2011. In our view this slowdown is a structural trend and may in fact intensify, leading to a Japanese-style "hard landing": a prolonged period of slow growth led by a sharp deceleration (or even a drop) in investment, and a much smoother consumption slowdown, which would allow the Chinese economy to rebalance. Pettis (2013) argues growth could slow to 3 percent per year; similarly, Nabar & N'Diaye (2013) mention a downside scenario where growth slows to less than 4 percent per year.[7] Among the reasons for such a scenario to occur, the most compelling in our view are: historical rebalancing precedents; overinvestment; unsustainable debt trends; and a growing real estate bubble.

First, it should be noted that many countries in the past adopted a growth model similar to the Chinese one; looking at how these countries rebalanced can shed some light on China's growth prospects. RGE (2013) identified 46 episodes of rebalancing following investment-led growth: on average, growth in the five years following the investment peak was 3.6 percent lower than growth in the five years preceding the peak; additionally, imbalances are now much greater in China than in most of the countries of RGE's sample, which may imply a sharper correction for China.[8] Eichengreen et al. (2012) adopt a somewhat different perspective and look for some common characteristics among countries that experienced a sharp growth slowdown; they find that China shares many of these characteristics, such as a high investment-to-GDP ratio, an undervalued currency, an ageing population.

Second, China's extremely high investment-to-GDP ratio naturally raises the question of overinvestment. Concerns are not new (Dollar & Wei, 2007), but have been exacerbated since the 2009 investment surge. In a recent paper based on cross-country comparisons, Lee et al. (2012) estimate that China may have overinvested between 12 and 20 percent of GDP from 2007 to 2011. Focusing on China, Shi & Huang (2014) find some evidence of overinvestment in infrastructure in western provinces, as early as 2008, casting some doubt on the economic efficiency of the *Go West* policy. Finally, Standard & Poor's (2013) finds that, among a 32-country sample, China has the highest downside risk of an economic correction because of low investment productivity over recent years. This has led to rising excess capacity in a number of sectors: IMF (2012d) estimates that the capacity utilization rate dropped from almost 80 percent before

[7] According to the authors, "continuing with the current growth model reliant on factor accumulation and efficiency gains related to labor relocation (across sectors from the countryside into factories) could cause the convergence process to stall with the economy growing at no more than 4 percent". This scenario relies on the assumptions that reforms are delayed, and the economy fails to rebalance orderly; in that case, ultimately "the investment-to-GDP ratio corrects sharply downward (by about 10 percentage points)".

[8] In RGE's sample, investment peaked at 36.1 percent of GDP on average, whereas China's investment-to-GDP ratio reached 46.1 percent in 2012.

the crisis, to around 60 percent in 2012.

Third, the investment surge has been financed by a sharp increase in overall debt, in contrast with the 2003-07 period where debt remained constant as a share of GDP (see figure A.3). In that sense, it can be argued that China switched from an investment- and export-led growth model before the crisis, to a credit-fuelled investment-led growth model after the crisis. Whereas most of the initial credit surge was due to bank lending, shadow banking progressively took the lead as a way to circumvent the authorities' tougher controls on bank lending. While the fast-growing shadow banking sector entails its own risks, as argued by Xiao (2012), what is most worrying is that current debt trends are clearly unsustainable. Drehmann et al. (2011) document the predictive power of the credit-to-GDP gap[9] as an early warning signal for financial crises; by this metrics, China is well into the danger zone.

Fourth, the bursting of a real-estate bubble may well be the trigger of a hard landing, just as for Japan at the beginning of the 1990s. The Chinese context is indeed especially prone to the development of real-estate bubbles, as evidenced by Ahuja et al. (2010) and Wu et al. (2012): housing is the main alternative investment vehicle for households in search of higher returns than the capped-rate deposits; and land sales are an important source of funds for local governments, since their spending needs cannot be met by their limited fiscal revenue and Central Government transfers.[10] In our view rising price-to-rent ratios (see figure A.4) and price-to-income ratios (see figure A.5) point to the existence of a bubble, at least in the largest coastal cities. Above all, extremely high (and rapidly rising) cement production levels make the Chinese case look worse than any of the past known cases of real estate bubbles (see figure A.6). China's development stage clearly cannot explain this pattern (see figure A.7); nor can urbanization, the pace of which has remained fairly stable in the past few years (see figure A.8). Should China's real-estate bubble burst, it would have severe consequences on local public finances, real activity, and banking system (Ahuja et al., 2010).

2.2 China and commodity markets: stylized facts and literature review

China's development over the past decade has been strongly biased towards investment, as argued above, and as such, has been highly commodity-intensive. China's demand for oil, while rising significantly over the period (+68 percent between 2003 and 2011, according to the Australian *Bureau of Resources and Energy Economics*), falls in fact far behind its demand for metals, especially copper (+157 percent) and iron ore (+213 percent); in 2011 China represented around 11 percent of global oil consumption, 41 percent of global copper consumption and 54 percent of global iron ore consumption (see figures A.9, A.10

[9] i.e., a significant upward deviation of credit-to-GDP from its historical trend.

[10] Whereas local governments receive around 50 percent of total fiscal revenues in China, they are responsible for the quasi-totality of social spending and, especially since 2008, of the investment-based stimuli. They are theoretically not allowed to borrow, and have to rely on Local Government Financing Vehicles.

and A.11). High investment levels and the urbanization process in China have indeed significantly boosted its demand for metals, as argued by Yu (2011).[11] On the contrary, oil demand may be more related to consumption (and the development of the automobile sector, figure A.14), since coal, rather than oil, is the main energy source in China (figure A.15).

China's rising demand has been pointed as one of the main drivers of the commodity price boom over the last decade. Previous research has mainly focused on the impact of China's (and India's) rapid growth on the global oil market (Hicks & Kilian, 2013). Some papers also studied their impact on other commodities' price: Francis (2007) documents the impact of China on oil and metals prices; Arbatli & Vasishtha (2012) attribute a significant part of metals' price increases (but a rather limited part of oil price increases) to growth surprises in emerging Asia. Farooki (2010) argues that the base metals price boom was driven by the Chinese demand for raw materials as inputs into infrastructure, construction and manufacturing (as well as to supply side constraints in terms of capacity and expansion). Roache (2012) finds a significant effect of China's industrial activity on copper prices. Finally, Erten & Ocampo (2013) show that non-oil commodity (especially metals) price super-cycles are essentially demand-determined; they attribute the on-going super-cycle primarily to China's industrialization and urbanization.

Given China's growing importance in the world economy, several recent papers have tried to assess potential spillovers from a shock originating in China. Using a GVAR model, Feldkircher & Korhonen (2012) find that a 1 percent positive shock to Chinese output translates into a 0.1 to 0.5 percent rise in output for most large economies. Samake & Yang (2011) use a mix of GVAR and SVAR models to investigate both direct (through FDI, trade, productivity, exchange rates) and indirect (through global commodity prices, demand, and interest rates) spillovers from BRICs to LICs. Similarly, Dabla-Norris et al. (2012) document the expanding economic linkages between LICs and "emerging market leaders" and find that the elasticity of growth to trading partners' growth is high for LICs in Asia, Latin America and the Caribbean, and Europe and Central Asia; moreover, for commodity-exporting LICs in Sub-Saharan Africa and the Middle East, terms of trade shocks and demand from the "emerging market leaders" are the main channels of transmission of foreign shocks. Focusing on the consequences of China's WTO accession, Andersen et al. (2013) find that roughly one-tenth of the average annual post-accession growth in resource-rich countries was due to China's increased appetite for commodities. Using a GVAR model that takes into account trade, financial, and commodity price linkages, Cashin et al. (2012) find that the MENA countries are more sensitive to developments in China than to shocks in the Euro Area or the United States. Finally,

[11] Admittedly, part of China's apparent consumption of metals could be attributed to its growing role as the "world factory", to the extent that metals can be used to produce goods that are exported to other parts of the world. However, data on end-use of global demand for copper (figure A.12) and steel (which is itself the main use of iron ore; figure A.13) show that construction and infrastructure building are a very significant part of metals' end-use at the global level; for steel, the construction share is probably even higher in China (50 percent in 2007, according to Sun et al. 2008; Yu 2011 gives a similar figure of 55 percent for construction and infrastructure) than at the global level (38 percent). Hence, a significant part of metals' demand is related to China's own internal demand, and is not intended to be reexported.

also using a GVAR model, Rebucci et al. (2012) show that the long-term impact of a China GDP shock on the typical Latin American economy has increased by three times since mid-1990s.[12]

However, few papers so far have explicitly focused on the negative spillovers of a growth slowdown in China. Ahuja & Nabar (2012) find that a one percentage point slowdown in investment in China is associated with a reduction of global growth of just under one-tenth of a percentage point (the impact being about five times larger than in 2002), with regional supply chain economies and commodity exporters with relatively less diversified economies being the most vulnerable.[13] Using a two-region factor-augmented VAR model, Ahuja & Myrvoda (2012) find that a 1 percent decline in China's real estate investment would cause a 0.05 percent global output loss (with Japan, Korea, and Germany among the hardest hit) and a metal prices decline of 0.8 to 2.2 percent.[14] Finally, using a Bayesian VAR methodology, Erten (2012) finds that a permanent slowdown of Chinese growth to 6 percent would affect relatively more Latin American countries than emerging Asia.[15]

Turning to individual countries, the IMF has in recent years regularly assessed the impact of a significant slowdown in China on commodity exporters. IMF (2011) estimates that a "tail risk scenario" where Chinese growth drops to 6 percent (due to problems in the real estate market, or financial market disturbances) for one year before rebounding, would cause real GDP in Australia to fall by about 1/4 to 3/4 percent relative to baseline;[16] IMF (2012b) warns that a hard landing in China may also trigger a fall in house prices in Australia. Turning to Chile, IMF (2012c) provides some evidence on its high dependency to commodity exports,[17] and estimates that a 10 percent decline in copper prices would reduce GDP by 0.8 percent over 8 quarters; the report also puts forward investment as a significant transmission channel, since "investment appears to be very sensitive to copper prices (while private consumption also tends to increase during copper price booms)". Similarly, IMF (2013c) shows the high and rising dependency of Peru to commodity exports (mining exports accounted for 60 percent of total exports, and 15.5 percent of GDP, in 2011)[18] and China (which has replaced the United States as Peru's largest export destination in 2011);

[12] Although they do not find evidence that this may be due to the commodity price channel.

[13] Their results do show a decrease in metal prices, although the commodity price channel is not explicitly taken into account when assessing the impact on commodity exporters.

[14] The results of these two papers were also summarized in IMF (2012a).

[15] More specifically, emerging Asia's growth would decelerate from 3.5 percent to 1.7 percent in two quarters, before rebounding to 2.9 percent at the forecast horizon; in contrast, Latin American economies would suffer a reduction in their growth rate from 2.8 percent to 2 percent in three quarters, but the deceleration would continue to about 1.3 percent at the end of the forecasting period. Erten attributes the stronger impact on Latin America to their reliance on primary commodity exports and less diversified productive structures.

[16] More precisely, slower growth in China would trigger a persistent fall in global commodity prices by about 13 percent; government revenue would fall due to lower commodity-related tax revenues and lower economic activity; the nominal trade balance would worsen by about 1.5 percent of GDP. However a depreciation of the Australian dollar and cuts in the policy interest rate would help buffer the shock.

[17] Specifically, the report states that "Chile is one of the most commodity dependent economies among emerging markets: [...] commodities represent almost 70 percent of total exports, with a very high concentration in metals (mainly copper); [...] commodity-related fiscal revenues are also significant, accounting for 17 percent of total revenues (3.5 percent of GDP) in 2012".

[18] However, the IMF also notes that the export structure may have helped to reduce vulnerabilities: copper (23 percent of total exports) and gold (22 percent of total exports) represent the major part (80 percent) of mineral exports; the fact that gold prices show little correlation with other metal prices (due to the status of gold as a "safe haven asset" in crisis times)

the report states that "Peru's vulnerability to China is not only related to a possible slowdown but also to the impact of Chinese demand on global commodity prices as development patterns change". Finally, IMF (2013a) mentions the Chinese hard landing scenario as a significant downside risk for Colombia.

3 Methodology and data

3.1 General overview of the methodology

Global VAR (GVAR) models, first developed by Dees et al. (2007) and based on the work of Pesaran et al. (2004), are now widely used in the literature.[19] One of the value added of the GVAR methodology is to allow to study international linkages despite time sample limit.This is thus particularly relevant to assess global spillovers from a given country, in our case from China.

At the center of the GVAR modeling framework are individual VARX models (one for each country). The global VAR model is then obtained by combining all individual VARX models. More precisely, the country i's VARX model can be written as follows:

$$x_{it} = a_{i0} + a_{i1}t + \sum_{j=1}^{p} \Phi_{ij} x_{i,t-j} + \sum_{k=0}^{q} \Gamma_{ik} x^*_{i,t-k} + u_{it}$$

where x_{it} is the vector of country i specific variables and x^*_{it} the vector of foreign variables for the country i; x^*_{it} is a weighted average of all other countries' specific variables. The GVAR toolbox allows to choose the number of lags (p and q) with some information criteria (we choose SBC) and also allows to test for unit roots, co-integration relationships and weak exogeneity. The whole GVAR model can be rewritten as:

$$x_t = b_0 + b_1 t + \sum_{i=1}^{l} F_i x_{t-i} + v_t \tag{1}$$

where $x_t = [x_{1t}; x_{2t}...; x_{nt}]$ and F_i are based on Φ_i and Γ_i (hence on weights).[20] The companion form of the GVAR model is as follow:

$$X_t = FX_{t-1} + D_t + V_t \tag{2}$$

may have helped to buffer negative terms of trade shocks.

[19] We estimate the model with the GVAR toolbox (available on CFAP's website: http://www-cfap.jbs.cam.ac.uk/research/gvartoolbox/index.html) and used our own code to construct conditional forecast.

[20] l is the maximum of lags (l=$max(p, q)$).

If for example $l = 3$, equation (2) is of the form:

$$\begin{pmatrix} x_t \\ x_{t-1} \\ x_{t-2} \end{pmatrix} = \begin{pmatrix} F_1 & F_2 & F_3 \\ I_k & 0 & 0 \\ 0 & I_k & 0 \end{pmatrix} \begin{pmatrix} x_{t-1} \\ x_{t-2} \\ x_{t-3} \end{pmatrix} + \begin{pmatrix} b_0 + b_1 t \\ 0 \\ 0 \end{pmatrix} + \begin{pmatrix} v_t \\ 0 \\ 0 \end{pmatrix}$$

Conditional and unconditional forecasts: In order to study the potential impact of a hard landing in China, we use conditional forecast methodology (so that we can constrain some Chinese variables over the forecast period); this is conceptually similar to counterfactual analysis, as in Pesaran et al. (2007) or Dubois et al. (2009). It can be shown that the mean μ_h and variance-covariance Ω_{hh} matrix of the forecast of x_t for horizon h (x_{t+h}) can be written as:[21]

$$\mu_h = E_1 F^h X_T + \sum_{s=0}^{h-1} E_1 F^s D_{T+h-s}$$

and:

$$\Omega_{hh} = E_1 \sum_{s=0}^{h-1} F^s \tilde{\Sigma} F'^s E_1'$$

where $E_1 = (I_k 0_{k\times k} 0_{k\times k})$, T is the time sample size and

$\tilde{\Sigma} = \begin{pmatrix} \Sigma & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}$ if for example $l = 3$.

where Σ is the variance-covariance of the residuals of the GVAR model.

As shown by Pesaran et al. (2007), under the assumption of normality of x_{t+h} and for a given matrix of constraints Ψ corresponding to the set of conditions for the conditional forecast, one can write the mean μ_h^* of the conditional forecast as follows:[22]

$$\mu_h^* = \mu_h + (s'_{h\bar{H}} \otimes I_k)\tilde{\Omega}(I_{\bar{H}} \otimes \Psi')[(I_{\bar{H}} \otimes \Psi)\tilde{\Omega}(I_{\bar{H}}(I_{\bar{H}} \otimes \Psi')]^{-1}\tilde{g}_{\bar{H}}$$

where $s_{h\bar{H}}$ is the $\bar{H} \times 1$ selection vector with unity as its h^{th} element and zeros elsewhere, and $\tilde{\Omega}_{\bar{H}}$ is the

[21] See Pesaran et al. (2007) for details.

[22] It is also possible to calculate the variance-covariance matrix of conditional forecast but we do not need it here. See Pesaran et al. (2007, p. 65) for details.

$k\bar{H} \times k\bar{H}$ matrix:

$$\tilde{\Omega}_{\bar{H}} = \begin{pmatrix} \Omega_{11} & \Omega_{12} & \cdots & \Omega_{1\bar{H}} \\ \Omega_{21} & \Omega_{22} & \cdots & \Omega_{2\bar{H}} \\ \vdots & \vdots & \ddots & \vdots \\ \Omega_{\bar{H}1} & \Omega_{\bar{H}2} & \cdots & \Omega_{\bar{H}\bar{H}} \end{pmatrix}$$

where:

$$\Omega_{ij} = \begin{cases} E_1 \left(\sum_{s=0}^{i-1} F^s \tilde{\Sigma} F'^s \right) F'^{(j-i)} E_1' & \text{if } i < j \\ E_1 F'^{(i-j)} \left(\sum_{s=0}^{i-1} F^s \tilde{\Sigma} F'^s \right) E_1' & \text{if } i > j \end{cases}$$

and $\{\Omega_{ii}\}_{i=1}^{\bar{H}}$ are given above. Finally, Ψ is a matrix c constraints defined such that $\Psi x_{T+h} = d_{T+h}$ where d_{T+h} is a $c \times 1$ vector of constants which give the constraints for the conditional forecast.

Bootstrap of forecasts: In order to take into account parameter uncertainty we use bootstraps technique to R simulated within sample values of x_t.[23] For each simulation, we choose $v_t^{(r)}$ drawn with nonparametric method and we construct $x_t^{(r)}$ with estimated parameters of equation (1):

$$x_t^{(r)} = b_0 + b_1 t + \sum_{i=1}^{l} F_i x_{t-i} + v_t^{(r)}$$

This allows us to estimate $F_i^{(r)}$ and then apply unconditional and conditional forecast methodology described above in order to obtain $\mu_h^{(r)}$ and $\mu_h^{(r)*}$. Hence, based on our R simulations it is straightforward to calculate median and other quantiles of conditional and unconditional forecasts.

3.2 Data and modeling choices

Our study covers 25 countries, of which 19 are modeled separately and the remaining 6 grouped into the "rest of the world" (RoW hereafter), from Q2 1992 to Q4 2012.[24] Six of them are mineral commodity exporters: Australia, Brazil, Chile, Peru, India and South Africa.[25]

For all countries, we include the following variables: real GDP, inflation, investment, and real effective exchange rate. Furthermore, we add real exports as a domestic variable for our six mineral commodity exporters. Finally, as global variables we choose oil and metal price indexes.[26] While the inclusion of

[23] Our methodology is inspired by bootstrap used in the GVAR toolbox for GIRF and GFEVD and by Greenwood-Nimmo et al. (2012). We ran 1000 replications.

[24] Our countries are Australia, Austria, Belgium, Brazil, Canada, China, Chile, Finland, France, Germany, India, Italy, Japan, Korea, Mexico, Norway, New Zealand, Peru, South Africa, Spain, Sweden, Switzerland, United Kingdom, United States and Russia. The 6 countries grouped into the rest of the world are Canada, Norway, Sweden, Switzerland, United Kingdom and United States.

[25] We choose to focus on those 6 countries since (i) they are major metal exporters and (ii) a significant share of their exports goes to China. See table B.2 for more details.

