External imbalances between China and the US:
a dynamic analysis with a life-cycle model*

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Abstract

This paper uses a life-cycle model to study the role of population ageing and the low level of pension income in retirement as drivers of China's persistent trade surplus vis-a-vis the United States. In the model, the fast increase in life expectancy coupled with the relatively low pension expenditures can help to explain its high savings, the persistent trade surplus and the accumulation of a sizeable net foreign asset position. The model predicts a positive net foreign asset position and trade balance for China for most years in the simulation period even though China's high productivity growth has a strong negative impact on its trade balance.
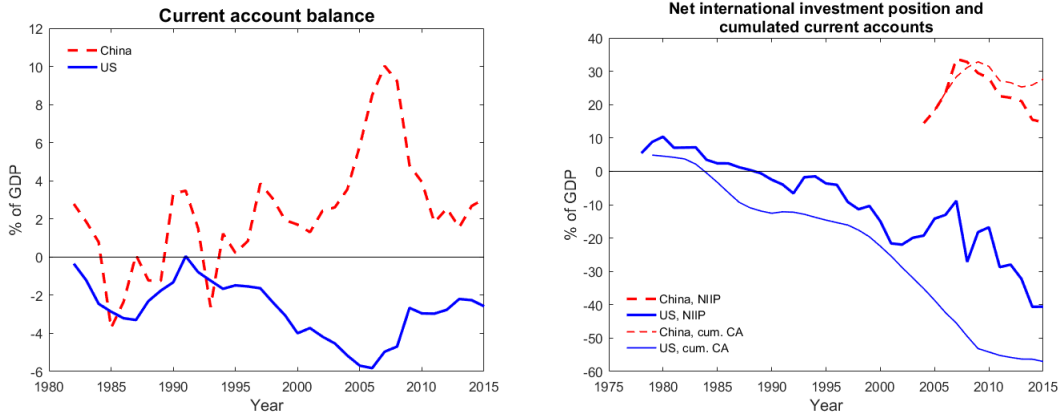
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Figure 1: Left panel: Current account balance. Right panel: Net international investment position and cumulated current account balance. Source: IMF Balance of Payment Statistics and author's calculations.

1 Introduction

China and the United States, the world's largest economies, have both experienced large and persistent external imbalances during the past decades (figure 1). The US has run a current account deficit since 1982, apart from a short-lived surplus in 1991, and by the end of 2015, its net foreign debt had risen to 40 % of GDP. In China, the situation has been the opposite: its current account has been positive since 1990 (apart from a brief plunge in 1993) and, by 2015, it had accumulated a net foreign asset position which amounted to 15 % of its GDP.[1]

This paper suggests that recent demographic developments and differences in the level of social security between China and the US have had a large impact on these observed external imbalances. During the period from 1980 to 2015, life expectancy increased considerably faster in China than in the US, but at the same time, its old age social security expenditures were significantly lower. In the two-country life-cycle model of the paper, these developments cause the Chinese households to prepare for the lengthening of the retirement periods, which results in an increase in aggregate savings and an improvement of China's current account balance, which in turn contributes to the build-up of its foreign asset position. The impact of this channel appears quantitatively large, and the model predicts

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[1]Trade balances are pictured in Appendix A (figure 16). The US has run a trade deficit since 1976. China's trade balance has been positive since 1990 apart from a brief plunge in 1993. The bilateral trade balance has followed a similar pattern: ever since mid-80s', the US' imports from China have exceeded its exports to the country, and the bilateral trade deficit has increased at an accelerating rate until recent years.

a positive trade balance for China for the majority of the simulation period.

Earlier research on external imbalances based on the basic neoclassical theory has focused on the industrialized world, and struggled to explain the capital flows from fast growing emerging economies to industrialized countries, including the capital outflows from China (see *e.g.* the discussion in Gourinchas and Rey, 2013). The theory predicts capital to flow into countries with fast productivity growth. However, while this can explain capital flows within the industrialized world, for fast-growing, emerging economies the explanation does not hold. For instance, Ferrero (2010) shows that productivity growth differentials can indeed explain the majority of the fluctuations of the trade balance between the US and G6 countries from 1970 to 2005, but for China, the same model predicts a counterfactual trade deficit during the simulation period. The counterfactual results are driven by fast productivity growth in China: the average annual total factor productivity (TFP) growth was 2 % in China and 1 % in the US between 1980 and 2015.

The main contribution of this paper is to provide an explanation for the persistent external imbalances between China and the US. It is related to recent literature suggesting alternative factors behind the external imbalances between emerging and industrialized economies. Several studies emphasize the importance of financial markets (Caballero et al. 2008, Mendoza et al. 2009 and Song et al. 2011). One explanation is that the underdevelopment of financial markets in the emerging economies and their inability to supply safe assets has caused the flight of capital from the emerging markets. This strand of literature puts less emphasis on explaining the observed high household savings and low propensities to consume in emerging economies, which are the key element driving the capital flows in this paper.

Rather than focusing on the role of the financial markets, Eugeni (2015) explores the role of social security in the emerging world in creating excess savings and capital outflows. Eugeni shows that the absence of a social security system (a pay-as-you-go pension system) leads to higher savings and capital exports in a two-country model where only one of the two countries has a social security system. This result supports finding of this paper about the relevance of demographic transition coupled with social security expenditures.

In this paper, I use a two-country life-cycle model *á la* Gertler (1999) to quantify the importance of

social security differentials in shaping the dynamics of the bilateral trade balance and the net foreign asset position between the US and China between 1980 and 2015. The role of social security is analysed in addition and relative to exogenous demographic changes, fiscal policy and productivity differences. The model builds on the Ferrero (2010) model by adding three new features: a social security system, endogenous labour supply and distortionary taxation. One aim of this paper is therefore to analyse whether these features can overturn the counterfactual predictions of Ferrero (2010).

The results suggest that the level of social security expenditures has a quantitatively significant impact on households' saving and consumption decisions and, therefore, on the current account, trade balance and net foreign asset positions between China and the US. The model predicts a trade surplus for China for the majority of the simulation period, which is based on the fact that social security expenditures in China have been only one third of those in the US between 1980 and 2015. In addition, demographic changes have a strong influence on the observed accumulation of foreign assets in China over time. In the model, population ageing leads to large savings as households prepare for the long retirement period by accumulating financial wealth. Because the demographic transition has been faster in China than in the US, the model predicts current account surpluses for China. Furthermore, even after controlling for the high productivity growth which has a strong negative impact on the trade balance, the model still predicts a positive net foreign asset position and trade balance for most years in the simulation period.

The rest of the paper is organized as follows. Section 2 discusses the related literature. Section 3 presents the model. Section 4 presents the results of the static and dynamic analysis. Finally, section 5 concludes.

2   Literature review

The paper is related to literature using life-cycle and OLG models to analyse external imbalances, population ageing and social security, but also more generally to literature on external imbalances between emerging and industrialized economies and the real interest rates.

