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

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Abstract

We model capital flows among Chinese provinces using a theory-based variance decomposition that allows us to gauge the importance of various channels of external adjustments at the regional level: variation in intertemporal prices—domestic and international interest rates and the real exchange rate—and intertemporal variation in quantities (cash flows of output, investment and government spending). We find that our simple framework can account for around 85 percent of the variation in regional capital flows over the 1985-2010 period. Our results suggest that the relative importance of private and state-owned enterprises, a province's level of integration into the world economy and its sectoral composition play an important role for external adjustment vis-à-vis the rest of China and the world. Specifically, we find strong empirical support for the view that differential access of private and state-owned enterprises to finance is a key driver of China's surpluses. We discuss implications of our results for global imbalances in capital flows.

JEL classification: F30, F32, F40
Keywords: China, Chinese provinces, Capital flows, Current account, Global imbalances, External adjustment, Present-value models, Regional business cycles

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1 Introduction

The empirical fact that international capital tends to flow uphill—from big emerging economies such as China to highly developed countries such as the US—has been an issue of intensive academic and policy debate over the last decade. This pattern is a theoretical challenge to neoclassical growth models and therefore has rightfully been dubbed a puzzle (Gourinchas and Jeanne, 2013). It 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 these patterns theoretically (Caballero et al., 2008; Mendoza et al., 2009; Song et al., 2011; Aguiar and Amador, 2011). However, so far, we have relatively little evidence about the patterns of intranational capital flows in the country that—with its persistent surpluses over the last decade—best exemplifies this capital allocation puzzle: 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 on global imbalances and their origins. Specifically, we model province-level net exports using 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 can further be disaggregated into variation in national real interest rate, the excess return on international assets over the domestic interest rate, and 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. As we show, our simple model can account for up to 85 percent of the net exports variation in a panel of 30 provinces over the 1985-2010 period. Variation in cash flow explains on average 70 percent of external adjustment and intertemporal prices, on average, account for the remaining 15 percent.

However, these numbers mask considerable cross-provincial heterogeneity in the importance of adjustment channels. As also documented in Cudré (2014), China's provinces are characterized by an internal capital allocation puzzle, with some of the most quickly growing provinces displaying the most persistent surpluses. Our decomposition of provincial net exports puts us into a position to correlate province-level patterns of external adjustment with a host of regional characteristics: i) the relative role of private and state-owned enterprises (SOE) in the provincial economy and their differential access to finance, ii) measures of openness to international FDI and trade, iii) sectoral composition of the local economy and iv) demographic factors. All of these characteristics have been identified in the empirical and theoretical literatures as potential drivers of China's external surplus. However, a taxonomy that allows to assess the relative importance of these factors is lacking to date. Our focus on the cross-section of China's province-level net exports allows us to provide such a taxonomy by identifying through which channels these characteristics impact interprovincial and international capital flows.

Our results suggest that the relative role of private and state-owned enterprises (SOEs) has a particularly strong impact on the patterns of external adjustment at the province-level: variation in domestic (as opposed to international) interest rate and expected variation in future investment (i.e. net output) are much more important drivers of capital flows in provinces with high share of private enterprises in the economy. Conversely, in provinces with a strong presence of SOEs, we see that variation in international interest rate and relative price of non-tradables is more important. This pattern is consistent with a view of the Chinese economy (Song et al., 2011) in which private enterprises and households are subject to considerable financial repression, whereas state-owned enterprises have preferential access to international finance through the state-owned banking system. As a result, saving decisions by private households and firms should be driven by variation in the domestic (financially repressed) interest rate and firm savings should predict future private investment because such investment has to be financed from internal funds. This is what our empirical findings suggest. We also find a significant impact on capital flows from internal price adjustment (i.e. in the relative price of non-tradables such as a housing) in less developed regions. This seems consistent with the view that housing may serve as a savings vehicle where other investible assets are hard to come by.

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

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

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. 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 $r_t^N = i_t^N - E_t(\pi_{t+1})$ 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 interpre-

[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 $(1 + r_t^{T,k}) =$

tation. 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 $r_t^{T,k} = i_t^W - \Delta s_{t+1} - E_t(\pi_{t+1})$, 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 $r_t^{T,k} = r_t^N$. For example, we would expect that more urbanized provinces with more international trade or regions with a stronger presence of state-owned enterprises—which have preferential access to international finance—would have a relatively higher level of δ^k (lower financial repression). By contrast, less open and financially developed provinces may be characterized by a lower value of δ^k (more financial repression). We will corroborate this conjecture in our empirical analysis.

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

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

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:[3]

$$\widetilde{\frac{NX}{NO_t}}^k = c \sum_{l=1}^{\infty} \kappa^l E_t \left\{ \Delta \widetilde{c}_{t+l}^k - \widetilde{r}_{t+l}^{T,k} \right\} + \sum_{l=1}^{\infty} \kappa^l E_t \left\{ \widetilde{r}_{t+l}^{T,k} - \Delta \widetilde{no}_{t+l}^k \right\} \quad (1)$$

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 parameters b and c are the long-term means of B/NO and C/NO. The discount parameter takes the form $\kappa = exp \left[E(\Delta no_t^k) - E(r_t^{T,k}) \right]$. In the derivation, 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.

$(1+i_t^W)(1-\tau_t^k)/(1+\pi_t^k)$, 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.

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

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:

$$\sum_{t=0}^{\infty} \beta^t E_0 \left[\frac{X\left(C_t^{N,k}, C_t^{T,k}\right)^{1-\gamma}}{1-\gamma} \right]$$

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 $P_t^{*k} X_t^k = C_t^{T,k} + P^k C_t^{N,k} = C_t^k$ 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

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

which can be rewritten in terms of aggregate consumption expenditure as

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

The aggregate price index for consumption is given by $P_{t+1}^*/P_t^* = (P_{t+1}/P_t)^{1-\alpha}$. A detailed derivation of the model is available in the mathematical appendix of this paper (not for publication). 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

$$E_t(\Delta c_{t+1}^k) = \frac{1}{\gamma} E_t\left(r_{t+1}^k\right) + constant \qquad (3)$$

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.[4] Plugging in for $r^k_{t+1}/\gamma = E(\Delta c^k_{t+1})$, and using the decomposition $r^{T,k}_t = r^N_t + \delta^k \tau_t$ from above, we obtain the following expression for net exports

$$\frac{\widetilde{NX_t}}{NO_t}^k = -\sum_{l=1}^{\infty} \kappa^l E_t \Delta \widetilde{no}^k_{t+l} + \phi \sum_{l=1}^{\infty} \kappa^l E_t \widetilde{\Delta q}^k_{t+l} + [1-\phi] \sum_{l=1}^{\infty} \kappa^l E_t \widetilde{r^N}_{t+l} + \delta^k \left[[1-\phi] \sum_{l=1}^{\infty} \kappa^l E_t \widetilde{\tau}_{t+l} \right] \tag{4}$$

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). A detailed derivation of the former decomposition is available in the mathematical appendix of the paper (not for publication).

This equation suggests four channels of net exports adjustment.[5] The first term reflects the intertemporal consumption smoothing 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 country 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.[6]

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 is the effect on intertemporal substitution 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 analogy to Hoffmann (2013), we refer to this channel as "internal tilting" since it is driven by relative variation in expected prices of only regionally consumed (non-tradable) to both internationally and domestically consumed (tradable)

[4]This follows Bergin and Sheffrin (2000) and Bouakez and Kano (2009). However, these models do not feature a savings wedge.

[5]Thereafter, we assume $0 < \phi < 1$, which is fulfilled for values of risk aversion (γ) higher than one and most empirical values of the consumption ratio (c).

[6] However, as we discuss in detail below, even in quickly growing economies this channel can also be consistent with surpluses. If financial frictions require firms to finance investment from retained earnings , these saving surpluses will predict increases in investment that can at least temporarily exceed output growth.

goods. For example, we would expect that anticipated rises in the local price of housing, schooling or medical care could be important determinants of saving decisions.

The third and fourth 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. 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 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, both channels become stronger as the intertemporal elasticity of substitution $(1/\gamma)$—and $(1-\phi)$—increases.

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):

$$X_t^k = \sum_{\boldsymbol{l=1}}^{\boldsymbol{p}} \boldsymbol{A_l(k)} X_{t-l}^k + \varepsilon_t^k$$

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 $\boldsymbol{A}_l(k)$ are 5×5 coefficient matrices of the p-th order VAR and $\boldsymbol{\varepsilon_t^k}$ 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

$$Z_t^k = \boldsymbol{A_{\{k\}}} Z_{t-1}^k + U_t^k \tag{5}$$

where $\boldsymbol{A_{\{k\}}}$ is the companion matrix of the VAR estimated on province k data and $U_t^k = \begin{bmatrix} \varepsilon_t^k, & 0, & \dots & , 0 \end{bmatrix}'$ the associated vector of residuals. Then, once the VAR-parameters have been estimated, the expectation terms are easily backed out as

$$\sum_{l=1}^{\infty} \kappa^l \boldsymbol{E}_t X_{t+l}^k = \boldsymbol{e}_x' \kappa \boldsymbol{A_{\{k\}}} \left[\boldsymbol{I} - \kappa \boldsymbol{A_{\{k\}}} \right]^{-1} Z_t^k$$

where X_t stands, in turn, for Δno_t^k, Δq_t^k, r_t^N, τ_t, $\frac{NX}{NO}_t^k$ and $\boldsymbol{e}_x$ is the unit vector associated with the position of 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:

$$\widehat{\frac{NX}{NO}}_t^k = \left[-e'_{\Delta no} + \phi e'_{\Delta q} + (1-\phi)(e'_r + \delta^k e'_\tau)\right] \kappa \boldsymbol{A}_{\{k\}} \left[\boldsymbol{I} - \kappa \boldsymbol{A}_{\{k\}}\right]^{-1} Z_t^k \qquad (6)$$

where again $\phi = c\left(1 - \frac{1}{\gamma}\right)$ and where we denote the predicted value of NX/NO from the model with a hat.

