A Provincial View of Global Imbalances: Regional Capital Flows in China*

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Abstract

We model capital flows among Chinese provinces. A version of the present value model of the current account (PVMCA) with non-tradable goods and a savings wedge accounts for around 80 percent of the variation in inter-provincial capital flows over the 1986-2010 period. The PVMCA also allows us to identify the channels of external adjustment in capital flows at the province-level: variation in intertemporal prices (domestic and international interest rates, the provincial real exchange rate) and intertemporal variation in quantities (output, investment and government spending). We find that cross-province variation in the importance of these channels is correlated with the importance of private and state-owned enterprises and demographic factors. We discuss implications of our results for global imbalances in capital flows.

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KEYWORDS: CHINA, CHINESE PROVINCES, CAPITAL FLOWS, CURRENT ACCOUNT, GLOBAL IMBALANCES, EXTERNAL ADJUSTMENT, PRESENT-VALUE MODELS, REGIONAL BUSINESS CYCLES

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1 Introduction

Over the last two decades, China has been running considerable and very persistent current account surpluses. This is a theoretical challenge to neoclassical growth models and has therefore rightfully been dubbed a puzzle (Gourinchas and Jeanne, 2013). China's surplus is also often seen as the main symptom of a perceived imbalance in international capital flows that could distort exchange rates, interest rates and asset prices at a global level (Bernanke, 2007). Considerable research effort has therefore been given to explaining this pattern theoretically (Caballero et al., 2008; Mendoza et al., 2009; Song et al., 2011; Aguiar and Amador, 2011) and empirically (Hoffmann (2013)). However, so far, we have relatively little evidence about the patterns of intra-national (i.e. regional) capital flows in China.

We attempt to fill that gap in this paper. We study empirically the dynamics and determinants of net exports at the level of Chinese provinces. Understanding this "cross-section" of China's net exports provides a useful disaggregated perspective for at least three reasons: first, given the importance of China for the world economy and given the sheer size of many individual provinces, it is interesting in its own right to check whether we can use standard models to understand intra-national capital flows in this huge country. Our answer to this question is a clear 'Yes'.

Second, China's persistent external surplus is the sum of net capital flows (net exports) across provinces. Figure 1 shows that the rise and decline of China's international net export surplus correlates closely with a widening of imbalances in net flows between provinces. Understanding the cross-section of provincial capital flows can therefore shed light on the determinants of global imbalances in ways that a pure time-series analysis of China's aggregate statistics cannot achieve. Specifically, having decomposed inter-provincial capital flows into different channels suggested by theory allows us to make a third contribution: to correlate the importance of these channels with various province-level characteristics — such as the relative importance of state-owned enterprises in the local economy or demographic factors — that recent theoretical models have put forward as explanations for China's structural surpluses. In this way, we provide a taxonomy of the extent to which various recent theories contribute to our understanding of China's current account puzzle. We emphasize that our aim in this context is to provide some first informative correlations for future research, not to document causality.

As framework for our analysis we use a stylized intertemporal model of capital flows in which we allow for a simple form of financial frictions in the form of a "savings wedge" in the mould of Gourinchas and Jeanne (2013). Our framework builds on Hoffmann (2013) and nests two broad channels of external adjustment in interprovincial capital flows: the first is variation in intertemporal prices, which we further disaggregate into variation in domestic real interest rate, the excess return on international assets over the domestic interest rate, and the regional real exchange rate (i.e. the relative price of tradable and non-tradable goods). The second is intertemporal variation in quantities—cash flows of output, investment and government spending. While the intertemporal price channel(s) reflect the impact of intertemporal substitution, we can think of the quantity channel as reflecting 'rainy-day' saving. As we show, our simple model accounts for around 80 percent of the variation in net exports in a panel of 30 provinces over the 1985-2010 period. Most of this is accounted for by rainy day savings.

These numbers mask considerable cross-provincial heterogeneity in the importance of adjustment channels, though. We show that heterogeneity in provinces' external adjustment patterns correlates in particular with two groups of province-level characteristics emphasized by the recent theoretical literature on China's external surplus: the relative role of private and state-owned enterprises (SOE) in the provincial economy and demographic factors. We have the following main findings. First, rainy-day saving is relatively more important in provinces with many private firms and with unfavorable demographics (either due to distorted sex ratios or high dependency ratios). Second, unfavorable demographics (in the form of distorted sex ratios) seem to make expected price increases for non-tradables more important as a driver of local savings behavior. The first finding seems consistent with the view that private firms have no access to external finance, forcing them to pay for tomorrow's investments from today's retained earnings, which contributes to high corporate savings rates today. It is also consistent with the interpretation that China's private saving rates are high because of weak social safety nets and demographic ageing. The second finding supports the view that adverse demographics exacerbates the role of expected price increases for non-tradables (housing, medical care, schooling) as a savings motive. Third, we find that differences in openness to FDI or trade also affect the patterns of interprovincial capital flows.

The paper is structured as follows. Section 2 introduces our theoretical and empirical framework. Then, Section 3 discusses the data. In a next step, we present our main results in Section

4. At last, Section 5 concludes.

2 The framework

2.1 Model

Our analysis follows the tradition of the intertemporal approach to the current account (Sachs et al., 1981; Bergin and Sheffrin, 2000; Kano, 2008; Hoffmann, 2013). However, to our knowledge, we are the first to extend and apply the empirical framework used in these studies to intranational data and, in particular, to data from Chinese provinces. Specifically, our setup extends Hoffmann (2013) to allow us to study a cross-section of regional economies. It is based on rather minimal identifying assumptions since it builds on the log-linearized version of an intertemporal budget constraint, similar to Lettau and Ludvigson (2001) and Gourinchas and Rey (2007).

Our starting point is the law of motion of a province's claims on the rest of the world (including other provinces and other countries), here expressed in tradable goods as

$$B_t^k = (1+r_t^{T,k})B_{t-1}^k + Y_t^k - I_t^k - G_t^k - C_t^k$$

where B_t^k is the stock of out-of-region assets and Y_t^k, I_t^k, G_t^k and C_t^k denote the province-level (k) values of real output, investment, government consumption and private consumption respectively. The term $r_t^{T,k}$ denotes the interest rate (expressed in terms of tradable goods) that the province obtains on its (end-of-last-period) holdings of out-of-province assets, B_{t-1}^k. We can then define the provincial net exports balance as

$$NX_t^k = \Delta B_t^k - r_t^{T,k} B_{t-1}^k = NO_t^k - C_t^k$$

where we use the notation $NO_t^k = Y_t^k - I_t^k - G_t^k$ to denote net output (i.e. the cash flow available for consumption to the province's residents).

China has a closed capital account. As has been widely documented, most of its foreign assets are in the the hands of the public sector or of state owned enterprises, while private or politically non-connected firms and households are subject to a considerable degree of financial repression (see Aguiar and Amador, 2011; Song et al., 2011). Following Gourinchas and Jeanne

(2013), we capture these frictions in a reduced form as a wedge between domestic and world real interest rates.[1] Specifically, we model the *de facto* real interest rate faced by residents of province k as

$$r_t^{T,k} = (1-\delta^k)(i_t^N - \mathbb{E}_t(\pi_{t+1})) + \delta^k(i_t^W - \Delta s_{t+1} - \mathbb{E}_t(\pi_{t+1}))$$

where i_t^N and i_t^W are the Chinese and the world (US) nominal interest rate respectively and Δs_{t+1} the percentage change in the nominal effective Renminbi exchange rate and $\mathbb{E}(.)$ is the expectations operator. Finally, π_{t+1} denotes Chinese tradables inflation. The coefficient δ^k captures differences across provinces in the degree of financial integration with world capital markets. We rewrite the preceding equation as

$$r_t^{T,k} = r_t^N + \delta^k \tau_t$$

where $r_t^N = i_t^N - \mathbb{E}_t(\pi_{t+1})$ is the national (domestic) real interest rate and $\tau_t = i_t^W - \Delta s_{t+1} - i_t^N$ is the excess return of investing into the foreign bond while borrowing in Chinese currency. Here, $\delta^k \tau_t$ can be interpreted as a measure of the province-level savings wedge.[2] This decomposition of the regional real interest rate has an intuitive interpretation. The first term (r_t^N) corresponds to saving incentives arising from the domestic real interest rate. The second term reflects variation in the excess returns on the international bond (τ_t). Note that the impact of τ_t is allowed to vary across provinces according to the loading parameter $\delta^k \in [0,1]$. A weight δ^k of one means that the province has full access to international markets, so that $r_t^{T,k} = i_t^W - \Delta s_{t+1} - \mathbb{E}_t(\pi_{t+1})$, the real return on the foreign bond. A weight of zero indicates that the region is financially repressed, so that households and firms are forced to invest into national assets at rate $r_t^{T,k} = r_t^N$.

Imposing the usual transversality constraint, the above law of motion can be solved forward, to yield the non-linear intertemporal budget constraint:

$$B_{t-1}^k = \sum_{l=0}^{\infty} \mathbb{E}_t \left\{ R_{t+l}^{T,k} \left[C_{t+l}^k - NO_{t+l}^k \right] \right\}$$

[1] Another justification for introducing a savings friction is that, using the methodology developed in Gourinchas and Jeanne (2013), Cudré (2014) identified them as the key driver of provincial external balances (as opposed to investment wedges).

[2] To see the formal similarity with a savings wedge in the Gourinchas-Jeanne setup, write $(1+r_t^{T,k}) = (1+i_t^W)(1-\tau_t^k)/(1+\pi_t^k)$, where τ_t^k is a province-specific wedge and i_t^W is the nominal world rate of interest. In our setup, we assume $\tau_t^k = \delta^k \tau_t$ (i.e. the province-level wedge is the product of a province-level degree of financial integration and a China-wide wedge vis-à-vis the rest of the world). Taking logs then gives the representation above. The assumption implicit in this formulation is that time variation in savings wedges is common across provinces, whereas the relative degree of access of provinces to the global capital market is unchanged over time. Since province-level interest rates are not directly observable, this approach allows us to calibrate τ_t directly from observables while estimating δ^k as a parameter of the model.

where $R_{t+l}^{T,k} = \left[\prod_{i=0}^{l}(1+r_{t+i}^{T,k})\right]^{-1}$. We build on Kano (2008) and log-linearize this expression to obtain a formula for the net exports / net output ratio that we abbreviate with the acronym NXO:[3]

$$\text{NXO}_t^k := \widetilde{\frac{NX}{NO_t}}^k = c\sum_{l=1}^{\infty}\left(\kappa^k\right)^l \mathbb{E}_t\left\{\Delta\tilde{c}_{t+l}^k - \tilde{r}_{t+l}^{T,k}\right\} + \sum_{l=1}^{\infty}\kappa^l \mathbb{E}_t\left\{\tilde{r}_{t+l}^{T,k} - \Delta\widetilde{no}_{t+l}^k\right\} \quad (1)$$

Here, Δno and Δc are the growth rates of net output and consumption expenditure respectively and the tilde denotes deviations from the unconditional mean. The parameter c is the province-specific long-term mean of C/NO. The discount parameter takes the form $\kappa = exp\left[E(\Delta no_t^k) - E(r_t^{T,k})\right]$ and also varies by province.[4] In the derivation above, we have assumed that $E(\Delta no_t^k) = E(\Delta c_t^k)$. Note that the approximation above follows directly from the intertemporal budget constraint and that we have, so far, not imposed any restrictions on technology or preferences.

In what follows, we restrict this setup using some theory. Specifically, we posit that each province's representative agent has lifetime CRRA utility over a consumption bundle composed of a tradable and non-tradable good:

$$\sum_{t=0}^{\infty}\beta^t\mathbb{E}_0\left[\frac{X\left(C_t^{N,k},C_t^{T,k}\right)^{1-\gamma}}{1-\gamma}\right]$$

where

$$X_t^k = X\left(C_t^{T,k},C_t^{N,k}\right) = C_t^{T,k\,\alpha}\times C_t^{N,k\,1-\alpha}$$

In this setting, it is well known that the intertemporal consumption allocation can be solved for independently from the intratemporal allocation between tradable and non-tradable goods. Specifically, we can define the price index of aggregate consumption by recognizing that, for any such index P_t^{*k}, it must be true that $P_t^{*k}X_t^k = C_t^{T,k} + P^kC_t^{N,k} = C_t^k$ for all P_t^k. Then replacing C_t^k with $P_t^{k*}X_t^k$ in the budget constraint, one obtains the Euler equation

$$\mathbb{E}_t\left(\beta\frac{P_t^{*k}}{P_{t+1}^{*k}}\left(\frac{X_t^k}{X_{t+1}^k}\right)^{\gamma}\left(1+r_{t+1}^{T,k}\right)\right) = 1$$

[3] Kano (2008) obtained an expression for the CA/NO ratio. As no income flows data among regions are available, we use the approximation $\widetilde{\frac{NX}{NO_t}}^k = \widetilde{\frac{CA}{NO_t}}^k - b\tilde{r}_t^{T,k}$, where b is the steady-state value of out-of-province assets.