OLG- and life-cycle models are in general used to study the economic implications of the slowdown of population growth and increasing life expectancy because of their ability to account for life-cycle

behaviour. The life-cycle model used in this paper was introduced by Gertler (1999), and it allows to model an economy with realistic average lengths of life, working time and time spent in retirement. The model nests the standard two-period OLG model. In comparison to large-scale multi-period OLG models, the advantage of the Gertler framework is its parsimony, which allows to obtain analytical solutions for aggregate consumption and labour supply and helps to track the mechanisms behind the results.

The Gertler (1999) model has previously been applied by Kilponen et al. (2006), Fujiwara and Teranishi (2008), Ferrero (2010) and Carvalho et al. (2016). The Ferrero (2010) paper is most closely related to this paper, as it also focuses on the external balance and the real interest rate in a two-country world. Ferrero (2010) analyses the effects of demographics, fiscal policy and productivity on the external balance between the US and six other industrialized countries. The main finding is that productivity differentials together with demographic developments can explain the majority of the dynamics of the bilateral trade balance between these industrialized countries during the simulation period (1970-2005). However, if the model is extended to include China, the predictions are counterfactual. This paper enriches the Ferrero (2010) model by introducing a pay-as-you-go social security system together with variable labour supply and distortionary labour taxes with the aim of explaining the trade balance between an emerging and industrialized economy, China and the United States.

Other papers building on the Gertler (1999) model include Kilponen et al. (2006), Fujiwara and Teranishi (2008) and Carvalho et al. (2016). Kilponen et al. (2006) analyse the implication of population ageing and social security in a small open economy (Finland). As opposed to Kilponen et al. (2006), the focus of this paper is on the role of ageing and social security with regards to the external imbalances between two large economies, and the relative importance of these factors in comparison to TFP growth and fiscal policy. Kilponen et al. (2006) relax Gertler's assumption of a stationary demographic structure by allowing for nonstationary demographics. Fujiwara and Teranishi (2008) use the Gertler model to analyse the welfare implications of monetary and fiscal policy on different age groups in a closed economy. They study the evolution of variables such as the real interest rate in economies with different demographic structures: a young economy, an old economy and an economy with no life-cycle structure. In comparison to Fujiwara and Teranishi (2008), this paper analyses a

two-country world economy, and the model has been enriched with social security and distortionary taxation. Carvalho et al. (2016) apply the model to analyse the impact of population ageing on the real interest rate in a closed economy, consider also the role of social security. In contrast, by studying social security in a two-country model, this paper captures the external effects of social security differences between large economies. In addition, as the paper also features endogenous labour supply together with distortionary taxes, the quantitative findings are robust to the effects of social security through the labour supply channel.

Eugeni (2015) builds a two-country OLG-model with a two-period life cycle to analyse the role of social security on the formation of external imbalances and the fall of the real interest rate. She finds that a country with no social security experiences higher savings and asset accumulation, and therefore develops a positive net foreign asset position. Therefore she suggests that social security may play a key role in explaining the capital outflows from countries such as China. In contrast to Eugeni, who analyses social security in a two-period OLG framework, this paper features a rich demographic structure which allows to analyse the quantitative effects of social security together with demographic changes. In addition, this paper attempts at quantifying the dynamic effects of a richer set of long-term factors including TFP and fiscal policy. As regards the effects of social security, this paper also takes into account of social security through the labour supply channel.

Saarenheimo (2005), Domeij and Floden (2006) and Bárány et al. (2016) use multi-period OLG models to analyse questions related to external imbalances, population ageing and social security in a multi-country setting. Saarenheimo (2005) studies the effects of population ageing on global variables including the real interest rate, asset prices and external imbalances in a 73-cohort OLG model with five countries. Domeij and Floden (2006) also use an OLG-model to analyse the effects of demographic transition on the international capital flows in a model economy consisting of 18 OECD countries and the rest of the world. Bárány et al. (2016) use a multi-period OLG model to analyse the role of demographic change together with credit constraints and social security on external capital flows in a multi-country setting. In addition to building on the Gertler (1999) framework, this paper contrasts Saarenheimo (2005), Domeij and Floden (2006) and Bárány et al. (2016) by focusing on the observed dynamics of external imbalances in the past decades between China and the US instead of a multi-

country world. The paper also explicitly models and takes into account the effects of endogenous labour supply and distortionary taxation, which are not featured in the above-mentioned papers but which according to Kilponen et al. (2006) play an important role in an ageing economy. The model also allows labour supply by elderly which is consistent with the fact that work income accounts for more than 30 % of older people's income in the United States (OECD, 2015) and that work income has been the primary source of support for a significant proportion of elderly population in China (Naughton, 2007). Unlike Saarenheimo (2005), Domeij and Floden (2006) and Bárány et al. (2016), this paper also explicitly models and takes into account the effects of fiscal policy on the external imbalances.

Recent literature on external imbalances between emerging and industrialized countries typically highlights the role of financial markets. Caballero et al. (2008) develop a model which rationalizes the international capital flows as a global equilibrium outcome driven by differences in different regions' abilities to supply financial assets. Also Mendoza et al. (2009) argue that when countries with less developed financial markets, resulting in low enforceability of financial contracts, integrate to the international financial system, capital flows towards more developed financial markets occur. Song et al. (2011) propose a model for the Chinese economy in which the firms are heterogeneous in productivity and in access to the financial markets. The capital outflows occur because the productive firms have limited access to financial markets, and therefore the domestic financial markets are unable to provide sufficient investment opportunities to the households despite high productivity growth. In this paper, I have assumed no frictions in financial markets in order to focus on the potential explanatory power of the life-cycle aspects and social security systems. Introducing financial markets friction through e.g. firm heterogeneity as in Song et al. (2011) would be a possible extension to the model in this paper.

3 The model

The model is a symmetric two-country model which captures the effects of demographic changes through a life-cycle structure as in Gertler (1999).[2] Population in a country at time t consists of two groups of individuals: workers, whose total number is N_t^w, and retirees, whose number equals N_t^r. All agents are assumed to enter the economy as workers at the age of 20 and remain workers with probability $\omega_{t,t+1}$ and retire with probability $1-\omega_{t,t+1}$. Retirees face the probability $\gamma_{t,t+1}$ of surviving to the next period. These parameters can be calibrated such as to match the observed average lengths of life, time spent at work and time spent at retirement.

3.1 Households

The preferences of households are given by a CES nonexpected utility function of the form

$$V_t^z = \left\{ \left[(C_t^z)^v \, (1 - l_t^z)^{1-v} \right]^\rho + \beta_{t,t+1}^z \left[E_t \left(V_{t+1} \mid z \right)^\mu \right]^{\frac{\rho}{\mu}} \right\}^{\frac{1}{\rho}}, \quad z = \{w\,,\,r\} \tag{1}$$

where C_t^z is consumption and l_t^z the fraction of total time allocated to work at time t of a person type z (retiree if $z = r$ and worker if $z = w$). β_t^z is the subjective discount factor, and $E_t \left(V_{t+1} \mid z \right)$ is the expectation of the value function next period of the person type z. The Epstein-Zin preferences allow to separate income risk aversion from aversion to intertemporal substitution. Parameter ρ captures intertemporal elasticity of substitution which is given by $\sigma = 1/ \left(1 - \rho \right)$. Parameter μ captures attitudes towards income risk. Risk neutrality (i.e. $\mu = 1$) is assumed to yield consumption decisions that are linear in wealth, which facilitates the aggregation of the model. The only source of income risk is the exogenous probability to retire and thus the effect of income risk aversion is reasonable.