[26] When possible we extent the GVAR toolbox database. Data sources are available in table B.1.

real GDP and inflation is standard in the GVAR literature, our choice of including additional variables is motivated by the aim of our study, which is to assess the impact of a Chinese hard landing on commodity exporters. In particular, we try to identify three possible transmission channels to commodity exporters: through commodity prices, through export volumes, and through investment (since lower commodity prices should reduce the incentives to invest in the mining sector). Including investment also has an additional advantage: it enables us to constrain scenarios where Chinese GDP growth and investment growth follow different paths, thus to simulate a rebalancing of the Chinese economy.[27] Finally, the inclusion of the real effective exchange rate is motivated by the fact that its depreciation may act as a buffer for commodity exporters, in the context of an adverse terms-of-trade shock.

Table B.3 summarizes which variables are endogenous and/or exogenous for each country. Foreign GDP and foreign inflation impact all countries; additionally, foreign investment is allowed to impact mineral commodity exporters (since metals are mostly used for investment) and Germany (since capital goods account for a significant share of its exports). For a given country i, foreign variables are weighted averages of other countries' variables; we define the weight of each other country j as the share of exports from country i to country j, in country i's total exports (as is common in the GVAR literature).

An important point to mention is that instead of linking global variables to a specific country or region (generally the United States, or the "Rest of the World"), as in usual GVAR modeling, we follow Georgiadis (2013) and choose to create two "commodity blocks" (one for each commodity price, namely "MPI block" and "oil block").[28] These "blocks" are treated in the GVAR model just as usual countries, while obviously they do not have the same domestic variables: for each of them, the only endogenous variable is the corresponding commodity price. Their foreign variables are weighted countries' GDP and inflation and, for the "MPI block", investment (since metals are mostly used for investment); weights are defined as countries' shares in the global demand for the corresponding commodity.[29] Conversely, the "commodity blocks" are allowed to impact mineral commodity exporters and, for oil, Russia.[30]

Finally, our methodology does not incorporate financial contagion. Indeed, a hard landing in china may negatively affect confidence elsewhere in the world, hampering investment; and the resulting rise in risk aversion may trigger significant capital outflows from emerging economies towards safe havens (as has been the case at the end of 2008). An interesting issue for further research would be to see how spillovers

[27] Indeed both scenarios we consider are rebalancing scenarios, a hard landing being an "uncontrolled rebalancing" scenario while a soft landing would be an "optimistic rebalancing" scenario; see subsections 4.1 and 4.2.

[28] Georgiadis only introduces one commodity block, focusing on oil prices.

[29] Weights for the "MPI block" are calculated with copper and iron ore consumption (see tables B.4 and B.5); weights for the "oil block" are calculated with regional oil demand for oil (see table B.6) which is then split between countries according to their weights in the region's GDP.

[30] This means that we do not take into account a possible positive spillover effect from a fall in metals prices, to commodity importers; our choice is motivated by Erten & Ocampo (2013) who find that global GDP impacts non-oil commodity prices, but do not find any reverse causality. As for oil, a fall in oil prices led by a negative demand shock would probably have a positive impact on oil importers, but the effect may be small; see ECB (2010, table 4, page 49).

from a hard landing in China could interact with the coming Fed tapering: the fall in commodity prices would undoubtedly cause commodity exporters' current account deficits to widen, which itself could exacerbate investors' concerns over these economies, as recent months' events showed for India, South Africa, Indonesia, Brazil and Turkey.

4 Results

We now turn to the results from our two different scenarios, the first one being a Chinese hard landing (subsection 4.1), and the second one being a soft landing (subsection 4.2). Each of these scenarios is compared to the unconditional forecast.

4.1 Hard landing

In our hard landing scenario, Chinese GDP growth drops from 2014Q1 onwards,[31] and quickly stabilizes at 3 percent per year over the forecast horizon. This growth slowdown is driven by a sharp deceleration in investment, which is assumed to stagnate (0 percent growth) over the forecast horizon. Our scenario implicitly assumes that consumption would hold up better, growing at around 6 percent over the forecast horizon. In that sense, our scenario can be viewed as an "uncontrolled rebalancing" scenario: the investment-to-GDP would fall from 46 percent in 2012, to around 40 percent five years later.

Our results are illustrated in figures A.23 to A.30. Looking first at regions, we find Latin America and Asia (ex. China) to be the most seriously impacted ones (see figure A.23, middle and lower center panel): Latin American growth would stabilize at 1.8 percent per year at the end of the forecast (1.2 percent lower than in the unconditional forecast), while Asian (ex. China) growth would fall to 2.9 percent per year (also 1.2 percent lower than in the unconditional forecast). Due to a sharper initial impact, the cumulated growth loss would be higher for Latin America (-5.6 percent) than for Asia ex. China (-4.4 percent, see figure A.25 and table B.8); these results are comparable to those of Erten (2012), who finds a somewhat larger impact on Latin America than on Asia. On the contrary, advanced economies would be less affected (figures A.23, bottom left and right panel, and A.25), since emerging economies still represent a rather low share of their exports' destinations; the euro area would be slightly more impacted than overall advanced economies, in line with Germany's higher market share in China. Overall, global growth would fall to around 2 percent per year, compared to nearly 4.5 percent in the unconditional scenario.

Focusing now on countries and specifically on commodity exporters, the most severely impacted ones would be Peru, Brazil, Chile and Australia with respective cumulated growth loss of 8.6%, 6.7%, 5.9% and 5.9%

[31] While we do expect such a hard landing to occur in the coming years, the chosen starting date (2014Q1) is only illustrative and should not be considered as a forecast.

over five years (see figures A.24 and A.25, and table B.7). Indeed their exposure to China through the trade channel has risen significantly in recent years (see figures A.16 to A.19). Russia and Finland also rank high, but the confidence interval for Russia is very large; this could be interpreted as a high dependency on oil prices for Russia, and a high sensitivity of oil prices to demand.[32] Korea would be significantly impacted as well (with a 5.9% cumulated growth loss over five years), because of its geographical proximity and hence strong trade links with China (between 2008 and 2012, China represented on average 40% of Korean exports).[33] Our results are somewhat different from IMF (2013d), which find that among commodity exporters, Mongolia (not in our sample), Australia, oil exporters, and Chile would be the most affected by a Chinese slowdown; in particular, the impact they find on Peru is surprisingly low. Our results also differ from Ahuja & Nabar (2012), who find Asian countries (notably Korea) to be more impacted by a Chinese investment slowdown than commodity exporters, and Ahuja & Myrvoda (2012) who find Japan, Korea, and Germany to be among the hardest hit by a Chinese real estate slowdown; this may be due to the fact that they do not take directly into account the commodity price channel.

Our results also enable us to look at the different transmission channels from a Chinese growth shock to commodity exporters – commodity prices, exports volumes and investment – as well as the exchange rate behavior as a possible shock absorber. *First*, regarding commodity prices, figure A.27 shows that metals prices would be much more affected than oil prices, as expected.[34] Indeed, China is by far the largest copper and iron ore user in the world (with 44% of global consumption on average from 2008 to 2012), and metals use is predominantly linked to investment. By contrast, China accounts for "only" 10% of global oil demand and oil use may be more related to consumption (especially in China where coal is by far the prime source of industrial energy).

Second, the real effective exchange rate would depreciate in Australia, Brazil, Chile and South Africa, due to worsening terms-of-trade, which would help buffer the shock to some extent. By contrast, we do not find a strong effect on Peru's exchange rate, which could explain why Peru's growth would be the most affected; indeed the exchange rate would not be allowed to accommodate the shock given the still high level of dollarization in the country (see IMF 2013c). Furthermore, India's exchange rate would actually appreciate: while India exports some iron ore, it also imports a lot of oil, so its terms-of-trade may in fact improve.

Third, as shown in figure A.29, export volumes would be negatively impacted in five out of our six commodity exporters (except for Peru, where we find a non-significant increase); we find Chile and South

[32] In turn, the high dependency of Finland on Russia (its largest trading partner) explains why Finland also ranks high.

[33] We also find a rather strong impact on India, which may be somewhat overestimated because many important trading partners of India (Middle-East, ASEAN) are not included in our sample: the countries we included in the sample together account for only 39% of India's exports, which gives an unduly high weight for China in India's foreign variables.

[34] Metals prices would fall by -35% after five years in the hard landing scenario, against a +20% rise in the unconditional scenario. For oil, we find a +15% rise (hard landing) versus a +50% rise (unconditional).

Africa to be the most severely impacted. As regards investment, Latin America would be the most affected region (figure A.30), which is consistent with our expectation that lower metals prices would reduce incentives to invest in the mining sector.[35]

4.2 Soft landing

Our soft landing scenario is based on World Bank (2013): Chinese GDP growth progressively slows to 7% per year at the end of the forecast horizon (2018), while the investment-to-GDP ratio falls from 46 percent in 2012, to around 42 percent five years later. This scenario thus implicitly assumes that investment growth progressively slows, to 5% at the end of the forecast period, while consumption accelerates to around 9% per year. In that sense it can be characterized as an "optimistic rebalancing" scenario, something which World Bank (2013) acknowledges through its assumptions that major reforms are implemented and no major shock occurs.

Our results are illustrated in figures A.31 to A.38. We will not detail them here, as the main conclusions drawn from subsection 4.1 still hold, while obviously the impacts are smaller. A few points are nevertheless worth noting. *First*, Latin America remains the most impacted region, through the same transmission channels as discussed earlier, followed by Asia (ex. China). *Second*, the impact on advanced economies is very close to zero, and anyway not significant; thus a growth slowdown in China, from 10% (unconditional forecast) to 7% (soft landing) may not have any adverse impact on advanced economies, *provided China truly rebalances* (which means that consumption would accelerate, thereby benefiting advanced economies' exports).

To conclude, the fact that mineral commodity exporters, and among them Latin American countries, are the most affected in both scenarios (hard and soft landing), suggests that the Chinese growth rebalancing process itself will have its winners and losers, mineral commodity exporters falling in the latter category.

4.3 How low could metals prices fall?

Focusing now on metals prices, our results echo those of RGE (2012b): they find a sharper impact of a Chinese hard landing (see their "crash and burn" scenario) on copper and iron ore demand, than on oil demand. Similarly, our results point to a stronger negative impact of a Chinese hard landing on metals prices than on oil prices, in line with their different end-use patterns (mostly investment for metals, and consumption for oil) in the context of a rebalancing process (investment slowing much more than consumption), and also reflecting a much higher share of China in metals' global consumption compared

[35] The impact we find is however rather strong, and may be partly due to the initial points of the time series, which include the end of the hyperinflation period in Brazil.

to oil. However, RGE (2012a) find a much stronger impact of a hard landing on copper prices (-80 percent after four years), than we do for overall metal prices (-40 percent after five years). We discuss below some of the limits of our results regarding metals prices.

First, one reason we may *overestimate* the impact on metals prices is that not all Chinese metals consumption is linked to domestic investment; some of it is related to manufacturing and goods exports.[36] However, as evidenced by figures A.12 and A.13, the extent of possible overestimation due to this specific factor may not be very large.

Second, the methodology we chose does not allow us to incorporate expectations. Since our model is mostly linear, the decrease in metals prices occurs at a regular pace. However, in a hard landing scenario, financial markets would probably quickly revise down their expectations, thus provoking a much quicker adjustment in metals prices. Consequently, the temporal profile of the implied growth slowdown for commodity exporters may be somewhat different from what we find, with a sharper initial contraction.

Third, and perhaps most importantly, an underlying assumption of the methodology we use is that metals prices are mostly determined by demand; we do not take into account production aspects. In fact, prices should rather be determined by supply-demand equilibrium, i.e. by inventories (Frankel & Rose 2010 give some evidence of the role played by inventories in determining mineral commodity prices); this in turn may generate non-linearities, as shown by Deaton & Laroque (1992). Figure A.20 indeed shows that copper prices are closely related to inventories. In case of an unexpected negative demand shock, production may take time to adjust, leading to a rapid accumulation of inventories and a sharp drop in price. Our results would then probably *underestimate* the impact of a Chinese hard landing on metals prices.

These last considerations can be replaced into the broader context of commodity price cycle theories. Sturmer (2013) recalls that commodity prices are subject to long-term fluctuations and boom-and-bust cycles. Focusing on oil, Dvir & Rogoff (2009) argue that price booms are due to persistent aggregate demand shocks combined with supply constraints; similarly, Jacks (2013) characterizes commodity price super-cycles as "demand-driven episodes closely linked to historical episodes of mass industrialization and urbanization which interact with acute capacity constraints in many product categories – in particular, energy, metals, and minerals". Indeed, when prices are low, extracting industries have few incentives to invest and expand capacity; when confronted to an unexpected positive demand shock, they are unable to adjust quickly, as investment projects take several years to complete in capital-intensive mining sectors (Erten & Ocampo, 2013); supply constraints thus generate a price boom (as can be expected from the shape of supply curves, the vertical part of which indicating the maximum production capacity; see

[36] Our choice to weight the global demand impact on the "metals country" with countries' respective shares of metals' apparent consumption, implies that the whole metals' apparent consumption of a given country is assumed to be linked to its own domestic uses. In fact, part of China's apparent consumption is related to manufactured goods that are exported, thus ultimately linked to *other* countries' internal uses.

figures A.21 and A.22), which in turn makes investment profitable and push extracting industries to expand capacity. Conversely, when facing an unexpected negative demand shock, extracting firms tend to maintain production at high levels, thereby exacerbating the fall in price (Radetzki, 2008).[37]

The surge in mineral commodity prices during the 2000s can thus be explained as the result of unexpectedly strong Chinese growth (Arbatli & Vasishtha, 2012),[38] leading to supply constraints due to a lack of investment in extracting industries in the previous years (Morgan Stanley, 2012). Jacks (2013) shows that 15 out of 30 commodities, including copper, iron ore and steel, demonstrate above-trend real prices starting from 1994 to 1999; since most commodity prices cycles are typically 10 to 20 years long, Jacks goes on arguing that the turning point may come soon. Supporting this view, Morgan Stanley explains that the commodity price boom generated a supply-expanding investment surge that will lead to a significant *acceleration* in production capacity expansion in coming years;[39] unless global demand *accelerates*, which is highly unlikely,[40] prices are set to decrease.

Overall, the fall in metals prices provoked by a hard landing in China may probably be stronger than we found, because both trends that originated the price boom may be about to reverse simultaneously: *first*, Chinese demand, which used to be strong, would weaken significantly; *second*, production capacity, which has been insufficient for several years, may be about to expand strongly. Our methodology does not allow us to take into account the later effect, nor the non-linearities that may come along with it.

4.4 Could emerging economies recouple?

Finally, our results also shed light on the decoupling-recoupling debate. As noted by Willett et al. (2011) there has been different versions of the decoupling hypotheses. By the mid-2000s, decoupling was seen as the possibility that emerging economies could maintain their own growth dynamism, thanks to strong domestic demand, thus consistently outperforming advanced economies' growth. At the end of 2007, after the subprime crisis erupted in the US, some analysts even asserted that emerging economies had become unaffected by advanced economies' business cycles; this thesis was proven wrong with the *Great Recession*, and recoupling talks quickly spread. However, as emerging economies managed to weather the crisis quite well, and soon resumed high growth, the decoupling theory rapidly reappeared: emerging economies were not immune to advanced economies' business cycles, but they still were able to outperform them in terms of growth. In other words, the "growth gap" between emerging and advanced economies had remained

[37] Cited by Sturmer (2013), underlining the "common experience in the extractive sector that firms keep their utilization rates high even after negative price and demand shocks hit the market".

[38] Consensus Forecasts systematically underestimated China's growth between 2004 and 2007.

[39] For copper, Morgan Stanley estimates that "the increase in global supply *in each of the next seven years* will be roughly equal to the increase in supply over the decade to 2011"; for iron ore, global supply may double from 2011 to 2020 (see figures A.21 and A.22).

[40] Even an optimistic rebalancing scenario for China, away from investment, would imply a slowdown in demand for metals.

mainly intact, and would remain so in the foreseeable future; emerging economies were increasingly bound to become the world's main growth drivers.

Our results cast some doubts on this theory. As shown in figure A.26, a hard landing in China would cause the "growth gap" between emerging and advanced economies to tighten significantly, from 7 percent in the years 2007-09, to less than 2 percent from 2015 onwards: in other terms, emerging economies may (at least *partially*) recouple, *under the assumption that China lands hard.*[41] Admittedly, much of the reduction in the "growth gap" derives directly from our very assumption: China itself represents a large part of emerging economies' aggregate GDP, so a hard landing would mechanically drive down overall emerging economies' growth. That being said, for all the reasons mentioned in subsection 2.1, we consider a hard landing to be a quite plausible scenario for China; what our results indicate, is that under these circumstances the most affected would be other emerging economies, whether because of their geographical proximity (Asia) or because of the commodity link (Latin America).[42]

These findings echo those of Rebucci et al. (2012), who note that "the emergence of China as an important source of world growth might be the driver of the so called *decoupling* of emerging markets business cycle from that of advanced economies reported in the existing literature". Similarly, Levy Yeyati & Williams (2012) finds that the real decoupling is in fact more a growing dependence on China.[43] Esterhuizen (2008) relates the decoupling theory to commodity prices, and estimates that "recoupling may become a reality if commodity prices collapse".[44] Decoupling could thus be reinterpreted as the consequence of China's emergence as a major economy, its highly unbalanced growth pattern (with an excessive reliance on commodity-intensive investment), and the implied spillovers of commodity exporters.[45] Supporting this hypothesis, is the fact that many emerging economies took off *simultaneously*, at the beginning of the 2000s; that the exceptionally large Chinese stimulus package, with a high investment content, probably helped commodity exporters to weather the crisis;[46] and that, once again, many emerging economies are now facing difficulties *simultaneously*, as China's growth is slowing.[47] If China were to land hard, decoupling may turn out to be more a decade-long parenthesis, rather than the "new normal". In other

[41] Under the unconditional scenario, the "growth gap" would remain at high levels, around 5-6 percent (since the unconditional scenario does nothing but prolong existing trends, i.e., replicate pre-crisis patterns). Under the soft landing scenario, the "growth gap" would stabilize around 4 percent, as shown in figure A.34.

[42] Given the strength of its commodity link to China (Farooki, 2010), extending our work to Sub-Saharan Africa may also lead to question the sustainability of its recent take-off.

[43] Levy Yeyati & Williams' results also point to a financial recoupling between advanced and emerging economies.

[44] However, Esterhuizen puts greater emphasis on the role played by the US, rather than China, as a commodity importer.

[45] It should be noted that many large emerging economies (notably Latin American countries, Russia and Middle-East) are commodity exporters, and thus depend to some extent on China. Emerging Asia, although comprising few commodity exporters, is also dependent on China because of geographical proximity. The only emerging economies that do not have strong links to China are those of Eastern Europe; while they also experienced a significant take-off at the beginning of the 2000s, this had probably more to do with booming credit in the context of financial integration with Western Europe, and ultimately proved to be unsustainable in a number of them in the aftermath of the Great Recession.

[46] Figure A.1 shows that the Chinese trade deficit vis-à-vis commodity exporters widened significantly starting from 2009-10. Additionally, it is worth noting that Australia, which is among the countries most dependent to China, did not experience any recession in 2009.

[47] There are admittedly alternative (complementary) explanations, such as sluggish growth in advanced economies, or spillovers from Fed's announcements about tapering.

words, the convergence process at work for the last decade may stall, and a number of emerging economies could remain caught in the "middle-income trap".

5 Conclusion

We estimated in this paper the potential spillovers of a hard landing in China on the rest of the world, with a special focus on mineral commodity exporters. After recalling the main arguments pointing to a hard landing scenario in China, we used conditional forecast in a Global VAR framework to assess its impact. We found evidence for each of the three transmission channels embedded in our methodology: a Chinese hard landing would cause commodity prices to fall (especially for metals, while oil prices would be less affected), export volumes would be affected, as well as investment (in line with worse expected prospects for extracting industries); in all but one case, the exchange rate would act as a buffer as terms-of-trade worsen. Outside China, we found Latin America to be the most impacted region, followed by Asia, which is in line with other studies; advanced economies would be less affected.