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.[7] Note that in the above setup, except for national interest rate and excess returns, we let the VAR-parameters vary at the provincial level, 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 using a GMM-procedure 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, we can use (6) to decompose the variance of each province's net exports as follows. Write the component that is unexplained by the model as $res^k = NX^k/NO^k - \widehat{NX/NO}^k$, take the variance on both sides

[7] Rewriting equation (6) for a given companion matrix $\boldsymbol{A}$ as $e'_{nx} = \left[-\boldsymbol{e}'_{\Delta no} + \phi \boldsymbol{e}'_{\Delta q} + (1-\phi)(\boldsymbol{e}'_r + \delta^k \boldsymbol{e}'_\tau)\right] \kappa \boldsymbol{A} \left[I - \kappa \boldsymbol{A}\right]^{-1}$ and denoting the right-hand side of this restriction with $\boldsymbol{\Psi}(\boldsymbol{A})$, the Wald-statistics $\left[\boldsymbol{e}'_{nx} - \boldsymbol{\Psi}(\boldsymbol{A})\right] \frac{\partial \boldsymbol{\Psi}(\boldsymbol{A})}{\partial \boldsymbol{A}} var(\boldsymbol{A})^{-1} \frac{\partial \boldsymbol{\Psi}(A)}{\partial A}' \left[\boldsymbol{e}'_{nx} - \boldsymbol{\Psi}(\boldsymbol{A})\right]'$ is asymptotically distributed as a χ^2 with m degrees of freedom where m is the dimension of the companion matrix $\boldsymbol{A}$.

and plug in for $\widehat{NX/NO}^k$ from (6). Then, dividing by $var(NX^k/NO^k)$, one gets

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

where

$$\begin{aligned}
\beta^k_{\Delta no} &= \frac{cov\left(-\boldsymbol{e}'_{\Delta no}\kappa \boldsymbol{A_{\{k\}}}\left[\boldsymbol{I} - \kappa \boldsymbol{A_{\{k\}}}\right]^{-1} Z^k_t, NX^k/NO^k\right)}{var(NX^k/NO^k)} \\
\beta^k_{\Delta q} &= \frac{cov\left(\phi \boldsymbol{e}'_{\Delta q}\kappa \boldsymbol{A_{\{k\}}}\left[\boldsymbol{I} - \kappa \boldsymbol{A_{\{k\}}}\right]^{-1} Z^k_t, NX^k/NO^k\right)}{var(NX^k/NO^k)} \\
\beta^k_r &= \frac{cov\left((1-\phi)\boldsymbol{e}'_r\kappa \boldsymbol{A_{\{k\}}}\left[\boldsymbol{I} - \kappa \boldsymbol{A}_{\{k\}}\right]^{-1} Z^k_t, NX^k/NO^k\right)}{var(NX^k/NO^k)} \\
\beta^k_\tau &= \frac{cov\left(\delta^k(1-\phi)\boldsymbol{e}'_\tau\kappa \boldsymbol{A_{\{k\}}}\left[\boldsymbol{I} - \kappa \boldsymbol{A}_{\{k\}}\right]^{-1} Z^k_t, NX^k/NO^k\right)}{var(NX^k/NO^k)} \\
\beta^k_{res} &= \frac{cov(res^k, NX^k/NO^k)}{var(NX^k/NO^k)}
\end{aligned}$$

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

$$\boldsymbol{\beta}^k = \left[\begin{array}{ccccc} \beta^k_{\Delta no} & \beta^k_{\Delta q} & \beta^k_r & \beta^k_\tau & \beta^k_{res} \end{array}\right]'$$

and we call $\boldsymbol{\beta}^k$ the pattern of external adjustment of province k. In what follows, we also allow for the possibility that the elements of $\boldsymbol{\beta}^k$ vary over time.[8]

At the level of each province, the elements of $\boldsymbol{\beta}^k$ could easily be estimated from time-series OLS regressions of the expected present values of $\widetilde{\Delta no^k}$, $\widetilde{\Delta q^k}$, $\widetilde{r^N}$ and $\widetilde{\tau}$ on NX^k/NO^k respectively. However, our main interest in this paper is also to analyze to what extent province-level characteristics (such as financial and economic development, industrial structure, demography, etc...) affect the patterns of external adjustment and, potentially, also to allow for time-variation in these variables. We therefore posit that the

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

external adjustment in province k through a given channel is an affine-linear function of a vector $\boldsymbol{z}_t^k$ of province-level characteristics so that

$$\beta_x^k(t) = \beta_x + \boldsymbol{\gamma}_x' \boldsymbol{z}_t^k \tag{8}$$

where x denotes the respective channel. The coefficient β_x measures the average (across-provinces) importance of channel x and the vector $\boldsymbol{\gamma}_{\mathbf{x}}$ describes the sensitivity of the respective external adjustment channel to variation in characteristics (z) across provinces. This assumption on $\beta_x^k(t)$ allows us to analyze the cross-provincial variation in external adjustment patterns using a panel set-up. Specifically, we estimate $\beta_x^k(t)$ from the following relationship

$$x_t^k = \alpha + \tau_t + \mu^k + \beta_x^k(t) \times \left[\frac{NX}{NO}\right]_t^k + \boldsymbol{\psi}' \times \boldsymbol{z}_t^k + \nu_t^k \tag{9}$$

where x_t^k stands in turn for the VAR-implied expectations of the corresponding channel. On the right hand side of (9), α is a constant and τ_t and μ^k are time- and province fixed-effects. The vector $\boldsymbol{z}_t^k$ stacks characteristics as before. For each channel, equation (9) can be estimated as a panel regression once we plug in from (8) above:

$$x_t^k = \alpha + \tau_t + \mu^k + \beta_x \times \left[\frac{NX}{NO}\right]_t^k + \boldsymbol{\gamma}_x' \times \boldsymbol{z}_t^k \times \left[\frac{NX}{NO}\right]_t^k + \boldsymbol{\psi}' \times \boldsymbol{z}_t^k + \nu_t^k \tag{10}$$

The coefficient on $\left[\frac{NX}{NO}\right]_t^k$ then measures the average importance of the channel x across provinces (β_x), whereas the coefficients on the interaction terms of the regional net exports with the province-level characteristics ($\boldsymbol{\gamma_x}$) capture the sensitivity of the respective channel to variation in characteristics over provinces and time.

3 Data

3.1 General remarks

When not mentioned otherwise, 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 22 provinces, 5 autonomous regions and 4 municipalities of Mainland China.[9] The *China Data Center* (CDC) of the University of Michigan provides electronic access to the yearbooks and made main statistics conveniently available.[10] For most provinces,

[9] 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. Thereafter, the term province will be used as general qualifier.

[10] `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

our online access only covers regional statistical yearbooks over the 1990s and 2000s. Thus, it happens that the data are sometimes incomplete. We will primarily rely on data directly retrieved from recent online yearbooks and complete possible gaps with CDC sheets. This allows us to take account of revisions as much as possible.

The quality of provincial and aggregate Chinese *National Accounts* data is an important issue explored in detail in Cudré (2012). This analysis revealed 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. This suggests that, 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 is some uncertainty concerning the levels of aggregate and regional statistics, our exploratory analysis also showed that the sum of province-level GDP, investment and saving data is generally highly correlated with movements in aggregate statistics.[11] Since our empirical analysis focuses on a log-linearized model that emphasizes the movements in these variables over time rather than their specific levels, we are reasonably confident that our province-level data capture important aspects of external adjustment among China's provinces. In the appendix (Section A), we provide a description of the data and indicators used in our analysis. Apart from Tibet—for which data are incomplete—we are able to estimate the model for all 30 provinces.

4 Results

4.1 Fitting the model to province-level net exports

We estimate the province-level VAR 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). For each province, we then estimate the parameters of the model—$1/\gamma$, κ and δ—based on a three-dimensional grid-search procedure that minimizes the squared deviation between

did not systematically adapt past values.

[11] 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.

the right hand side of (4) and the respective province's observed net export / net output ratio. 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 cumulated 2000 real GDP and their rank. Results for the ten largest provinces—accounting for more than 60% of output—are in boldface. We refer to Table 4 for more details about the specification (sample length, number of lags, net output deflator, consumption ratio and ϕ parameter).[12] For most provinces, our simple model provides a good fit: the mean correlation between actual and predicted net exports is 0.96 while the lowest value is 0.77. The model also matches the standard deviation of actual province-level net exports quite closely: the average relative standard deviation is 1.06.

While large cross-provincial variations exist, on average, we find a plausible value of γ of 2.59 (i.e. an average elasticity of substitution of 0.39). This coefficient is comparable with values conventionally used in the literature (see e.g. Hoffmann (2013)). For the discount factor, we find a value of 0.95 on average. The GDP-weighted means are close to the non-weighted parameter values. Consequently, results of small—and potentially "noisier"—provinces do not affect the parameters and the fit massively. Note in particular that the model seems to perform especially well when applied to relatively large and more developed provinces. Figure 1 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.

4.2 Channels of adjustment

We turn to the decomposition of the variance of province-level net exports into four channels as in equation (7). For each province, the results of this decomposition are given in Table 2. By way of example, Figure 3 provides a plot of actual and model-implied net exports along with a breakdown into the four channels for four provinces: Liaoning, Shanghai, Guangdong and Yunnan.

[12] The model is estimated on the 1985-2010 period with the exception of five regions that have a reduced sample. Guangxi, Yunnan (South) and Shaanxi (West) experienced huge decline in net exports toward the end of the sample. Shanxi and Ningxia (West) had very high volatility in their relative net export in the initial reform years. The consumption ratio is estimated over the sample length using the same deflator as for output and government consumption. Some smaller, less developed provinces happen to have a value higher than one but the GDP-weighted value is 0.92. Apart from a few exceptions, the ϕ parameter is lower than one. Thus, even if large variations in parameters exist, the GDP-weighted mean of all parameters is in an economically plausible value range.

With a little more than three quarters on average, expected variation in regional cash flow—net output (NO)—accounts for the bulk of variation in province-level capital flows, with variation in intertemporal prices—internal price (IP), domestic (DR) and international interest rate (IR)—accounting for the rest. However, these numbers mask considerable variation across provinces. We provide a map of the variance decomposition of net output in Figure 4, where provinces are classified per quartile. Variation in cash flow available for consumption seems to be important in some coastal regions as well as central China. By contrast, in Figure 5, the dynamics of the relative price of non-tradables seem to play a bigger role in less developed regions (i.e. the South and part of the Center and Manchuria) while its contribution is negative for most eastern provinces.

In the City-Provinces such as Shanghai and Beijing, variation in world interest rate is an important driver of variations in net exports. This is clearly in line with the notion that these major cities are more open to foreign trade and capital, which we would expect to facilitate access to finance from abroad. Conversely, in the East Coast provinces, with their many private SMEs that do not have access to formal finance, financial repression—expected variation in domestic real interest rate—is a key driver of capital flows. A geographical representation of the interest rate channel (both domestic and international) is available in Figure 6.

4.3 Regional external adjustment: panel analysis

In the preceding section, the contribution of the different factors has been estimated for each region separately. In order to gain an overview of the general patterns of regional external balance, we now turn to estimating the patterns of external adjustment in a panel framework as discussed in Section 2.3. We start with a general characterization of external adjustment in the average province. Equation (10) is estimated without any province-level characteristics (i.e. without the z_t^ks), which gives us the specification

$$x_t^k = \alpha + \tau_t + \mu^k + \beta_x \times \left(\frac{NX}{NO}\right)_t^k + \nu_t^k$$

where the x stands for one of the VAR-implied expectations of the four channels from equation (4). Results of this exercise (i.e. the β_xs) are given in the first panel of Table 3, where bold type indicates significance at the 10% confidence level. The panel-based estimates reveal again that the bulk of capital flows among Chinese provinces is driven by expected variation in quantities: net output fluctuations explain around 70 percent of the variation in NX/NO for the average province. Variation in the expected relative price of non-tradables and expected domestic and international interest rates each drive around 5 percent. Though these numbers seem small at first sight, they are all significant.

The second row of the table shows the result of a panel estimate in which we weigh the channels and net exports by the provincial real GDP share.[13] A geographical representation of the relative weights is available in Figure 2. While variation in net output remains the main driver of NX/NO (the point estimate now increases to 0.82), we now also find a much bigger role for the domestic interest rate channel than in the unweighted panel (11 percent of the variation in NX/NO vs 5 percent). At first sight, this suggests that financial repression may be an important driver of saving dynamics in the more developed and larger provinces with their many private firms, most of which do not have access to formal finance. It seems that the significance of the relative price of non-tradables and the international interest rate channels is driven to a large extent by smaller regions as it turns out to disappear in this configuration. The residual share is at its lowest (3 percent).