[4] Even though c and κ will vary by province, for the sake of readability, we will generally drop the index k for these and other province-specific constants whenever it is unambiguous to do so.

which can be rewritten in terms of aggregate consumption expenditure as

$$\mathbb{E}_t\left(\beta\left(\frac{C_t^k}{C_{t+1}^k}\right)^{\gamma}\left(\frac{P_t^{*k}}{P_{t+1}^{*k}}\right)^{1-\gamma}\left(1+r_{t+1}^{T,k}\right)\right)=1 \tag{2}$$

The aggregate price index for consumption is given by $P_{t+1}^*/P_t^* = (P_{t+1}/P_t)^{1-\alpha}$. Hence, (2) links aggregate consumption expenditure growth to the consumption-based real interest rate, which is the national real interest rate corrected for the savings wedge and real exchange rate changes (defined as the change in the relative price of the non-traded good relative to the tradable good). Assuming that consumption growth, the real exchange rate, and the real interest rate are jointly log-normal, Bergin and Sheffrin (2000) show that this condition can be log-linearized to obtain

$$\mathbb{E}_t(\Delta c_{t+1}^k)=\frac{1}{\gamma}\mathbb{E}_t\left(r_{t+1}^k\right)+constant \tag{3}$$

where r_t^k is the consumption-based real interest rate of province k,

$$r_{t+1}^k = r_{t+1}^{T,k}+(1-\alpha)(\gamma-1)\Delta p_{t+1}^k$$

and where Δp_{t+1}^k reflects the change in relative non-tradable prices.

We now substitute for consumption growth and the real interest rate term on the right-hand side of the log-linearized budget constraint.[5] Plugging in for $r_{t+1}^k/\gamma = E(\Delta c_{t+1}^k)$, and using the decomposition $r_t^{T,k} = r_t^N + \delta^k \tau_t$ from above, we obtain the following expression for NXO

$$\text{NXO}_t^k = \underbrace{-\sum_{l=1}^{\infty}\kappa^l \mathbb{E}_t \Delta\widetilde{no}_{t+l}^k}_{\text{NXO}_{\Delta no,t}^k} + \underbrace{\phi\sum_{l=1}^{\infty}\kappa^l \mathbb{E}_t \widetilde{\Delta q}_{t+l}^k}_{\text{NXO}_{\Delta q,t}^k} + \underbrace{[1-\phi]\sum_{l=1}^{\infty}\kappa^l \mathbb{E}_t \widetilde{r^N}_{t+l}}_{\text{NXO}_{r,t}^k} + \underbrace{\delta\left[[1-\phi]\sum_{l=1}^{\infty}\kappa^l \mathbb{E}_t \widetilde{\tau}_{t+l}\right]}_{\text{NXO}_{\tau,t}^k} \tag{4}$$

where we have introduced additional notation so that $\phi = c\left(1-\frac{1}{\gamma}\right)$ and $\Delta q_{t+1} = (1-\alpha)\Delta p_{t+1}$ is the change in the provincial real exchange rate (i.e. the inflation differential in the relative price of non-tradables and tradables).

This equation suggests four channels of net exports adjustment.[6] The first term, $\text{NXO}_{\Delta no,t}^k$,

[5] This follows Bergin and Sheffrin (2000) and Bouakez and Kano (2008). However, these models do not feature a savings wedge.

[6] Thereafter, we assume $0 < \phi < 1$, which is fulfilled for values of risk aversion (γ) higher than one and most

reflects the standard 'rainy-day' saving channel channel that is emphasized by basic versions of the neoclassical model (see e.g. Obstfeld and Rogoff, 1996, chapter 2). If output is below (above) trend, so that the sum of its expected changes is positive (negative), the province should run a deficit (surplus) *ceteris paribus*. It is the intuition underlying this channel that has contributed to the conventional perception of China's persistent surpluses as an empirical puzzle: according to this intuition, an emerging economy with high future expected GDP growth rates should run a deficit.[7]

The second to fourth terms all capture how expected variation in prices and interest rates impacts on capital flows. These channels can therefore potentially help explain departures from the simplest neoclassical benchmark model of net exports behavior. The second term, $\text{NXO}^k_{\Delta q,t}$, is the impact of expected changes in the local price of non-tradables (i.e. intratemporal substitution). If the price of the provincial consumption bundle relative to tradable goods is expected to rise in the future, there is an incentive to save more in terms of tradables today. In analogy to Hoffmann (2013), we refer to this channel as "internal tilting" or "intratemporal substitution" since it is driven by relative variation in expected prices of only regionally consumed (non-tradable) to both internationally and domestically consumed (tradable) goods. For example, we would expect that anticipated rises in the local price of non-tradables such as housing, schooling or medical care could be important determinants of saving decisions.

The third ($\text{NXO}^k_{r,t}$) and fourth ($\text{NXO}^k_{\tau,t}$) terms capture how variation in the (China-wide) real rate of interest and in the impact of the excess return on the foreign bond respectively affect province-level capital flows.We refer to them as the "intertemporal substitution" channel. If province-level interest rates are temporarily high (because national interest rates or the savings wedge are high), so that the sum of future interest-rate deviations from the long-term mean interest rate is positive, consumers will want to defer consumption and save more. We call the first term the domestic

empirical values of the consumption ratio (c).

[7] Even though we do not fully spell out the investment side of the model, we note the following: as in all neoclassical models, the household here is assumed to choose consumption by taking the path of investment and output as given. This includes, in particular, the possibility that investment itself could be subject to frictions. For example, if lack of access to external funds forces firms to finance future investment from current retained earnings, saving surpluses will predict future increases in investment which, *ceteris paribus*, would imply an expected decline in net output. In such a setting, a NXO surplus might predict low net output growth because corporate savings predicts increasing investment and not because households save to cushion future declines in their incomes. Unfortunately, our data are not sufficiently detailed to allow us to distinguish between savings by firms or households at the province-level.

interest rate channel since national—as opposed to global—interest rate variation should matter only in repressed financial markets. We refer to the second term as the world interest rate channel. Clearly, as the intertemporal elasticity of substitution $(1/\gamma)$—and thus $(1-\phi)$—increases, both intertemporal substitution channels become relatively more important vis-à-vis the intratemporal channel.

The two interest rate terms deserve further comment. Consistent with the standard intertemporal approach of the current account, interest rates capture common variation across provinces in our model. Specifically, $\text{NXO}^k_{r,t}$ reflects the impact of a common, country-wide factor on province-level capital flows while the wedge-term $\text{NXO}^k_{\tau,t}$ can be interpreted as a global factor that reflects world-wide variation in interest and exchange rates.[8] Note that the relative importance of these factors (and their role relative to purely idiosyncratic variation in relative prices and outputs) will differ across provinces. Specifically, in our empirical implementation we will let the parameters ϕ and δ vary by province. The former governs the relative importance of idiosyncratic and common variation for capital flows while the latter affects the relative importance of the two common factors (the country-wide and the global one).[9]

2.2 Empirical implementation

Equation (4) is the focus of our empirical analysis of province-level net exports. For each region in our sample, we proxy the expectations on the right hand side of (4) using a vector autoregressive model (VAR):

$$X_t^k = \sum_{l=1}^{p} \mathbf{A}_l(k) X_{t-l}^k + \varepsilon_t^k$$

where $X_t^k = \begin{bmatrix} \Delta no_t^k & \Delta q_t^k & r_t^N & \tau_t & (NX/NO)_t^k \end{bmatrix}'$ is the vector of endogenous variables, the $\mathbf{A}_l(k)$ are 5×5 coefficient matrices of the p-th order VAR for province k and ε_t^k is the vector of reduced-form residuals. Stacking $Z_t^k = \begin{bmatrix} X_t^k, & X_{t-1}^k, & \dots & ,X_{t-p+1}^k \end{bmatrix}'$, one can write the VAR companion form as VAR(1) so that

$$Z_t^k = \mathbf{A}_{\{k\}} Z_{t-1}^k + U_t^k \tag{5}$$

[8]In the same spirit, Hoffmann (2013) and Kano (2008) exploit common variation interest rates to identify global shocks.

[9]The next subsection describes in detail how we estimate the decomposition (4) from province-level data. Here we just note that by including interest rates for the country as a whole in our empirical models, we implicitly account for much of the cross-province correlations in the determinants of intra-national capital flows.

where $\mathbf{A}_{\{k\}}$ is the companion matrix of the VAR estimated on province k data and $U_t^k = \left[\begin{array}{cccc} \varepsilon_t^k, & 0, & ... & ,0 \end{array} \right]'$ the associated vector of residuals. Then, once the VAR-parameters have been estimated, the expectation terms are easily backed out as

$$\sum_{l=1}^{\infty} \kappa^l \mathbb{E}_t x_{t+l}^k = \mathbf{e}_x' \kappa \mathbf{A}_{\{k\}} \left[I - \kappa \mathbf{A}_{\{k\}} \right]^{-1} Z_t^k$$

where x_t stands, in turn, for Δno_t^k, Δq_t^k, r_t^N, τ_t and $\mathbf{e}_x$ is the unit vector associated with the position of variable x in the vector Z_t^k (i.e. the first unit vector for Δno, the second for Δq_t etc.). Plugging this representation of the expectation terms into (4) above, one gets the NX/NO ratio predicted by the model for each province:

$$\widehat{\text{NXO}}_t^k = \left[-\mathbf{e}_{\Delta no}' + \phi \mathbf{e}_{\Delta q}' + (1-\phi)(\mathbf{e}_r' + \delta \mathbf{e}_\tau') \right] \kappa \mathbf{A}_{\{k\}} \left[I - \kappa \mathbf{A}_{\{k\}} \right]^{-1} Z_t^k \tag{6}$$

where again $\phi = c\left(1 - \frac{1}{\gamma}\right)$ and where we denote the predicted value of NXO_t^k from the model with a hat. Then, denoting the present value of Z_t^k as $\mathbb{Z}_t^k = \kappa \mathbf{A}_{\{k\}} \left[I - \kappa \mathbf{A}_{\{k\}} \right]^{-1} Z_t^k$, we obtain the contributions of the individual channels as $\text{NXO}_{\Delta no,t}^k = -\mathbf{e}_{\Delta no}' \mathbb{Z}_t^k$, $\text{NXO}_{\Delta q,t}^k = \phi \mathbf{e}_{\Delta q}' \mathbb{Z}_t^k$, $\text{NXO}_{r,t}^k = (1-\phi)\mathbf{e}_r' \mathbb{Z}_t^k$ and $\text{NXO}_{\tau,t}^k = \delta(1-\phi)\mathbf{e}_\tau' \mathbb{Z}_t^k$ respectively.

For each province and for any known set of parameter values $1/\gamma$, κ, c and δ, the predicted net exports can now be compared to the actual net exports. This can be done either through an informal comparison of the predicted net exports with the data (in terms of correlation and variance) or formally, based on a Wald test. Note that we let the VAR companion matrix $\mathbf{A}_{\{k\}}$ vary by province, allowing for potentially very different dynamics in outputs and prices across regions.

One decision we have to take at this junction is to what extent we want to allow the parameters of the theoretical model like c (the long-term consumption ratio) and in particular $1/\gamma$ (the intertemporal elasticity of substitution) to differ across regions. In principle, c can be recovered from the data. *Prima facie*, it would seem natural to restrict the preference parameter γ to be the same across regions. However, we would expect that the technologies available for intertemporal substitution—and, thus, measured elasticities—vary widely across provinces, e.g. with the level of development. Whether we would also expect this to be the case with respect to the extent to which provinces have access to international markets is an open question. On the one hand, more open or developed provinces may benefit from a more developed financial system and may have access to finance from international banks or firms. On the other hand, state-owned firms may have a privileged access to international markets. We therefore estimate $1/\gamma$, κ and δ for each province separately. We discuss the details of this estimation in Section 4.1.