Our contribution to the literature is twofold. *First*, in terms of methodology, we modeled metals and oil prices as two separate entities in our Global VAR framework, while other studies mostly use a single commodity price variable which is generally endogenous to the United States (this is especially the case for oil); on the contrary, the exceptionally high share of China in metals' world consumption needed to be taken into account in a specific way in our view. *Second*, we contribute to the decoupling-recoupling debate by showing that, *under the assumption that China lands hard*, the "growth gap" between emerging and advanced economies would significantly be reduced (what we refer to as *partial recoupling*). We thereby challenge the common view that emerging economies should be tomorrow's global growth drivers.

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Appendix

A Figures

A.1 Stylized facts

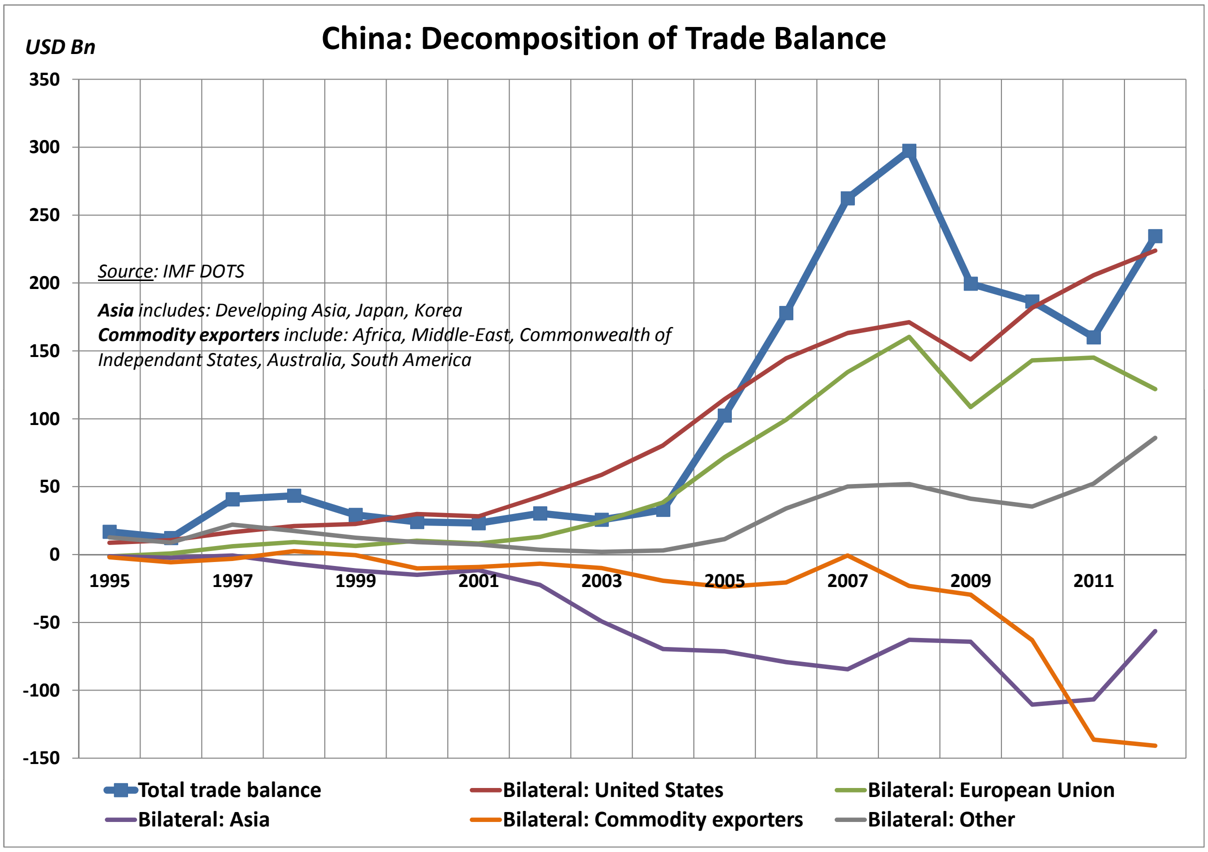


Figure A.1: China's bilateral external imbalances.

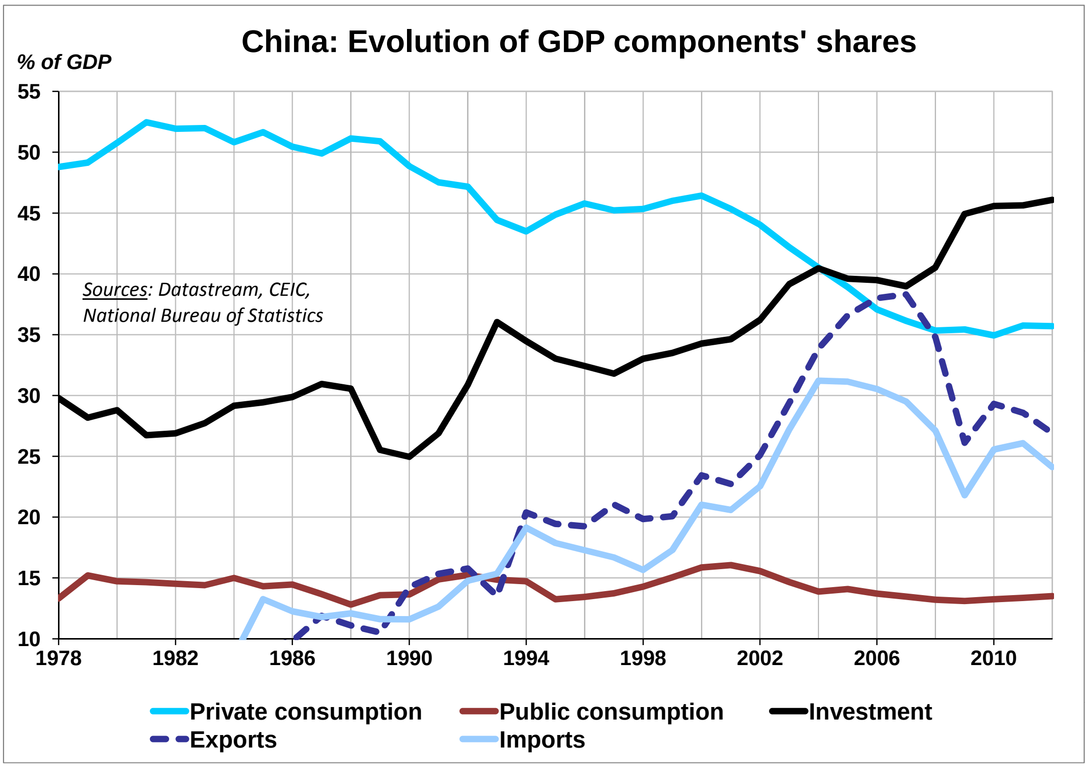


Figure A.2: China's internal imbalances.

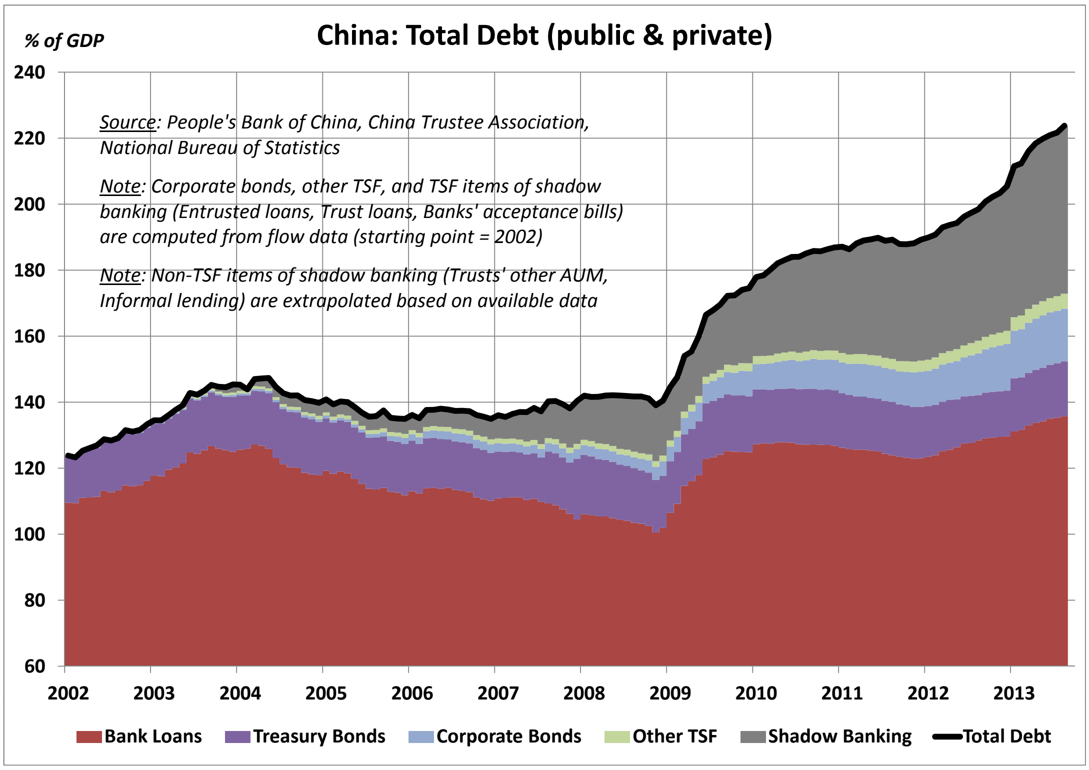


Figure A.3: China's total debt surge.

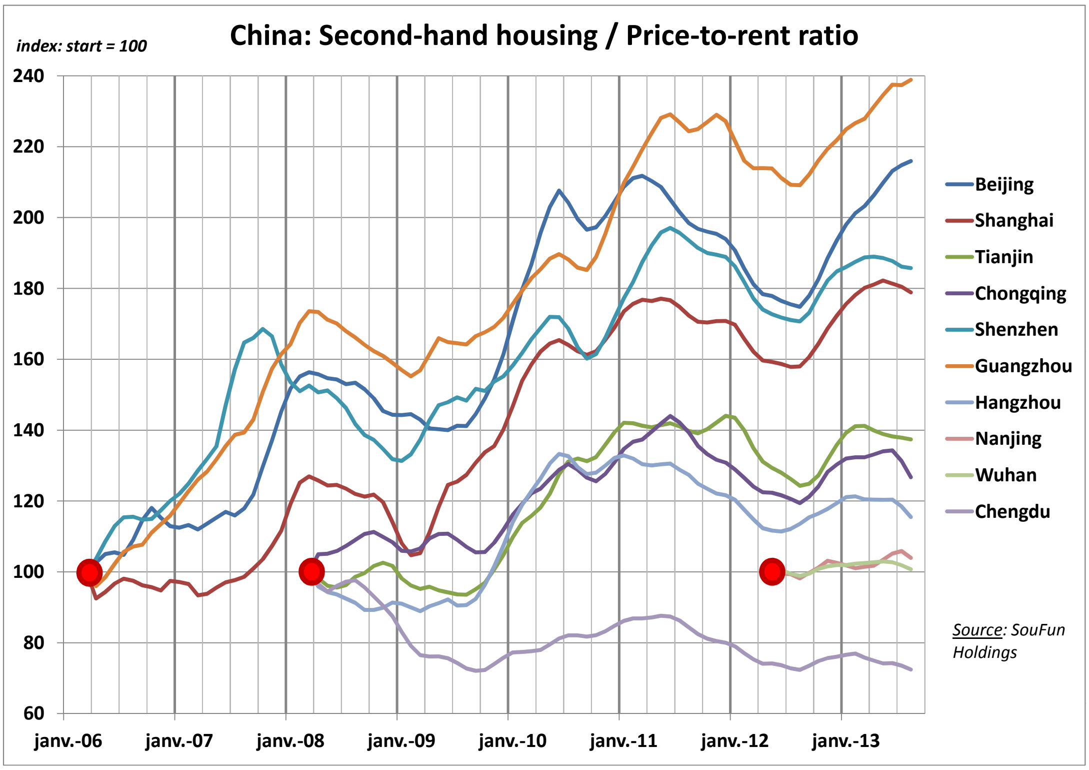


Figure A.4: Price-to-rent ratios in China's ten largest cities.

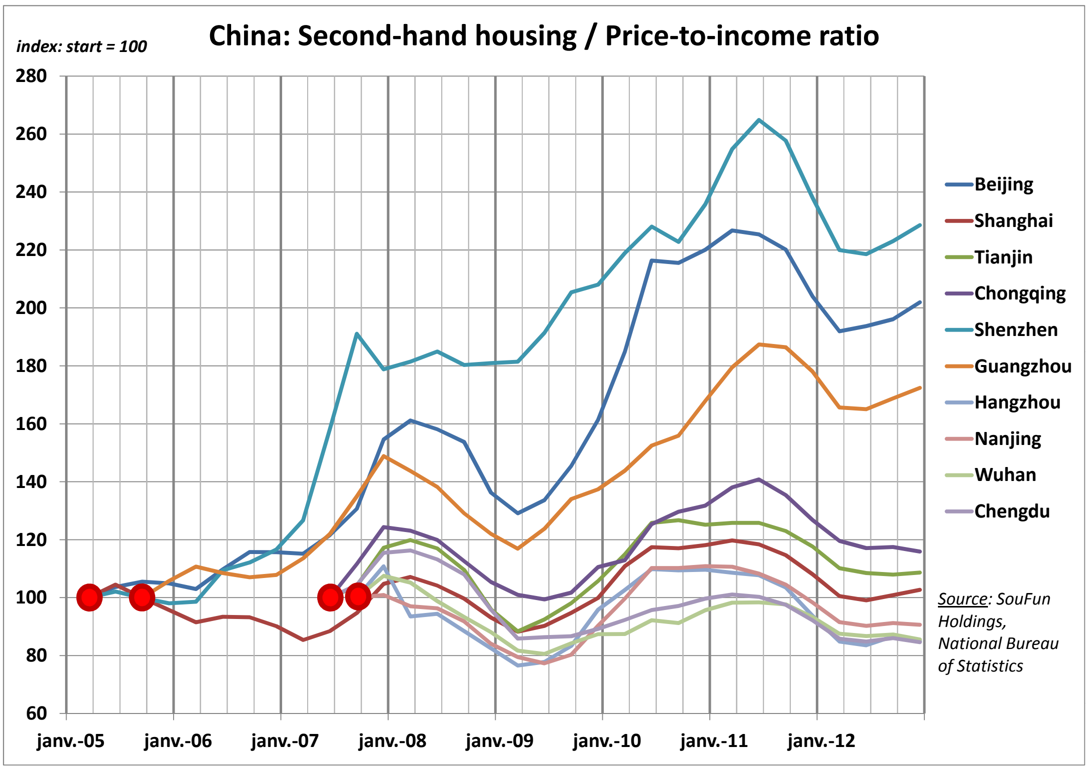


Figure A.5: Price-to-income ratios in China's ten largest cities.

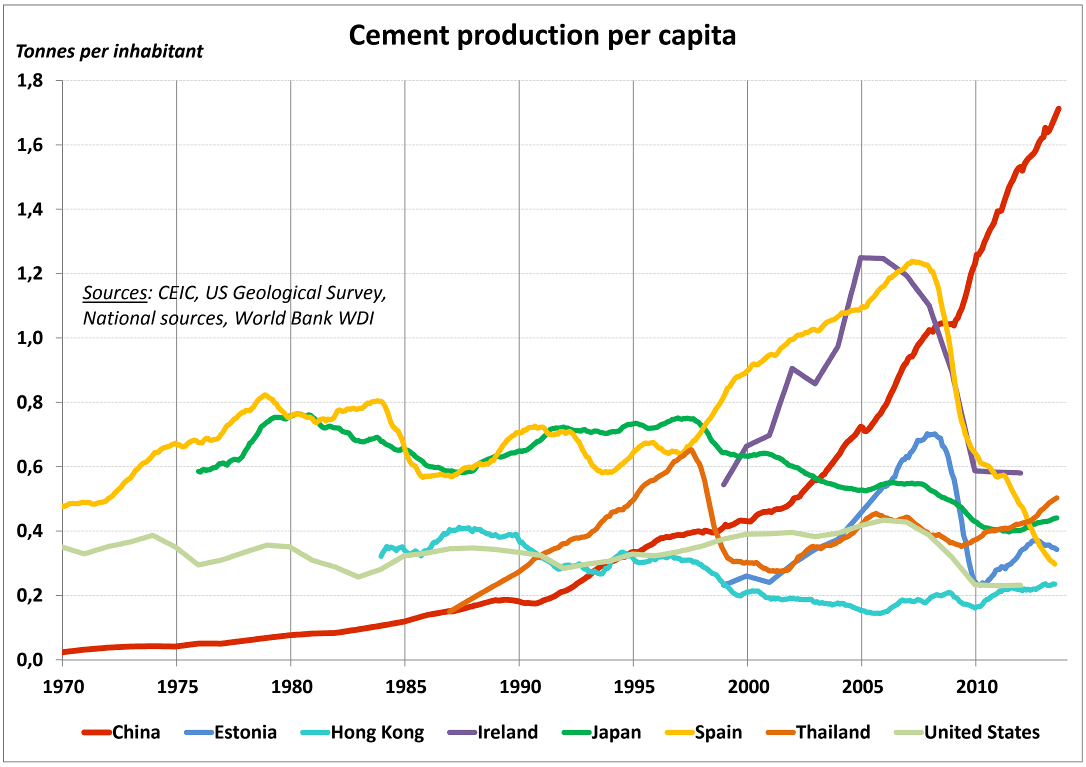


Figure A.6: Cement production in China compared to past real estate bubbles.

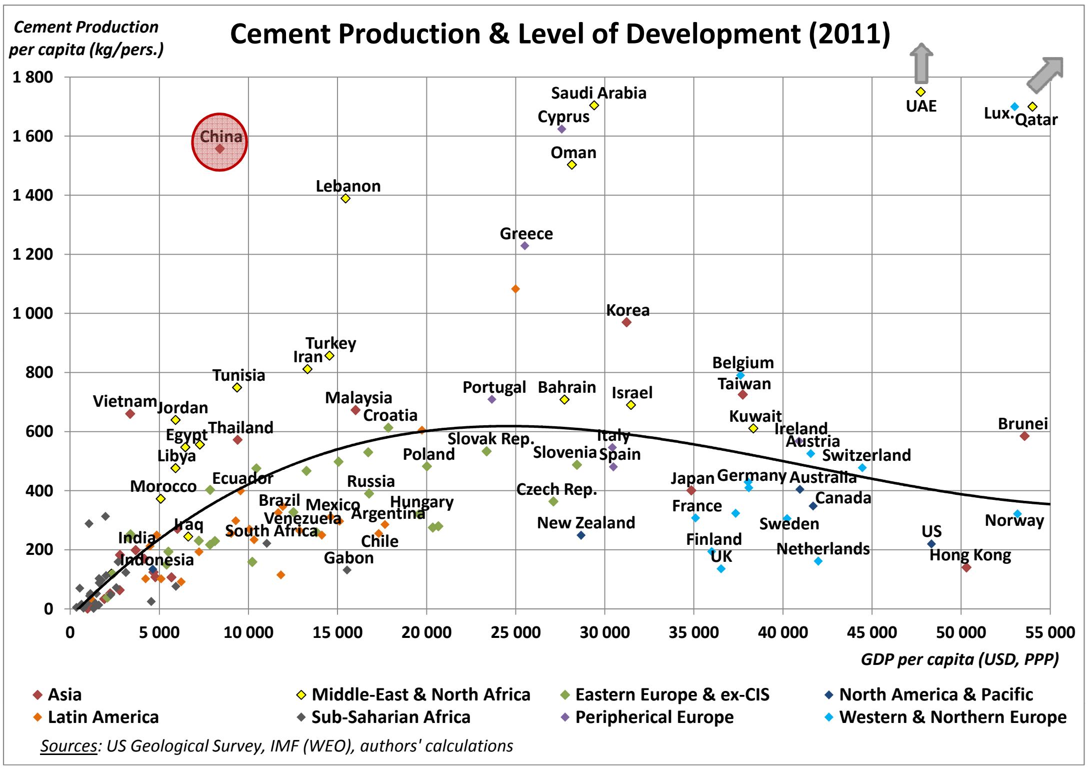


Figure A.7: Cement production and level of development.