3.1.1 Retirees

Retirees expectation of the value function is $E_t \left(V_{t+1} \mid r \right) = V_{t+1}^r$ and the effective discount factor is $\beta_{t,t+1}^r = \beta \gamma_{t,t+1}$ which takes into account that he or she might not survive to the next period. A retiree born in period j and retired in period i chooses consumption-saving allocation and leisure to

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[2] Appendix B describes the life-cycle structure in more detail.

maximize

$$V_t^{jr}(i) = \left\{ \left[\left(C_t^{jr}(i) \right)^v (1 - l_t^r)^{1-v} \right]^\rho + \beta \gamma_{t,t+1} \left(V_{t+1}^{jr}(i) \right)^\rho \right\}^{\frac{1}{\rho}}, \tag{2}$$

subject to

$$A_{t+1}^{jr}(i) = \frac{R_t A_t^{jr}(i)}{\gamma_{t-1,t}} + W_t \xi l_t^{jr} (1 - \tau_t) + S_t^r - C_t^{jr}(i). \tag{3}$$

Retirees consume out of their non-human wealth A_t^r, labour income $W_t \xi l_t^{jr}$ net of taxes τ_t and lump sum social security transfer S_t^r. The productivity of a unit of labour provided by retirees is only ξ times that of a worker ($\xi \in (0, 1)$), which leads to a lower labour supply by retirees in the equilibrium. Retirees participate in a perfect annuities market which provides insurance against the uncertainty of the time of death so that each retiree receives a gross return on wealth of $R_t / \gamma_{t-1,t}$. R_t is the world interest rate that clears the international capital market. As pension income is financed by a transfer from the tax payers to the retirees, the assumed pension scheme here is a public PAYG (pay-as-you-go) pension system.

The first order condition with respect to leisure is

$$l_t^{jr}(i) = 1 - \frac{C_t^{jr}(i) \varsigma}{W_t \xi (1 - \tau_t)}, \tag{4}$$

where $\varsigma = \frac{1-v}{v}$. The retiree's decision rule for consumption is given by

$$C_t^{jr}(i) = \epsilon_t \pi_t \left(\frac{R_t A_t^{jr}(i)}{\gamma_{t-1,t}} + H_t^{jr}(i) + P_t^r \right), \tag{5}$$

where marginal propensity to consume (mpc) out of wealth is $\epsilon_t \pi_t$ and where $H_t^{jr}(i)$ and $P_t^{jr}(i)$ are the present discounted values of a retiree's lifetime human wealth and pension benefits. The marginal propensity to consume evolves according to the nonlinear difference equation

$$\epsilon_t \pi_t = 1 - \frac{\epsilon_t \pi_t}{\epsilon_{t+1} \pi_{t+1}} \gamma_{t,t+1} \left(\frac{W_t (1 - \tau_t)}{W_{t+1} (1 - \tau_{t+1})} \right)^{\rho \sigma (1-v)} \beta^\sigma (R_{t+1})^{\rho \sigma}. \tag{6}$$

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3.1.2 Workers

Workers expectation of the value function is $E_t\left(V_{t+1}\mid w\right) = \omega_{t,t+1}V_{t+1}^w + (1-\omega_{t,t+1})\,V_{t+1}^r$ and the effective discount factor is $\beta_{t,t+1}^w = \beta$. A worker born in period j chooses consumption-saving allocation and leisure to maximize

$$V_t^{jw} = \left\{\left[\left(C_t^{jw}\right)^v\left(1-l_t^{jw}\right)^{1-v}\right]^\rho + \beta\left[\omega_{t,t+1}V_{t+1}^{jw} + (1-\omega_{t,t+1})\,V_{t+1}^{jr}\right]^\rho\right\}^{\frac{1}{\rho}}. \tag{7}$$

subject to

$$A_{t+1}^{jw} = R_t A_t^{jw} + W_t l_t^{jw}(1-\tau_t) - C_t^{jw}. \tag{8}$$

As retirees, workers consume out of nonhuman wealth and wage income net of taxes less a lump sum tax paid by each worker. The proportional income tax (τ_t) is paid both by the workers and the retirees. Workers and retirees in both countries consume a single (numeraire) good which can be traded internationally.

The first order condition with respect to labour is

$$l_t^{wj} = 1 - \frac{C_t^{wj}\varsigma}{W_t(1-\tau_t)}. \tag{9}$$

The consumption Euler equation for workers is

$$C_t^{jw}\left[\left(\frac{W_t(1-\tau_t)}{W_{t+1}(1-\tau_{t+1})}\right)^{\rho(1-v)}\beta R_{t+1}\Omega_{t+1}\right]^\sigma = \omega_{t,t+1}C_{t+1}^{jw} + (1-\omega_{t,t+1})\epsilon_{t+1}^{\frac{\sigma}{1-\sigma}}\chi C_{t+1}^{jr}, \tag{10}$$

where $\chi = \xi^{-(1-v)}$ and Ω_t is an adjustment term that weights the gross return, *i.e.* an additional discount factor in the workers value function, given by $\Omega_t \equiv \omega_{t-1,t} + (1-\omega_{t-1,t})\epsilon_t^{\frac{1}{1-\sigma}}\chi$.

The worker's marginal propensity to consume out wealth, π_t, evolves according to

$$\pi_t = 1 - \frac{\pi_t}{\pi_{t+1}}\left(\frac{W_t(1-\tau_t)}{W_{t+1}(1-\tau_{t+1})}\right)^{\rho\sigma(1-v)}\beta^\sigma(R_{t+1}\Omega_{t+1})^{\sigma-1}. \tag{11}$$

Worker's decision rule for consumption is

$$C_t^{jw} = \pi_t(R_t A_t^{jw} + H_t^{jw} + P_t^{jw}), \tag{12}$$

where H_t^{jw} is the present discounted value of a worker's human wealth net of taxation and P_t^{jr} is the present discounted value of a worker's pension benefits once retired.