2.3 Channels of province-level external adjustment

Once the parameters κ, c, γ and δ have been determined for each province, we can use (6) to obtain estimates for each channel $\text{NXO}^k_{x,t}$ for $x = \{\Delta no, \Delta q, r, \tau\}$. Then defining the component that is unexplained by the model as $\text{NXO}^k_{res,t} = \text{NXO}^k_t - \widehat{\text{NXO}}^k_t$ we have

$$\text{NXO}^k_t = \text{NXO}^k_{\Delta no,t} + \text{NXO}^k_{\Delta q,t} + \text{NXO}^k_{r,t} + \text{NXO}^k_{\tau,t} + \left(\text{NXO}^k_t - \widehat{\text{NXO}}^k_t\right)$$

Now take the variance on both sides and dividing by $var(\text{NXO}^k_t)$ to get

$$1 = \beta^k_{\Delta no} + \beta^k_{\Delta q} + \beta^k_r + \beta^k_\tau + \beta^k_{res} \tag{7}$$

where

$$\beta^k_{\Delta no} = \frac{cov\left(\text{NXO}^k_{\Delta no,t}, \text{NXO}^k_t\right)}{var(\text{NXO}^k_t)} \qquad \beta^k_{\Delta q} = \frac{cov\left(\text{NXO}^k_{\Delta q,t}, \text{NXO}^k_t\right)}{var(\text{NXO}^k_t)}$$

$$\beta^k_r = \frac{cov\left(\text{NXO}^k_{r,t}, \text{NXO}^k_t\right)}{var(\text{NXO}^k_t)} \qquad \beta^k_\tau = \frac{cov\left(\text{NXO}^k_{\tau,t}, \text{NXO}^k_t\right)}{var(\text{NXO}^k_t)}$$

$$\beta^k_{res} = \frac{cov\left(\text{NXO}^k_{res,t}, \text{NXO}^k_t\right)}{var(\text{NXO}^k_t)}$$

and where again $\phi = c\left(1 - \frac{1}{\gamma}\right)$. Here, $\beta^k_{\Delta no}$ is the contribution of output variation (consumption smoothing or net output channel), $\beta^k_{\Delta q}$ is the contribution of expected changes in relative price of non-tradables (internal price channel), β^k_r is the contribution of (expected) variation in the national real rate of interest (domestic channel) and β^k_τ the variation arising from changes in excess returns (world or international channel). The coefficient β^k_{res} is the fraction of the variance of province k's net exports that remains unexplained by the model.

For notational compactness, we collect the various β^k_xs into the vector

$$\beta^k = \begin{bmatrix} \beta^k_{\Delta no} & \beta^k_{\Delta q} & \beta^k_r & \beta^k_\tau & \beta^k_{res} \end{bmatrix}'$$

and we call β^k the pattern of external adjustment of province k. [10]

At the level of each province, the elements of β^k can now be estimated from time-series regressions of $\text{NXO}^k_{x,t}$ on NXO^k_t. However, simple OLS would neglect the possibility, that the errors in these regressions are most likely to be correlated across provinces. This correlation could take many forms. It may, for example, reflect spillovers between neighboring provinces, leading to a typical spatial correlation pattern that decays with distance. More generally, the correlation may reflect unmodelled sectoral, country-wide or even global shocks that affect provinces differently. Neglecting such common factors could lead to biased estimates of β^k if the current account itself is correlated with the unobserved common factors.

We follow Pesaran (2006) and estimate a model in which we control for such common correlated effects (CCE) by augmenting the province-level regression with cross-province averages of both the dependent and the independent variable. Hence, we estimate the external adjustment pattern of province k from regressions of the form

$$\text{NXO}^k_{x,t} = \beta^k_x \text{NXO}^k_t + \mathbf{a}'_k F_t + \text{constant}^k_x + \varepsilon^k_{tx,t} \tag{8}$$

where $F_t = \begin{bmatrix} \overline{\text{NXO}}_{x,t}, & \overline{\text{NXO}_t} \end{bmatrix}'$ is the vector of the cross-sectional averages (denoted by overbars) of the dependent and the independent variables and $\mathbf{a}_k$ is a vector of associated loadings that are of no further interest for our analysis.

Pesaran (2006) proposes a mean group (CCEMG) and a pooled estimator (CCEP) for the average (panel) effect $\beta_x = E_K\left(\beta^k_x\right)$, where $E_K(.)$ denotes the cross-sectional mean. Since estimates of β^k for individual provinces are likely to be relatively noisy, our empirical analysis reports this average effect—first for all provinces and then for meaningful sub-groups that we form based on observable province characteristics such as demography or openness.

3 Data

Most of the data used in this paper are from the *National Statistical Yearbooks* of the People's Republic of China and from the *Provincial Statistical Yearbooks* of the 31 provinces (strictly speaking: 22 provinces, 5 autonomous regions and 4 municipalities) of Mainland China.[11] We

[10] Note that these β^k_xs are not to be confused with the discount parameter of the utility function (β).

[11] The autonomous regions are Tibet, Xinjiang, Guangxi, Inner Mongolia and Ningxia. The cities of Beijing, Tianjin, Shanghai as well as the region of Chongqing are municipalities. In this paper, we use the term 'province' as

accessed the data via the *China Data Center* (CDC) of the University of Michigan which provides electronic access to the yearbooks.[12] In our analysis, we include all provinces except Tibet—for which data are too incomplete—allowing us to report results for 30 provinces for the period 1986-2010.

The quality of provincial and aggregate Chinese *National Accounts* data is an important issue explored in detail in Cudré (2012) who documents large discrepancies between aggregate statistics and the sum of provincial statistics. For example, the sum of province-level GDPs was about 11 percent higher than the officially published national value in 2010. The bulk of this large error stems from an excess of regional over national investment, which has been widening since the mid-1990s. Conversely, the discrepancy between cumulated provincial saving and national saving shows no clear trend over time. Still, the sum of province-level saving overestimated national values by round 7 percent of China's GDP in 2010. All in all, since the mid-2000s, the sum of province-level net exports will generally be lower than the corresponding official aggregate statistics. Other authors have argued that China's current account surplus is overstated for a variety of reasons (see Zhang, 2008). Whether regional data are worse than national ones is an open question (e.g. the *2004 Economic Census* validated provincial GDP data and invalidated national ones (Holz, 2008)).

While there are discrepancies between the levels of aggregate and regional statistics, aggregates of province-level data are generally highly correlated with movements in the corresponding official aggregate statistics.[13] Since our empirical analysis focuses on a log-linearized model that emphasizes the movements in these variables over time rather than their specific levels, our province-level data still allows us to capture important aspects of external adjustment among China's provinces. In Section A of the appendix, we provide a detailed description of the data.

a general qualifier for provinces, autonomous regions and municipalities.

[12] `http://chinadataonline.org/`. The CDC reports values as soon as they are published in the corresponding yearbook. Although data have sometimes been subject to official revisions in later years, the CDC did not systematically adapt past values.

[13] For example, over 1985-2010, the correlation of the first difference of national net exports with cumulated net exports is 0.80. It rises to 0.87 for 2000-2010, the period in which global imbalances arose.

4 Results

4.1 Fitting the model to province-level net exports

We first ascertained the stationarity of the data using panel unit root tests. These are discussed in section B of the appendix and presented in Table A.1. We then proceeded to estimate the province-level VARs, generally with one or two lags. This allows us to back up the VAR-implied expectations on the right hand side of the present-value relation (4).[14] For each province, we then estimate the parameters of the model—$1/\gamma$, κ and δ— based on a three-dimensional grid-search that minimizes a linear Wald test of the cross-equation restrictions (6).[15] This can be interpreted as a minimum-distance estimation method with a Chi-squared criterion function. In the grid-search procedure, we let the coefficient of relative risk aversion (γ) vary between 0.2 and 5, the discount parameter (κ) between 0.900 and 0.995 and the world market integration parameter (δ) between 0 and 1.

Table 1 summarizes the estimated parameter values, the general fit of the model in terms of correlation and the relative variance of predicted to actual net exports. In order to better appreciate the economic importance of provinces, we provide their relative share of China's real GDP in 2000 and their rank in terms of size. Results for the ten largest provinces—accounting for more than 60% of output—are in boldface. We refer to Table A.2 for more details about the specification (sample length, number of lags, net output deflator, consumption ratio and ϕ parameter).[16] For most provinces, our simple model provides an excellent fit: the mean correlation between actual and predicted net exports is 0.87 while the lowest (positive) value is 0.42 and the median is 0.98. The model also matches the standard deviation of actual province-level net exports well: the average relative standard deviation is 1.17.

[14] All VAR systems appear stationary with exception of Shandong where we find one eigenvalue of the companion matrix to be outside of unit circle. For formal stationarity tests, see Table A.1in appendix.

[15] Since equation (6) holds for all Z_t we have the non-linear set of cross-equation restrictions $\mathbf{e}'_{nx} = \left[-\mathbf{e}'_{\Delta no} + \phi \mathbf{e}'_{\Delta q} + (1-\phi)(\mathbf{e}'_r + \delta^k \mathbf{e}'_\tau)\right] \kappa \mathbf{A} \left[I - \kappa \mathbf{A}\right]^{-1}$. Based on Monte-Carlo evidence, Bouakez and Kano (2009) show that the standard non-linear Wald test of the PVMCA is biased against the null in small samples and advocate the use of the linear version instead. Multiplying with $[I - \kappa \mathbf{A}]$ and rearranging yields the linear set of restrictions $\mathbf{R}(\phi, \delta^k, \kappa) = \mathbf{e}'_{nx} + \left[-\mathbf{e}'_{nx} + \mathbf{e}'_{\Delta no} - \phi \mathbf{e}'_{\Delta q} - (1-\phi)(\mathbf{e}'_r + \delta^k \mathbf{e}'_\tau)\right] \kappa \mathbf{A} = 0$. We choose ϕ, δ and κ to minimize $\mathscr{W}^l = \left[\mathbf{R}(\phi, \delta^k, \kappa)\right] \left[\frac{\partial \mathbf{R}(\mathbf{A})}{\partial \mathbf{A}} \widehat{\Sigma} \frac{\partial \mathbf{R}(\mathbf{A})}{\partial \mathbf{A}}'\right]^{-1} \left[\mathbf{R}(\phi, \delta^k, \kappa)\right]'$where $\widehat{\Sigma}$ is the covariance matrix of the VAR-parameters. $\mathscr{W}^l$ has a χ^2-distribution with $m - p$ degrees of freedom, where m is the dimension of the companion matrix and p the number of estimated parameters ($p = 3$ in our case).

[16] The model is estimated on the 1986-2010 period with the exception of five provinces for which we have a shorter sample: Guangxi, Yunnan, Shaanxi, Shanxi and Ningxia. For all provinces, the consumption ratio c is estimated over the sample length using the same deflator as for output and government consumption.

Figure 2 provides a graphical representation of the predicted and real net exports of the three largest provinces (Shandong, Guangdong and Jiangsu) and seven other provinces representative of the geographical and structural diversity of China. The correlation between the predicted and the actual NXO_t^k is optically striking. The considerable graphical fit is confirmed by the formal Wald tests: only for 8 of the 30 provinces would we reject the null at the 5 percent level. Among the 10 largest provinces (which among themselves account for more than 60 percent of China's aggregate GDP) we reject the model for only one (Guangdong). As is apparent from Figure 2, even for Guangdong province the graphical fit of the model remains considerable.

In Figure 3, by way of example, we provide a graphical breakdown into the various channels for four selected provinces. However, due to the noise in the data and the nature of the modelling, we refrain from interpreting parameters for individual provinces in the following. Standard errors for the estimated parameters are given in Table A.3 in the appendix. While there is large cross-provincial variation in the estimates, on average, we find a plausible value of γ of 2.8 (i.e. an average elasticity of substitution of 0.35). This coefficient is comparable with values conventionally used in the literature (see e.g. Hoffmann (2013)). For the discount factor, we find an average value of 0.96. As a final observation, we see that the model seems to perform especially well when applied to relatively large provinces for which the data quality plausibly is also higher. In Appendix (C), we examine the robustness of the model's fit with respect to various alternative specifications concerning deflator methodology and choice of parameters.

4.2 Patterns of external adjustment

We now turn to the decomposition of the variance of province-level net exports into four channels based on equation (7). The top panel of Table 2 reports panel estimates of provincial adjustment patterns $\beta_x = E_K(\beta_x^k)$ based on the full sample of all 30 provinces and for different weighting schemes (equal, GDP- and population weights).[17] These panel-based estimates reveal that the bulk of capital flows among Chinese provinces is driven by expected variation in quantities: depending on the weighting procedure, net output fluctuations explain between 74 and 85 percent of the variation in NXO for the average province. Conversely, variation in relative prices of non-tradables or interest rate variation do not seem to play a major role for the average province and

[17] All estimates are obtained using the pooled common-correlated effects (CCEP) estimator. Pesaran (2006) shows that the pooled estimator has slightly better convergence in small samples than the mean group estimator.

are not significant.

The price channels do have some importance for geographical subgroups of provinces, however. For the provinces on the East coast the domestic interest rate channel is found to be significant, consistent with the view that for these relatively rich provinces' lack of access to international finance might be an important driver of external flows. For provinces in the region of Manchuria, we find that internal price variation also plays a certain role. This could be an indication that commodity prices impact external dynamics of these provinces with their focus on heavy industry and natural resources extraction.