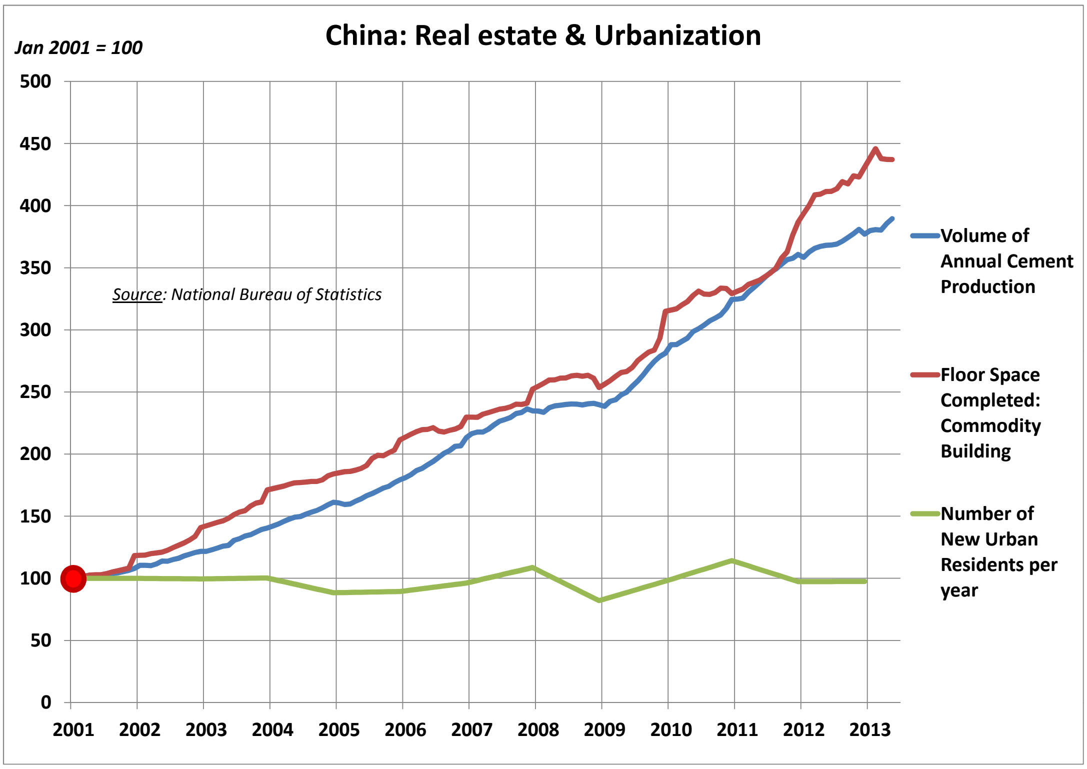


Figure A.8: Urbanization and real estate in China.

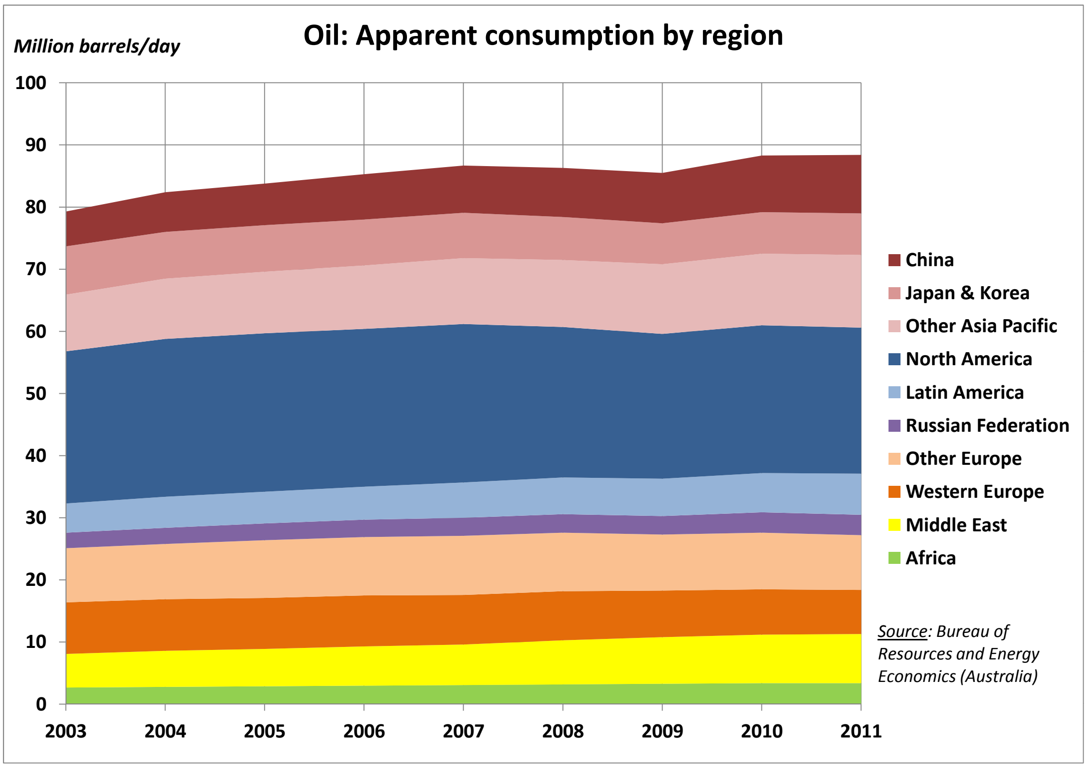


Figure A.9: Oil consumption by region.

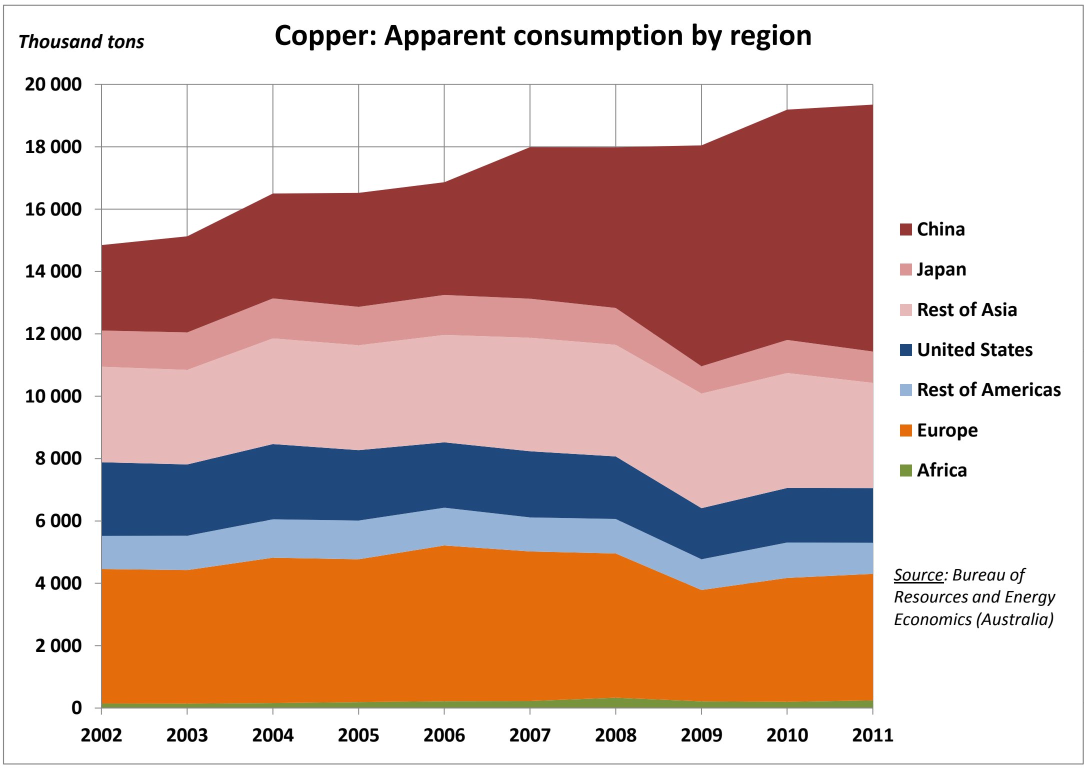


Figure A.10: Copper consumption by region.

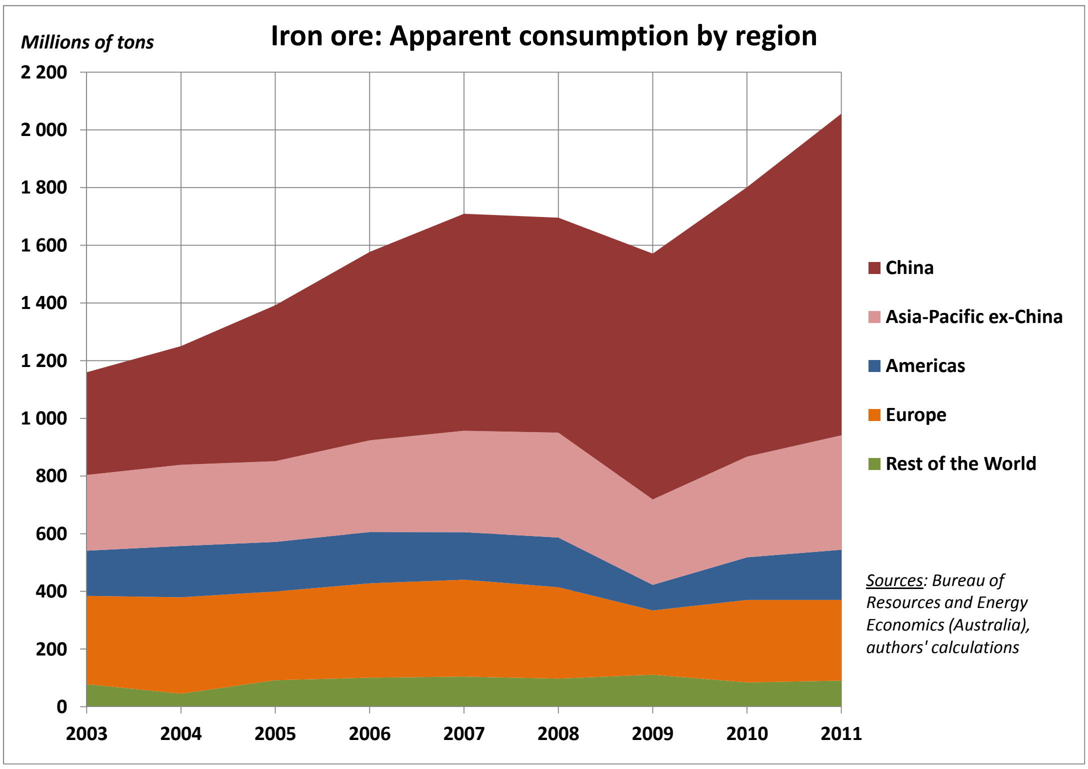


Figure A.11: Iron ore consumption by region.

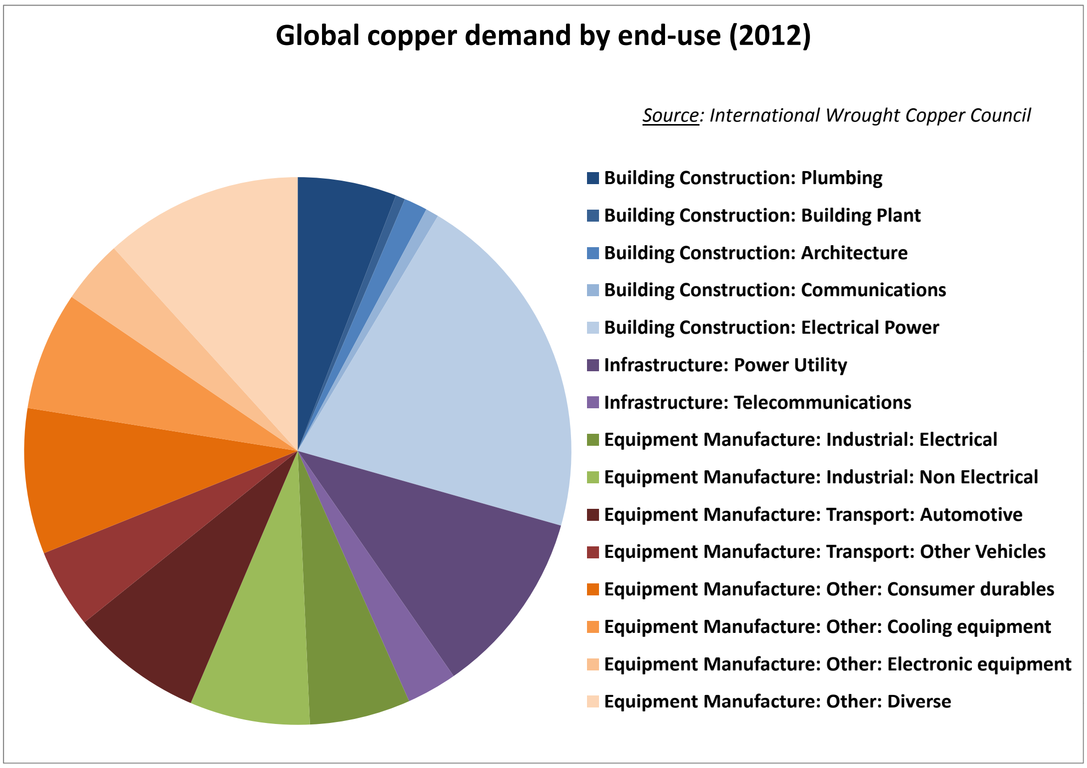


Figure A.12: Global demand by end-use: copper.

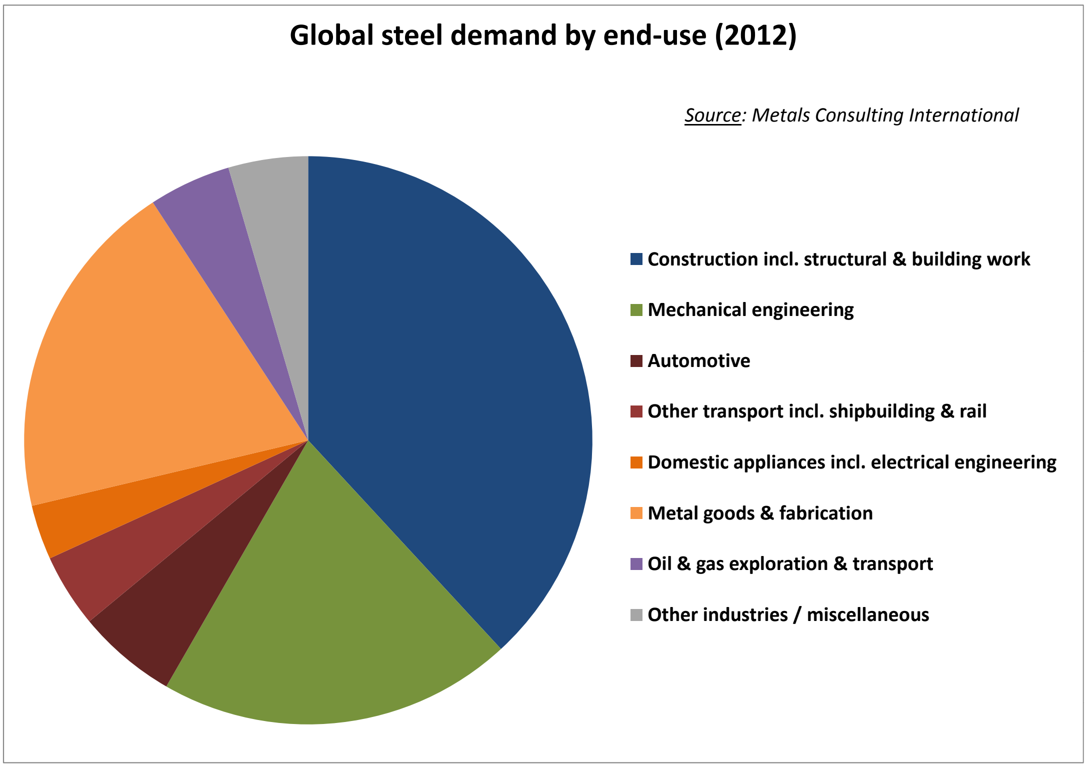


Figure A.13: Global demand by end-use: steel.

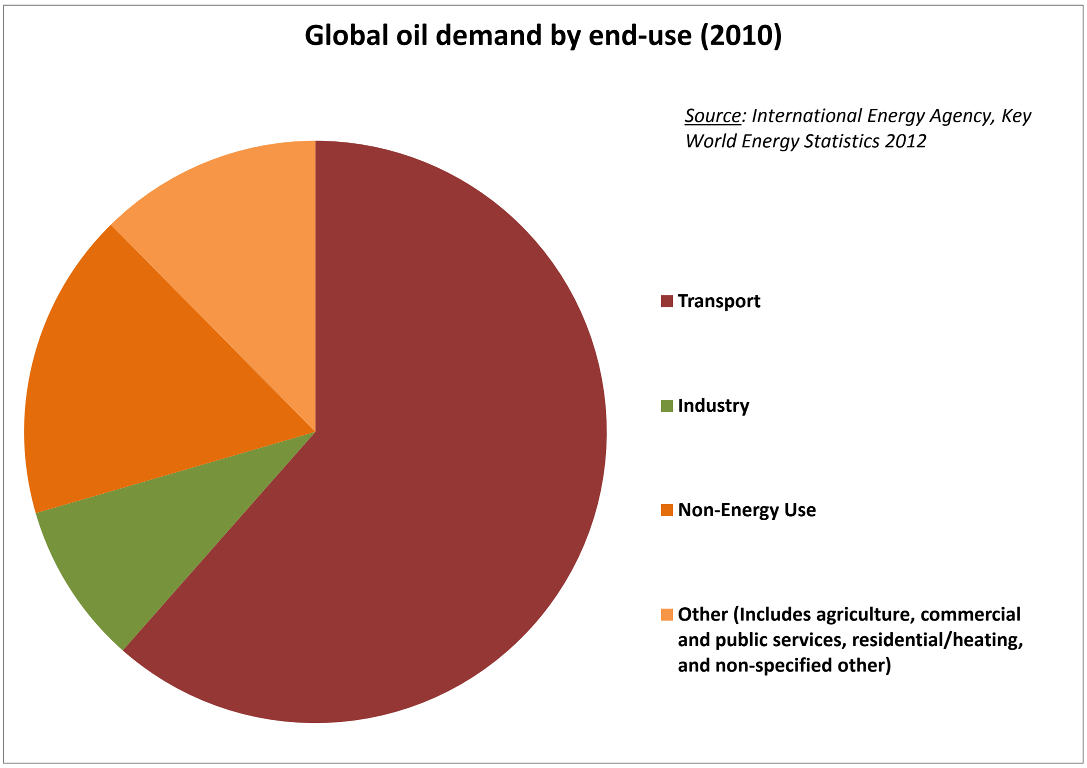


Figure A.14: Global demand by end-use: oil.