3.1.3 Aggregation

Because marginal propensities to consume, both for retirees and workers, do not depend on individual characteristics, aggregation is straight forward. Let λ_t denote the share of assets held by retirees such that $\lambda_t = \frac{A_t^r}{A_t}$. Aggregate consumption can then be expressed as

$$C_t = \pi_t A_t R_t(\epsilon_t \lambda_t + 1 - \lambda_t) + \pi_t(H_t^w + P_t^w) + \epsilon_t \pi_t(H_t^r + P_t^r). \tag{13}$$

The distribution of aggregate assets between retirees and workers evolves according to

$$\lambda_{t+1} = \omega_{t,t+1}\left(R_t\lambda_t\frac{A_t}{A_{t+1}}(1 - \epsilon_t\pi_t) + \frac{W(1-\tau_t)L_t^r\xi + S_t^r - \epsilon_t\pi_t(H_t^r + P_t^r)}{A_{t+1}}\right) + (1 - \omega_{t,t+1}). \tag{14}$$

The present discounted value of retirees aggregate human wealth is

$$H_t^r = \xi L_t^r W_t(1 - \tau_t) + \gamma_{t,t+1}\frac{\psi_t}{\psi_{t+1}}\frac{H_{t+1}^r}{(1 + n_{t,t+1})R_{t+1}} \ . \tag{15}$$

The discount rate of the present value of total human wealth for current retirees is augmented by the growth rate of retired labour force which is captured by the ratio of the dependency ratios. Similarly, the present discounted value of workers' aggregate human wealth is

$$H_t^w = L_t^w W_t(1 - \tau_t) + \omega_{t,t+1}\frac{H_{t+1}^w}{(1 + n_{t,t+1})R_{t+1}\Omega_{t+1}} + (1 - \omega_{t,t+1})\frac{H_{t+1}^r\epsilon_{t+1}^{\frac{1}{1-\sigma}}\chi}{\psi_{t+1}(1 + n_{t,t+1})R_{t+1}\Omega_{t+1}}. \tag{16}$$

Present discounted value of retirees' aggregate pension benefits at time t is

$$P_t^r = S_t + \gamma_{t,t+1}\frac{\psi_t}{\psi_{t+1}}\frac{P_{t+1}^r}{R_{t+1}} \tag{17}$$

and the present discounted value of social security for workers

$$P_t^w = \omega_{t,t+1}\frac{P_{t+1}^w}{(1+n_{t,t+1})R_{t+1}\Omega_{t+1}} + (1-\omega_{t,t+1})\,\frac{P_{t+1}^r\epsilon_{t+1}^{\frac{1}{1-\sigma}}\chi}{\psi_{t+1}(1+n_{t,t+1})R_{t+1}\Omega_{t+1}}. \tag{18}$$

3.2 Firms

Goods market is competitive and the representative firm chooses labour, capital and investment to maximize the present discounted value of profits given by

$$V\left(I_{t-1}\,,\,K_t\right) = \left[\left(X_tL_t\right)^\alpha K_t^{1-\alpha} - W_tL_t - I_t + \frac{V\left(I_t\,,\,K_{t+1}\right)}{R_{t+1}}\right] \tag{19}$$

subject to the law of motion of capital accumulation

$$K_{t+1} = (1-\delta)\,K_t + \left[1 - \frac{\phi}{2}\left(\frac{I_t}{I_{t-1}} - \mu_t\right)^2\right]I_t, \tag{20}$$

where the term μ_t ensures that along the balanced growth path, investment adjustment costs equal zero. Aggregate effective labour force, L_t, consists of the effective labour input by the two agent types such that $L_t = L_t^w + \xi L_t^r$. Capital depreciates at rate $\delta \in (0\,,\,1)$ and there is a quadratic adjustment cost to investing new capital, the size of which is determined by $\phi > 0$. The firm produces the consumption good with constant returns to scale Cobb-Douglas production technology such that aggregate output is given by $Y_t = (X_tL_t)^\alpha K_t^{1-\alpha}$, where X_t is level of exogenous labour augmenting productivity at time t which grows at rate x_t. $\alpha \in (0\,,\,1)$ is the labour share. Productivity growth follows an AR(1) process given by $x_t = (1-\theta)x_{ss} + \theta x_{t-1} + u_t^x$.

3.3 Government

Government consumes G_t in each period and pays retirees a total amount of P_t of social security benefits. The expenditures are financed with tax revenues T_t and by issuing debt B_{t+1}. Government

spending, social security and fiscal policy are assumed to be an exogenously determined fraction of output: $G_t = \bar{g}_t Y_t$, $P_t = \bar{p}_t Y_t$ and $B_t = \bar{b}_t Y_{t-1}$. Government's per period budget constraint is $B_{t+1} = R_t B_t + G_t + P_t - T_t$. and the intertemporal budget constraint is

$$R_t B_t = \sum_{v=0}^{\infty} \frac{T_{t+v}}{\prod_{z=1}^{v} R_{t+z}} - \sum_{v=0}^{\infty} \frac{G_{t+v}}{\prod_{z=1}^{v} R_{t+z}} - \sum_{v=0}^{\infty} \frac{P_{t+v}}{\prod_{z=1}^{v} R_{t+z}} \ . \tag{21}$$

Government's per period discount rate equals the world interest rate R_t and it is lower than the households' per period discount rates. With elastic labour supply, total tax revenue is

$$T_t = \tau_t W_t L_t \ . \tag{22}$$

Labour tax τ_t endogenously adjust according to satisfy the government budget constraint.

3.4 A competitive world equilibrium and steady-state

A competitive world equilibrium is a sequence of quantities and prices such that in each country (i) households maximize utility subject to their budget constraints, (ii) firms maximize profits subject to their technology constraints, (iii) the government chooses a path for taxes and debt, compatible with intertemporal solvency, to finance an exogenous level of total spending, and (iv) all markets clear.

In each economy, households' aggregate nonhuman wealth equals the aggregate capital stock, government bonds and net foreign assets F_t,

$$A_t = K_t + B_t + F_t \ . \tag{23}$$

Net foreign asset position evolves according to

$$F_{t+1} = R_t F_t + NX_t \tag{24}$$

and the trade balance NX_t is determined by the aggregate resource constraint

$$NX_t = Y_t - (C_t + I_t + G_t) \ . \tag{25}$$

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The current account CA_t, the change in the net foreign asset position, consists of net interest payments on foreign assets and the trade balance

$$CA_t = (R_t - 1) F_t + NX_t \ .$$ (26)

Return R_t is equalized across the two countries and in equilibrium, foreign asset positions in the two countries sum up to 0, *i.e.* $F_t + F_t^* = 0$. The law of one price is assumed to hold.

4 Dynamics of the external imbalances between US and China

The transition process of the Chinese economy which started in 1978 has been gradual, but already by the mid-1990s China had adopted a functioning market economy (see Naughton, 2007). Also the growth of international trade was fast: by 1993, the share of exports and imports had grown to over 40 % of GDP from approximately 10 % of GDP in 1978 (see figure 3). Integration to the global economy accelerated when China joined the World Trade Organization in 2001, and by 2015, it had become the world's largest merchandise trader. China's transition period coincides with the formation of large external imbalances in China and the US both multilaterally and against each other.

This section analyses the drivers of the (long-term) dynamics of the bilateral external imbalances during the transition period. The analysis is done by introducing exogenous changes, which are considered to be potential drivers of the imbalances, to the model presented in chapter 3. The exogenous drivers I use here include demographic changes, differences in pension systems, fiscal policy and productivity growth differentials, and they are discussed in more detail in section 4.1. The dynamic transition of the model economy is simulated in two different ways, first with a standard deterministic simulation and then with a deterministic simulation with learning, i.e. the paths of exogenous variables are updated in every period. The second simulation mimicks the case where agents revise their expectations according to the latest available information. The method is also known as extended path and was originally proposed by Fair and Taylor (1983).