In Table 3, we now turn to examining how patterns of external adjustment covary with observable provincial characteristics other than geography. To this end, for each characteristic, we split the sample of provinces into two groups based on whether a province is above or below median with respect to this characteristic. We then re-estimate the pattern of external adjustment on each of these subgroups.[18]

The characteristics we focus on can be categorized into three groups. Each of these groups corresponds to a broad set of theoretical explanations that have been put forward for China's big saving surplus: i) indicators of the relative role of state-owned and private enterprises in the local economy, ii) demographic indicators, and iii) indicators of integration into the world economy. We refer to Section A.7 in appendix for more details about the data used for regional characteristics. To represent the first group, we use the share of state owned enterprises in gross industrial output value (*SOE*) in the province. Song et al. (2011) have emphasized the contribution to province-level savings of frictions that private firms face in obtaining external finance for investment. In addition, workers in private firms often do not have the social safety nets that employees of state-owned enterprises enjoy. This is also likely to affect savings and, therefore, could matter for patterns of external imbalances (Chamon and Prasad, 2010). We use the share of private-sector employment as an alternative indicator in this first category. As a third indicator of a province's transformation status to a market economy we use a general index of marketization initially developed by Fan et al. (2001).[19]

[18]Forming groups of provinces based on the median is more robust to outliers in the measurement of the characteristics than would be a direct regression of the province-specific β_x^k on these characteristics. This matters because both the individual β_x^k as well as a lot of province-characteristics (for which in many cases we only have a few years of observations) are likely to be noisy. For completeness, we report the province-specific adjustment patterns in Table A.4 in the appendix.

[19]Besides the relative role of state and private enterprise in the local economy, this indicator also takes account of various other aspects such as province-level competition in the banking sector, regional differences in the legal

As demographic indicators we use the sex ratio of male to female population, the (old age) dependency ratio and the urbanization rate. Wei and Zhang (2009) have emphasized the role that distorted sex ratios may play for household saving in urban areas, arguing that a traditional preference of Chinese families for sons led to selective abortions of girls after the introduction of the one-child policy in the 1980s. By the late 1990s this had materialized in a highly distorted sex ratio, leading to increased competition of husbands for wifes in the marriage market. Many potential husbands therefore can only find a partner if they bring a house as a dowry. Wei and Zhang (2009) argue that the need to buy a home for their son would tend to increase the savings rates of many families while at the same time driving up housing prices. We also consider the dependency ratio (measured as the share of people above 65) as a potential driver of savings in an ageing society (Modigliani and Cao, 2004; Chamon et al., 2013). Finally, we condition on the urbanization rate as a third demographic indicator because there are differences in economic structure of rural and urban China which clearly could affect patterns of capital flows. As indicators of economic openness we consider the ratio of province-level used FDI relative to output and, as a measure of trade openness, the sum of international exports and imports relative to GDP.

The first panel of Table 3 reports the results for the first group of characteristics. We find that the importance of the rainy-day channel ($\beta^k_{\Delta no}$) is higher in provinces with a high share of private-sector employment. For these provinces the role of the domestic interest rates is also relatively more important. The results suggest that the contribution of the quantity channel $\text{NXO}^k_{\Delta no}$ increases with the share of domestic private firms in the economy. This pattern would be consistent with the view that that households or firms in provinces with a lot of private firms tend to accumulate more rainy-day savings. In view of the findings of Song et al. (2011) we believe this to be a plausible interpretation: since private firms lack access to external finance, it means that they need to finance future investment from retained earnings. As a consequence, high corporate savings rates should predict future increases in investment (which, ceteris paribus, means lower net output in our framework). Also, private firms do not have access to international capital markets, making the domestic interest rates more important for them for corporate savings and borrowing decisions. The pattern would also be consistent with the fact that employees of private firms usually do not enjoy the safety net provided to workers of state firms, giving them a stronger

framework, or the extent to which a province is subject to restrictions on labour migration and interregional flows in goods and services. It therefore overlaps to some extent with the indicators on trade and financial openness.

incentive for rainy-day saving.[20]

Sample splits based on demographic variables are reported in the second panel of Table 3. In provinces with higher sex ratios, the role of rainy day savings for the dynamics of capital flows tends to be lower whereas anticipated increases in the price of non-tradables matters relatively more. This is consistent with the view put forward by Wei and Zhang (2009) who showed that distorted sex ratios in favor of boys lead to severe competition in the marriage market and require families to save up for a house or apartment as dowry for future husbands. The price of housing directly affects the internal price ratio between non-tradables (where housing is considered) and tradables. We also find that rainy day savings become less important for provinces with unfavorably high old-age dependency ratios. A higher share of currently old people, most of which would not have formal significant pension entitlements, would tend to create a drag on savings rates. Splitting the sample based on urbanization rates reveals a more important role for the rainy-day and the domestic interest rate channels in more urbanized provinces. While we have no theoretical explanation for this pattern, it is consistent with our previous observation that the model seems to fit the data better in more developed provinces.

Finally, sample splits based on province-level indicators of economic openness are reported in the third panel of Table 3. Capital flow dynamics in more open provinces, both in terms of trade and of FDI, seem to a larger extent to be motivated by rainy-day savings and by domestic interest rate variation. There is also some evidence that the world interest rate matters slightly more in high-FDI provinces (though the latter is not significant at conventional levels with a t-stat of 1.48) and less in provinces with low trade openness. Overall, the results support two conclusions. First, our model again seems to fit the data better in more open provinces – the sum $(1-\beta_{res})$ of the coefficients for the four channels in our model increases. Secondly, and possibly more interestingly , there is also some evidence that capital flows in more open provinces are to a larger extent determined by country-wide and global factors such as NXO_r and NXO_τ.

4.3 Implications for China's aggregate surplus

In this section, we examine the implications of our province-level analysis for China's aggregate surplus. Figure 4 plots the sum of province-level net exports (familiar from Figure 1) over our sample period against the sum of fitted values from our province-level models. The two lines

[20] We thank an anonymous referee for suggesting this second mechanism.

comove almost perfectly. In particular, the China-wide aggregate of our fitted province level net exports clearly replicates the run-up in China's net exports from the late 1990s until 2007/08 and the subsequent sharp decline. This suggests that our model could have substantial power for understanding the province-level sources of global imbalances before 2007/08 and their subsequent—partial—correction.

To shed light on this issue, we add up the regional model-based decompositions from each province to obtain China-wide aggregates of our four channels (Figure 5). As was the case for most provinces, the bulk of variations in aggregate net exports and also most of the run-up over our sample period are driven by intertemporal variation in national cash flow (net output). This 'rainy-day' channel also accounts for most of the dynamics of China's surplus. In the preceding section we established that cross-province variation in the importance of state-owned enterprises and demographic characteristics affects the importance of this rainy-day channel. Our findings here therefore suggest that these characteristics may also be important for China's aggregate surplus.

Variation in the world interest rate plays only a relatively minor role overall, consistent with the view that China's economy as a whole is relatively closed so that variation in global interest rate plays only a limited role for the saving decisions of private households and firms and, eventually, for aggregate external surpluses. This is also consistent with the view that, over most of the first decade of the 2000s, China's external balance was to a large extent reflected in official reserve accumulation, which, in turn, was driven by the need to counteract appreciation pressure on the Renminbi.

Expected variation in the domestic interest rate—a measure of general financial repression—is of relatively limited importance over the entire sample, but makes a persistent and positive contribution to China's surplus from the mid-1990s to the early 2000s. In this period, it was among the main drivers of national net export dynamics (with net output).

Interestingly, variation in the internal prices —intratemporal substitution— had an overall dampening effect on aggregate net exports in the period after the turn of the millenium. A possible interpretation of this finding is that non-tradable inflation contributed to an internal revaluation of the Renminbi that could not occur externally in a system of largely fixed nominal exchange rates.

The final question we ask is whether the bulk of China's external surplus can be explained by a subset of provinces. Figure 6 plots China's aggregate net exports (as implied by our model) against (model-implied) net exports of specific subgroups of provinces that score high on the three key dimensions we have been focusing on in the paper — i) the role of private versus state-owned enterprise in the local economy ii) demography and iii) openness. As is apparent from panels A-C, open provinces with many private firms or high dependency ratios, in aggregate, tend to run considerable surpluses for most of the sample period. This is consistent with the predictions of the earlier theroetical literature that has focused on these characteristics as drivers of China's surplus. But none of the three characteristics alone can quite explain the trend increase in China's surplus in the years before the financial crisis. However, panel D of Figure 6 shows that the provinces for which the transition to a market economy was relatively more advanced already in the 1990s (based on the broad index suggested by Fan et al. (2001)) among themselves can almost fully explain China's external flows in the years after 2000. As we have noted earlier, the marketization index by Fan et al. (2001) cuts across the categories we have discussed above, and in particular captures the role of the state in the economy (ownership, legal framework and perceptions reported by businessmen) as well as province-level opennesss to trade and migration in very broad terms. This suggests that it is the interaction of these factors that seems most relevant in explaining global imbalances from a Chinese perspective. This, in turn, ties in with findings above that suggest that rainy-day saving is the most important driver of China's external surplus. As we have documented, this channel that matters most for external adjustment in those provinces that are among the more advanced in their transition to a market economy. At the same time, we also showed that this channel also matters most for China's aggregate surplus.

5 Conclusion

We have proposed a simple, theory-based framework to analyze capital flows among Chinese provinces. Our framework nests two broad channels of external adjustment in interprovincial capital flows. The first is variation in intertemporal prices, which we further disaggregate into variation in the domestic real interest rate, the excess return on international assets over the domestic rate, and variability in the relative price of tradable and non-tradable goods. The second is intertemporal variation in quantities (cash flows of output, investment and government spending). As we show, our simple model can account for around 80 percent of the variation in a panel of 30 province-level net exports over the 1986-2010 period.

However, these aggregate numbers mask considerable heterogeneity in the relative importance of external adjustment channels across provinces. The second contribution of this paper, therefore, is to show how the relative importance of the various channels correlates with province-level characteristics. We have focused on three groups of characteristics that the literature has emphasized as potentially important in explaining China's persistent surpluses since the mid-1990s: i) the relative importance of private and state-owned enterprises (SOE), ii) demographics and iii) a province's degree of integration into the world economy.

We find evidence that the first two groups have an important bearing on the relative importance of rainy-day savings (expected variation in net output) vs. intratemporal substitution (variation in the relative price of traded and non-traded goods). As we have discussed, this impact is broadly consistent with recent theories that have either emphasized the role of financial frictions faced by private firms or demographic factors (such as distorted sex ratios or unfavorable dependency ratios) for household and corporate savings, as well as housing prices. Interestingly, we find that differences in openness to FDI or trade matter as well for the pattern of interprovincial capital flows.

Our framework has also allowed us to reconstruct aggregate Chinese net exports from the province-level up and thus to shed light on the 'provincial' roots of global imbalances. Our findings at the aggregate level are consistent with the findings at the province-level in that the provinces that are relatively more advanced in their transition to a market economy account for the bulk of China's surplus. Most of this surplus reflects rainy-day saving.