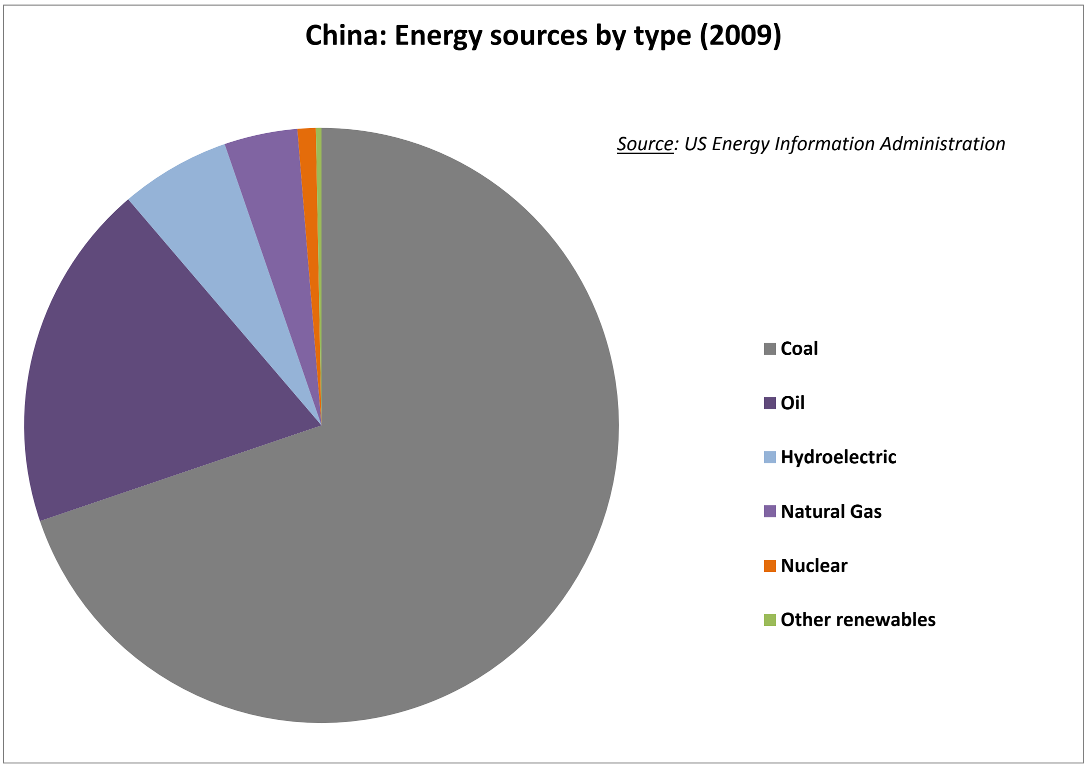


Figure A.15: Sources of energy in China.

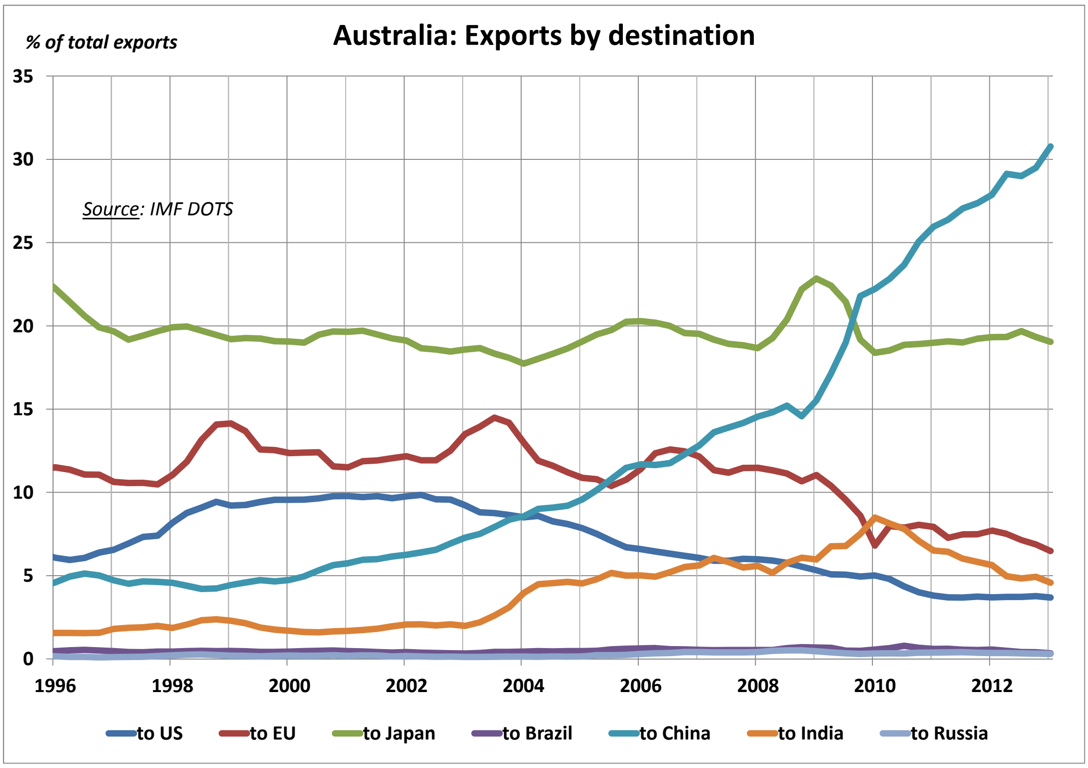


Figure A.16: Australia: Exports by destination.

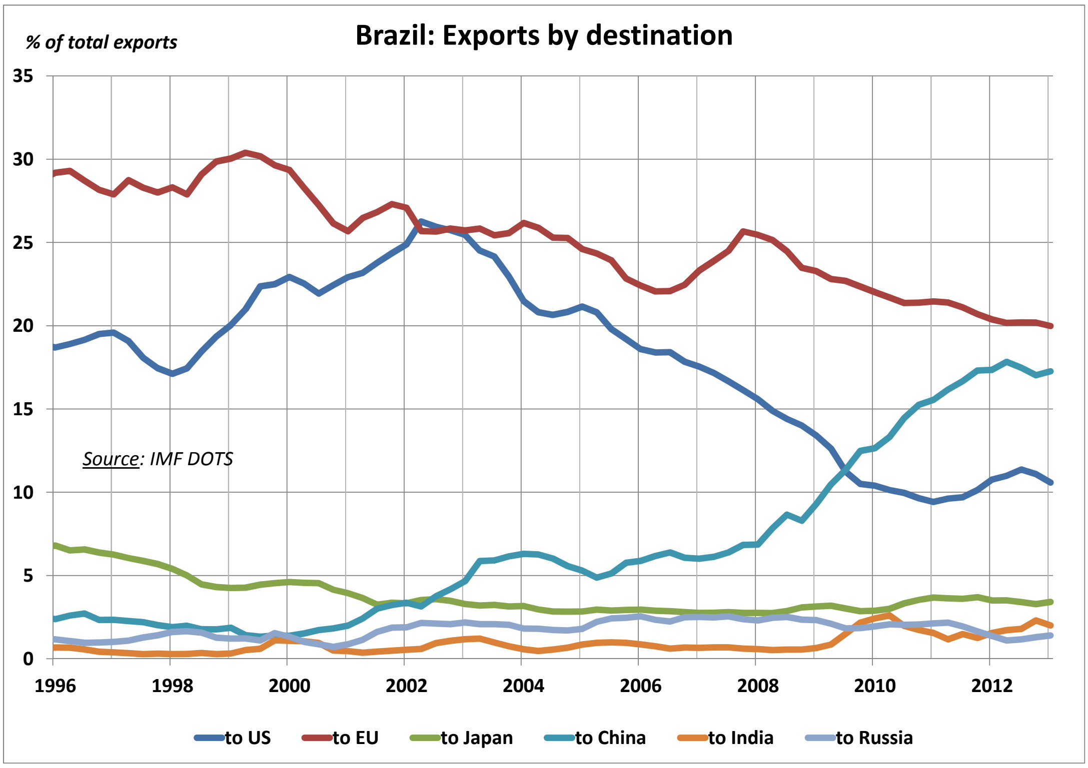


Figure A.17: Brazil: Exports by destination.

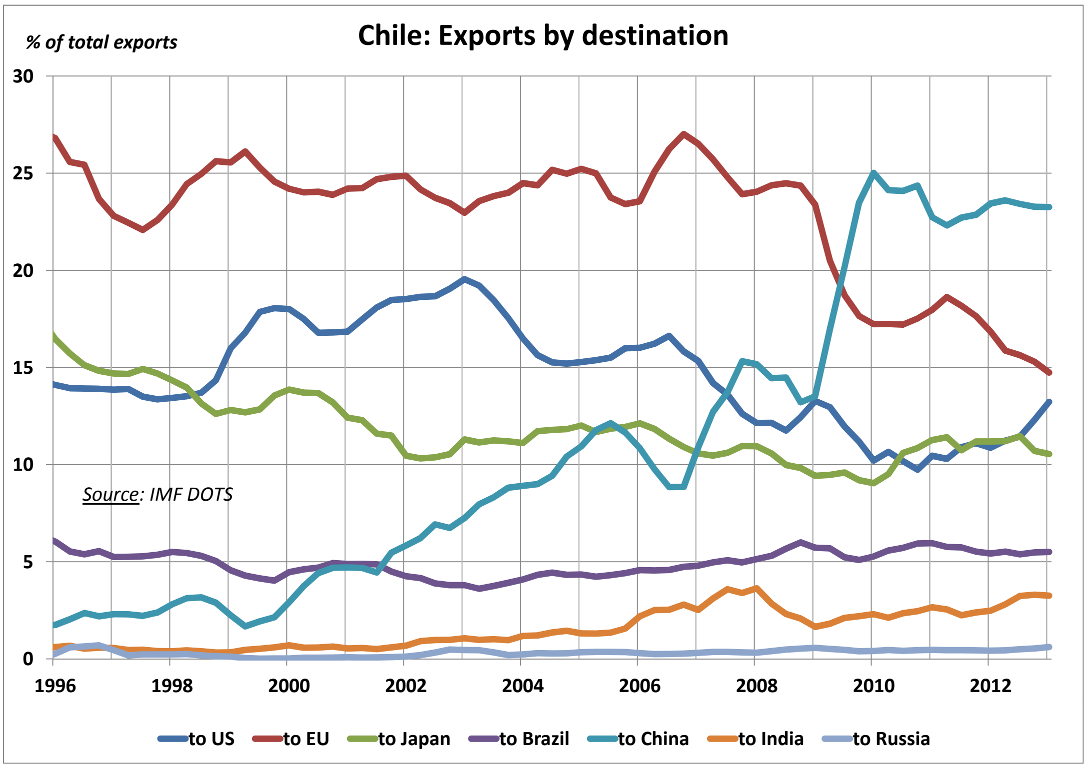


Figure A.18: Chile: Exports by destination.

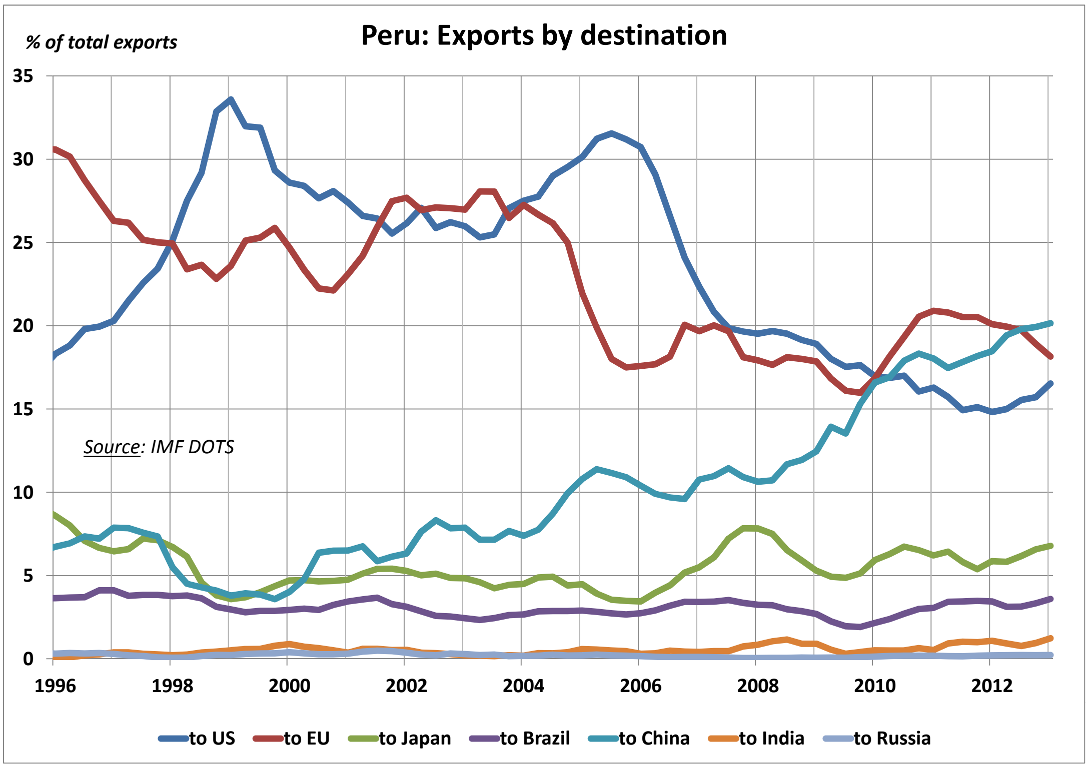


Figure A.19: Peru: Exports by destination.

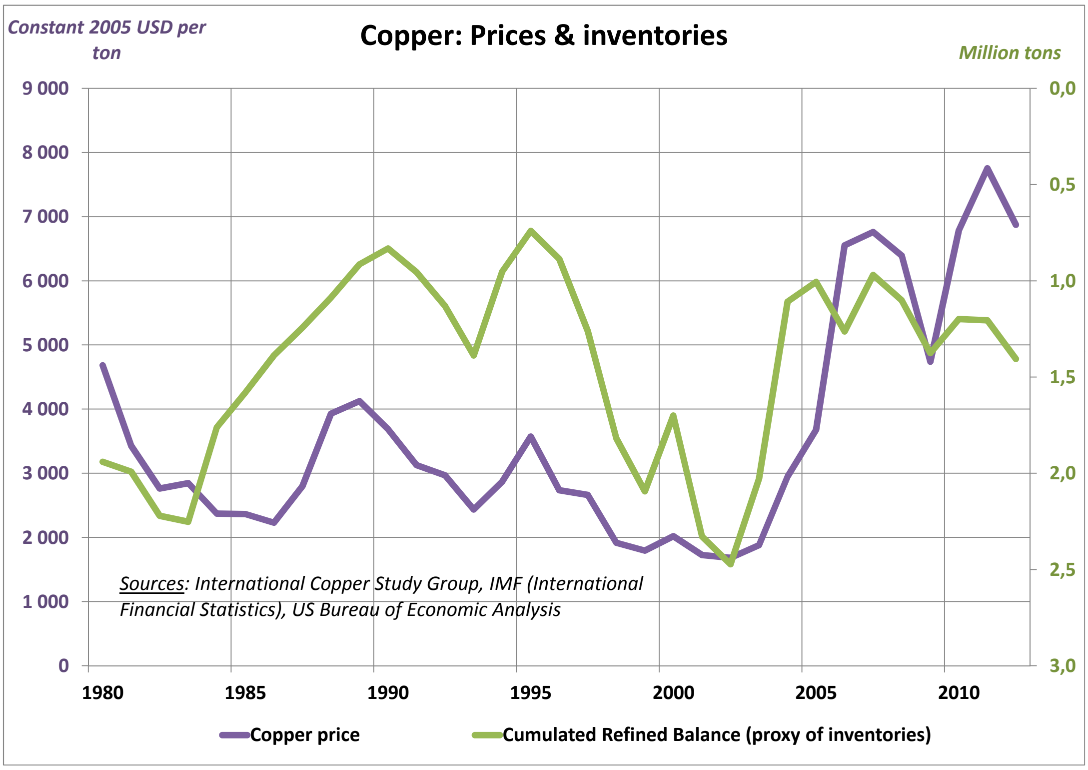


Figure A.20: Copper: Prices and inventories.

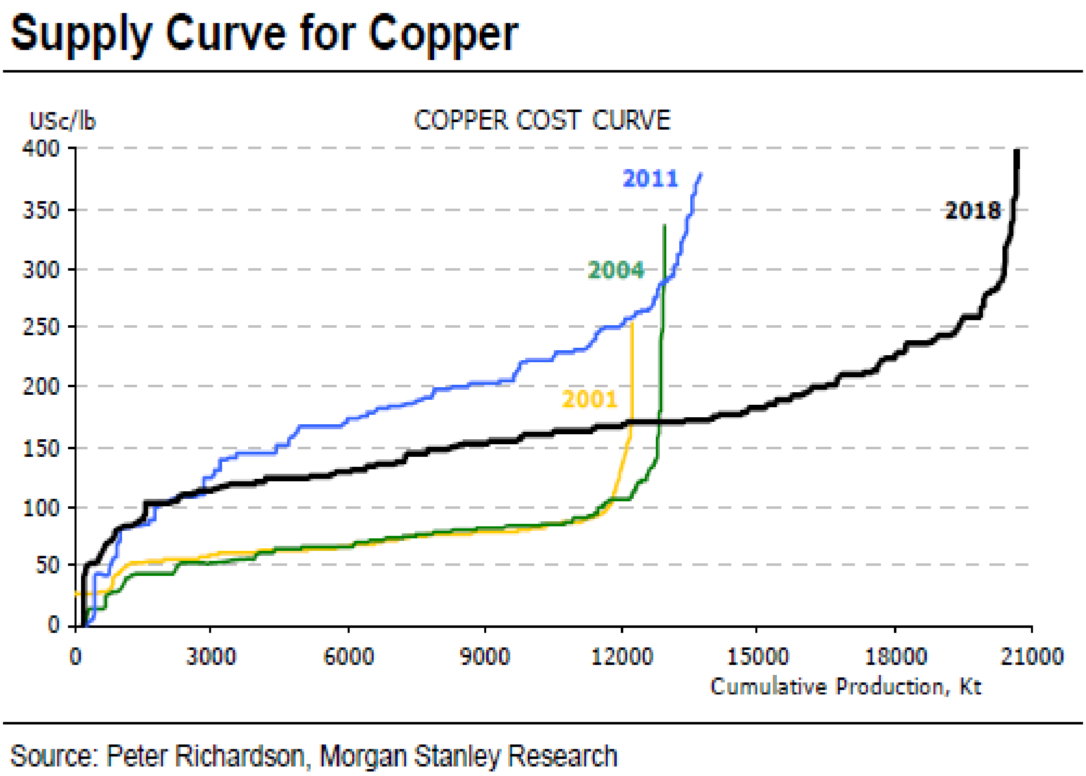


Figure A.21: Supply Curve of Copper: Evolution from 2001 to 2018.