Section 4.2. presents the calibration of the model and a comparative static analysis. Section 4.3. presents the results of a deterministic analysis. Section 4.4. present the deterministically simulated

**Exports and imports of goods and services (China)**
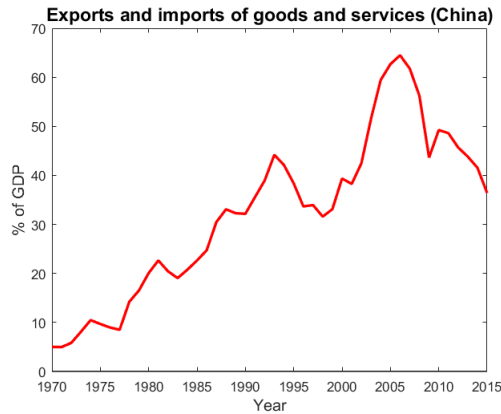
Figure 2: Merchandise trade in China as a share of GDP is the sum of merchandise exports and imports divided by the value of GDP, all in current U.S. dollars. Source: World Bank World Development Indicators.

transition path in which the paths of the exogenous variables are allowed to change in each period of the simulation.

4.1 The US and China from 1980 to 2015: demographics, social security, fiscal productivity and technological progress

The main long term trend captured by the simulation is the ongoing major change in the demographic structures of the countries. Throughout the simulation period, China's population has been far larger and also younger than US'. However, both countries have experienced a fall in population growth rates and an increase in life expectancy, which are still projected to continue (see figures 4 and 5). The increase in life expectancy has been faster in China. From 1980, China's life expectancy at birth has grown by almost 8 years (from 67.5 to 75.4 years), whereas in the US, the growth has been almost 5 years (from 74.3 to 78.9 years). Population growth rate has also fallen more in China due to the faster decline in fertility. The fall in the Chinese population growth was amplified by the introduction of the one-child policy in 1979. In the US, the fall in the population growth rate has been dampened by high net migration. However, in both countries the old-age dependency ratio (the ratio of population aged 65+ to population aged 20-64 years) has increased and is projected to increase even more in the next years (see figure 3).

Based on old revisions of the United Nations population forecast, the demographic transition has
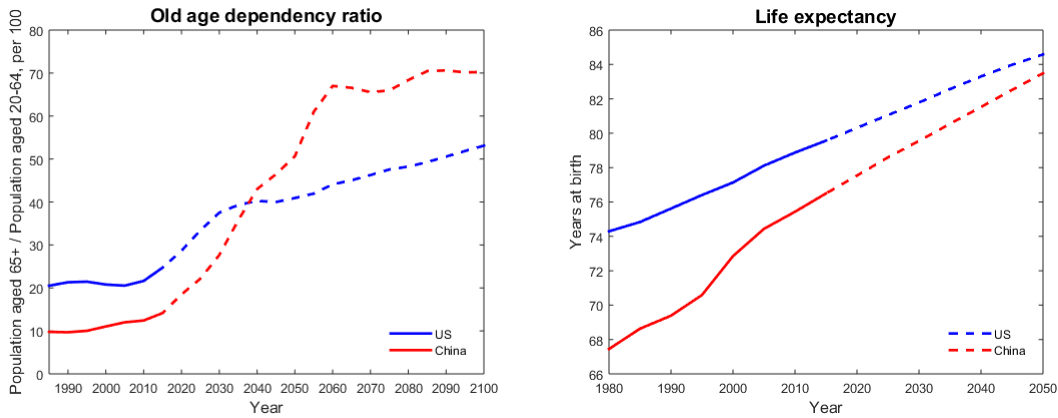
Figure 3: Left panel: Old age dependency ratio in the US and China (data frequency: 5 years) between 1985-2015 and projections until 2100. Right panel: Life expectancy at birth in the US and China in 1980-2015 and projections (medium variant) until 2050. Source: United Nations World Population Prospects: The 2015 Revision.

not been fully anticipated. Estimation and forecasting methodology have evolved over time and new census data has become available or been revised, resulting in changes in the forecasts. In fact, the forecasts of life expectancy at birth both in China and the US have been revised upwards in nearly every revision round (see figure 6). The projections of population growth rates have been several times revised upwards for the US and downwards for China (see figure 7). Also the time horizon of the demographic projections has increased over time. In the revision prior to 1994, the projections were made until 2025. Between 1994 and 2008, the projections were made until 2050, and since 2010, until 2100.