The third row presents results from an alternative weighting scheme that is based on the variance of the unexplained part of province-level net exports. In this weighting procedure, regions that are better explained by our model get a higher weight.[14] Estimates are qualitatively similar to the non-weighted and GDP-weighted versions, with all channels—with the exception of the domestic interest rate (DR)—being significant.

In the second and third panels of Table 3, we estimate the external adjustment patterns for geographic subgroups of provinces using GDP-weighting.[15] For provinces constituted of a major metropolitan areas (such as Beijing and Shanghai), we again find a big role for variation in international interest rate. To a lesser extent, the same seems true of southern provinces and Manchuria, two regions where the presence of large state-owned firms could have facilitated access to international financial markets. Conversely, in the East Coast and central regions, the domestic interest rate channel is found to be relatively important, consistent with the view that these provinces seem to have much less access to international finance.[16]

Interestingly, variations in domestic prices in non-tradables have a strong negative influence in eastern regions while it is small and positive in two neighboring geographic areas (the Center and Manchuria). Apart from idiosyncratic data issues, a potential explanation for the lack of significance in the channels of Western China is its heterogeneity and the high number of provinces (7). What is more, the model performs less

[13] We use 2000 real GDP as in Table 1 normalized by the largest province (Shandong=1).

[14] This weighting procedure uses the absolute residual share of the variance decomposition ($[max(abs(RES)) - abs(RES^k)]^2$). As for real GDP, we normalize by the highest weight (i.e. Hainan=1 has the best fit).

[15] The definition of regional clusters is as follows. Metropolises: Beijing, Tianjin and Shanghai. East Coast: Hebei, Shandong, Jiangsu, Zhejiang, Fujian and Guangdong. Manchuria: Liaoning, Jilin and Heilongjiang. Center: Henan, Hubei, Hunan, Anhui and Jiangxi. West: Shanxi, Inner Mongolia, Shaanxi, Ningxia, Gansu, Qinghai and Xinjiang. South: Chongqing, Sichuan, Yunnan, Guangxi, Guizhou and Hainan.

[16] The fact that Manchuria has a large domestic and international channel is not necessarily a contradiction. While this cluster historically had large state-owned firms, particularly in the heavy industry and energy-related sector, FDI, foreign and private firms started to thrive in the later reform period, particularly in Liaoning.

well for those regions. In the last row of the second panel (*NoMetro&EC*), we gather inner provinces (regions not being part of the more developed East Coast and not being Metropolises) in the same group. The differences between East Coast regions and inner regions does not seem to arise from the net output channel (0.86 vs 0.83) but rather from the relative importance of the internal price channel (-0.18 vs 0.05) and, again, the domestic channel (0.28 vs 0.07). The unexplained part is higher in hinterland provinces (0.04 vs 0.00).

The third panel of Table 3 also provides an indication that the pattern of adjustment is strongly affected by the degree to which a provincial economy can be characterized as either market-based or centrally planned. To this end, we use an index of marketization initially developed by Fan et al. (2001) and split provinces into two equal subgroups of high and low marketization.[17] Again, net output fluctuations remain the predominant force of external adjustment in both groups. But there is a marked distinction in the way in which prices and interest rates influence capital flows in the two categories of provinces: in the high-marketization group of provinces, variation in domestic and world interest rate respectively explains 15 and 13 percent of the variation in province-level net exports. In the low-marketization group, variation in world interest rate does not matter at all, while financial repression—variation in domestic interest rate—explains a much smaller share. Finally, in the low-marketization group of provinces, there is also a small but significant role for expected non-tradable price changes in explaining NX/NO while this figure is slightly negative and not significant for more advanced regions.

4.4 Province-level characteristics

Our ultimate goal is to assess the relative empirical merit of different theoretical explanations that have been put forward for China's current account surplus. To this end, we now characterize the heterogeneity in external adjustment patterns across provinces more sharply by correlating them with province-level characteristics. We categorize these characteristics into four groups, each of which corresponds roughly 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 and financial development, ii) indicators of integration into the world economy, iii) indicators of sectoral composition and iv) demographic indicators.

To quantify the impact of these charateristics on province-level external adjustment, we use the panel setup with interaction terms (10).[18] Specifically, we estimate:

[17] Rank based on the mean of the index over 1997-2005. Factors: government and market, ownership structure, goods market development, factor market development and legal framework.

[18] For a similar specification applied to international shock transmission during the interwar gold standard, see Hoffmann and Woitek (2011).

$$x_t^k = \alpha + \tau_t + \mu^k + \beta_x \times \left(\frac{NX}{NO}\right)_t^k + \boldsymbol{\gamma_x}' \times \boldsymbol{z}_t^k \times \left(\frac{NX}{NO}\right)_t^k + \boldsymbol{\psi}' \times \boldsymbol{z}_t^k + \varepsilon_t^k$$

where $\boldsymbol{z}_t^k$ is our vector of regional characteristics. To gain an impression of the link between external adjustment and particular provincial factors, we start by considering $\boldsymbol{z}_t^k$ one by one (one individual variable at a time). To at least partly alleviate the omitted variable issue, we systematically control for the mean level of development of a region ($Dvpt$), measured here as the average of real GDP per capita relative to national values over the sample period. As in the second and third panels of Table 3, channels and net exports are weighted by provincial real GDP share.[19]

Table 5 (left panel) gathers the results that we obtain for indicators related to the importance of the state/private sector in the regional economies. By looking at the interaction term of economic development and relative net exports in the following regressions, we generally find a bigger role for global variation in international interest rate in more developed provinces, and a more mitigated role for the internal terms of trade. This pattern is consistent with the view that housing prices are a less important margin of adjustment in more developed parts of the country, where *de facto* access to world financial markets is slightly better.

The results from Table 5 also clearly suggest that a higher share of SOEs (as measured by the share of state-owned firms in gross industrial output value, $SOE\ share$) in the provincial economy leads to a smaller contribution of the net output channel to external adjustment as well as a larger internal price and world channel. Alternative indicators of the presence of the state in the economy would lead to similar patterns.[20] Complementary evidence is borne out once we condition on a general indicator of the extent to which a province can be characterized as a market economy: higher levels of marketization ($Market$) coincide with a significantly bigger role of the domestic (financially repressed) interest rate and a smaller role of the internal price channel.

The literature—notably Song et al. (2011)—has emphasized that the major distinction between private and state-owned firms is that the former are financially repressed whereas the latter have preferential access to bank credit and therefore—indirectly—to international financial markets. Our results provide strong cross-provincial evidence

[19]There are two reasons why we favor this weighting scheme. First, small provinces have typically noisier data and very large variations in net exports. Second, essentially, we want to shed light on the drivers of global imbalances.

[20]As the bulk of bank loans mainly go to state-owned enterprises, we could use loans in financial institutions over GDP as an alternative indicator for the presence of the state in the economy. The sum of deposits and loans relative to GDP is usually interpreted as a rough index of financial development. This indicator would behave qualitatively in a similar way as loans, suggesting that financially more developed provinces have lower net output channel and higher international interest rate channel.

that supports this view. In particular, if the expanding private sector can only finance its growth from retained earnings, we will see that province-level surpluses predict increases in investment and, *ceteris paribus*, declines in net output. This is perfectly in line with our finding that the role of net output as a channel of external adjustment increases with the importance of the private sector. In the same mould, we would expect saving and investment decisions by financially repressed private households and firms to be more dependent on future domestic interest rates than on international ones, whereas the opposite should be true for state-owned enterprises with (implicit) access to international financial markets. This is exactly the pattern that we find in the data.

A last factor that we focus on is the balance of funds available in banks and financial institutions (the difference between deposits and loans normalized by provincial GDP). Another implication of Song et al. (2011) is that during the transition process, state firms shrink in favor of private enterprises. As the former's economic importance dwindles and their investment opportunities dry out, regions with faster growing private sector have an increasing surpluses of deposits compared to loans as the largely state-owned financial sector does not redirect funds to the emerging private sector. At first sight, our results are compatible with that explanation as they suggest that larger deposit surpluses ($Deposits - Loans/GDP$) make the domestic interest rate channel more important for explaining net exports adjustment.

In the second part of Table 5 (right panel), we discuss some demographic factors. Urbanization is related to a decrease in the importance of the net output channel and an increase in the contribution of other channels to net exports adjustment, particularly international interest rate. Thus, it seems that a higher level of urbanization—and the associated increase in economic complexity—of a region gives rise to alternative smoothing possibilities compared to the classical textbook adjustment. Unbalanced sex ratios have been proposed as one of the main driver of Chinese imbalances (Du and Wei, 2010). In fact, it seems that internal price of non-tradables relative to tradables play a more significant role in regions with higher male to female ratio. We observe a similar pattern for our human capital indicator: student enrollment in higher education seems to drive up the importance of that channel.

In the first part of Table 6 (left panel), we discuss factors related to the integration of provinces into the world economy. As we would expect, openness generally increases the role of world financial markets and therefore of the world interest rate for external adjustment. It also lowers the role of internal price adjustment of non-tradables, again consistent with the view that housing price adjustments are less important where alternative investible assets are available—which is likely to be the case in more open provinces. However, we generally also see a bigger role for the domestic (financially repressed) interest rate in more open provinces. This could be the case because these regions are also the ones where private enterprises tend to grow most quickly.

As discussed in the literature (e.g. Alder et al., 2013), special economic zones (SEZs) have played a pivotal role in China's development over the last decades. In our sample, FDI (FDI) seems to be significantly associated with an increasing contribution to international interest rates variability and a decreasing contribution to net output variability. Thus, regions where firms increasingly get access to foreign financing seem to experience a decrease in the classical channel of adjustment: private enterpreneurs are less dependent on their own savings to finance investment projects and supply working capital but increasingly have access to international markets via foreign firms.[21] Conclusions are very similar by using the relative importance of foreign investment in fixed asset ($FOInvFA$) as an alternative proxy.

In the second part of Table 6 (right panel), we focus on key indicators of economic structure. In our sample period (1986-2010), for most regions, the massive transformation of the Chinese economy is known to have primarily been driven by the structural change from a largely agricultural and resource-based economy to an industrial one. Private and foreign firms rapidly expanded at the cost of state-owned firms, particularly in the manufacturing sector. A larger share of the industrial sector relative to GDP ($Industry$) seems to be associated with a significant increase in the contribution of the net output channel and a decrease in other channels. It could indirectly corroborate earlier findings (i.e. if a rising share in industry was associated with a decreasing state sector).[22]

The share of the construction sector in the economy is strongly correlated with the internal price channel. At last, the domestic interest rate seems to play an important role in regions with an increasing patents density, even when controlling for large differences in economic development. If innovation stems from financially repressed private firms, this could be compatible with the preceding findings. The—initially surprising—negative coefficient on net output is driven by a few well-integrated provinces (e.g. Beijing and Shanghai) that already started the transition from an industrial to a service economy towards the end of the sample.[23]

4.5 Province-level characteristics (horse race)

We analyse next which of the the six main province-level characteristics from our standalone analysis above continue to matter in a multivariate setting, when all character-

[21]Note that FDI is not robust to the inclusion of development level. They are highly correlated.