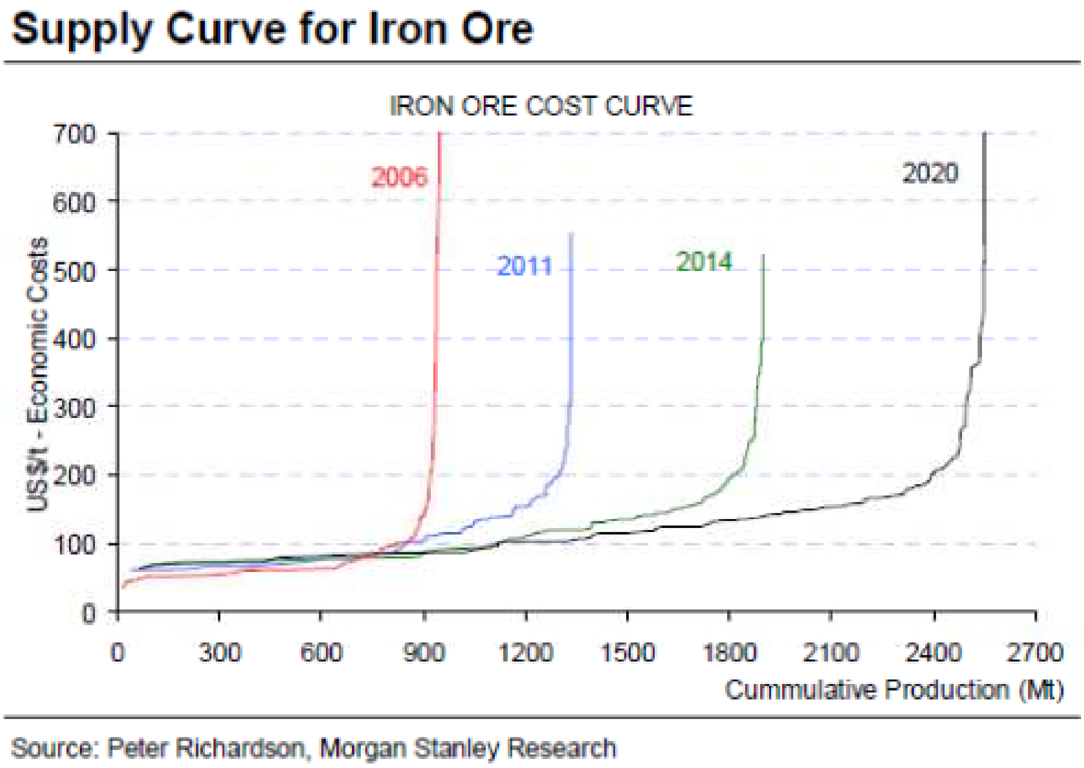


Figure A.22: Supply Curve of Iron Ore: Evolution from 2006 to 2020.

A.2 Simulation results: Hard landing

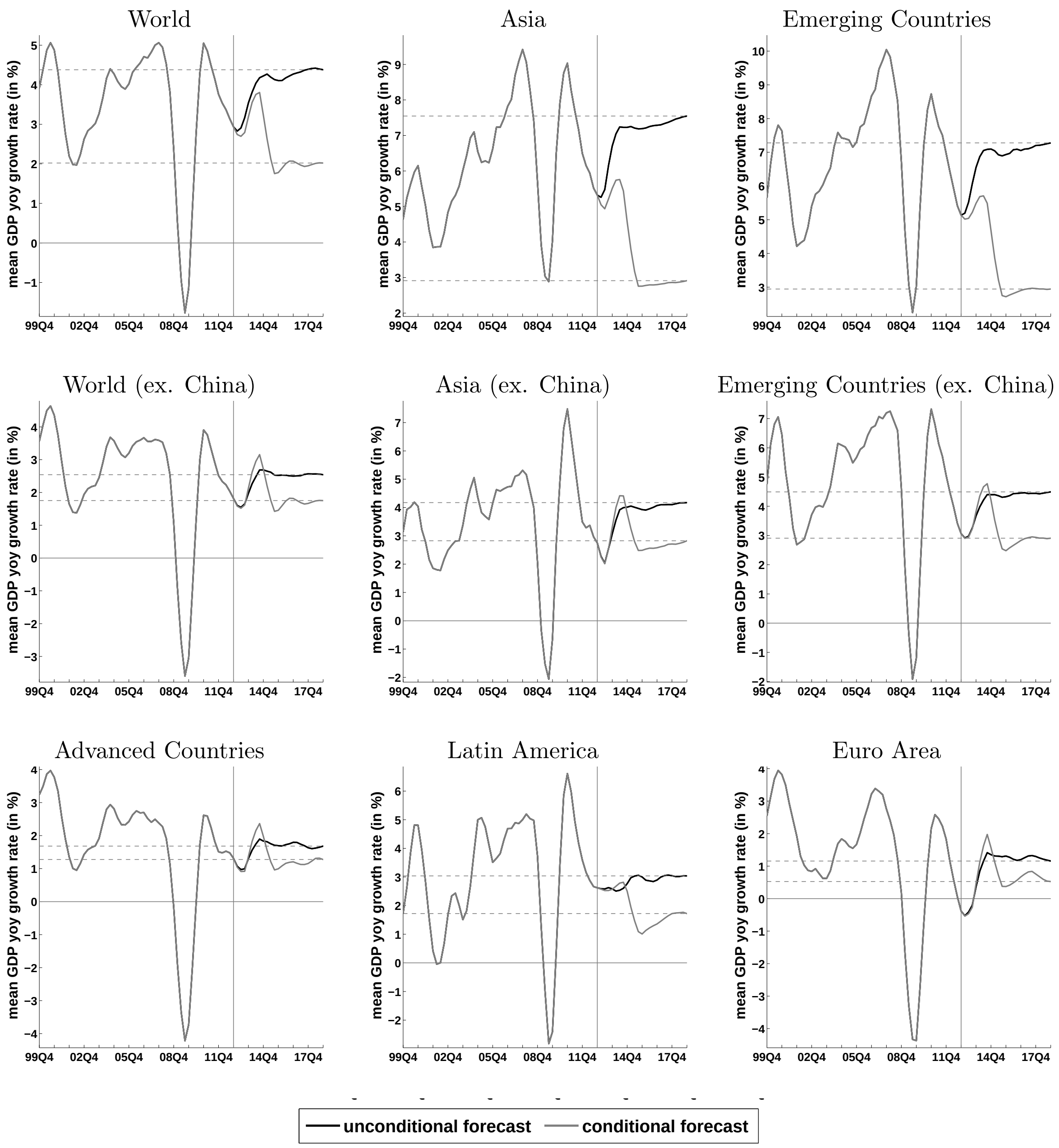


Figure A.23: Impact of a Chinese hard landing on given regions.

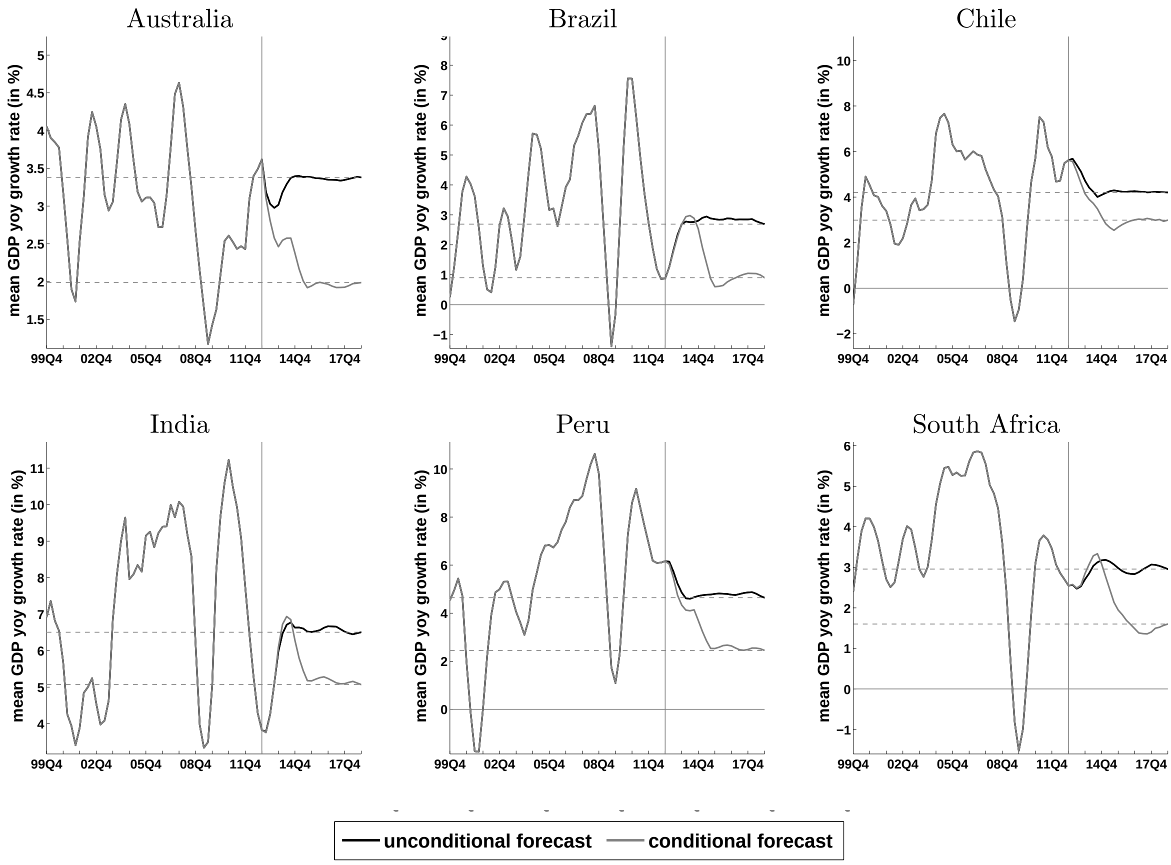
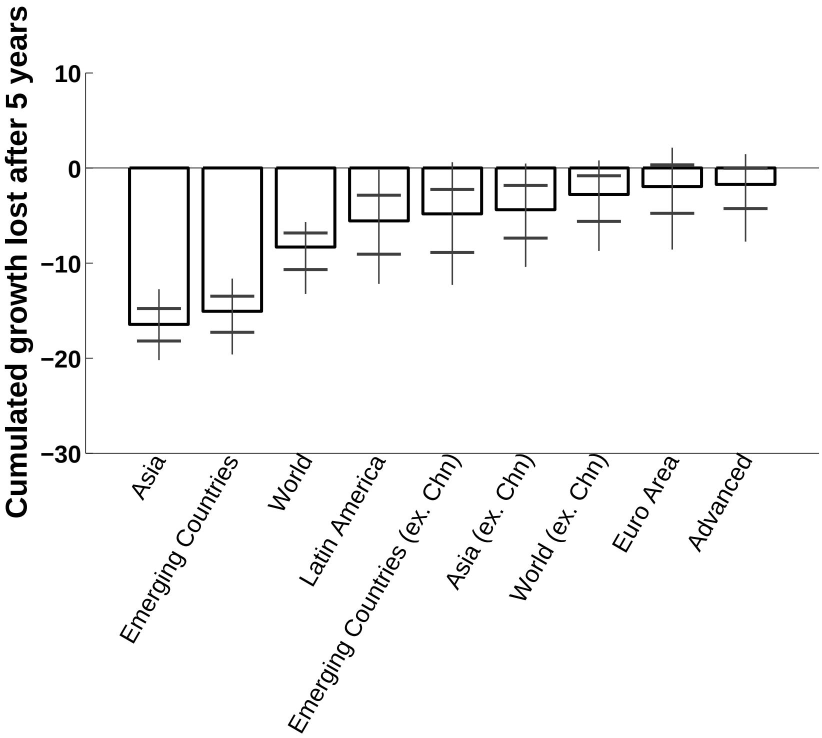


Figure A.24: Impact of a Chinese hard landing on given commodity exporters.



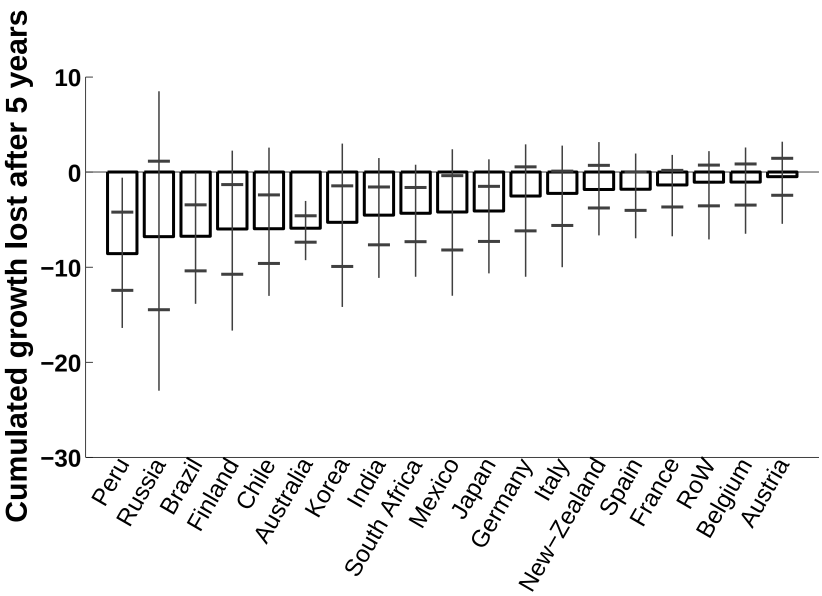


Figure A.25: Hard landing: Cumulated growth loss after 5 years.

†Bars represent medians. First and last quartiles are given by small horizontal lines. First and last deciles are given by vertical lines.

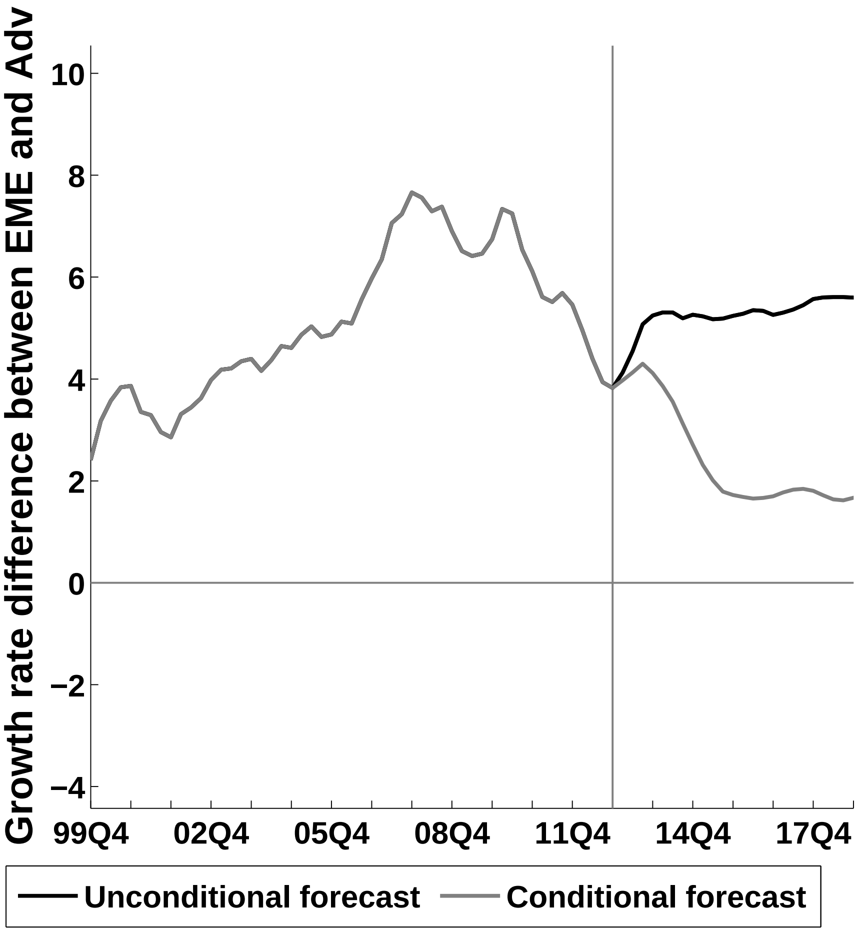


Figure A.26: Hard landing: Comparison Advanced versus Emerging Countries.

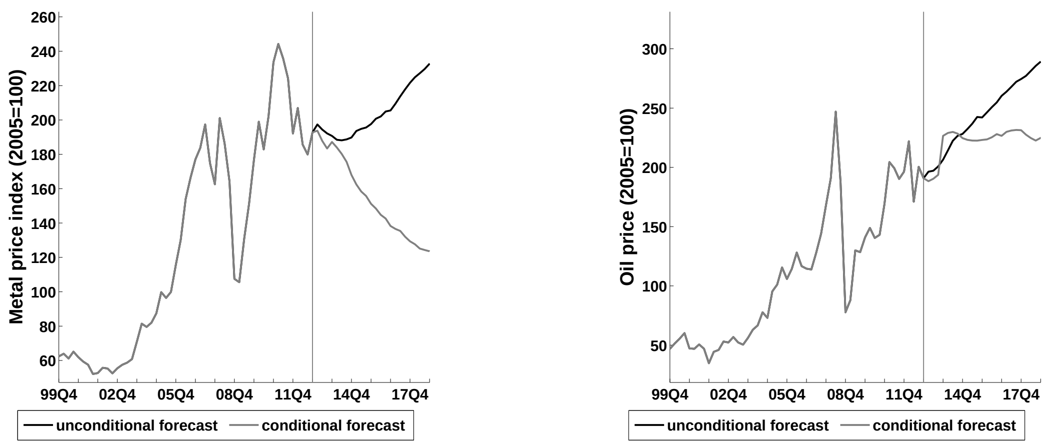


Figure A.27: Hard landing: Metal price index and oil price.

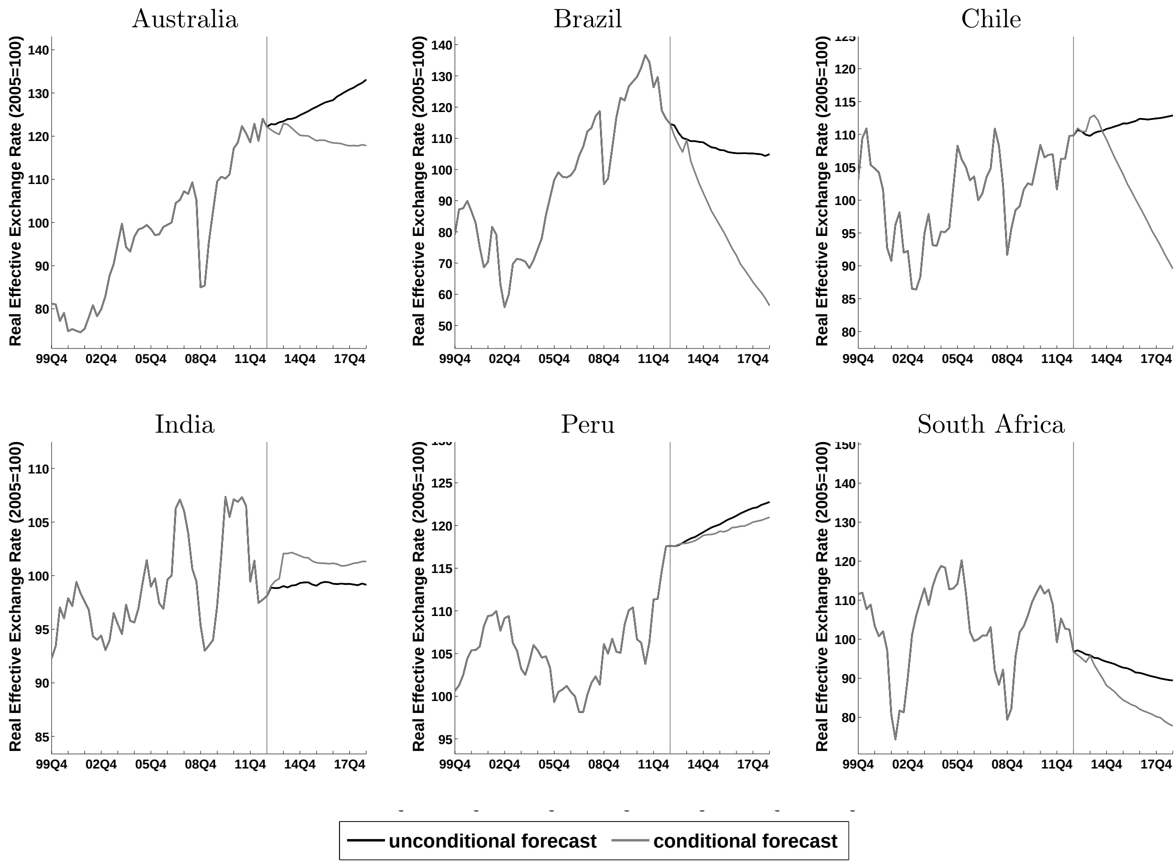


Figure A.28: Impact of a Chinese hard landing on exporters' real effective exchange rate.