As regards social security, in recent years, public pension spending in China as a share of GDP has been only one third as compared to the US (2.1 vs. 6.6 % according to the data from the Asian Development Bank; see figure 7). The GDP share of public social security expenditures has not changed substantially in either of the countries during the time for which the data is available. China's low GDP share of pension spending is not explained by its younger population structure alone, because its old-age dependency ratio has nevertheless been almost 50-60 % of that in the US (see figure 3). More importantly, the coverage of the pension scheme, defined as a share of population aged 15-65 covered by mandatory pension schemes, is only approximately 27.7 % in China (2010), compared to 71.4 % in the US (2005) (OECD, 2013). Therefore the model's assumption of full coverage yields conservative
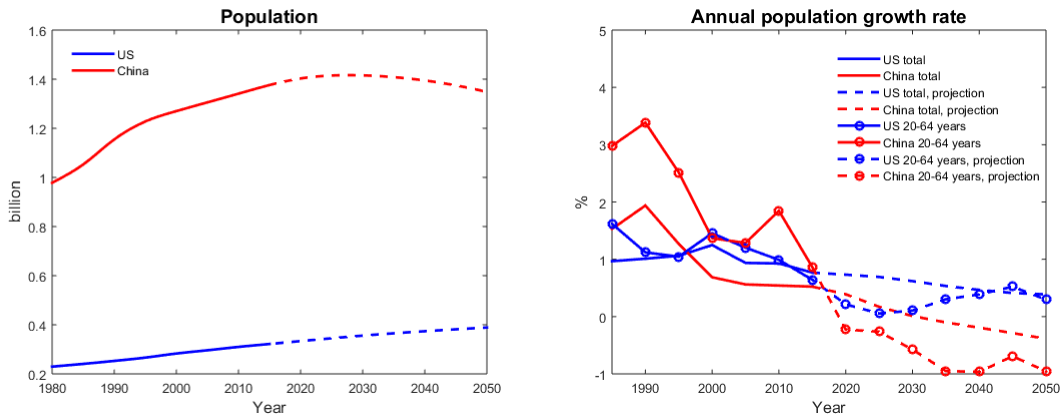
Figure 4: Left panel: Total population in the US and China in 1980-2015 and projections until 2050. Right panel: The annual population growth rate in the given year and 5 preceding years 1985-2015 and projections until 2050. Source: United Nations World Population Prospects: The 2015 Revision.
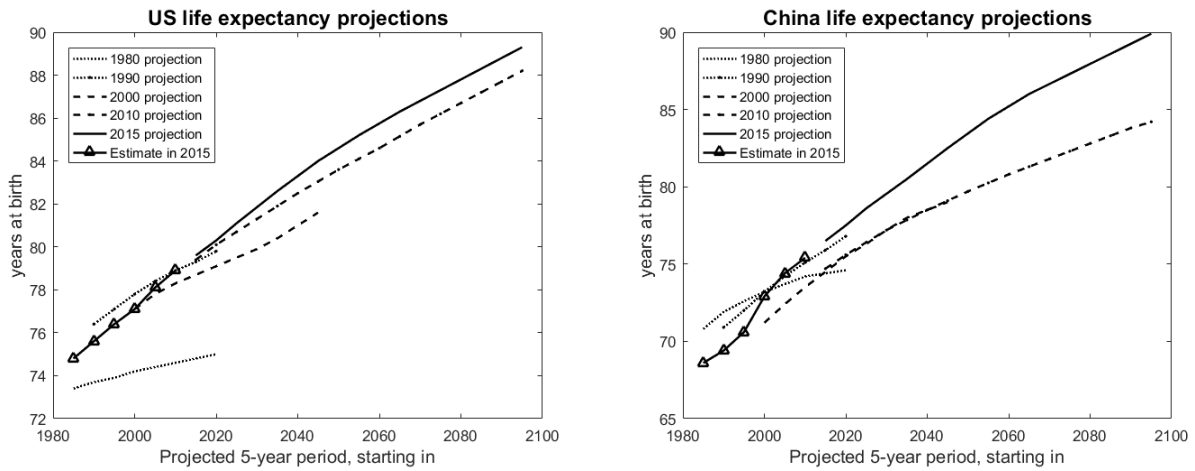
Figure 5: Left panel: Life expectancy at birth, US. Right panel: Life expectancy at birth, China. Source: United Nations World Population Prospects: 1980-2015 Revisions.
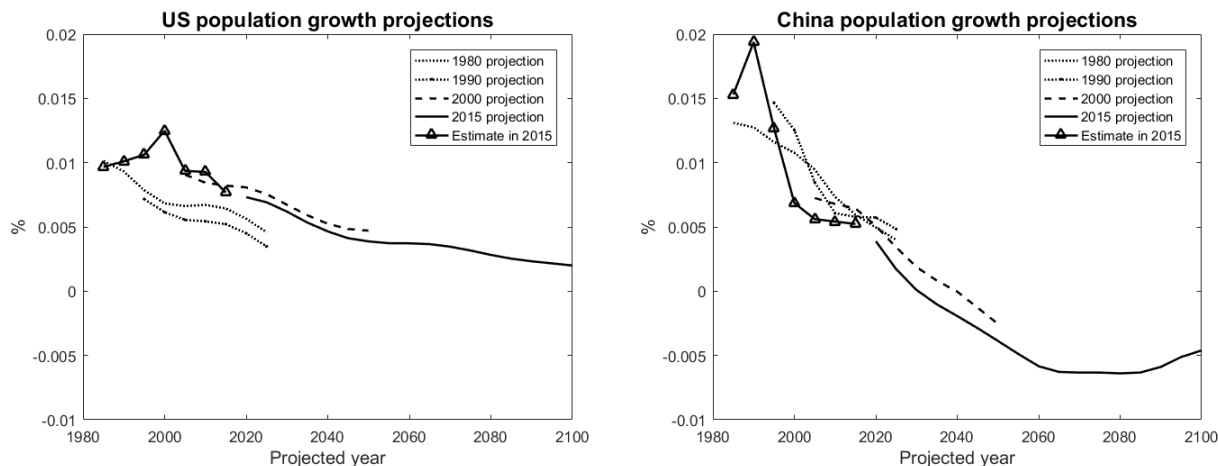
Figure 6: Left panel: Population growth rate, US. Right panel: Population growth rate, China. Source: United Nations World Population Prospects: 1980-2015 Revisions.

results in this respect: assuming heterogeneity in the coverage rate would imply that in China, the vast majority of the population would have no pension income at all. Finally, the pension systems in both countries can be classified pay-as-you-go based on the 3-pillar classification of pension systems by Pallares-Miralles et al. (2012).[34]

In addition to different level of social security expenditures, the countries have also differed in the fiscal policy stances. In the context of the model, these differences can be summarized by the level of government debt and government expenditures. Data of net government debt is not available for China, and therefore government debt is excluded from the analysis. Government expenditures, on the other hand, have for most of the simulation period been higher in the US than in China (on average 15.5 % of GDP in the US and 14.4% in China).

The counterfactual implications about trade surplus and net foreign debt that several neoclassical models in the earlier literature (including Ferrero, 2010) imply for China, are driven by its high

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[3]The classification is based on three principles: i) what the basic form of benefit promise is, ii) how the benefits are financed and iii) whether the system is privately or publicly managed. The classification is a simplified version of the World Bank's 5-pillar-classification. The majority of pensions systems under pillars 0 and 1 are PAYG, which supports the classification of the Chinese and American systems as PAYG systems. The Chinese pension system consists of pillars 0 (mandatory, publicly managed pension schemes aiming at adequacy) and 1 (publicly managed and mandatory system aiming at income replacement), both consisting of defined benefits rather than defined contributions. The American pension system, managed under "Social Security", consists of targeted programs under pillar 0 and defined benefit pension schemes under pillar 1. Neither the Chinese nor the American system have elements of pillar 2, which is a scheme that also aims at income replacement, but is privately managed.

[4]See Appendix C for a description of the old-age pension systems in China and the US.
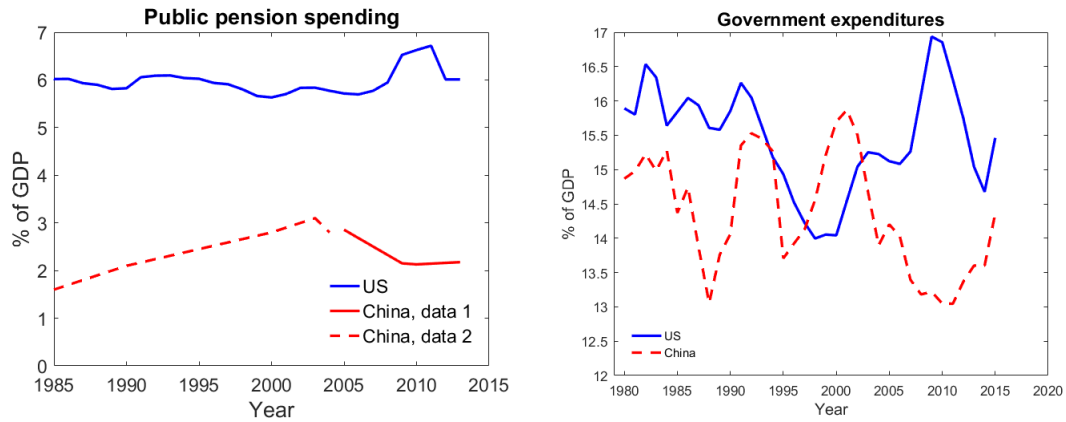
Figure 7: Left panel: Public pension expenditures, % of GDP in the US and China. Source: OECD Data on Social Protection and Asian Development Bank: Social Protection Index Database (data 1); Naughton (2007) (data 2).
Right panel: General government final consumption expenditures. Source: World Bank, World Development Indicators 2016.

productivity growth during most of the simulation period. Figure 8 shows the TFP growth rate for China and the US. On average, total factor productivity (TFP) grew every year by 1,9 % in China and by 0,9 % in the US between 1980 and 2012 .