[22]With some exceptions (e.g. Beijing or Shanghai), it seems true that high share in industry has been concomitant with a low share of state employment. However, it is not the case for relative changes over time.

[23]As already shown in Table 3, Metropolises tend to have a small net output channel.

istics are considered simultaneously. For the purpose of this exercise, we focus on the second half of the sample (1997-2010) , which coincides with the acceleration of the integration of coastal regions into the world economy and the general spread of marketization into the Chinese hinterland. An added benefit of limiting our sample period in this way is that all province-level characteristics with the exception of the demographic one ($SexRatio$) are avaiable on an annual basis. This allows us to treat them as time-varying in our interaction regressions and increases the data variation that we can use for identification. In all regressions, the province-level characteristics are cross-sectionally demeaned.[24] The results appear in Table 7.

The relation between sex imbalances ($SexRatio$) and external adjustment patterns are unchanged relative to the standalone specification, while the relative importance of the state in gross industrial output value ($SOE\ share$) is not significant anymore. Instead, the share of private employment ($EmplPrivate$) seems to play a key role in net exports adjustment, particularly for the net output channel (positive level-effect) and international interest rate channel (positive interaction term). Interestingly, surpluses in the financial sector ($Deposits - Loans/GDP$) are now also strongly correlated with an increase in the importance of the interest rate channel, particularly with the domestic one. This is consistent with the argument put forward by Song et al. (2011) that the accumulation of large surpluses of deposits over loans is a reflection of the emergence of private firms that largely rely on financing investment from retained earnings. Financial repression means that these firms and their workers have no other option but to deposit their savings into local bank accounts, leading to the observed surpluses.

As before, FDI (FDI) seems to increase the share of the international channel in net exports adjustment. Importantly, it has an even stronger opposite effect on the domestic interest rate channel. Regions with larger FDI share have better access to international markets and become less sensitive to domestic interest rates. The relative size of the industrial sector *per se* ($Industry$) does not seem to impact on net exports adjustment anymore. Still, it has a positive level effect on the internal price channel and the international channel as a standalone while it lowers the net output channel.

4.6 Implications for China's aggregate surplus

In this section, we examine the implications of our province-level analysis for China's aggregate surplus. Figure 7 plots the sum of province-level net exports over our sample period against the sum of fitted values from our province-level models.[25] The two lines 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

[24] To save on degree of freedom, we do not control for economic development in these regressions.

[25] The *raw* line corresponds to the data for all regions over 1985-2010.

until 2007/08 and the subsequent sharp decline. This suggests that our model has substantial power for understanding the province-level sources of global imbalances before 2007/08 and of 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 8). 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 channel also accounts for most of the correction of China's surplus. The negative 2009 shock stems from a large number of regions, independently of their characteristics. It is corroborated by official current account statistics.

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 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.

While the role of expected variation in the domestic interest rate—our measure of financial repression—appears limited overall, it makes a persistent and positive contribution to China's surplus. In fact, from the mid-1990s to 2000, it was the main driver of national net export dynamics. It started to rise again in the second half of the 2000s against the (possible) backdrop of an increasing discrimination in private firms' access to finance. More than half of the 2008 negative shock in that channel stemmed from three large and highly marketized provinces (Jiangsu, Shandong and Guangdong).

Variations in the internal terms of trade had a stabilizing effect on net exports in the period after the turn of the millenium, which was characterized by high and increasing surpluses. This suggests that internal price pressure on housing, medical expenses and schooling had a major dampening effect on China's burgeoning external surplus during this period. Non-tradable inflation therefore contributed substantially to the required internal revaluation of the Renminbi that could not occur externally in a system of largely fixed nominal exchange rates.

4.7 Robustness checks

In appendix (B.1), we construct an alternative panel with important adjustments in the net output deflators discussed in Section A.2 and in the number of lags. In another robustness check (B.2), we make the domestic interest rate discussed in Section A.4 region-specific in considering provincial instead of national RPI inflation. Our main findings are robust to such extensions.

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 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). As we show, our simple model can account for 85 percent of the variation in a panel of 30 province-level net exports over the 1985-2010 period.

More importantly, modelling province-level net exports allows us to identify how the patterns of external adjustment depend on province-level characteristics. We have focused on four 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) and the differential access of these types of firms to finance, ii) a province's degree of integration into the world economy in terms of openness to FDI or trade, iii) sectoral composition and iv) demographics.

We find that there are major differences in the patterns of adjustment across provinces. In particular, the relative importance of SOEs and private enterprise in the local economy has a major bearing on the pattern of external adjustment. Intertemporal variation in net output—GDP less investment and government spending—-is particularly important as a driver of capital flows in provinces with a strong presence of private firms, as is the domestic interest rate. This pattern is consistent with theories that see financial repression as a major source of China's persistent surpluses: under financial repression, private firms do not have access to bank finance and therefore have to finance investment from retained earnings. As a result, surpluses are better at predicting decreases in net output (via increases in investment) in provinces with a large share of private firms. The absence of access to international finance also means that the domestic (financially repressed) interest rate is the relevant driver of saving decisions of households and private firms.

Furthermore, we show that a higher integration into the world economy—international openness and FDI—is strongly related to a rising importance of international interest rate and to a decrease in intertemporal variation in quantities (net output). Foreign participation thus possibly alleviates financing constraints of the private sector. We also find that variation in non-tradable prices (e.g. housing) is an important driver of net export variation in less developed regions, suggesting that housing is particularly important as a savings vehicle when there is a lack of investible assets.

Our framework allows us to reconstruct Chinese net exports from the inside. We find that most of the 2000s run-up and the successive adjustment is driven by intertemporal variation in net output. During this period, the domestic interest rate channel (financial repression) makes a persistent and positive contribution to China's surplus. Variation in the world interest rate plays only a relatively minor (but increasing) role overall while internal price pressure on non-tradable goods has a major dampening effect on China's burgeoning external surplus.

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

	γ	κ	δ	$\rho(\hat{x}, x)$	$\sigma(\hat{x})/\sigma(x)$	$rGDP$	$rank$
Beijing	0.80	0.995	0.95	0.98	0.95	2.3%	15
Tianjin	5.00	0.995	0.90	0.99	0.88	1.5%	24
Hebei	**4.80**	**0.960**	**0.00**	**0.96**	**1.00**	**6.0%**	**6**
Shanxi	2.80	0.900	1.00	0.93	1.04	1.6%	23
Inner Mong.	0.70	0.900	0.00	0.98	1.06	1.7%	22
Liaoning	**1.60**	**0.940**	**0.30**	**0.99**	**1.03**	**4.9%**	**7**
Jilin	2.50	0.985	0.45	0.99	0.97	2.0%	18
Heilongjiang	1.50	0.935	0.00	0.99	0.96	3.4%	14
Shanghai	1.90	0.995	1.00	0.99	0.96	3.5%	12
Jiangsu	**1.10**	**0.900**	**0.00**	**0.99**	**1.15**	**8.6%**	**3**
Zhejiang	**1.70**	**0.925**	**0.00**	**0.97**	**0.98**	**6.2%**	**4**
Anhui	5.00	0.900	0.00	0.87	2.74	3.4%	13
Fujian	**5.00**	**0.900**	**0.95**	**0.99**	**1.18**	**3.8%**	**10**
Jiangxi	3.20	0.955	0.00	0.97	1.01	2.2%	17
Shandong	**2.60**	**0.925**	**0.15**	**0.97**	**1.03**	**9.1%**	**1**
Henan	**3.40**	**0.905**	**0.35**	**1.00**	**0.99**	**6.1%**	**5**
Hubei	**5.00**	**0.940**	**0.00**	**0.94**	**1.03**	**4.1%**	**9**
Hunan	5.00	0.900	0.00	0.94	1.88	3.5%	11
Guangdong	**2.30**	**0.900**	**1.00**	**0.94**	**1.03**	**8.8%**	**2**
Guangxi	1.10	0.995	0.00	0.98	0.99	2.2%	16
Hainan	1.10	0.985	0.00	1.00	1.00	0.4%	28
Chongqing	1.50	0.995	1.00	0.99	0.89	2.0%	19
Sichuan	**3.30**	**0.900**	**0.10**	**1.00**	**0.99**	**4.6%**	**8**
Guizhou	2.40	0.995	0.00	1.00	0.98	1.0%	27
Yunnan	3.30	0.945	1.00	0.87	0.92	1.9%	20
Tibet							
Shaanxi	0.60	0.995	0.00	0.77	0.72	1.8%	21
Gansu	0.80	0.995	0.00	0.86	0.97	1.1%	26
Qinghai	5.00	0.995	1.00	0.99	0.74	0.3%	30
Ningxia	2.00	0.995	1.00	0.98	0.87	0.3%	29
Xinjiang	0.70	0.995	0.00	0.93	0.92	1.4%	25
Median	2.35	0.95	0.05	0.98	0.99	2.2%	
Mean	2.59	0.95	0.37	0.96	1.06	3.3%	
Mean (rGDP)	2.69	0.93	0.32	0.96	1.10		

Results obtained from a three dimensional grid-search for γ, κ and δ by minimizing the squared distance between the real and estimated NX/NO. Tibet is excluded because of data issues. The ten largest provinces in terms of 2000 real GDP are in bold type and represent around 62% of cumulated output. The last row is the (2000) real GDP-weighted mean.

Table 2: Channels of external adjustment: variance decomposition by province

	NO	*IP*	*DR*	*IR*	*RES*
Beijing	0.51	0.00	0.17	0.25	0.06
Tianjin	0.78	0.16	-0.10	0.03	0.13
Hebei	0.96	-0.26	0.25	0.00	0.05
Shanxi	1.23	0.01	-0.03	-0.24	0.03
Inner Mong.	1.22	-0.05	-0.13	0.00	-0.04
Liaoning	0.50	0.14	0.14	0.24	-0.02
Jilin	1.07	0.11	-0.22	0.00	0.04
Heilongjiang	0.71	-0.01	0.26	0.00	0.04
Shanghai	0.94	-0.18	-0.15	0.33	0.06
Jiangsu	0.55	0.02	0.57	0.00	-0.13
Zhejiang	0.37	0.10	0.48	0.00	0.05
Anhui	2.05	0.30	0.03	0.00	-1.38
Fujian	1.05	-0.03	0.19	-0.05	-0.17
Jiangxi	0.59	-0.13	0.52	0.00	0.02
Shandong	1.88	-0.66	-0.01	-0.21	-0.01
Henan	0.93	0.03	0.06	-0.03	0.01
Hubei	0.95	0.21	-0.20	0.00	0.03
Hunan	1.79	-0.24	0.22	0.00	-0.77
Guangdong	0.70	-0.16	0.32	0.10	0.03
Guangxi	0.08	0.01	0.88	0.00	0.03
Hainan	0.74	-0.01	0.28	0.00	0.00
Chongqing	0.62	0.03	0.07	0.15	0.13
Sichuan	0.76	0.55	-0.35	0.03	0.01
Guizhou	1.13	0.08	-0.23	0.00	0.02
Yunnan	0.12	0.50	-0.24	0.41	0.20
Tibet					
Shaanxi	0.18	0.01	0.36	0.00	0.45
Gansu	-0.34	0.03	1.15	0.00	0.16
Qinghai	0.58	0.12	0.02	0.01	0.27
Ningxia	0.79	0.10	-0.01	-0.04	0.15
Xinjiang	0.42	0.01	0.43	0.00	0.14
Median	0.74	0.01	0.07	0.00	0.03
Mean	0.77	0.03	0.15	0.03	-0.01
Mean (rGDP)	0.89	-0.03	0.18	0.02	-0.05

The table presents estimates of the variance decomposition coefficients. NO: net output, IP: internal price, DR: domestic rate, IR: international rate. RES: unexplained part. The last row is the (2000) real GDP-weighted mean.