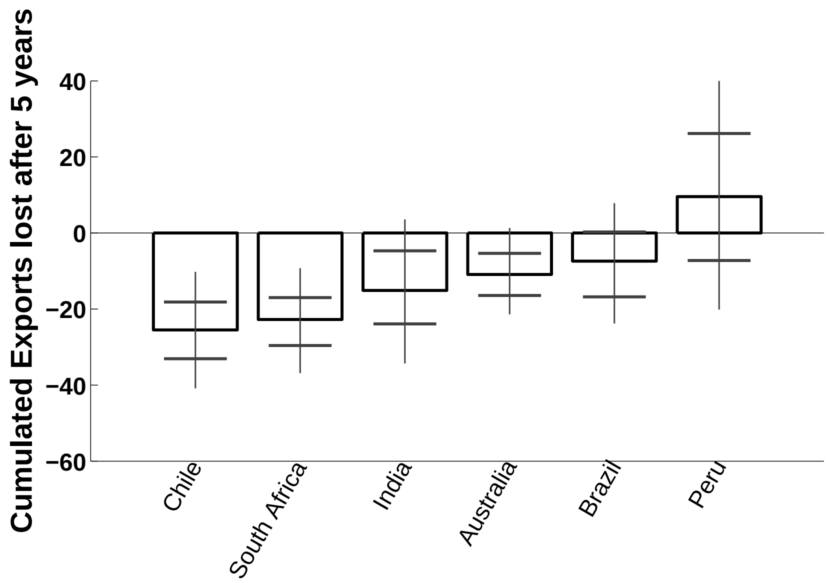


Figure A.29: Hard landing: Cumulated export loss.

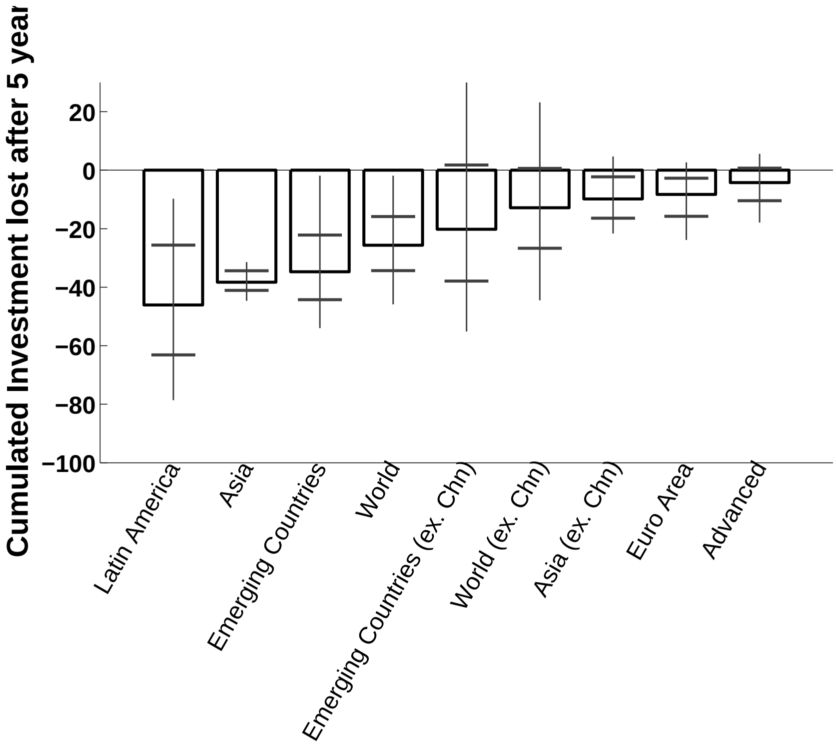


Figure A.30: Hard landing: Cumulated investment growth loss after 5 years.

†Bars represent medians. First and last quartiles are given by small horizontal lines. First and last deciles are given by vertical lines.

A.3 Simulation results: Soft landing

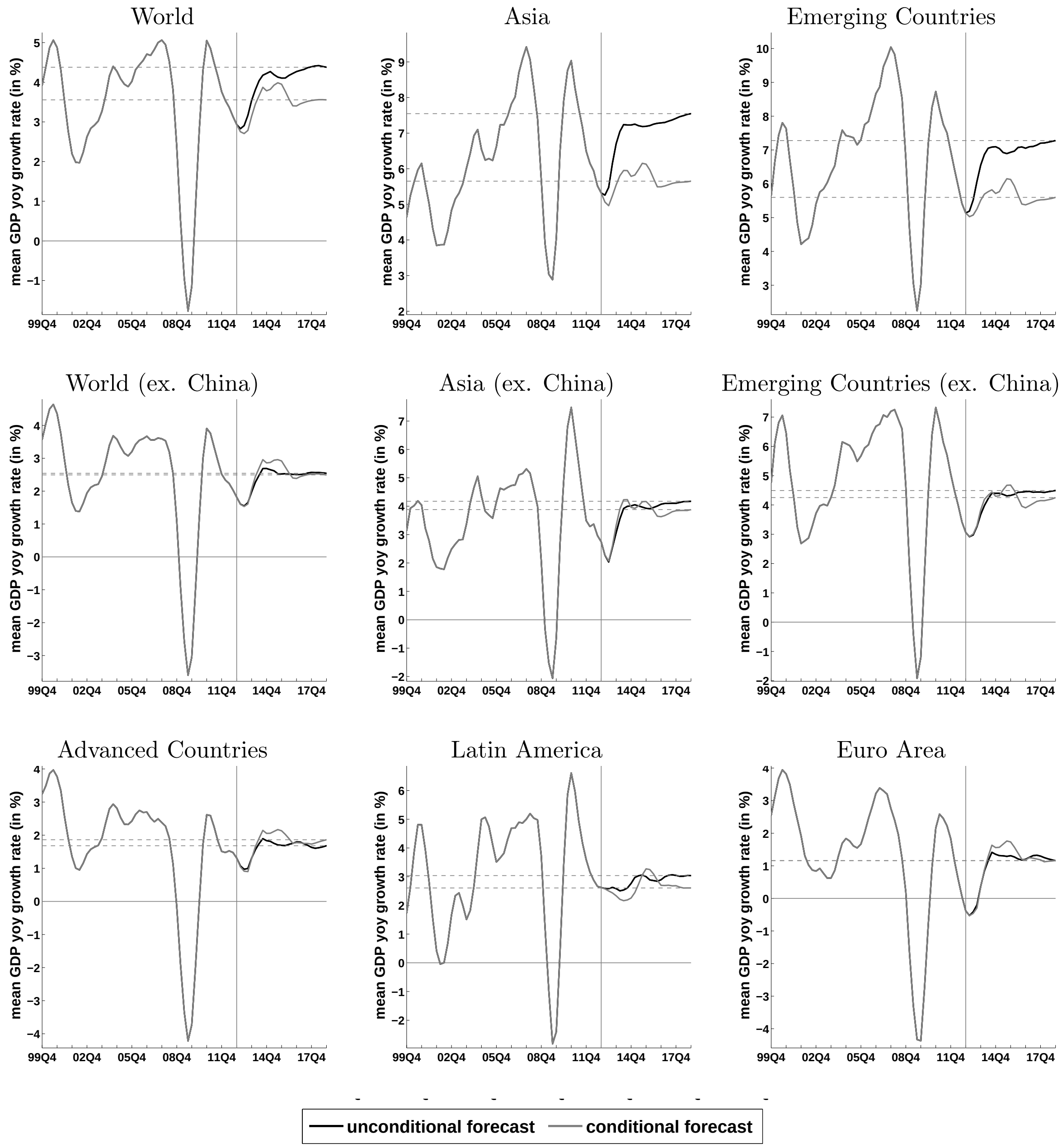


Figure A.31: Impact of a Chinese soft landing on given regions.

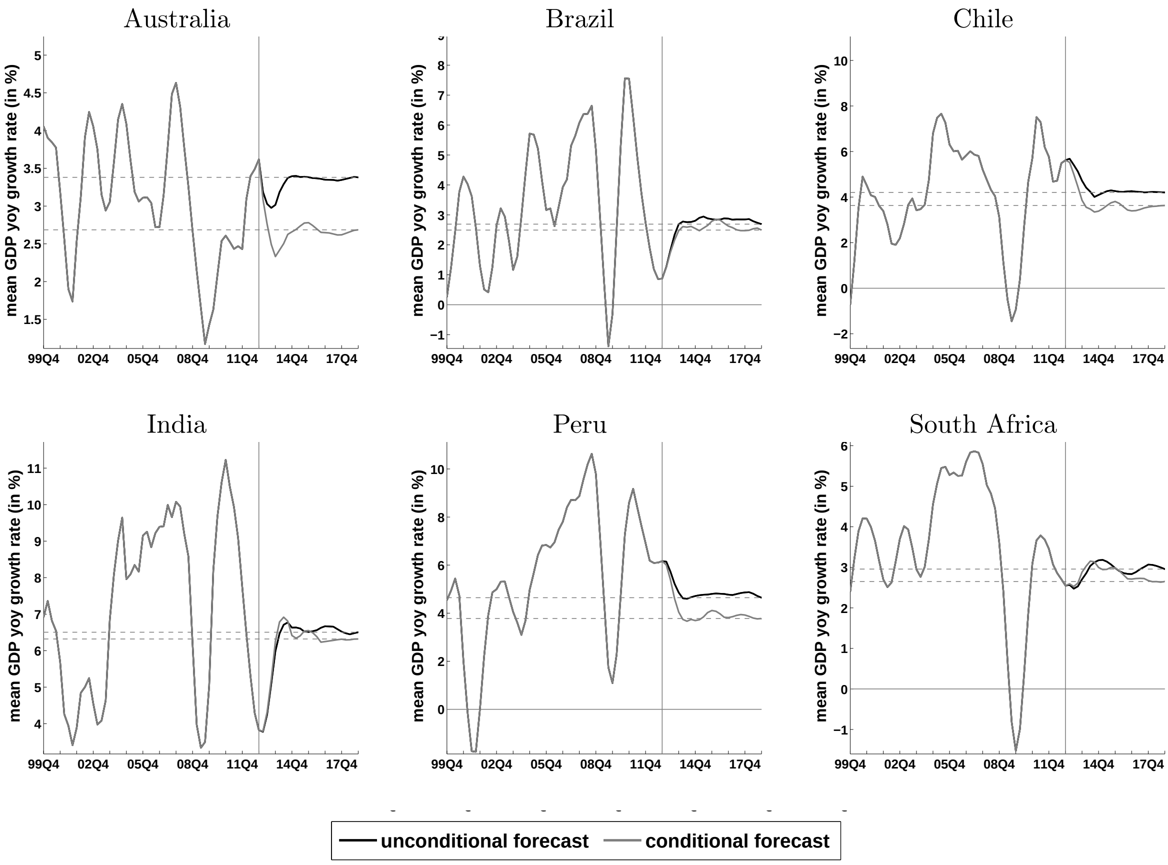
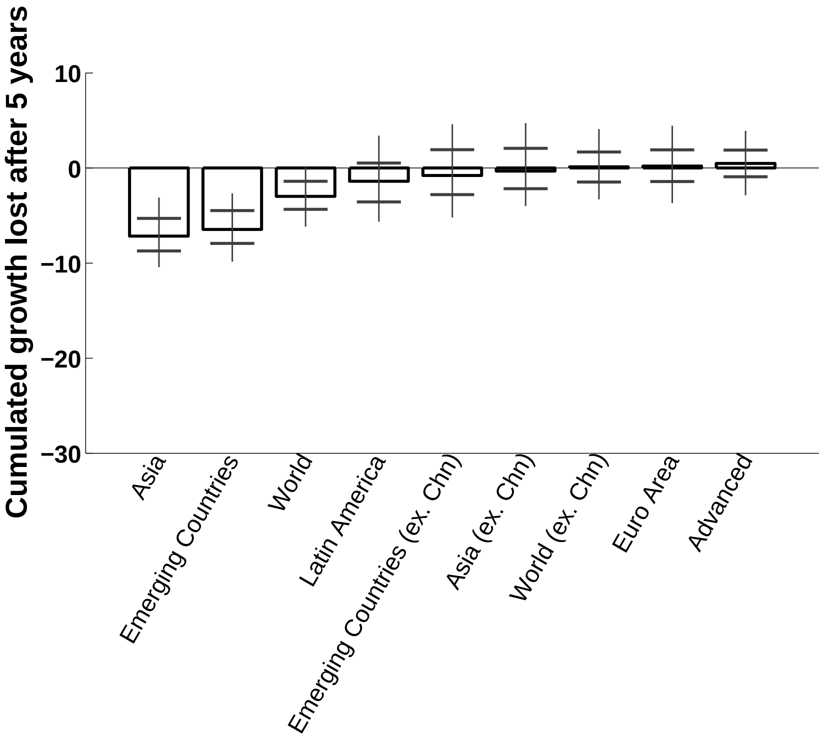


Figure A.32: Impact of a Chinese soft landing on given commodity exporters.



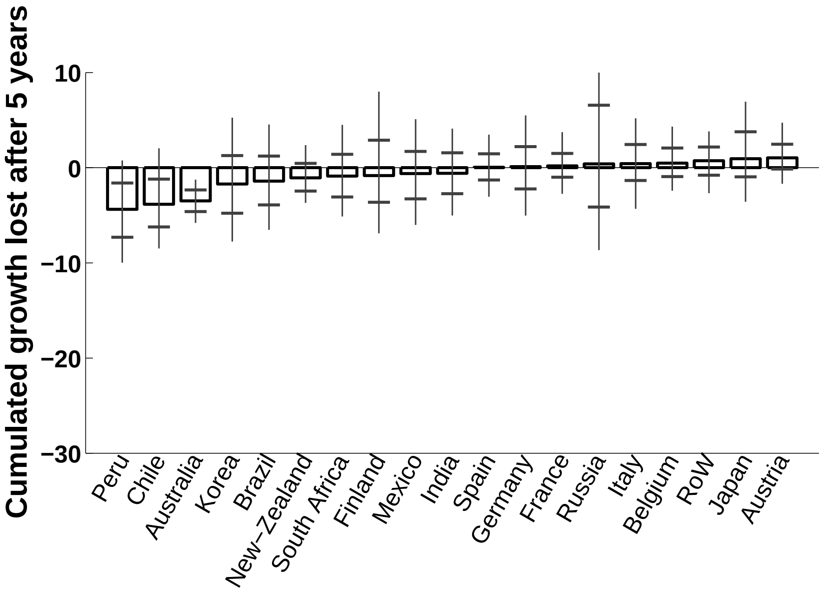


Figure A.33: Soft landing: Cumulated growth loss after 5 years.

†Bars represent medians. First and last quartiles are given by small horizontal lines. First and last deciles are given by vertical lines.

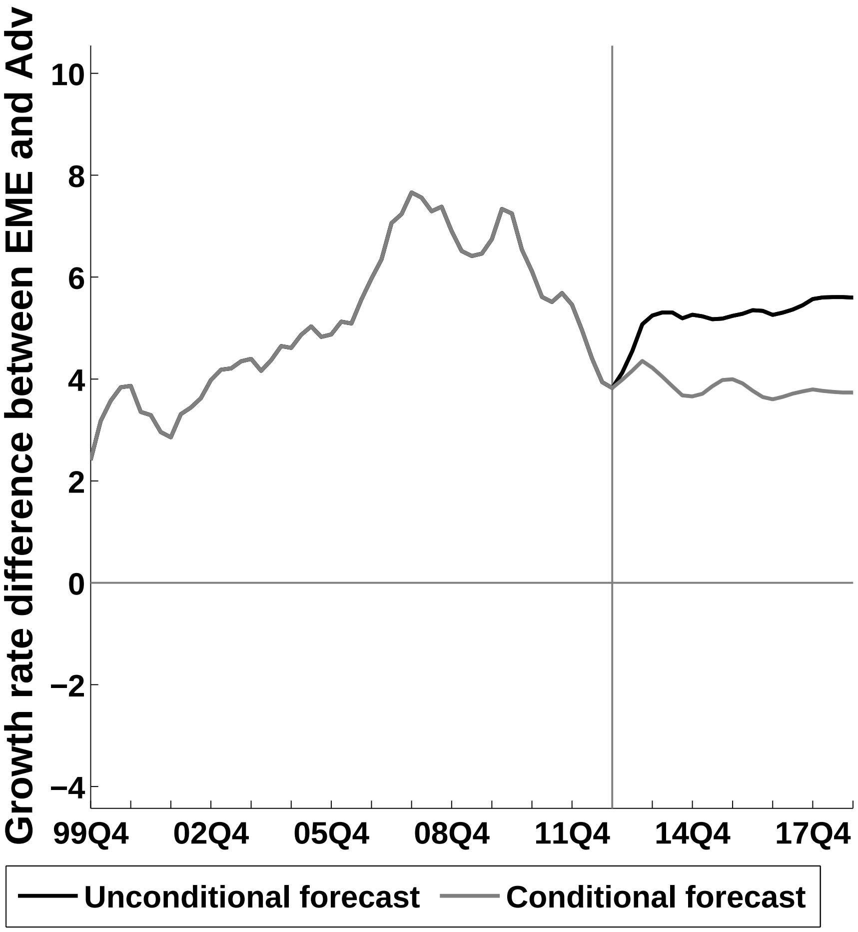


Figure A.34: Soft landing: Comparison Advanced versus Emerging Countries.

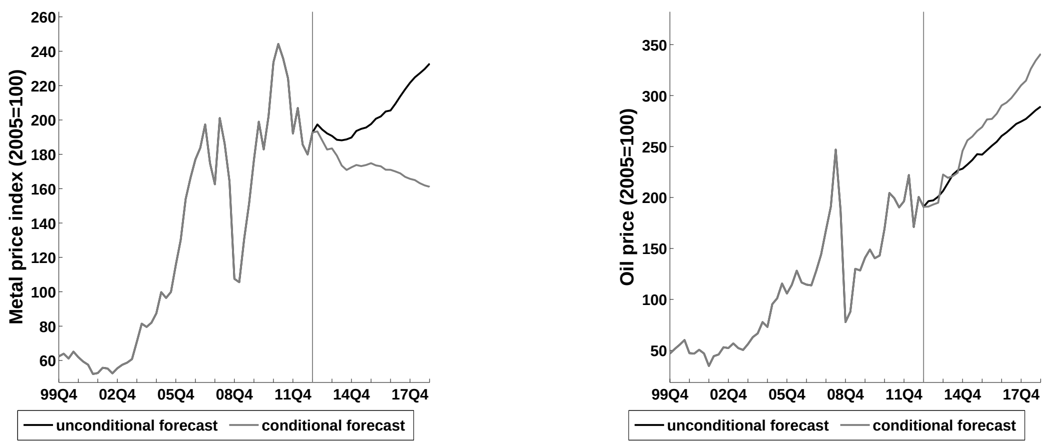


Figure A.35: Soft landing: Metal price index and oil price.