4.2 Calibration and the steady state

To analyse the dynamics of the external imbalances between China and the US between 1980 and 2015, the time-invariant model parameters are calibrated targeting the means of the trade balance (GDP share), the world real interest rate, consumption and investment (GDP shares) during the simulation period. The model's time-varying exogenous variables include life expectancy, population growth rate, pension expenditures, other government expenditures and TFP, and they are set to match the values directly observable in the data.

Table 1 presents the values of exogenously determined variables related to demography, fiscal policy, pensions and TFP. Because the dynamics are solved with two different simulation methods (with and without updates on the exogenous variables), the table presents the values of exogenous variables for both simulations.

In the first simulation (I), the model is calibrated so that in the initial state, the economies match

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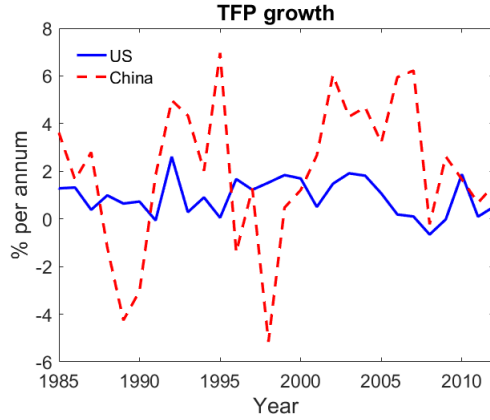
Figure 8: Annual TFP growth in the US and China 1980-2012. Source: Penn World Table.

the 1980 data, and converge to a new steady state in which they match the data in 2015. In the initial and final states, productivity and population growth rates (x and n^w) are the same across the countries to prevent one of the economies from outgrowing the other. The annual productivity growth rate is 1 % in both states, which is the average of the observed growth rates between the countries between 1980 and 2015. The annual growth rate of working age population decreases gradually from 2.15 % in 1980 to 0.5 % in 2015 and thereafter. The probability of staying in the labour force, ω, is the same in the initial and final state, and it is slightly higher in the US than in China ($\omega_{US} = 0.978$ and $\omega_{China} = 0.977$), corresponding to an (effective) age of retirement of 63 years in China and and 65 years in the US. Life expectancy, captured by the survival probability γ, differs between the countries in both states. It corresponds to the observed values of 74 years (US) and 68 years (China) in 1980 and 79 years (US) and 75 years (China) 2015, respectively. Government spending and public pension spending are permanently at different levels, matching the average in the data between 1980-2015. Government debt in both countries is 20 % of GDP (recall that no data on Chinese government net debt is available).

In the second simulation (II), the model is calibrated so that in the initial state, the economies match the 1980 data and converge to a new steady state. However, the agents' information set regarding the values of exogenous variables during the transition and in the terminal point, as well as the date when the terminal point is reached, is updated in each period. In particular, the agents' information

set regarding demographic variables consists of the most recent UN population forecast. As the UN population forecast is updated, agents information set is updated. The values of the demographic variables in each simulation round the projected values of the most recent UN forecast. In the final step of the simulation, the final steady state values match the predicted values for 2100 according to the 2015 UN forecast. The annual steady state growth rate of working age population decresases gradually from 2.15 % in 1980 to 0 % in the final steady state, which is the average population growth rate projected for the countries for 2100. Life expectancy increases from the 72.9 years (US) and 67.3 years (China) in 1980 to 88.7 years (US) and 85.2 years (China) in 2100. Other exogenous variables are as before.

Exogenous variable / targeted moment	Data			Model			
				I: Deterministic simulation		II: Deterministic simulation with updates	
	1980	2015 / at final steady state	Mean 1980-2015	Initial state 1980	Final steady state 2015	Initial state 1980	Final steady state
x_1, x_2 technology growth rate (US, China)			0.01 (mean between China and the US)	0.01	0.01	0.01	0.01
n_1, n_2 population growth rate (US, China)	0.0215 (mean between China and the US) (I and II)	0.005(projected mean in 2050) (I) 0.00 (projected mean in 2100) (II)		0.0215	0.005	0.0215	0.00
γ_1 probability to survive (if retired) / life expectancy at birth (US)	74.3 years (estimate 2015) (I) 72.9 years (estimate 1980) (II)	78.9 years in 2015 (estimate 2015) (I) 88.7 years in 2100 (projection 2015) (II)		0.894 / 74.3	0.932 / 78.9	0.8758 / 72.9 (first iteration; updated in each iteration round)	0.9580 / 88.7 (last iteration; updated in each iteration round)
γ_2 probability to survive (if retired) / life expectancy at birth (China)	67.5 years (estimate 2015) (I) 67.3 years (estimate 1980) (II)	75.4 years in 2015 (estimate 2015) (I) 85.2 years in 2100 (projection 2015) (II)		0.764/ 67.5	0.925/75.4	0.7506 / 67.3 (first iteration; updated in each iteration round)	0.9543 / 85.2 (last iteration; updated in each iteration round)
ω_1 probability to stay in the labour force / effective retirement age (US)			65 years (I & II)	0.9777 / 65	0.978 / 65	0.978 / 65	0.978 / 65
ω_2 probability to stay in the labour force / effective retirement age (China)			63 years (I & II)	0.9767 / 63	0.977 / 63	0.977 / 63	0.977 / 63
b_1 government debt, % of gdp (US)				0.2	0.2	0.2	0.2
b_2 government debt, % of gdp (China)				0.2	0.2	0.2	0.2
g_1 government spending, % of gdp (US)			0.155	0.155	0.155	0.155	0.155
g_2 government spending, % of gdp (China)			0.144	0.144	0.144	0.144	0.144
s_1 social security spending, % of gdp (US)			0.06	0.06	0.07	0.06	0.06
s_2 social security spending, % of gdp (China)			0.02	0.02	0.02	0.02	0.02

Table 1: Exogenous variables data and in the model.

Table 2 presents the values of time-invariant parameters, which are the same in both experiments. Labour share α is as in Ferrero (2010) and discount factor β as in Kilponen et al. (2006). Depreciation rate δ is 20 %. Consumption share in utility v, the relative productivity of retirees ξ and elasticity of intertemporal substitution σ and the investment adjustment cost factor ϕ are chosen so as to match the key moments. Parameter values are the same across the countries.

Parameter (targeted moment)		Value	Source
$\beta\ (R)$	discount factor	0.99	Kilponen et al. (2006)
α	labour share	$\frac{2}{3}$	Ferrero (2010)
δ	depreciation rate	0.2	
ϕ	investment adjustment cost factor	3	
σ	elasticity of intertemporal substitution	0.55	Ferrero (2010)
ξ	productivity of a unit of labour, retiree to worker	0.5	
v	elasticity of period utility with respect to consumption	0.7	

Table 2: Parameter values.