Table 3: Panel analysis of external adjustment

	NO	*IP*	*DR*	*IR*	*RES*
Weighting					
Same	**0.70** (11.17)	**0.06** (3.12)	**0.05** (1.69)	**0.05** (1.73	**0.14** (3.24)
Real GDP	**0.82** (11.50)	-0.02 (-0.55)	**0.11** (3.28)	0.05 (1.26	**0.03** (2.14)
Residual	**0.75** (10.78)	**0.05** (2.71)	0.05 (1.31)	**0.06** (1.77)	**0.10** (2.92)
	NO	*IP*	*DR*	*IR*	*RES*
Regions					
Metro	**0.62** (5.93)	-0.01 (-0.20)	0.05 (0.62)	**0.24** (9.43)	**0.10** (40.83)
East Coast	**0.86** (4.35)	**$-$0.18** (-3.09)	**0.28** (5.08)	0.05 (0.77)	0.00 (-0.10)
Manchuria	**0.64** (11.13)	**0.07** (1.91)	**0.15** (2.40)	**0.12** (2.08)	**0.02** (1.90)
Center	**0.92** (117.51)	**0.04** (6.20)	**0.06** (9.61)	**$-$0.03** (-25.34)	**0.02** (2.30)
West	**0.71** (2.85)	0.00 (-0.08)	0.12 (0.88)	-0.01 (-0.77)	0.18 (1.55)
South	**0.58** (5.27)	0.10 (1.15)	0.05 (0.70)	**0.14** (3.46)	**0.13** (2.36)
No Metro & EC	**0.83** (10.97)	**0.05** (2.67)	**0.07** (3.53)	0.01 (0.33)	**0.04** (1.79)
	NO	*IP*	*DR*	*IR*	*RES*
Dvpt Level					
Market High	**0.75** (8.19)	-0.06 (-1.18)	**0.15** (3.17)	**0.13** (3.42)	0.03 (1.55)
Market Low	**0.88** (14.84)	**0.04** (2.72)	**0.06** (3.00)	-0.01 (-0.70)	0.14 (1.46)

Panel estimates (β_x) of the respective channels from the regression $x_t^k = \alpha + \tau_t + \mu^k + \beta_x \times \left(\frac{NX}{NO}\right)_t^k + \varepsilon_t^k$, where x_t^k stands for the VAR-implied expectations of the channels. T-statistics clustered by regions based on Liang and Zeger (1986) in parentheses. Bold type indicates significance at the 10% confidence level. The first weighting procedure ($Real\ GDP$) uses 2000 real GDP computed using provincial CPI. The second weighting procedure ($Residual$) uses the absolute residual share of the variance decomposition $[max(abs(RES)) - abs(RES^k)]^2$. Both are normalized by the highest regional value. In the second and third panels, relative net exports and channels are GDP-weighted.

Table 4: Specification, data and grid-search results by province

	Sample	*Lag*	*NO Defl*	c	ϕ
Beijing	85-10	1	RPI	1.38	1.10
Tianjin	85-10	2	RPI PIFA	0.77	0.61
Hebei	85-10	1	GDP PIFA	0.79	0.64
Shanxi	87-10	1	RPI PIFA	0.88	0.70
Inner Mong.	85-10	1	RPI PIFA	1.04	0.83
Liaoning	85-10	1	GDP PIFA	0.78	0.62
Jilin	85-10	1	RPI PIFA	0.91	0.73
Heilongjiang	85-10	1	GDP PIFA	0.87	0.69
Shanghai	85-10	2	RPI PIFA	0.76	0.61
Jiangsu	85-10	1	RPI PIFA	0.68	0.55
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	0.80
Shandong	85-10	1	GDP PIFA	0.80	0.64
Henan	85-10	1	GDP PIFA	1.02	0.81
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	0.82
Hainan	85-10	1	RPI	1.19	0.95
Chongqing	85-10	1	GDP PIFA	1.20	0.96
Sichuan	85-10	1	GDP PIFA	1.06	0.85
Guizhou	85-10	1	RPI PIFA	1.21	0.96
Yunnan	85-09	2	GDP PIFA	1.04	0.83
Tibet					
Shaanxi	85-09	2	GDP PIFA	1.11	0.89
Gansu	85-10	2	GDP PIFA	1.13	0.90
Qinghai	85-10	1	RPI PIFA	1.67	1.34
Ningxia	89-10	2	RPI PIFA	1.40	1.12
Xinjiang	85-10	1	RPI PIFA	1.07	0.86
Median				1.00	0.80
Mean				1.01	0.81
Mean (rGDP)				0.92	0.73

Specification and choice of net output deflator as in main text. Consumption ratio (c) estimated from the data. Implied $\phi = c \times (1 - \frac{1}{\gamma})$ from grid-search (γ). Tibet is excluded because of data issues.

Table 5: Province-level characteristics (I), 1986-2010

STATE	*Net Output*	*Internal Price*	*Interest Rate* Domestic	*Interest Rate* Intern.	*Interest Rate* Total
NX/NO_t^k	**0.98** (8.05)	0.04 (0.74)	0.10 (1.36)	**−0.14** (−3.67)	−0.04 (−0.49)
$SOE\ share_t^k$	−0.02 (−0.82)	0.00 (−0.05)	0.01 (0.42)	0.01 (1.32)	0.02 (1.11)
$Dvpt^k \times NX/NO_t^k$	−0.09 (−0.78)	**−0.08** (−1.72)	0.01 (0.18)	**0.16** (6.26)	**0.17** (2.40)
$SOE\ share_t^k \times NX/NO_t^k$	**−0.29** (−2.31)	**0.17** (2.05)	−0.02 (−0.29)	**0.09** (2.10)	0.08 (0.97)
NX/NO_t^k	**1.02** (6.60)	**0.17** (3.71)	−0.11 (−1.20)	**−0.16** (−3.19)	**−0.27** (−2.56)
$Dvpt^k \times NX/NO_t^k$	−0.12 (−0.93)	0.01 (0.28)	−0.09 (−1.14)	**0.17** (5.63)	0.08 (0.93)
$Market^k \times NX/NO_t^k$	−0.01 (−0.34)	**−0.04** (−3.87)	**0.06** (3.09)	0.01 (0.65)	**0.06** (2.74)
NX/NO_t^k	**1.01** (9.71)	0.04 (0.85)	0.08 (1.32)	**−0.15** (−3.81)	−0.07 (−0.94)
$\frac{Deposits-Loans}{GDP}{}_t^k$	**−0.03** (−2.41)	0.01 (1.65)	0.00 (0.72)	**0.01** (2.09)	**0.02** (2.26)
$Dvpt^k \times NX/NO_t^k$	**−0.12** (−1.72)	−0.05 (−1.48)	−0.01 (−0.10)	**0.18** (5.64)	**0.17** (3.14)
$\frac{Deposits-Loans}{GDP}{}_t^k \times NX/NO_t^k$	−0.15 (−1.61)	−0.02 (−0.30)	**0.10** (2.39)	0.02 (0.78)	**0.13** (2.22)

DEMOGRAPHICS	*Net Output*	*Internal Price*	*Interest Rate* Domestic	*Interest Rate* Intern.	*Interest Rate* Total
NX/NO_t^k	**0.83** (20.63)	−0.01 (−0.34)	**0.11** (4.08)	**0.04** (2.74)	**0.15** (4.71)
$Urbanization_t^k$	0.03 (0.91)	0.00 (0.09)	**0.05** (1.70)	**−0.02** (−1.65)	0.02 (0.71)
$Dvpt^k \times NX/NO_t^k$	0.38 (1.45)	−0.14 (−0.82)	−0.08 (−0.38)	0.01 (0.15)	−0.06 (−0.35)
$Urbanization_t^k \times NX/NO_t^k$	**−1.54** (−2.16)	0.25 (0.51)	0.26 (0.52)	**0.50** (2.67)	0.76 (1.51)
NX/NO_t^k	6.30 (1.62)	**−4.32** (−2.48)	2.61 (1.44)	−2.02 (−1.49)	0.60 (0.23)
$Dvpt^k \times NX/NO_t^k$	**−0.15** (−1.66)	−0.04 (−1.55)	0.01 (0.08)	**0.18** (6.84)	**0.19** (2.66)
$SexRatio^k \times NX/NO_t^k$	−5.00 (−1.37)	**4.10** (2.51)	−2.37 (−1.40)	1.77 (1.38)	−0.60 (−0.25)
NX/NO_t^k	**0.96** (9.22)	0.05 (1.39)	0.09 (1.14)	**−0.14** (−3.51)	0.05 (−0.51)
$Dvpt^k \times NX/NO_t^k$	0.08 (0.44)	**−0.23** (−3.72)	0.06 (0.36)	**0.16** (3.33)	0.23 (1.21)
$HighEduc^k \times NX/NO_t^k$	−2.07 (−1.53)	**1.70** (3.48)	−0.51 (−0.44)	0.16 (0.45)	−0.34 (−0.25)

The table reports the results of panel regressions of the form $x_t^k = \alpha + \tau_t + \mu^k + \beta_x \times \left(\frac{NX}{NO}\right)_t^k + \boldsymbol{\gamma}_x' \times \left(\frac{NX}{NO}\right)_t^k \times \boldsymbol{z}_t^k + \boldsymbol{\psi}' \times \boldsymbol{z}_t^k + \varepsilon_t^k$, where x_t^k stands in turn for the VAR-implied expectations of the respective channel. The vector $\boldsymbol{z}_t^k$ stands for the different potential explanatory variables. T-statistics clustered by regions based on Liang and Zeger (1986) in parentheses. Bold type indicates significance at the 10% confidence level. The last column (Total) results from merging the domestic with the international interest rate channel.

$Dvpt$: mean real GDP per capita relative to national values over 1986-2010. $SOE\ share$: share of state-owned gross industrial output value. $(Deposits - Loans)/GDP$: deposits minus loans in banks and financial institutions normalized by GDP. $Market$: marketization index developed by Fan et al. (2001), 1997-2005 average. $Urbanization$: population share living in urban area (cross-sectionally demeaned). $SexRatio$: male to female ratio (2000 Census). $HighEduc$: student enrollment in institutions of higher education relative to population, 1997-2010 average.