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Table 1: Specification, grid-search results and basic fit measures

Province		I	II	III	IV	V	VI	VII	VIII
number	name	γ	κ	δ	$\rho(\widehat{\text{NXO}_t^k}, \text{NXO}_t^k)$	$\sigma(\widehat{\text{NXO}_t^k})/\sigma(\text{NXO}_t^k)$	*p-value*	GDP share	*rank*(GDP share)
1	Beijing	1.30	0.995	0.00	1.00	0.60	0.23	2.3%	15
2	Tianjin	2.20	0.995	0.00	0.99	1.01	0.95	1.5%	24
3	**Hebei**	**5.00**	**0.995**	**0.00**	**0.92**	**0.69**	**0.11**	**6.0%**	**6**
4	Shanxi	1.00	0.920	1.00	0.72	0.89	*0.04*	1.6%	23
5	Inner Mong.	1.30	0.995	1.00	0.96	3.25	*0.03*	1.7%	22
6	**Liaoning**	**1.30**	**0.965**	**0.40**	**0.99**	**1.50**	**0.79**	**4.9%**	**7**
7	Jilin	3.30	0.995	1.00	0.98	1.10	*0.04*	2.0%	18
8	Heilongjiang	4.40	0.995	0.45	0.99	0.86	0.30	3.4%	14
9	Shanghai	5.00	0.995	1.00	0.98	0.76	0.80	3.5%	12
10	**Jiangsu**	**0.70**	**0.900**	**0.00**	**0.97**	**1.29**	**0.84**	**8.6%**	**3**
11	**Zhejiang**	**5.00**	**0.995**	**0.00**	**0.93**	**1.04**	**0.25**	**6.2%**	**4**
12	Anhui	5.00	0.900	0.00	0.87	2.74	*0.02*	3.4%	13
13	**Fujian**	**5.00**	**0.915**	**1.00**	**0.99**	**1.28**	**0.86**	**3.8%**	**10**
14	Jiangxi	2.10	0.900	0.15	0.96	1.12	0.79	2.2%	17
15	**Shandong**	**3.10**	**0.995**	**0.00**	**0.99**	**1.88**	**0.74**	**9.1%**	**1**
16	**Henan**	**2.60**	**0.995**	**1.00**	**0.99**	**0.72**	**0.80**	**6.1%**	**5**
17	**Hubei**	**5.00**	**0.995**	**0.00**	**0.95**	**1.18**	**0.37**	**4.1%**	**9**
18	Hunan	5.00	0.900	0.00	0.94	1.88	0.97	3.5%	11
19	**Guangdong**	**5.00**	**0.970**	**1.00**	**0.93**	**1.01**	***0.03***	**8.8%**	**2**
20	Guangxi	1.20	0.995	0.00	0.98	0.92	0.49	2.2%	16
21	Hainan	0.80	0.955	0.15	1.00	1.04	0.83	0.4%	28
22	Chongqing	3.50	0.995	1.00	0.99	0.76	0.65	2.0%	19
23	**Sichuan**	**3.10**	**0.900**	**0.35**	**1.00**	**1.05**	**0.92**	**4.6%**	**8**
24	Guizhou	0.60	0.995	0.10	-0.78	0.39	0.35	1.0%	27
25	Yunnan	5.00	0.960	0.05	0.85	0.90	0.47	1.9%	20
	Tibet								
26	Shaanxi	1.40	0.900	0.00	0.66	0.40	0.73	1.8%	21
27	Gansu	0.20	0.995	1.00	0.42	2.95	0.10	1.1%	26
28	Qinghai	1.80	0.995	1.00	0.99	0.63	*0.02*	0.3%	30
29	Ningxia	1.90	0.900	1.00	0.99	0.55	*0.00*	0.3%	29
30	Xinjiang	1.70	0.995	0.00	0.95	0.60	*0.03*	1.4%	25
Median		2.40	0.995	0.15	0.98	1.01	0.42		
Mean		2.82	0.963	0.42	0.87	1.17	0.45		

Results obtained from a three dimensional grid-search for γ, κ and δ by minimizing the linear Wald test $\mathscr{W}^l$ as discussed in section 4.1. Tibet is excluded because of data issues. Parameter estimates are reported in columns I-III. Columns IV and V give the correlation and the ratio of standard deviations between the predicted and the actual NXO_t^k. Column VI gives the p-values associated with the linear Wald test $\mathscr{W}^l$ as defined in footnote (15). Columns VII and VIII give GDP shares (in terms of 2000 real GDP) of the respective province and its rank in terms of GDP share. The ten largest provinces are in bold type and represent around 62% of aggregate Chinese output.

Table 2: Panel analysis of external adjustment

	$\beta_{\Delta no}$	$\beta_{\Delta q}$	β_r	β_τ
I: All provinces				
equal weights	0.74^{***}	0.01	-0.02	0.02
	(5.11)	(0.25)	(-0.24)	(0.70)
GDP-weighted	0.83^{***}	-0.06	0.07	0.04
	(6.93)	(-1.02)	(1.36)	(0.61)
Population-weighted	0.85^{***}	-0.03	-0.06	0.04
	(7.39)	(-0.72)	(-0.34)	(1.17)
II: Regions				
Metro	0.81^{**}	-0.07	0.02	0.00
	(3.16)	(-0.71)	(0.28)	(0.11)
East Coast	0.77^{**}	-0.20	0.26^{***}	-0.00
	(2.58)	(-1.42)	(7.23)	(-0.09)
Manchuria	0.85^{***}	0.09^{***}	0.07	-0.00
	(10.66)	(4.57)	(0.97)	(-0.02)
Center	0.90^{***}	0.11	0.08	-0.00
	(4.70)	(1.33)	(0.66)	(-0.96)
West	0.50^{***}	0.04	-0.00	0.30
	(3.69)	(0.78)	(-0.00)	(0.51)
South	0.64^{***}	0.04	-0.08	0.03
	(4.26)	(0.72)	(-0.53)	(1.88)

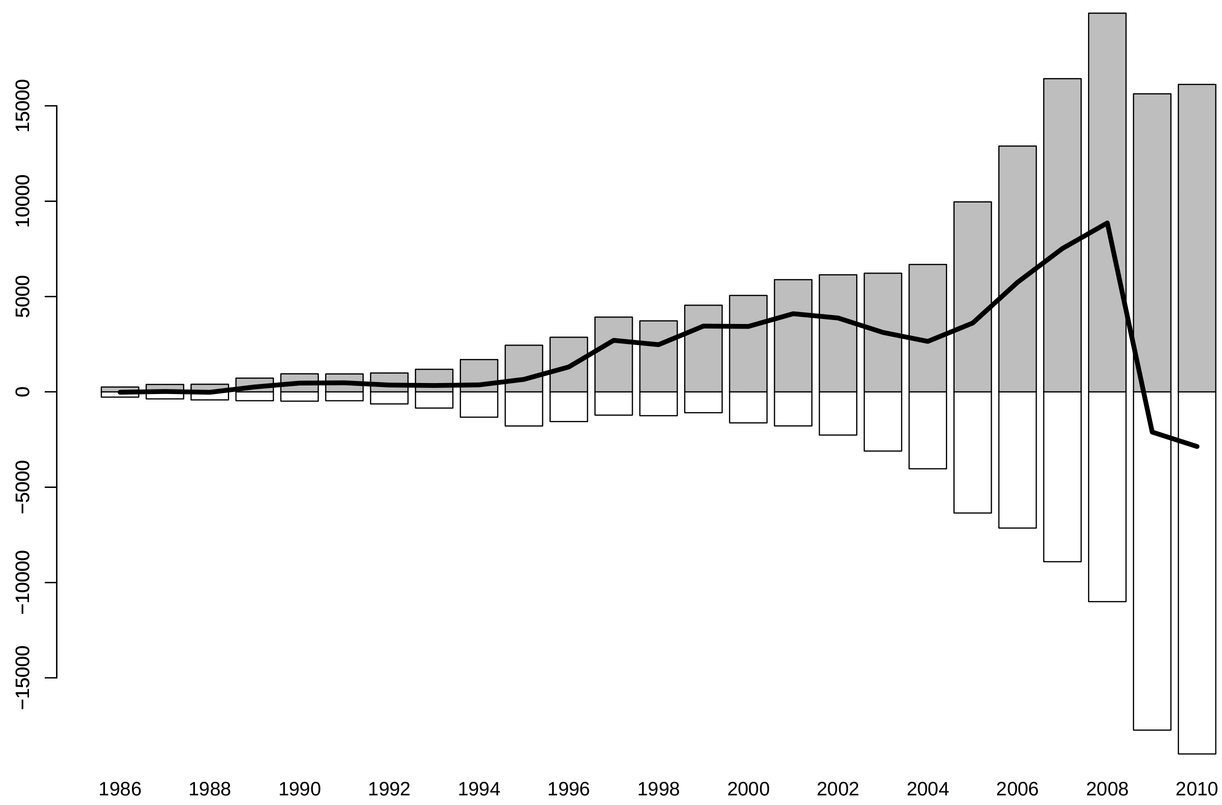
Panel estimates ($\beta_x = E_K(\beta_x^k) = \frac{1}{K}\sum_{k=1}^{K}\beta_x^k$) of the respective channels $x = \{\Delta no, \Delta q, r, \tau\}$ for various groups of provinces and different weighting schemes. The province-specific slopes β_x^k have been estimated from the common correlated effects regression $\text{NXO}_{x,t}^k = \beta_x^k \times \text{NXO}_t^k + \alpha' F_t + const + \varepsilon_t^k$. For the weighting procedures, we use 2000 real GDP (deflated with provincial CPI) and population. Results for sub-groups of provinces are based on GDP-weighting. Numbers in parentheses are t-statistics. 1 / 2 / 3 stars indicate significance at the 10%, 5% and 1% confidence level.

Table 3: Panel analysis of external adjustment by province-level characteristics

	$\beta_{\Delta no}$	$\beta_{\Delta q}$	β_r	β_τ
I: Sectoral composition				
SOE High	0.82 ***	0.04	-0.05	0.04
	(6.24)	(0.94)	(-0.54)	(0.69)
SOE Low	0.79 ***	-0.10	0.11 ***	-0.00
	(3.24)	(-1.54)	(3.52)	(-0.04)
Private Employment High	0.99 ***	-0.09	0.10 **	0.08
	(5.55)	(-1.50)	(2.23)	(1.48)
Private Employment Low	0.77 ***	0.05	-0.01	0.02
	(7.13)	(0.82)	(-0.12)	(0.38)
Market High	0.88***	−0.12	0.11*	0.09
	(6.27)	(−1.32)	(2.52)	(1.84)
Market Low	0.89***	0.03	−0.10	0.04
	(4.77)	(0.71)	(−0.75)	(0.57)
II: Demographics				
Sex Ratio High	0.63 ***	0.06 *	0.01	0.06
	(5.86)	(1.85)	(0.12)	(0.88)
Sex Ratio Low	0.86 ***	-0.12	0.12 **	0.02
	(5.06)	(-1.40)	(2.17)	(0.21)
Old Dep Ratio High	0.75 ***	-0.05	0.07 *	0.00
	(4.16)	(-0.88)	(1.90)	(0.07)
Old Dep Ratio Low	0.96 ***	-0.04	0.06	0.09
	(5.56)	(-0.38)	(0.50)	(0.47)
Urbanization High	1.05 ***	-0.09	0.10 *	0.07
	(5.18)	(-1.29)	(1.90)	(1.23)
Urbanization Low	0.64 ***	0.00	0.02	0.02
	(8.87)	(0.05)	(0.28)	(0.76)
III: Openness				
FDI High	0.91 ***	-0.14	0.12 **	0.10
	(7.84)	(-1.39)	(2.00)	(1.48)
FDI Low	0.84 ***	0.00	-0.09	0.05
	(5.09)	(0.04)	(-0.65)	(0.66)
Trade Openness High	0.91 ***	-0.10	0.12 **	0.06
	(6.74)	(-1.55)	(2.54)	(0.87)
Trade Openness Low	0.73 ***	0.04 ***	0.01	-0.04 *
	(30.74)	(3.69)	(0.40)	(-1.72)

Panel estimates ($\beta_x = E_K(\beta_x^k) = \frac{1}{K}\sum_{k=1}^{K}\beta_x^k$) of the respective channels $x = \{\Delta no, \Delta q, r, \tau\}$ for various sample splits of the 30 provinces. The sample splits are based on whether a province is above or below the median with respect to the respective characteristic. The province-specific slopes β_x^k have been estimated from the common correlated effects regression $\text{NXO}_{x,t}^k = \beta_x^k \times \text{NXO}_t^k + \alpha' F_t + const + \varepsilon_t^k$ in which the data are weighted by real GDP (deflated with provincial CPI) in 2000. Numbers in parentheses are t-statistics. 1 / 2 / 3 stars indicate significance at the 10%, 5% and 1% confidence level.

Figure 1: China's external and internal capital flows (100 million RMB), 1986-2010



NOTE: The figure shows the sum of China's province-level next exports (black line) and the sum of net exports of provinces with surpluses (deficits) in a given year in blue (red) bars.