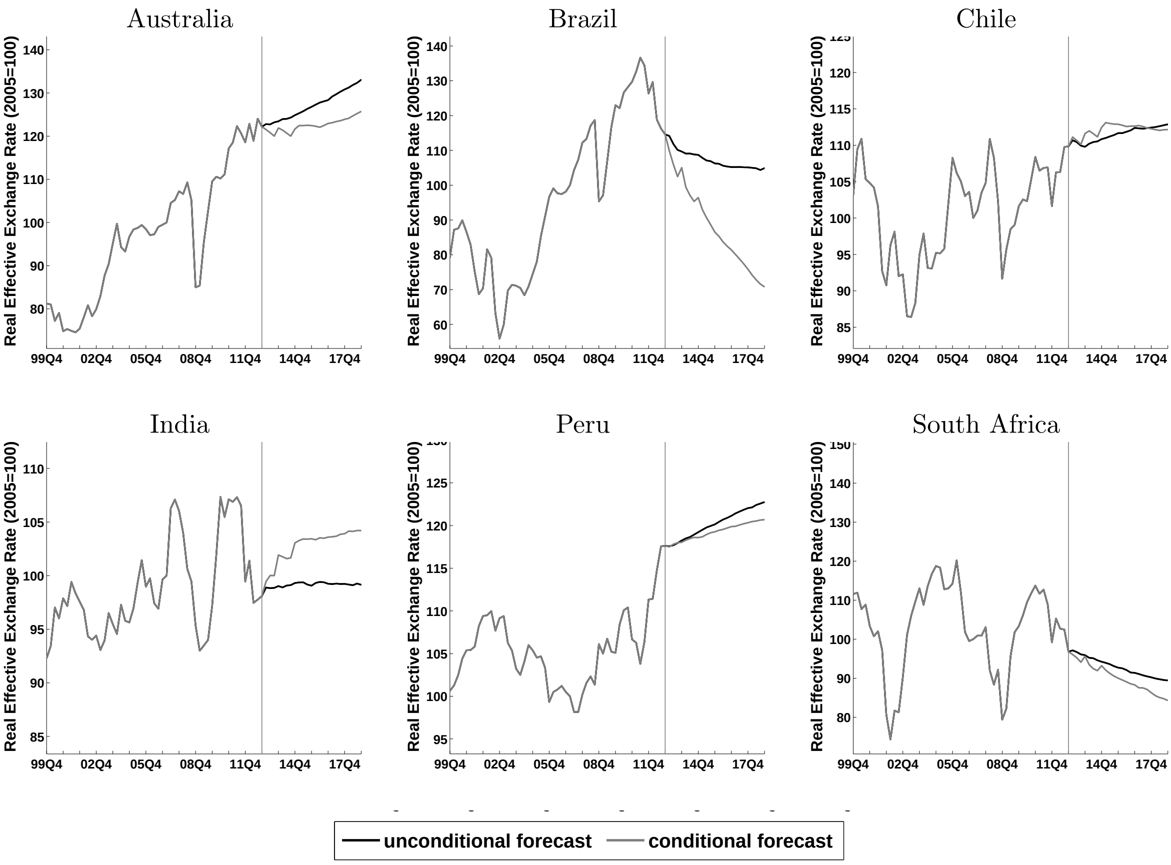


Figure A.36: Impact of a Chinese soft landing on exporters' real effective exchange rate.

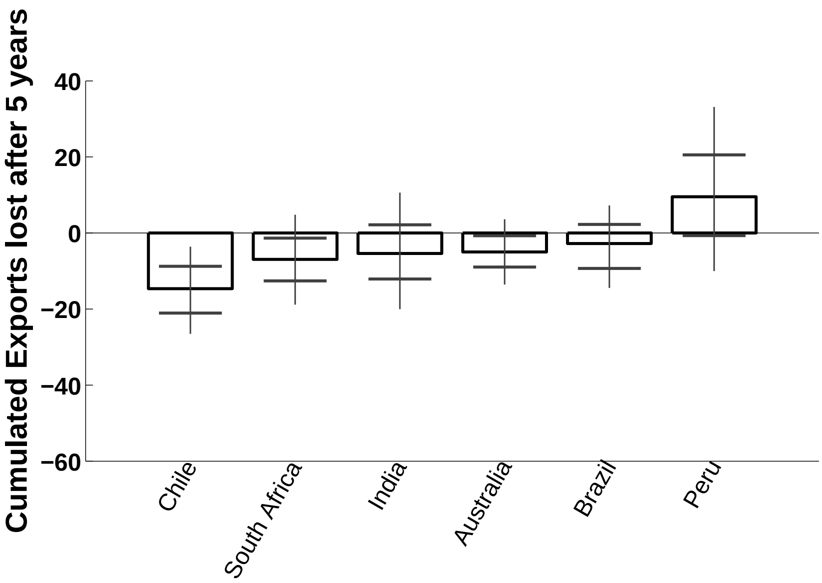


Figure A.37: Soft landing: Cumulated export loss.

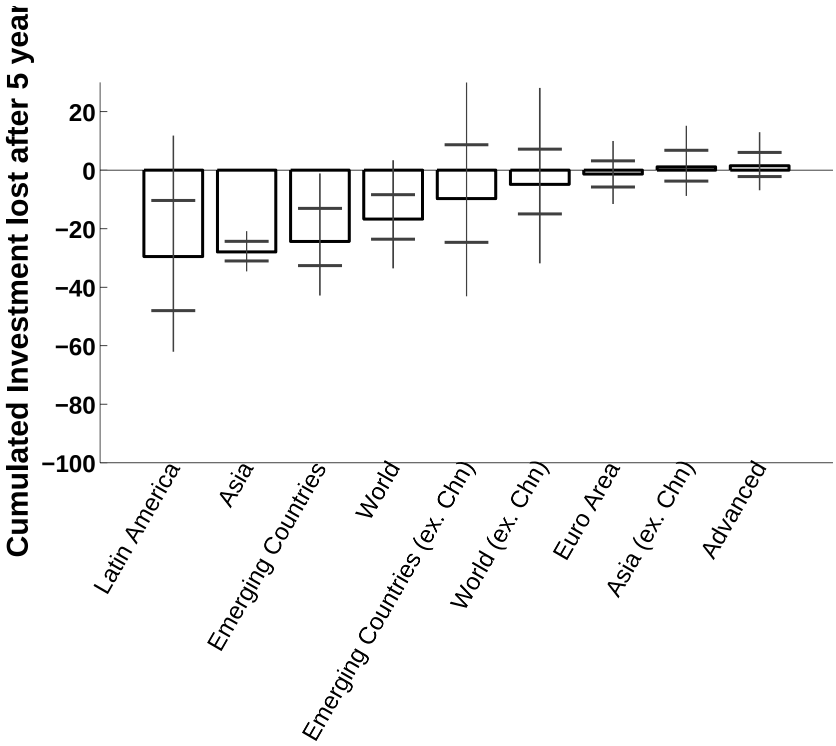


Figure A.38: Soft landing: Cumulated investment growth loss after 5 years.

† Bars represent medians. First and last quartiles are given by small horizontal lines. First and last deciles are given by vertical lines.

B Tables

Variable	Description	Sources
Real GDP (y)	Quarterly (2005=100) in log	National sources & IFS (Datastream codes ending in "GDP...D" when available)
Inflation (Dp)	Quarterly growth rate of the CPI	National sources (Datastream codes ending in "CONPRCF" when avaiable)
Real Effective Exchange Rate (REER)	Quarterly Index (2005=100) in log	BIS (codes ending in "BISRXNR" or "BISRXBR"), JP Morgan (codes ending in "JPMRBTF") and OECD
Nominal Investment (Inv)	(2005=100) in log	National sources (codes ending in "GFCF..B")
Real Export	Index (2005=100) in log. Only for Australia, Brazil, Chile, India, Peru & South Africa	OECD
Oil price	Price index (2005=100) in log. Simple average of three spot prices; Dated Brent, West Texas Intermediate, and the Dubai Fateh	IMF
Metal Price Index (MPI)	Price index (2005=100) in log. Includes Copper, Aluminum, Iron Ore, Tin, Nickel, Zinc, Lead, and Uranium Price Indices	IMF
Trade weights for exogenous variables	Average on 2008-2012	IMF-DTS & authors' calculation
Weights for commodity countries' exogenous variables	Average on 2008-2011	BREE Australia & authors' calculation

Table B.1: Data Sources

Country	Exports	Copper		Aluminium		Lead		Zinc		Coal		Crude Oil		Natural Gas		Iron Ore		Total	
	Ch	W	Ch	W	Ch	W	Ch	W	Ch	W	Ch	W	Ch	W	Ch	W	Ch	W	Ch
Argentina	7.43	0.00	0.00	0.00	0.00	0.03	0.35	0.00	0.00	0.00	0.00	0.50	6.77	0.00	0.00	0.03	0.45	0.56	7.57
Australia	27.52	1.16	4.22	0.22	0.81	0.08	0.31	0.32	1.18	1.61	5.87	1.11	4.04	0.00	0.00	17.19	62.46	21.70	78.87
Bolivia	3.65	0.11	3.09	0.01	0.18	0.25	6.95	0.41	11.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.78	21.46
Brazil	17.31	0.14	0.82	0.00	0.01	0.00	0.02	0.00	0.02	0.00	0.00	1.91	11.02	0.00	0.00	8.00	46.25	10.06	58.14
Canada	3.77	0.28	7.36	0.05	1.39	0.01	0.18	0.01	0.24	0.18	4.88	0.09	2.42	0.00	0.00	0.41	10.76	1.03	27.23
Chile	22.85	18.67	81.69	0.00	0.02	0.01	0.06	0.02	0.10	0.00	0.00	0.00	0.00	0.00	0.00	1.46	6.40	20.17	88.27
Colombia	3.49	0.42	11.96	0.03	0.83	0.00	0.00	0.00	0.00	0.24	6.97	2.06	58.94	0.00	0.00	0.57	16.27	3.32	94.98
EU-27	8.89	0.34	3.77	0.07	0.74	0.01	0.11	0.02	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.31	3.48	0.74	8.30
India	5.55	0.08	1.53	0.01	0.22	0.03	0.61	0.04	0.64	0.05	0.90	0.00	0.00	0.00	0.00	1.51	27.14	1.72	31.04
Indonesia	11.27	0.42	3.69	0.38	3.35	0.00	0.02	0.00	0.00	2.95	26.21	0.28	2.49	0.20	1.80	0.20	1.75	4.43	39.30
Korea	24.17	0.42	1.75	0.14	0.57	0.00	0.02	0.03	0.11	0.00	0.00	0.00	0.00	0.02	0.07	0.96	3.96	1.56	6.47
Kyrgyzstan	2.12	0.04	1.79	0.17	7.83	0.03	1.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	7.60	0.39	18.49
Malaysia	13.14	0.13	1.00	0.03	0.23	0.00	0.03	0.01	0.10	0.02	0.15	0.34	2.61	0.27	2.04	0.18	1.40	0.99	7.57
Mexico	1.71	0.50	29.11	0.02	1.31	0.06	3.23	0.00	0.21	0.00	0.00	0.38	22.35	0.00	0.00	0.09	5.37	1.05	61.60
Peru	15.25	6.93	45.45	0.01	0.07	1.59	10.40	0.84	5.49	0.00	0.02	0.00	0.00	0.08	0.54	2.19	14.38	11.65	76.35
Philippines	12.70	0.28	2.18	0.01	0.06	0.00	0.02	0.00	0.03	0.33	2.63	0.02	0.12	0.00	0.00	0.11	0.89	0.75	5.94
Qatar	3.93	0.00	0.00	0.01	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.49	12.35	2.57	65.38	0.03	0.82	3.10	78.71
Russia	7.26	0.39	5.39	0.01	0.18	0.09	1.27	0.00	0.06	0.19	2.63	3.58	49.28	0.01	0.19	0.46	6.38	4.75	65.38
South Africa	13.36	0.21	1.60	0.08	0.59	0.16	1.19	0.06	0.42	1.41	10.54	0.00	0.00	0.00	0.00	7.93	59.36	9.85	73.68
Thailand	11.98	0.01	0.07	0.02	0.13	0.00	0.00	0.00	0.02	0.00	0.00	0.11	0.89	0.00	0.00	0.06	0.52	0.19	1.63
Turkey	1.83	0.39	21.12	0.00	0.04	0.06	3.24	0.03	1.80	0.00	0.00	0.00	0.00	0.00	0.23	0.04	2.24	0.52	28.68

Sources: UN Comtrade & authors' calculation.
Bilateral commodity trade among considered countries and China. The second column corresponds to the share of total exports to China in overall exports. Columns W correspond to the share of exports of each commodity to China from a given country over total exports. On the other side, columns "Ch" correspond to the share of exports of each commodity to China over exports to China.

Table B.2: Share of commodity exports to China (in %).

Countries	Endogenous variables							Exogenous variables						
	y	Dp	Inv.	X	REER	Oil price	MPI	y	Dp	Inv.	X	REER	Oil price	MPI
Australia	x	x	x	x	x			x	x	x			x	x
Austria	x	x	x		x			x	x					
Belgium	x	x	x		x			x	x					
Brazil	x	x	x	x	x			x	x	x			x	x
Canada	x	x	x		x			x	x					
China	x	x	x		x			x	x					
Chile	x	x	x	x	x			x	x	x			x	x
Finland	x	x	x		x			x	x					
France	x	x	x		x			x	x					
Germany	x	x	x		x			x	x	x				
India	x	x	x	x	x			x	x	x			x	x
Italy	x	x	x		x			x	x					
Japan	x	x	x		x			x	x					
Korea	x	x	x		x			x	x					
Mexico	x	x	x		x			x	x					
Norway	x	x	x		x			x	x					
New Zealand	x	x	x		x			x	x					
Peru	x	x	x	x	x			x	x	x			x	x
South Africa	x	x	x	x	x			x	x	x			x	x
Spain	x	x	x		x			x	x					
Sweden	x	x	x		x			x	x					
Switzerland	x	x	x		x			x	x					
United Kingdom	x	x	x		x			x	x					
USA	x	x	x		x			x	x					
Russia	x	x	x		x			x	x				x	
MPI block							x	x	x	x				
OIL block						x		x	x					

Note: y= Real GDP, Dp = Inflation, Inv.=Nominal Investment, X=Real Exports, REER=Real Effective Exchange Rate and MPI= Metal Price Index.In our GVAR specification Canada, Norway, Sweden, Switzerland, United Kingdom and USA are grouped in Row (Rest of the World).

Table B.3: GVAR specification.

Country/Region	2008	2009	2010	2011
Africa				
South Africa	0.5	0.5	0.3	0.4
Total	1.8	1.2	1.1	1.3
Americas				
Argentina	0.2	0.1	0.1	0.1
Brazil	2.1	1.7	2.4	2.2
Canada	1.1	0.8	0.8	0.7
Chile	0.6	0.5	0.5	0.5
Mexico	1.8	1.9	1.7	1.2
United States	11.1	9.0	9.1	9.0
Peru	0.3	0.3	0.3	0.3
Total	17.2	14.4	14.9	14.1
Asia				
China	28.4	39.0	38.2	40.6
Chinese Taipai	3.2	2.7	2.8	2.3
India	2.8	3.0	2.7	2.1
Indonesia	1.1	1.1	1.1	1.1
Japan	6.5	4.8	5.5	5.2
Korea, Rep. of	4.5	5.1	4.4	3.8
Malaysia	1.2	1.2	1.0	1.1
Turkey	2.0	1.8	1.9	2.0
Thailand	1.4	1.2	1.3	1.2
Total	54.6	64.0	62.7	63.1
Europe				
Finland	0.3	0.4	0.4	0.4
France	2.1	1.2	1.0	0.9
Germany	7.8	6.2	6.8	6.4
Greece	0.4	0.3	0.2	0.3
Italy	3.5	2.9	3.2	3.1
Poland	1.3	1.2	1.3	1.3
Russian Federation	4.0	2.3	2.4	3.5
Spain	1.7	1.7	1.7	1.6
Sweden	1.0	0.8	0.9	0.8
United kingdom	0.2	0.1	0.2	0.1
Total	25.2	19.6	20.5	20.8

Sources: Bureau of Resources and Energy Economics & authors' calculation.

Table B.4: Shares of copper consumption by country (in %).

Country/Region	2008	2009	2010	2011
Africa and Middle East				
Qatar	0.1	0.1	0.2	0.2
Saudi Arabia	0.4	0.4	0.5	0.4
South Africa	1.0	0.7	0.5	0.3
Americas				
Argentina	0.3	0.1	0.4	0.3
Brazil	4.2	2.5	3.6	4.4
Canada	0.8	0.3	0.7	0.6
Mexico	0.2	0.1	0.1	0.1
United States	3.7	1.9	3.1	2.8
Venezuela	0.9	0.7	0.3	0.3
Asia and Oceania				
Australia	1.9	2.0	1.0	2.4
China	43.9	54.3	51.8	54.2
Chinese Taipei	0.9	0.8	1.0	1.1
India	6.9	6.4	6.4	6.1
Indonesia	0.1	0.1	0.1	0.1
Japan	8.3	6.7	7.5	6.2
Korea, Rep. of	2.9	2.7	3.1	3.1
Malaysia	0.3	0.1	0.2	0.2
Pakistan	0.1	0.0	0.0	0.1
Europe				
Austria	0.5	0.3	0.3	0.4
Belgium-Luxembourg	0.7	0.2	0.4	0.4
Bulgaria	0.0	0.0	0.0	0.0
Czech Republic	0.4	0.3	0.3	0.3
Finland	0.2	0.1	0.2	0.2
France	1.1	0.6	0.8	0.7
Germany	2.7	1.8	2.4	2.0
Hungary	0.1	0.1	0.1	0.1
Italy	1.0	0.5	0.7	0.7
Netherlands	0.6	0.4	0.5	0.5
Poland	0.5	0.3	0.3	0.3
Portugal	0.0	0.0	0.0	0.0
Romania	0.3	0.1	0.1	0.1
Russian Federation	5.2	5.1	5.1	4.1
Slovakia	0.3	0.3	0.3	0.2
Spain	0.4	0.3	0.3	0.3
Sweden	0.4	0.1	0.2	0.2
Turkey	0.4	0.4	0.4	0.3
Ukraine	3.1	2.7	2.8	2.3
United Kingdom	0.9	0.6	0.6	0.5
Rest of the World	4.2	5.9	3.5	3.5

Sources: Bureau of Resources and Energy Economics & authors' calculation.

Table B.5: Shares of iron ore consumption by country (in %).

Country/Region	2008	2009	2010	2011
Africa	3.7	3.9	3.9	3.8
China	9.2	9.5	10.3	10.6
Japan and Korea. Rep. of	8.0	7.7	7.6	7.6
Latin America	6.8	7.0	7.1	7.5
Middle East	8.2	8.8	8.8	8.9
North America	28.1	27.2	27.0	26.6
Russian Federation	3.5	3.5	3.7	3.7
Western Europe	9.2	8.8	8.3	8.0
Other Asia Pacific	12.5	13.1	13.0	13.2
Other Europe	10.9	10.5	10.3	10.0

Sources: Bureau of Resources and Energy Economics & authors' calculation.

Table B.6: Shares of oil demand by country/region (in %).

Country	Hard Landing	Soft Landing
Australia	-5.91	-3.49
Austria	-0.48	1.03
Belgium	-1.04	0.48
Brazil	-6.75	-1.41
Chile	-5.95	-3.84
Finland	-5.99	-0.83
France	-1.36	0.19
Germany	-2.52	0.11
India	-4.53	-0.58
Italy	-2.24	0.43
Japan	-4.09	0.94
Korea	-5.28	-1.72
Mexico	-4.20	-0.61
New Zealand	-1.84	-1.06
Peru	-8.57	-4.37
South Africa	-4.33	-0.88
Spain	-1.80	0.04
Rest of the World	-1.06	0.73
Russia	-6.79	0.40

Table B.7: Median cumulated growth lost after 5 years for each countries (in %).

Region	Hard Landing	Soft Landing
Advanced	-1.72	0.48
Asia	-16.45	-7.17
Asia (ex. China)	-4.38	-0.32
Emerging Countries	-15.07	-6.47
Emerging Countries (ex. China)	-4.92	-0.78
Euro Area	-1.95	0.21
Latin America	-5.57	-1.40
World	-8.32	-2.98
World (ex. China)	-2.79	0.13

Table B.8: Median cumulated growth lost after 5 years for each region (in %).