Table 6: Province-level characteristics (II), 1986-2010

INTERNATIONAL	Net Output	Internal Price	Interest Rate Domestic	Interest Rate Intern.	Interest Rate Total	STRUCTURE	Net Output	Internal Price	Interest Rate Domestic	Interest Rate Intern.	Interest Rate Total
NX/NO_t^k	**0.97** (7.90)	0.03 (0.67)	**0.10** (1.67)	**−0.14** (−3.69)	−0.03 (−0.47)	NX/NO_t^k	0.27 (1.23)	**0.35** (2.53)	0.18 (1.12)	0.06 (0.52)	**0.24** (1.82)
$Openness_t^k$	**0.02** (2.44)	0.01 (1.50)	**−0.01** (−1.96)	0.00 (−0.82)	**−0.01** (−2.10)	$Industry_t^k$	−0.03 (−0.61)	−0.02 (−0.78)	0.03 (1.35)	0.00 (0.08)	0.04 (1.09)
$Dvpt^k \times NX/NO_t^k$	−0.11 (−0.94)	−0.02 (−0.44)	−0.03 (−0.43)	**0.17** (6.12)	**0.14** (1.90)	$Dvpt^k \times NX/NO_t^k$	**−0.15** (−2.33)	−0.05 (−1.51)	0.01 (0.20)	**0.18** (8.39)	**0.20** (3.38)
$Openness_t^k \times NX/NO_t^k$	−0.07 (−1.25)	**−0.08** (−3.99)	**0.11** (2.15)	**0.03** (1.73)	**0.13** (2.28)	$Industry_t^k \times NX/NO_t^k$	**1.55** (3.70)	**−0.67** (−2.10)	−0.20 (−0.78)	**−0.43** (−2.19)	**−0.63** (−2.96)
NX/NO_t^k	**0.87** (11.74)	−0.01 (−0.26)	**0.10** (3.19)	0.02 (0.37)	**0.11** (1.74)	NX/NO_t^k	**1.14** (**7.14**)	−0.06 (−1.04)	0.11 (0.90)	**−0.17** (−4.28)	−0.06 (−0.38)
FDI_t^k	0.06 (0.84)	0.00 (0.01)	0.01 (0.37)	−0.05 (−1.02)	−0.04 (−0.93)	$Construction_t^k$	0.23 (1.13)	0.00 (0.00)	−0.04 (−0.33)	−0.14 (−1.64)	−0.18 (−1.19)
$FDI_t^k \times NX/NO_t^k$	**−1.34** (1.73)	−0.34 (−0.80)	0.38 (0.57)	**1.30** (3.37)	**1.68** (2.71)	$Dvpt^k \times NX/NO_t^k$	−0.12 (−1.52)	−0.06 (−1.63)	0.01 (0.13)	**0.17** (6.67)	**0.18** (2.88)
						$Construction_t^k \times NX/NO_t^k$	−2.99 (−1.21)	**1.84** (2.16)	−0.25 (−0.13)	0.44 (0.66)	0.19 (0.08)
NX/NO_t^k	**0.98** (8.31)	0.04 (0.72)	**0.10** (1.76)	**−0.14** (−3.87)	−0.04 (−0.63)	NX/NO_t^k	**0.71** (3.75)	0.05 (0.41)	**0.26** (2.46)	−0.08 (−1.13)	0.19 (1.41)
$Dvpt^k \times NX/NO_t^k$	−0.07 (−0.51)	−0.01 (−0.15)	−0.10 (−1.33)	**0.15** (5.06)	0.05 (0.70)	$Dvpt^k \times NX/NO_t^k$	0.33 (1.04)	−0.07 (−0.35)	**−0.28** (−1.77)	0.07 (0.67)	−0.21 (−1.02)
$FOInvFA^k \times NX/NO_t^k$	−0.93 (−1.49)	−0.50 (−1.13)	**1.29** (3.54)	**0.40** (2.52)	**1.69** (4.28)	$Patents^k \times NX/NO_t^k$	**−1.09** (−1.70)	0.03 (0.08)	**0.67** (2.19)	0.26 (1.24)	**0.93** (2.26)

The table reports the results of panel regressions of the form $x_t^k = \alpha + \tau_t + \mu^k + \beta_x \times \left(\frac{NX}{NO}\right)_t^k + \boldsymbol{\gamma}_x' \times \left(\frac{NX}{NO}\right)_t^k \times \boldsymbol{z}_t^k + \boldsymbol{\psi}' \times \boldsymbol{z}_t^k + \varepsilon_t^k$, where x_t^k stands in turn for the VAR-implied expectations of the respective channel. The vector $\boldsymbol{z}_t^k$ stands for the different potential explanatory variables. T-statistics clustered by regions based on Liang and Zeger (1986) in parentheses. Bold type indicates significance at the 10% confidence level. The last column (Total) results from merging the domestic with the international interest rate channel.

$Dvpt$: mean real GDP per capita relative to national values over 1986-2010. $Openness$: international exports and imports over GDP. FDI: used FDI over GDP. $FOInvFA$: foreign-owned share in investment in fixed assets (including Hong-Kong and Macau). $Industry$: industry sector share of GDP. $Construction$: construction sector share of GDP. $Patents$: granted patents over population, 1997-2010 average.

Table 7: Province-level characteristics (III), horse race, 1997-2010

	Net Output	*Internal Price*	*Interest Rate* Domestic	*Interest Rate* Intern.	*Interest Rate* Total
NX/NO_t^k	**0.73** (13.62)	**0.06** (1.85)	0.06 (1.24)	**0.09** (3.73)	**0.16** (2.99)
$SexRatio^k \times NX/NO_t^k$	−5.90 (−1.03)	**5.96** (1.94)	−2.99 (−0.90)	**2.06** (2.05)	−0.92 (−0.26)
$SOE\ share_t^k$	−0.01 (−0.34)	0.01 (0.63)	−0.01 (−0.63)	0.01 (1.38)	0.00 (0.11)
$SOE\ share_t^k \times NX/NO_t^k$	−0.59 (−1.00)	0.23 (1.20)	−0.04 (−0.13)	0.19 (1.17)	0.15 (0.38)
$EmplPrivate_t^k$	**0.08** (1.94)	**−0.03** (−1.90)	**−0.04** (−1.69)	−0.01 (−0.37)	**−0.04** (−1.66)
$EmplPrivate_t^k \times NX/NO_t^k$	−0.30 (−0.44)	0.36 (1.34)	−0.32 (−0.62)	**0.36** (1.97)	0.04 (0.07)
$\frac{Deposits-Loans}{GDP}{}_t^k$	**−0.03** (−1.97)	0.01 (1.49)	0.00 (0.42)	**0.01** (1.84)	0.01 (1.15)
$\frac{Deposits-Loans}{GDP}{}_t^k \times NX/NO_t^k$	**−0.47** (−3.07)	−0.02 (−0.35)	**0.31** (3.01)	**0.09** (2.42)	**0.40** (3.73)
FDI_t^k	0.16 (1.24)	−0.09 (−1.63	−0.04 (−0.43)	**−0.06** (−1.87)	−0.10 (−1.01)
$FDI_t^k \times NX/NO_t^k$	0.16 (0.10)	0.68 (0.89)	**−2.07** (−1.82)	**1.06** (1.70)	−1.01 (−0.78)
$Industry_t^k$	**−0.17** (−2.75)	**0.07** (1.88)	0.03 (0.54)	**0.05** (1.86)	**0.09** (1.75)
$Industry_t^k \times NX/NO_t^k$	0.44 (0.42)	0.05 (0.10)	0.08 (0.09)	−0.48 (−1.49)	−0.40 (−0.41)

The table reports the results of panel regressions of the form $x_t^k = \alpha + \tau_t + \mu^k + \beta_x \times \left(\frac{NX}{NO}\right)_t^k + \boldsymbol{\gamma}_x' \times \left(\frac{NX}{NO}\right)_t^k \times \boldsymbol{z}_t^k + \boldsymbol{\psi}' \times \boldsymbol{z}_t^k + \varepsilon_t^k$, where x_t^k stands in turn for the VAR-implied expectations of the respective channel. The vector $\boldsymbol{z}_t^k$ stands for the different potential explanatory variables. T-statistics clustered by regions based on Liang and Zeger (1986) in parentheses. Bold type indicates significance at the 10% confidence level. The last column (Total) results from merging the domestic with the international interest rate channel. Factors are cross-sectionally demeaned.

$SexRatio$: male to female ratio (2000 Census). $SOE\ share$: share of state-owned gross industrial output value. $EmplPrivate$: share of private and self-employed relative to total employment. $(Deposits - Loans)/GDP$: deposits minus loans in banks and financial institutions normalized by GDP. FDI: used FDI over GDP. $Industry$: industry sector share of GDP.

Figure 1: NX/NO: data (solid) versus predicted (dashed), 1986-2010

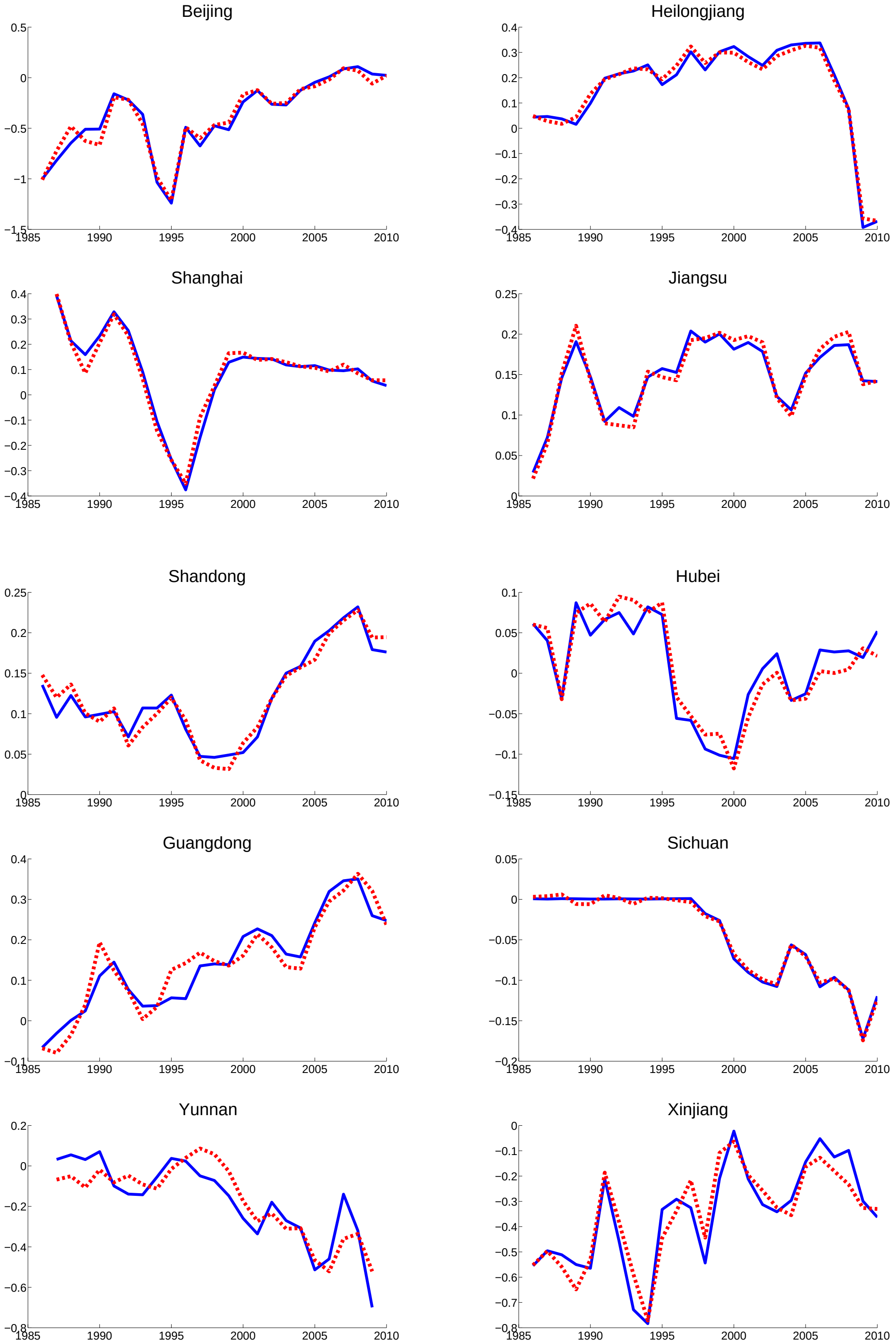


Figure 2: Real GDP weights (2000, largest province=1)