Figure 2: NX/NO: data (solid) versus predicted (dashed), 1986-2010

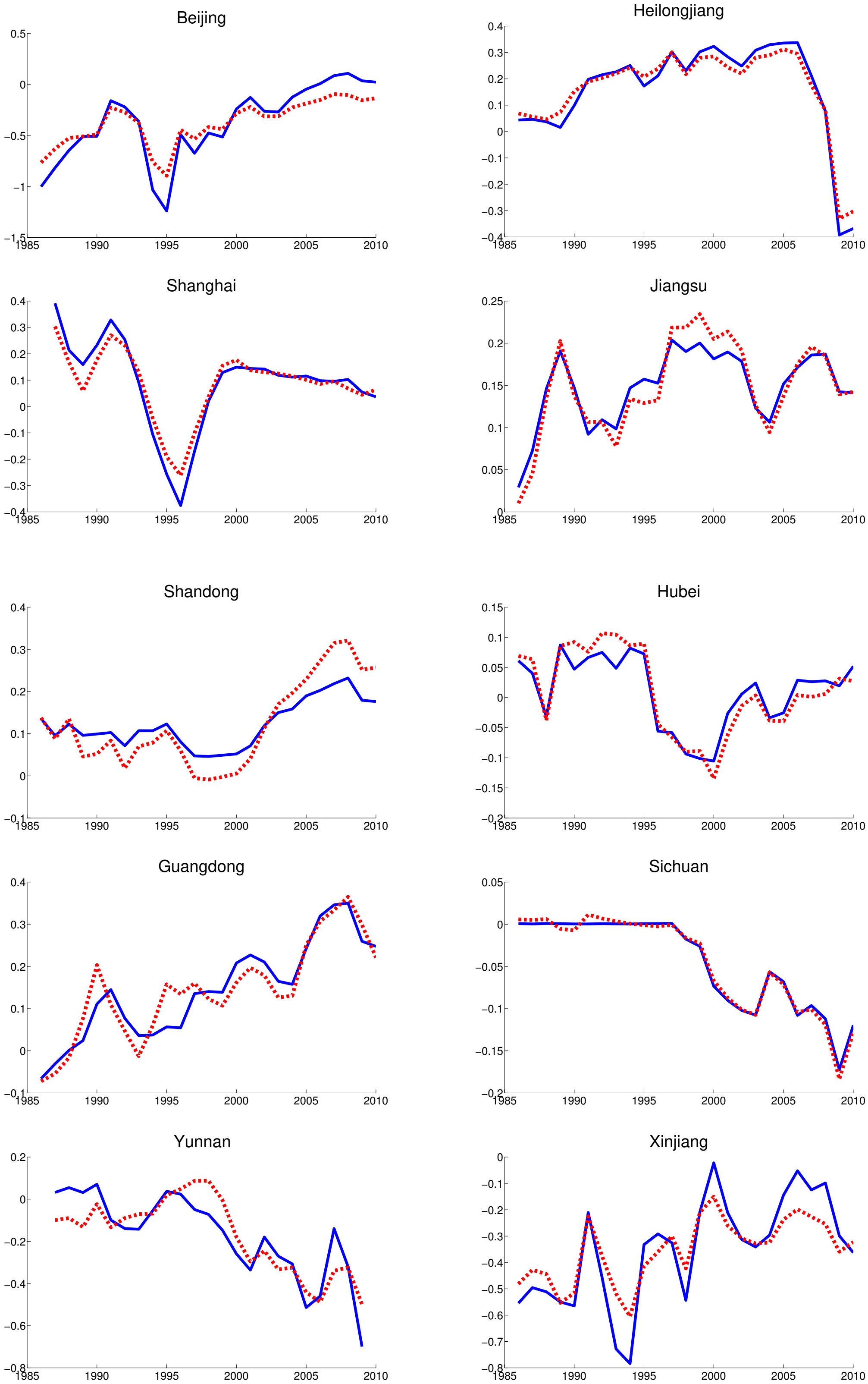


Figure 3: Channels of adjustment for four regions, 1986-2010

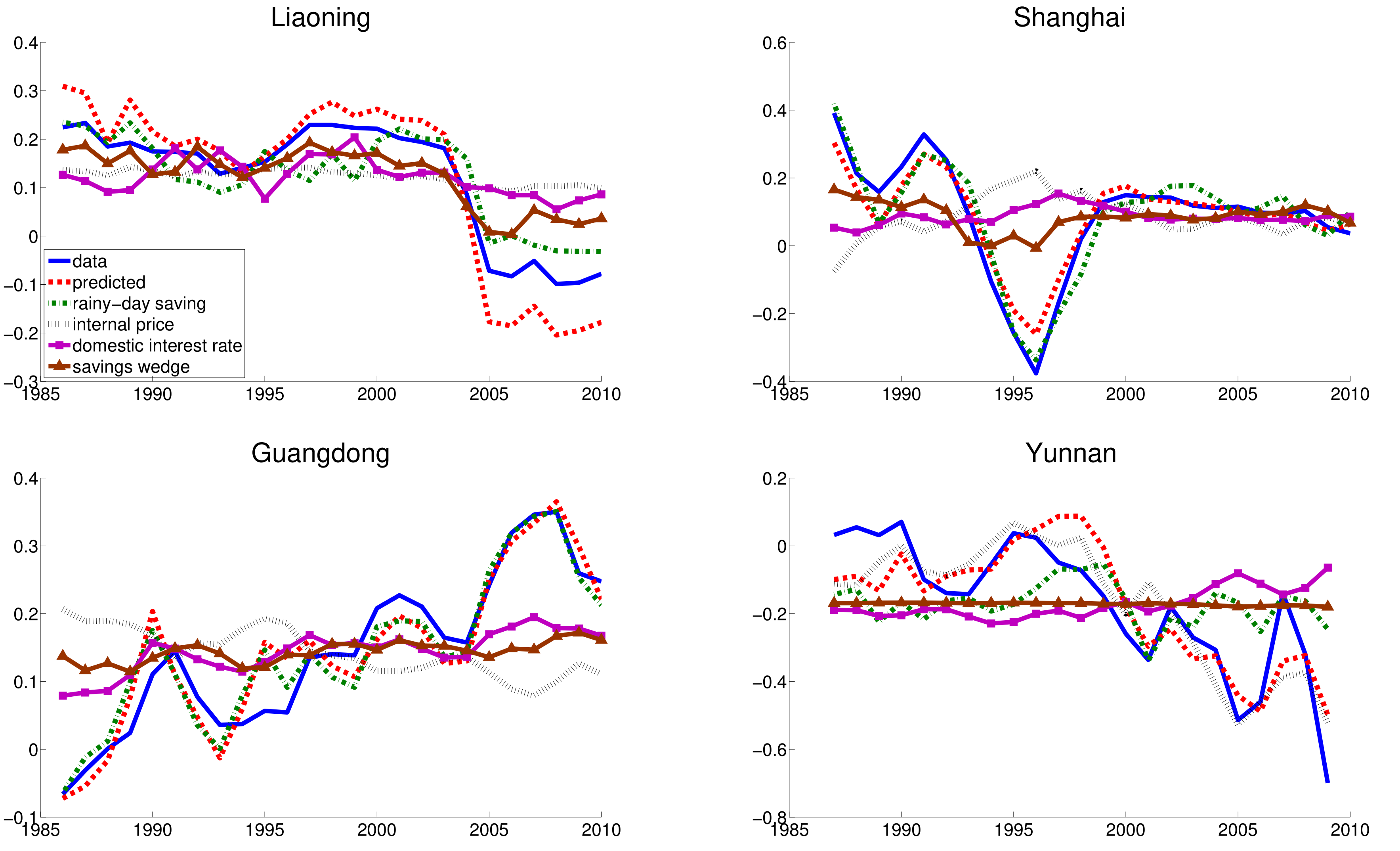
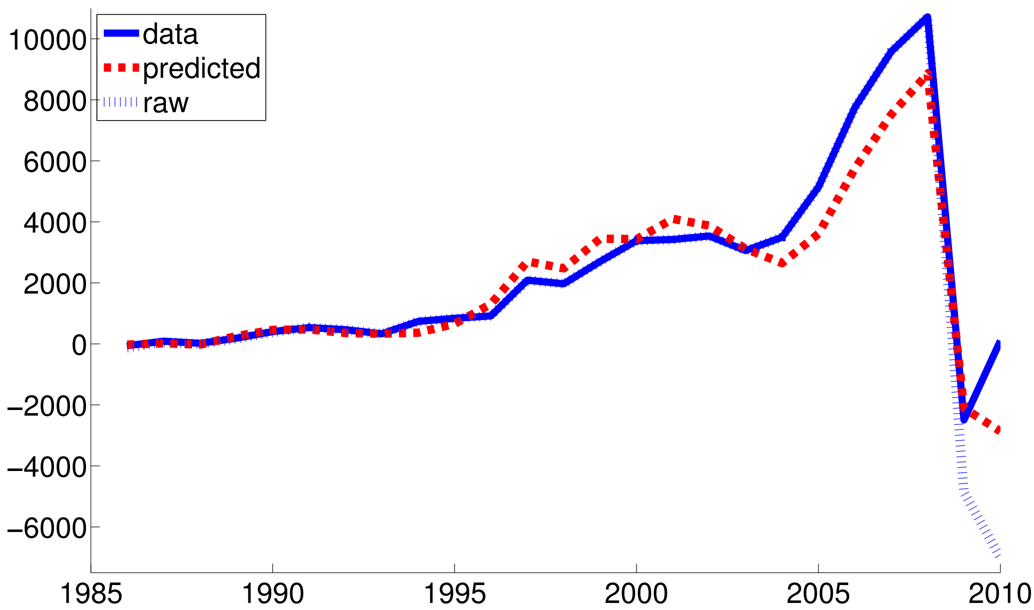


Figure 4: Cumulated nominal net exports (100 million RMB), 1986-2010



The “raw” line corresponds to the data for all regions over 1985-2010 (without reduced sample length for 5 provinces as discussed in footnote (16)).

Figure 5: Nominal aggregate channels of net exports (100 million RMB, demeaned), 1986-2010

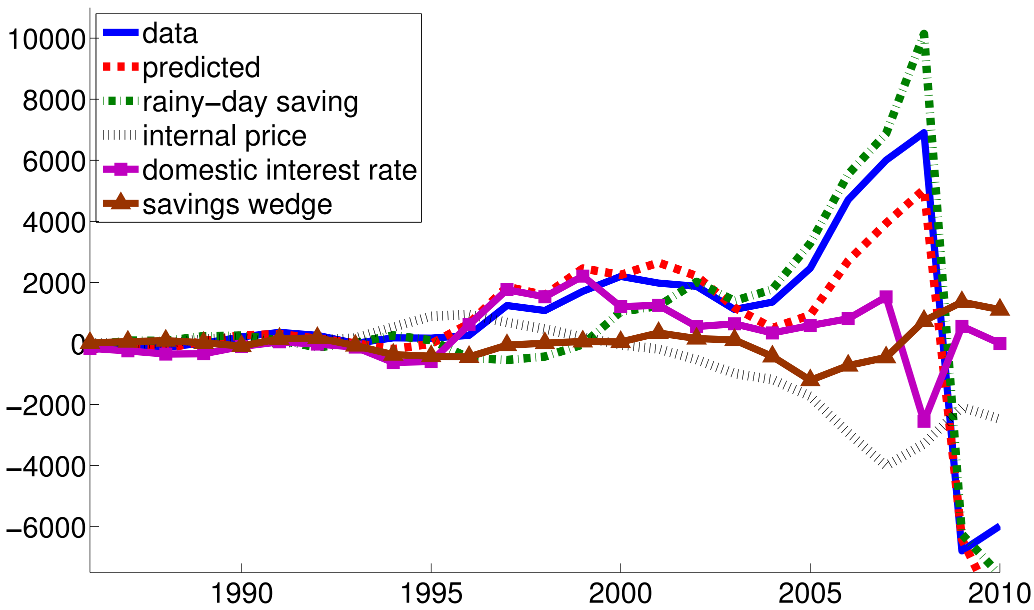
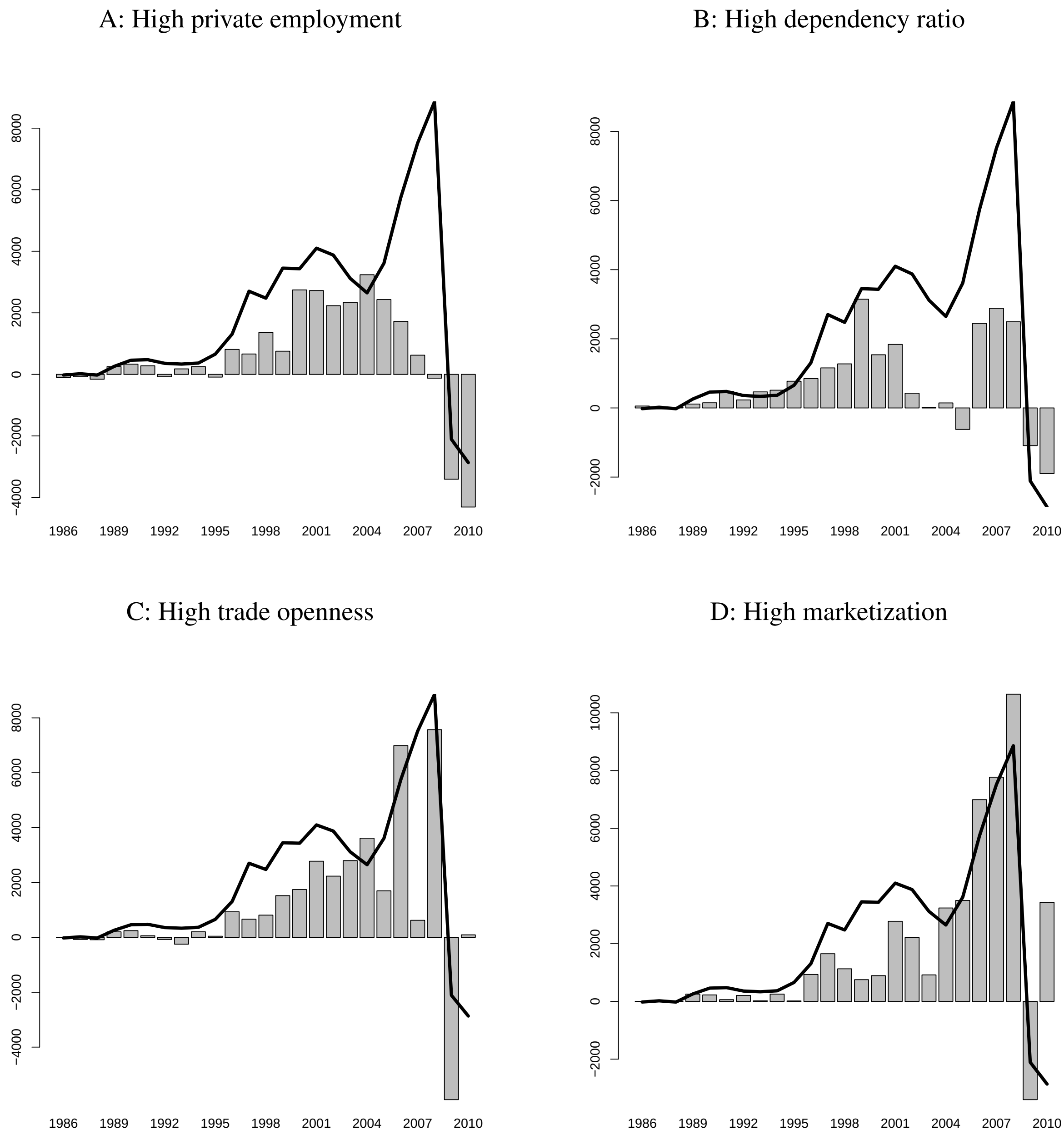