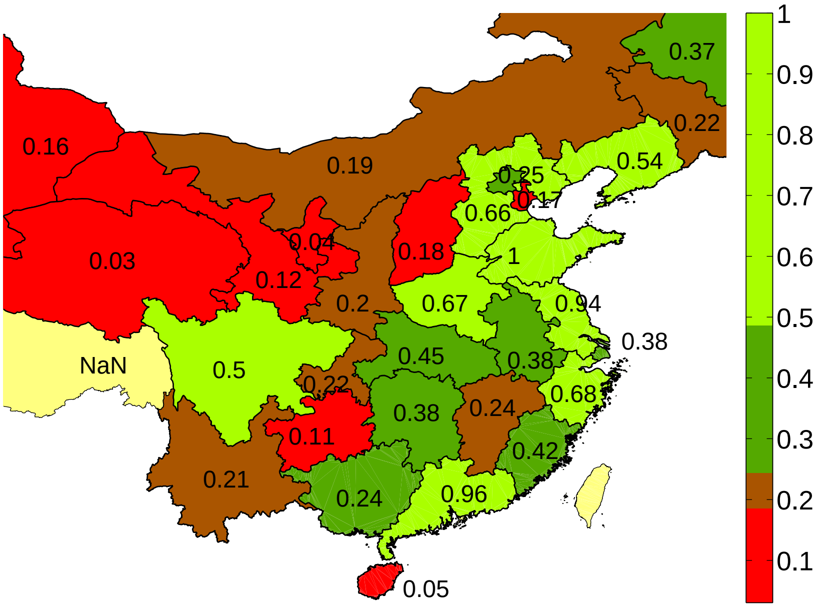


Figure 3: Channels of adjustment for four regions, 1986-2010

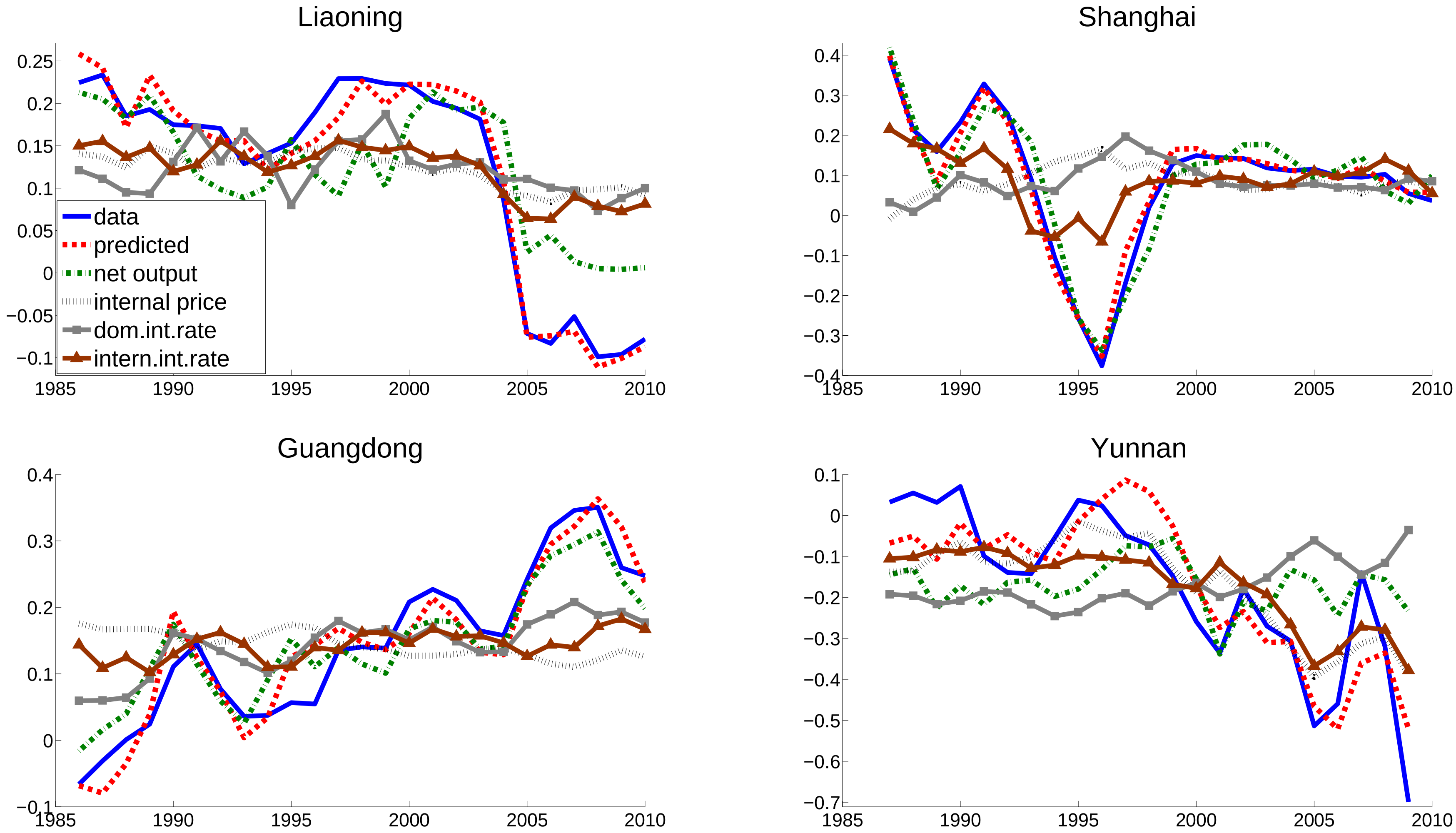


Figure 4: Net output channel β, 1986-2010

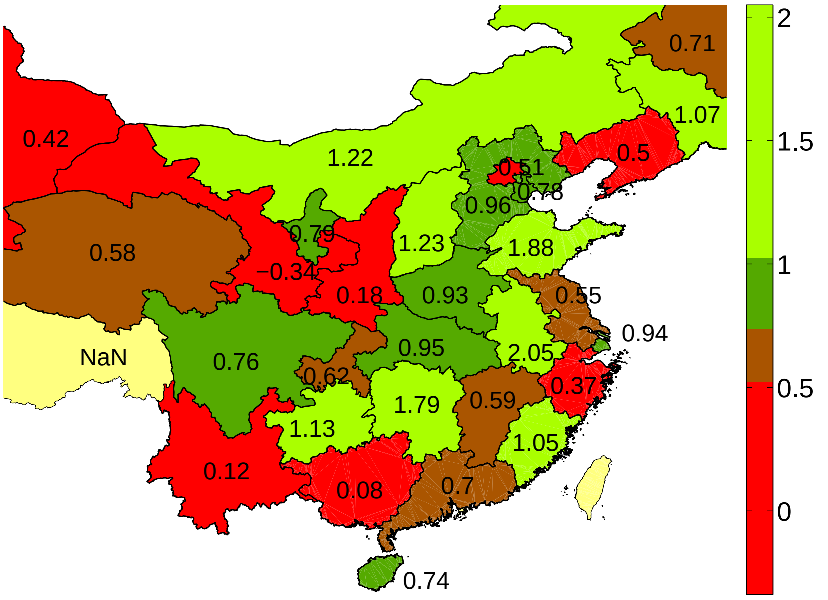


Figure 5: Internal price channel β, 1986-2010

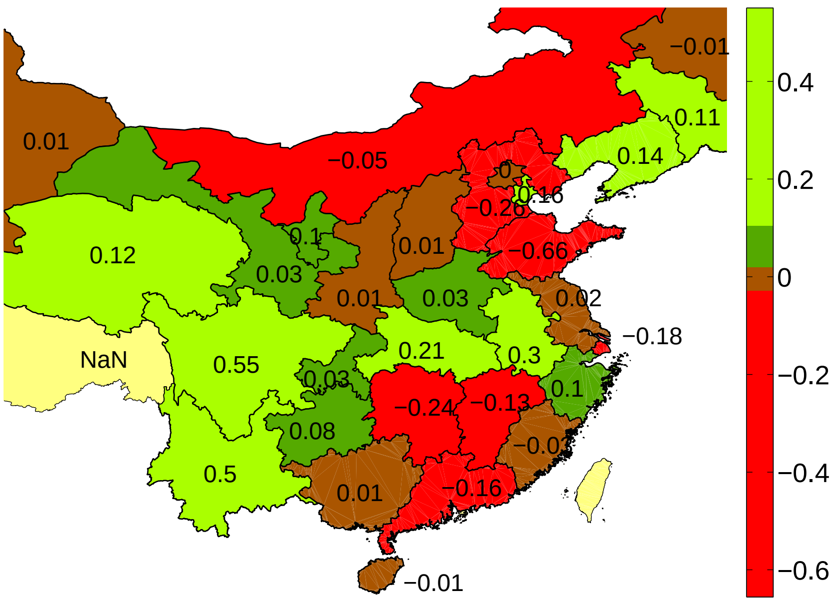


Figure 6: Interest rate channel β (world and domestic), 1986-2010

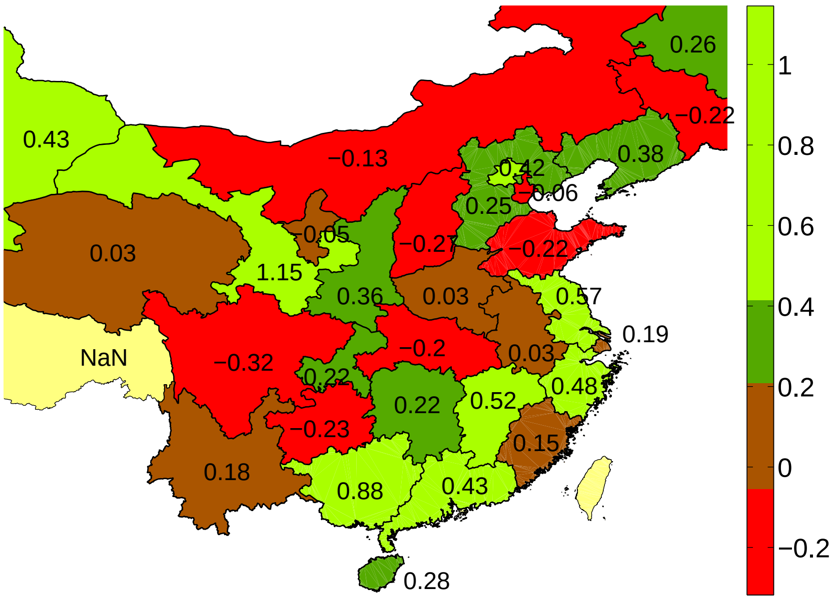


Figure 7: Cumulated nominal net exports (100 million RMB), 1986-2010

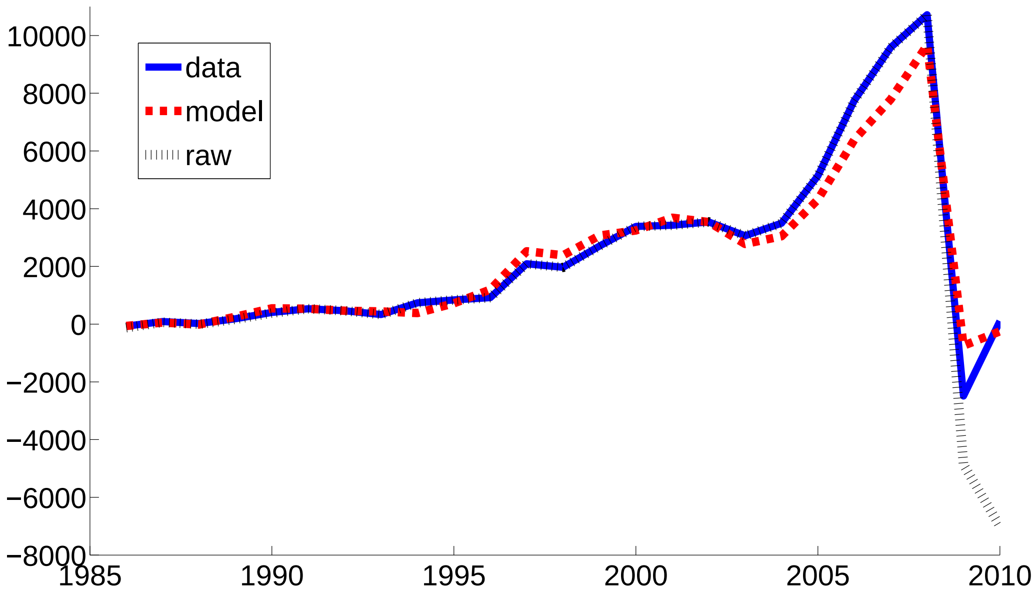
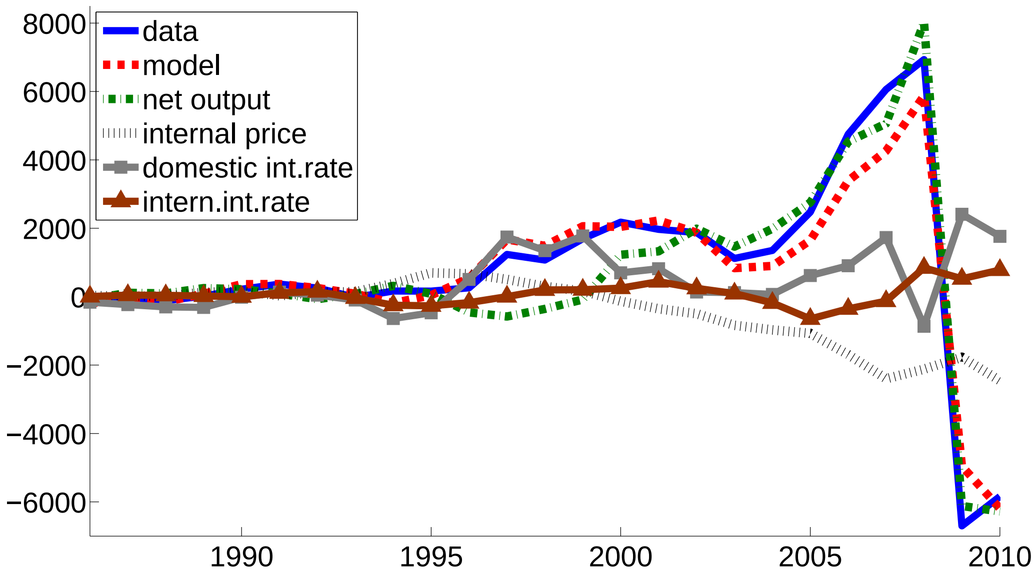


Figure 8: Nominal aggregate channels of net exports (100 million RMB, demeaned), 1986-2010



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A Data Appendix

A.1 Population

Chinese population data are a topic of their own. Two main problems are plaguing them: the underreported birth numbers as a consequence of the one child policy (Scharping, 2001) and the *"largest (voluntary) migration in human history"* (Chan, 2013). We tried to address the second issue. Basically, three sources of population estimates exist. The Hukou *Household Registration System* population data is reported by the *Public Security Authorities*.[26] It can be considered as a *de jure* statistic because it does not capture migration flows adequately. Typically, richer coastal provinces have an underestimated population and hinterland provinces a too high population (Chan and Wang, 2008). An alternative is the use of 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. They are usually referred to as *de facto* data.

The yearbooks population data often are a combination of the three sources that we have already mentioned. We carefully compared CDC data, recent yearbooks, sample surveys, censuses and existing studies 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.[27] In the end, we are not primarily interested in a precise estimation of the correct level of population *per se* but at least want to avoid sudden jumps in net output per capita due to (frequent) changes in data reporting.

A.2 Net output

Net output is computed using data on GDP, government consumption and investment from the regional statistical yearbooks. The choice of the appropriate deflator(s) of the components of net output is of great importance. No official explicit 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. A nation-wide GDP deflator is available from the IMF (IFS). While CPI (consumer price index) data are largely available and capture a relatively broad price development, our model is expressed in terms of tradable goods. PPIs (producer price indices) are limited to agricultural and industrial

[26]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)

[27]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).

products and are not available across the board. In our opinion, a natural proxy is RPI (retail price index) which, like CPI, has the advantage of being broadly available.

The noisiness of the data and the large differences in economic structure among provinces force us to be sophisticated in our deflating methodology. First, we choose among two main types of deflators: RPI from official statistics and GDP from IFS (both using national values). While RPI certainly is a good proxy for the price of tradable goods, it may be inappropriate for more developed provinces (e.g. the ones that have a sectoral structure close to China). We base our deflator choice on key macroeconomic indicators. Using regional data on provincial sectoral GDP, we compile statistics on the average size of the primary, construction, industry and tertiary sector relative to China and observe the correlation of these variables over time between regional and national data. 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.

Regions very similar to China in terms of the size, correlation and economic concentration of sectors are deflated using the official GDP deflator from IFS (half of regions) while highly specialized provinces will be deflated with national RPI (other half of sample). The use of national deflators instead of regional ones is motivated by the fact that the use of the tradable good as the numéraire implies that inflation in that good should be similar inside China. Furthermore, no regional off-the-shelf GDP deflator is available.[28] At last, we use the (noisy) RPI regional data in our indicator for internal price.

If investment has been a major driver of variations in Chinese output over the last decades, this is even more the case on the regional level, particularly for less developed regions in the West. We gather descriptive statistics on investment to output ratio. When necessary (for instance when large shocks in investment and/or a very high level are observed), we deflate investment with regional PIFA (price of investment in fixed asset), starting as soon as data become available (1992).

We thus end up with 4 different deflators for the three components of net output: national GDP (3 provinces), national RPI (4), national GDP with regional PIFA for investment (12) and national RPI with regional PIFA for investment (11). The provincial deflators are available on Table 4.

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 inter-

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

provincial flows in goods and services. In Cudré (2012), it is showed 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.[29]