Figure 6: Contribution of different province groups to China's external flows



NOTE: The figure shows plots of the model implied aggregate net exports for all provinces (black line) and the aggregate net exports of provinces with above-median levels of private employment, dependency ratios, trade openness and marketization (grey bars).

Appendix to

"A provincial view of global imbalances: regional capital flows in China" (for publication as additional web material)

A Data

A.1 Population

Chinese population data have two major biases: the underreported birth numbers as a consequence of the one child policy (Scharping, 2001) and the *"largest (voluntary) migration in human history"* (Chan, 2013). In this paper, we address the latter issue. We use three sources of population estimates. The Hukou *Household Registration System* population data is reported by the *Public Security Authorities*.[21] It can be considered as a *de jure* statistic because it does not capture migration flows adequately. Richer coastal provinces have an underestimated population and hinterland provinces a too high population (Chan and Wang, 2008). An alternative is the use of two sources of *de facto* data: regular sample surveys of round 1% of the population and population censuses (1982, 1990, 2000 and 2010). They should better approximate resident population but unfortunately, the time of the survey as well as the definition of permanent residents and migrants are not always consistent over time.

The yearbooks population data often are a combination of these three sources. We carefully compared CDC data, recent yearbooks, sample surveys, censuses and existing studies (Chan and Wang, 2008) to at least avoid sudden jumps due to changes in definition and assemble our own population time series. We tried to consider de facto data as much as possible, particularly for provinces traditionally heavily influenced by migration.[22] We are not primarily interested in a precise estimation of the correct level of population *per se*. Our primary goal is to avoid sudden jumps in net output per capita due to changes in data reporting and definition.

[21] The Hukou aims at limiting rural migration by restricting access to welfare goods and services for non-urban residents such as health care, insurances or education (Chan, 2010)

[22] Central China as well as Chongqing and Sichuan have been the main outflow regions. Shanghai, Guangdong and to a lesser extent other eastern provinces have been net recipients (Chan, 2013).

A.2 Net output

Net output is obtained using GDP, government consumption and investment data from the regional statistical yearbooks. In this section, we discuss the choice of the appropriate deflator(s) of the components of net output. Starting with GDP, we face the problem that no official regional GDP deflator data are published. Brandt et al. (2012) constructed regional GDP deflators but their sample stops in 2007 and does not include all provinces. We could use a nation-wide GDP deflator available from the IMF (IFS). Our model is expressed in terms of tradable goods. For that reason, a natural alternative to GDP is the retail price index (RPI), which has the advantage of being broadly available across provinces.

The noisiness of the data and the large differences in economic structure among provinces force us to use a flexible methodology regarding deflators. First, we choose among two main types of deflators: RPI from official statistics and GDP-deflators from the IFS. While RPI is a good proxy for the price of tradable goods, it may be inappropriate for more developed provinces that have a higher share of services and other non-traded sectors and that more closely reflect the sectoral structure of China as a whole. We therefore base our deflator choice on how similar a province is to the Chinese average.

To conduct this comparision, for each province, we compile GDP shares of the primary, construction, industry and tertiary sectors and observe their correlation over time with the corresponding shares for China as a whole. Furthermore, we construct our own index of economic specialization relative to the national economy using the share of GDP arising from the four preceding sectors.

The half of the 30 regions that appears most similar to China as a whole in terms of the size, correlation and economic concentration of sectors are deflated using the official GDP deflator from IFS. Data for the other half of highly specialized provinces will be deflated with the national RPI. The use of national deflators instead of regional ones is motivated by three arguments. First, the use of the tradable good as the numéraire implies that inflation in that good should be similar inside China. Second, no regional off-the-shelf GDP deflator is available. We want to avoid introducing a bias as half of provinces would be deflated with province-specific RPI while the other half would be deflated with national GDP prices.[23] Third, we already use the potentially

[23] By using agriculture, industrial and service (or consumer) price indices, one could deflate the production approach GDP components separately. We refrain from it for two reasons. First, we use expenditure approach GDP data as we

noisy RPI regional data in our indicator for internal price.

Investment has been a major driver of variations in Chinese output over the last decades. This is even more the case at the regional level, particularly for less developed regions in the West. Over the sample period, for a lot of provinces, we observe very large shocks in investment to output ratios and/or a very high investment level. In these cases, we separately deflate investment with the province-level price of investment in fixed asset (PIFA), starting as soon as data become available (1992).

Across our 30 provinces, we thus end up with four different modes of deflating the three components of province-level net output (GDP, government consumption and investment): i) with the national GDP-deflator for all three components (4 provinces), ii) with the national RPI for all components (3 provinces), iii) with national GDP-deflator for GDP and government consumption as well as regional PIFA for investment (11 provinces) and iv) with national RPI for GDP and government consumption as well as regional PIFA for investment (12). For each province, Table A.2 reports the exact deflator. We explore the effect of a changes in the deflation procedures in Section C.1.

A.3 Net exports

Net exports (i.e. external surplus or deficit) correspond to the regional difference between saving and investment. Note that this indicator includes international and interprovincial flows in goods and services. Cudré (2012) shows that large discrepancies in regional external balances exist in China. As most provinces have near neutral or positive international trade balance, a substantial part of theses cross-sectional differences stems from interregional capital flows. Unfortunately, we were unable to include income and current transfers to extend the analysis to the current account level.[24]

Discussion about the potential effect of extending the analysis to the current account can only be speculative at this stage due to lack of data. For regions having a considerable share of migrant workers in their labor force, we would expect a high share of household remittances to

are interested in net exports dynamics. Second, numerous data issues strongly distort regional structural indicators (see Brandt and Zhu (2010) for more).

[24]By comparison, for China as a whole, trade and services capture most of the current account dynamics. Over the last decades, income flows have been slightly negative with the exception of 2007 and 2008. Current transfers have been more sizeable and stabilized at a positive level since the mid-2000s. Still, they only amount to 15% of the trade balance between 2005 and 2010 on average.

lower their current account and increase it in hinterland provinces. Another important pattern is certainly linked to the capital outflows generated by the returns on FDI of foreign firms. Well-integrated coastal provinces certainly have a lower true current account than we may think by using net exports. The potential large transfers between government and/or state-owned enterprises among provinces are another issue. One would expect them to raise the current account of less developed provinces. At last, it could well be that Zhang (2008) argument that overreporting (underreporting) of exports (imports) has magnified national net exports statistics affects more surplus provinces with a large share of foreign and private firms (i.e. the East Coast).

A.4 Domestic interest rate

The domestic nominal interest rate is approximated using the mean of the official deposit and lending rate from the People's Bank of China (IFS, May 2012 CD).[25] The expected common inflation (in terms of tradable goods) is proxied with national RPI (retail price index) inflation of the preceding period. Note that regional inflation in RPI is used in the internal price indicator.

A.5 International interest rate

The nominal world interest rate is proxied with the yearly average of the *Federal Reserve Board* 3-Months Treasury Bill. Ex-post changes in exchange rate are proxied by the next period growth rate of the nominal effective exchange rate index (IFS, May 2012 CD). The extent to which regions are sensitive to the world interest rate is varying depending on their level of integration with the world economy. This parameter (δ) is integrated in the grid-search procedure.

A.6 Internal price

In this section we discuss how we approximate the regional relative price index of non-tradable relative to tradable goods ($\Delta q_{t+1} = (1-\alpha)\Delta p_{t+1}$). For the regional share of non-tradables in consumption expenditure $(1-\alpha)$, we use data from the urban and rural *Household Survey* available from 1993 to 2010. We define tradables as expenditures on food and clothes while non-tradables is composed of healthcare, transport/communication, education/culture, as well as residence/housing. Household surveys expenditure data are separated between urban and rural

[25] The PBC fixes an upper bound for deposit rate and a lower bound for lending rate. Both time series are highly correlated.

population. For that reason, we take the average share of both shares in non-tradables weighted by regional urbanization rate.[26] The average regional shares of non-tradables are between 0.32 and 0.45.[27] For the price of tradable goods (i.e. the denominator of p), we take regional RPI (retail price index) data.

Approximating the price of non-tradable goods (the numerator of p) is challenging. To get a complete time series over the period, we are forced to combine different sources according to data availability and scope. For 1984, we use regional CPI. From 1985 to 1999, we use SPI (services price index) as we expect it to capture non-tradable expenditures better than CPI. The initial years are exclusively urban observations (1985-1988) while the rest (1989-1999) is available at the provincial level. Unfortunately, SPI stopped to be published in the 2000s. We use data on regional CPI categories to construct a non-tradable CPI index from 2000 to 2010 using the relative mean expenditure weight of each category over urban and rural data.[28]

The progressive liberalization of the housing market in the 2000s led to a fast growth in real estate prices. Given that empirical fact, we want to consider housing prices in our indicator for the price of non-tradable goods. Unfortunately, housing price is not included directly in Chinese CPI but in fixed capital formation (Lijuan, 2010). Rents, interest rates of housing loans and maintenance costs are considered but they certainly miss the bulk of the dynamics. Instead, we integrate the average selling price of housing per square meter in the CPI of non-tradables from 2000 to 2010. We replace the corresponding category of CPI (residence/housing) with the housing price index but keep its relative weight unchanged.[29]

Empirically, the provincial time series for Δq seem plausible. On average, our indicator of relative prices more than tripled between 1984 and 2010. While variations were low in the 1980s, the increase was most pronounced in the 1990s and continued on a somewhat lower trend in the 2000s.

[26] For urbanization, we use Shen (2006), data from the *Statistical Yearbooks* and interpolated assuming constant growth rates.

[27] The rapid increase in the expenditure share on non-tradable goods is a stylized fact of the reform period. While our model does not allow for a time-varying $1-\alpha$, the fact that we only consider later years (1993-2010) because of data availability issues means that our value is already relatively high. Furthermore, the upward trend is very similar among provinces.

[28] For China, CPI on health expenditures has a weight of 16%, transport/communication 28%, education/culture 23% and residence/housing 33%. In the tradables, food (82%) has a higher weight than clothing (18%).

[29] Besides being available for a relative long period (1999-2010), the average selling price contains residential and business transactions. It should thus be representative of the general price patterns prevailing on the housing market.