For regions having a considerable share of migrant workers in their labor force, we would expect a high share of household remittances to 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. Here again, 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's 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 and the Metropolises).

A.4 Domestic interest rate

The relevant domestic nominal interest rate is computed using the mean of the official deposit and lending rate from the People's Bank of China (IFS, May 2012 CD).[30] 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.

[29]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.

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

A.6 Internal price

Numerous possibilities arise for computing a 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. As household surveys expenditure data are separated between urban and rural population, we take the average share of both shares in non-tradables weighted by regional urbanization rate.[31] We end up with regional shares of non-tradables between 0.32 and 0.45.[32] 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 more challenging. To get a complete time series over the period, we 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 computed 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.[33]

Against a backdrop of financial repression, the progressive liberalization of the housing market in the 2000s led to a fast growth in real estate prices. Household quickly redirected their savings towards housing and the ownership rate increased substantially. 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. To correct for that, 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.[34]

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

[32] 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 reform 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.

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

[34] 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 price patterns prevailing on the housing market.

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.

B Robustness checks

B.1 Alternative specification

We construct an alternative panel with important adjustments in the net output deflators discussed in Section A.2 and in the number of lags (1 or 2). We choose an alternative specification. Of the 30 provinces, 26 have a change in specification (10 in the number of lags, 12 in the deflator and 4 in both). We weren't able to find an alternative for 4 provinces.[35]

On average, deep parameters are roughly similar to the baseline case. The general fit is only marginally worse and the model still does a remarkable job in explaining regional net exports. In the panel setting, the net output channel rises in importance while most price channels become smaller and lose significance. With real GDP-weighting, two price categories are still significant: the internal price channel is more negative (-0.13 vs -0.02) and the domestic one nearly doubles in size (0.21 vs 0.11). The main regional results discussed in Section 4.3 are maintained. The East Coast and the Center have an even larger financial repression channel. Net output adjustments are now clearly more important in more marketized provinces than in less marketized ones.

It seems that the increase in the size of the net output and domestic interest rate channels comes at the cost of less significance and a lower coefficient in our factor regressions. The presence of the state in the economy (e.g. $SOE\ share$) now seems to significantly negatively impact on the financial repression channel instead of net output, which is still compatible with our story. Interestingly, in a shorter sample (1997-2010), the coefficient on the share of private employment interacted with net exports has a positive and significant sign for the net output channel. On top of that, it is robust to the inclusion of other factors.[36] It corroborates earlier findings.

Most importantly, our conclusions concerning the impact of the respective channels on global imbalances are similar: the aggregate net output and domestic interest rate channels have similar dynamics. The world interest rate does not contribute to aggregate imbalances anymore. The internal price channel is still negative over the period with the exception of 2009/2010.

[35] By using alternative deflators, Jilin experiences a huge shock in net exports. Jiangxi has highly asymmetric channels. Shandong and Gansu have a miserable fit. These provinces are neither related geographically nor are they similar economically speaking. Thus, they should not invalidate our test.

[36] Private employment is only time-varying for 1997-2010. That is why we didn't use it in the full sample part.

B.2 Region-specific interest rate

As explained in Section A.4, we used national RPI (retail price index) inflation as a proxy for inflation in tradable good in our proxy for domestic interest rate and used regional RPI in the internal price index of Section A.6. Considering differences in inflation across provinces (i.e. make the domestic interest rate region-specific) could influence our patterns substantially. In this section, we consider provincial instead of national RPI inflation in the domestic interest rate channel.

Changes in parameters and general fit of the model are minor. In the panel regressions, the financial repression channel is slightly smaller but still strongly significant. Other channels are not affected much. In the standalone factor regressions (with development as control), patterns are similar. If at all, coefficients on the presence of the state are even higher (e.g. $SOE\ share$, $Market$, $Deposits - Loans/GDP$). Aggregate patterns are similar.