A.7 Province-level characteristics

The provincial characteristics used in Section 4.2 are briefly discussed in this section. The importance of the state in the local economy (*SOE*) is proxied with the share of state- and commonly-owned gross industrial output value. We use the share of private and self-employed people to total employment as an alternative indicator of the importance of the private sector in a region (*Private Employment*). The marketization index (*Market*) is a broad indicator of a province's transformation status to a market economy developed by Fan et al. (2001). The index covers five major areas: size of the government in the regional economy, economic structure (growth of the non-state sector and the reform of the state enterprises), inter-regional trade barriers and price control, regional integration of factor-markets (including labor mobility) and legal frameworks. We consider the regional average of the index over 1997-2005. The demographic variables are the 2000 fifth national population census male to female sex ratio (*Sex Ratio*) and the share of older people in the population (above 65) (*Dep. Ratio*). The degree of integration into the world economy (*FDI*) is measured by the share of used FDI inflows over GDP. In order to estimate the level of openness to trade of a province (*Trade Openness*), we take the sum of foreign exports and imports (by place of destination and origin) converted into RMB using the IMF average exchange rate and normalize them by provincial GDP. The urbanization level (*Urbanization*) corresponds to the share of the population living in urban area according to the official statistical yearbooks and Shen (2006).

B Unit root tests

In Table A.1 we examine the stationarity properties of the province-level data used in the estimation of the VARs. Since the variables r^N and τ are the same for all provinces, we only report individual time-series ADF tests for these. The data for net output (no), the internal price ratio / real exchange rate (q) and for the net export / net output ratio (NXO) vary by province, however. For these variables, we report the Pesaran (2007) version of the Im et al. (2003) (IPS) test which, in addition, allows for cross-sectional dependence. As the IPS-test, this so-called CIPS-test averages the t-statistics from augmented Dickey-Fuller (ADF) regressions obtained for the individual provinces. But as in the common-correlated effects procedure described in the main text, the individual ADF regressions in the CIPS test are augmented with the cross-sectional means of the differences and the lagged level of the respective variable to account for cross-sectional dependence.

The results strongly suggest that *no* and q are difference-stationary, while r^N and τ are stationary in levels. The CIPS test for NXO_t^k would only allow us to reject the null that this variable is non-stationary if we augment the regression with one lag and even then only at the 8 percent-level. In the last row of the upper panel, we also report the CIPS test statistics based on a sample where we have dropped three provinces for which NXO_t^k appears the most clearly non-stationary based on their individual ADF tests. Based on this sub-sample of 27 provinces we can clearly reject the null of non-stationarity in the case with one lag.

C Robustness checks

C.1 Net output deflators

In our main specification, we chose between GDP deflator or RPI deflator based on provincial characteristics (see Section A.2 and Table A.2). In this section, we use the same deflator for all provinces irrespective of their economic structure but still deflate investment with the price of investment in fixed assets when necessary. While this specification does not seem appropriate for a few provinces, the model still does an excellent job in fitting the provincial net exports with a correlation (average of 0.91 for GDP and 0.71 for RPI) and relative standard deviation (average of 1.37 and 1.42) very similar to the baseline specification.[30]

C.2 Common coefficient of relative risk aversion

We initially let the coefficient of relative risk aversion (γ), be determined as part of the grid-search procedure (see Table 1). In this section, we fix gamma so that it corresponds to the average value of the baseline specification across provinces (2.8). The ability of the model to mimick regional net exports is robust to such a loss in degree of freedom for the quasi-majority of provinces and results are comparable to the main specification (average correlation of 0.90 and relative standard deviation of 1.07).

[30] In general, deflating with GDP across the board is feasible but implies that we have to exclude 5 provinces due to very low or even negative net output values in some years. RPI does not have this issue but the fit deteriorates strongly for a few provinces (Hebei, Sichuan and Gansu).

C.3 Long run consumption ratio

The consumption ratio (c) has so far been determined by the average of empirical values reported for Chinese regions. In steady state, one would expect the long run value of the consumption to be unity. As easily observable on Table A.2 in appendix, empirical values of more developed provinces are mostly below 1, while less developed inner provinces register level above unity difficult to square with an equilibrium state. In this section, we force the consumption ratio to be equal to unity and let the grid search determine the three main parameters (γ, δ and κ) as in the main specification. The effects of this modification for aggregate statistics are minor and, apart from Guangdong which now has an inner gamma solution, this does not impact how well the grid-search converges.

Table A.1: Stationarity tests

I: Pesaran (2007)panel unit root test

	2 lags		1 lag		deterministics
Variables	*CIPS*	*p-value*	*CIPS*	*p-value*	
no_t^k	-1.80	>0.10	-2.14	>0.10	trend
Δno_t^k	-2.32	0.01	-3.37	0.01	drift
q_t^k	-2.39	>0.10	-2.52	>0.10	trend
Δq_t^k	-2.51	0.01	-3.66	0.01	drift
NXO_t^k, all provinces	-1.19	>0.10	-1.52	0.08	none
NXO_t^k, 27 provinces	-1.41	>0.10	-1.71	0.02	none

H_0: all individual time-series are non-stationary

II: Augmented Dickey-Fuller tests for r_t^N and τ_t

	2 lags		1 lag		0 lag	
Variables	*Test*	*P-value*	*Test*	*P-value*	*Test*	*P-value*
r_t^N	-2.54	0.11	-3.67	0.00	-2.93	0.06
τ_t	-3.15	0.02	-4.25	0.00	-4.54	0.00

H_0: individual time-series has unit root

The table reports the results of unit root tests for the data used in the estimation of the province-level VARs. For the variables that vary by province (*no*, *q* and *nxo*), Panel I reports the CIPS-statistics of Pesaran (2007). The last column of Panel I reports the specification for the deterministic terms chosen for the particular test. The last row in Panel I reports the Pesaran (2007) test for a reduced sample where the three provinces for which individual ADF tests signal most clearly that NXO_t^k is non-stationary are dropped (Henan, Yunnan and Heilongjiang). Panel II reports the ADF tests for the two variables that are the same in all province-level VARs – the domestic real interest rate r^N and the excess return of investment in foreign assets (the savings wedge), τ.

Table A.2: Specification, data and grid-search results by province

	Sample	*Lag*	*NO Defl*	*c*	ϕ
Beijing	85-10	1	RPI	1.38	0.32
Tianjin	85-10	1	RPI PIFA	0.77	0.42
Hebei	85-10	1	GDP	0.82	0.66
Shanxi	87-10	1	RPI PIFA	0.88	0.00
Inner Mong.	85-10	1	RPI PIFA	1.04	0.24
Liaoning	85-10	1	GDP PIFA	0.78	0.18
Jilin	85-10	1	RPI PIFA	0.91	0.64
Heilongjiang	85-10	1	GDP PIFA	0.87	0.67
Shanghai	85-10	2	RPI PIFA	0.76	0.61
Jiangsu	85-10	1	RPI PIFA	0.68	-0.29
Zhejiang	85-10	1	GDP	0.85	0.68
Anhui	85-10	1	RPI	1.00	0.80
Fujian	85-10	1	GDP	0.98	0.79
Jiangxi	85-10	1	GDP PIFA	1.00	0.52
Shandong	85-10	1	GDP PIFA	0.80	0.54
Henan	85-10	1	GDP PIFA	1.02	0.63
Hubei	85-10	1	RPI	0.99	0.79
Hunan	85-10	2	GDP PIFA	0.94	0.75
Guangdong	85-10	1	GDP	0.86	0.69
Guangxi	85-08	1	RPI PIFA	1.02	0.17
Hainan	85-10	1	RPI PIFA	0.95	-0.24
Chongqing	85-10	2	GDP PIFA	1.20	0.86
Sichuan	85-10	1	GDP PIFA	1.06	0.72
Guizhou	85-10	1	RPI PIFA	1.21	-0.80
Yunnan	85-09	2	GDP PIFA	1.04	0.83
Tibet					
Shaanxi	85-09	2	GDP PIFA	1.11	0.32
Gansu	85-10	2	GDP PIFA	1.13	-4.52
Qinghai	85-10	1	RPI PIFA	1.67	0.74
Ningxia	89-10	2	RPI PIFA	1.40	0.66
Xinjiang	85-10	1	RPI PIFA	1.07	0.44
Median				0.99	0.62
Mean				1.01	0.29

Tibet is excluded because of insufficient data coverage. The model is estimated on the 1985-2010 period with the exception of five regions that have a reduced sample (see Footnote 16 for more details). The number of lags (1 or 2) is chosen according to model fit with the data. We discuss the choice of the net output deflator methodology in Section A.2. An alternative net output deflator choice is tested in Section C.1. The consumption ratio (c) is estimated from the data using the same deflator as for output and government consumption. We report the implied $\phi = c \times (1 - \frac{1}{\gamma})$ from the optimal coefficient of risk aversion (γ) obtained by grid-search as explained in Footnote 15.

Table A.3: Standard errors of estimated parameters by province

	γ	κ	δ
Beijing	2.15	0.44	0.05
Tianjin	2.15	0.42	0.03
Hebei	2.07	0.32	0.04
Shanxi	1.27	0.37	0.03
Inner Mong.	1.90	0.42	0.04
Liaoning	1.96	0.40	0.04
Jilin	2.09	0.41	0.04
Heilongjiang	2.21	0.46	0.04
Shanghai	2.16	0.42	0.05
Jiangsu	2.03	0.38	0.04
Zhejiang	1.97	0.40	0.03
Anhui	2.02	0.46	0.04
Fujian	2.12	0.44	0.04
Jiangxi	2.01	0.32	0.04
Shandong	2.05	0.22	0.04
Henan	1.45	0.43	0.04
Hubei	2.11	0.37	0.01
Hunan	1.89	0.22	0.03
Guangdong	1.93	0.46	0.04
Guangxi	2.04	0.43	0.02
Hainan	1.95	0.43	0.04
Chongqing	1.16	0.40	0.04
Sichuan	1.81	0.37	0.03
Guizhou	1.00	0.42	0.05
Yunnan	1.61	0.41	0.03
Tibet			
Shaanxi	1.91	0.43	0.03
Gansu	1.87	0.41	0.04
Qinghai	1.77	0.45	0.05
Ningxia	1.02	0.44	0.05
Xinjiang	2.08	0.49	0.03

The table presents estimates of the standard errors of the parameters γ, κ and δ based on a bootstrap procedure. For each province, we generated 200 artificial observations for the VAR sample length by drawing from the empirical distribution of the data. Based on each of these 200 artificial data sets, we re-estimated the VAR and used the artificial VAR estimates to estimate the parameters γ, κ and δ using the GMM procedure described in the main text. The table reports the standard deviations over these 200 estimates.

Table A.4: Channels of external adjustment: variance decomposition by province

Province					
number	name	$\beta_{\Delta no}$	$\beta_{\Delta q}$	β_r	β_τ
1	Beijing	0.51	0.00	0.06	0.00
2	Tianjin	1.29	-0.31	0.07	0.00
3	Hebei	0.44	-0.13	0.24	0.00
4	Shanxi	1.13	0.00	-0.20	-0.55
5	Inner Mong.	2.34	0.03	-0.23	0.89
6	Liaoning	0.90	0.07	0.08	0.68
7	Jilin	1.16	0.19	-0.15	0.06
8	Heilongjiang	0.87	0.19	-0.13	-0.07
9	Shanghai	0.75	-0.04	-0.10	0.15
10	Jiangsu	0.98	-0.05	0.76	0.00
11	Zhejiang	0.64	0.25	0.27	0.00
12	Anhui	-0.79	-0.58	0.04	0.00
13	Fujian	1.19	-0.04	0.23	0.01
14	Jiangxi	-0.41	-0.29	1.04	-0.11
15	Shandong	2.84	-0.12	-0.02	0.00
16	Henan	1.14	-0.02	-0.28	-0.64
17	Hubei	0.89	0.22	-0.15	0.00
18	Hunan	1.10	-0.03	0.09	0.00
19	Guangdong	0.92	-0.24	0.14	0.04
20	Guangxi	0.45	0.00	0.44	0.00
21	Hainan	0.56	0.03	0.17	-0.04
22	Chongqing	0.70	0.00	0.00	0.02
23	Sichuan	0.66	0.43	-0.25	0.10
24	Guizhou	1.21	-0.07	-1.38	0.06
25	Yunnan	-0.04	0.45	-0.24	0.02
26	Tibet				
27	Shaanxi	0.08	0.03	0.16	0.00
28	Gansu	-0.42	-0.30	6.19	-5.01
29	Qinghai	0.60	0.06	-0.02	-0.01
30	Ningxia	0.53	0.07	-0.01	-0.03
31	Xinjiang	0.30	0.01	0.16	0.00
Median		0.73	0.00	0.05	0.00
Mean		0.75	0.00	0.23	-0.14

The table presents estimates of the province-level external adjustment patterns β_x^k obtained from the variance decomposition 7 where $x = \{ \Delta no \quad \Delta q \quad r \quad \tau \}$ for the full sample period. Estimates obtained from Pesaran's (2006) common correlated effects procedure.

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