	Variable (mean 1980-2015)	Data		Model	
			Source	I: Deterministic simulation	II: Deterministic simulation with updates
R	World real interest rate	1.03	Real interest rate: IMF, International Financial Statistics. CPI inflation: IMF, World Economic Outlook 2015.	1.03	1.03
$\frac{NX_1}{Y_1}$	Trade balance / output (US)	-0.01		-0.01	-0.02
$\frac{NX_2}{Y_2}$	Trade balance / output (China)		World Bank, World Development indicators.	0.01	0.02
$\frac{C_1}{Y_1}$	Consumption / output (US)	0.65		0.52	0.53
$\frac{C_2}{Y_2}$	Consumption / output (China)	0.44		0.50	0.50
$\frac{I_1}{Y_1}$	Investment / output (US)	0.22	IMF, World Economic Outlook 2015.	0.33	0.34
$\frac{I_2}{Y_2}$	Investment / output (China)	0.40		0.36	0.35

Table 3: Comparison of simulated moments versus data.

4.2.1 Steady state implications of the model

Throughout the simulation period, China has had a younger population, lower retirement age and lower levels of social security and government expenditures than the US. This section presents a comparative

static analysis around the steady state to illustrate the effects of life expectancy and social security in the model.

Figure 9 shows the steady state effects of life expectancy. The economies are assumed to be in 2015 steady state of the deterministic simulation so that the values of the exogenous variables in both of the countries match the average of the observed values between the countries in 2015. Only the value of the parameter γ, which determines life expectancy, differs. In the US,$\gamma_1 = 0.9319$, which corresponds to a life expectancy of 79 years, and in China, γ_2 varies between 0.92 and 0.9319. At the dotted vertical line the life expectancy in China matches the observed value in 2015 ($\gamma_2 = 0.9247$ corresponding to a life expectancy of 75.4 years), where the difference in life expectancies between the countries is 6.8 years. This implies a positive trade balance of 0.002 % of GDP and a negative net foreign assets position of 4 % of GDP for China in the steady state. The smaller the life expectancy in China is, the larger is its trade surplus and net foreign debt in the steady state.

The model predicts that the country with relatively old population accumulates a positive net foreign asset position and satisfies its higher consumption demand by importing goods from abroad. Higher life expectancy increases the households' motive to save for retirement and therefore their financial wealth is higher in the country with higher life expectancy.[5] Households' financial wealth is invested partly in foreign assets: the world interest rate is below the autarky rate of the country with lower life expetancy, and therefore it is willing to borrow from abroad. Even though the country with higher life expetancy is constantly running a trade deficit, it earns a high enough interest rate on its foreign assets to be able to hold a positive net foreign asset position. Even though the marginal propensities to consume (henceforth, mpc's) are lower in the country with higher life expetancy, its consumption is high because its residents are wealthier and a higher share of nonhuman wealth is held by retirees.

The higher the life expectancy in China (the larger γ_2), the lower is the world real interest rate, as the aggregate financial wealth in the world is higher. The effect is quantitatively similar to what was observed by Ferrero (2010).

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[5]The impact of population ageing on households' choice can be non-monotonic because of endogeneity of labour supply and households' heterogeneity. Higher life expectancy increases households' saving but also their labour supply. Under certain calibrations, if the life-expectancy is high enough, the increase in labour supply by retirees can be large enough to mitigate the need for workers to increase their savings, in which case the interest rate in an ageing economy may fall (see discussion in Fujiwara and Teranishi, 2008).
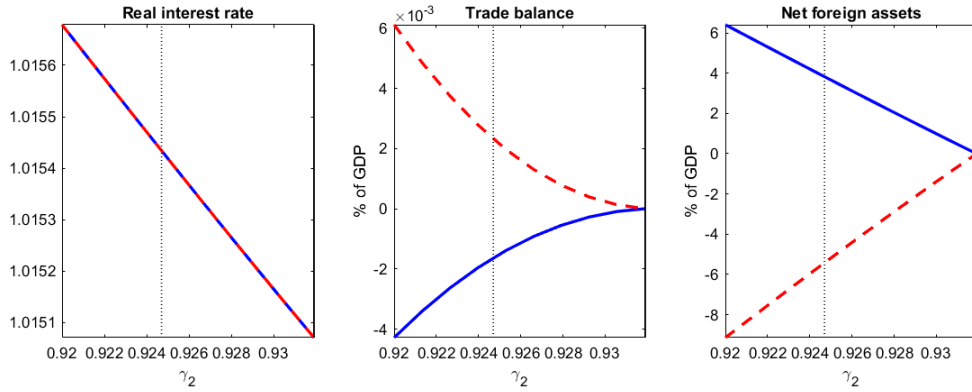
Figure 9: Steady states for $0.92 \leq \gamma_2 \leq 0.9319$ and $\gamma_1 = 0.9319$ with distortionary taxes (blue line = US and red dotted line = China). At the leftmost vertical line, $\gamma_2 = 0.9247$, which corresponds to the observed life expectancy in China in 2015.

Figure 10 presents the comparative statics with public pension spending. As before, the economies are assumed to be identical in other respects, and the values of exogenous variables corresponds to the average of observed levels in 2015. Public pensions spending in the US is set at 6 % of GDP and varies between 2 and 6 % in China. The observed 4 % difference in the share of GDP that is spent on public pensions implies a trade deficit of 1.5 % of GDP and a positive net foreign assets position of 70 % of GDP for China in the steady state. The higher the social security spending in China is, the smaller is its net foreign asset position and the larger its trade surplus in the steady state.

Because the Chinese retirees have lower pension income, Chinese households accumulate more assets before retirement and therefore have more financial wealth. The high level of financial wealth pushes down the world real interest rate. The world interest rate is below the US autarky rate, which causes capital flows from China to the US. Due to the lower pension expenditures, China can also maintain a lower tax rate, which leads to higher labour supply and level of human wealth. As the residents in China have more human wealth and assets in the steady state, its aggregate consumption is higher. The model therefore predicts China to constantly import more, and finance the imports with interest payment on its foreign assets. The effect of social security on external imbalances is remarkable, and it seems likely that social security can be an important factor in understanding the high level of savings in China.

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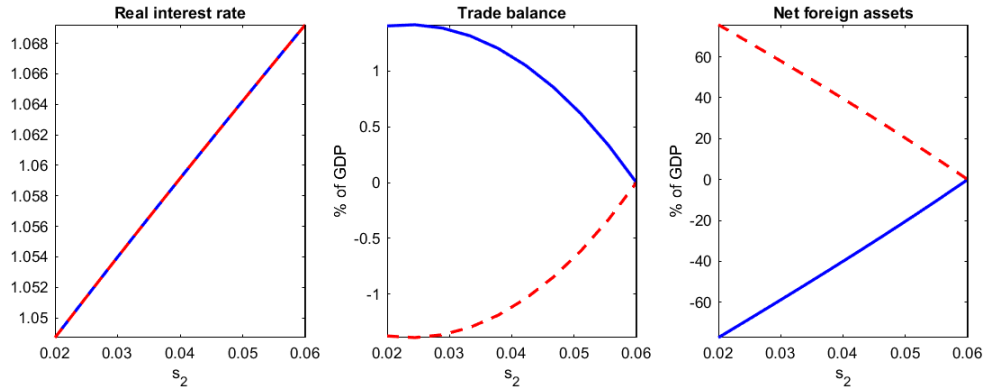
Figure 10: Steady states for $0.02 \leq s_2 \leq 0.06$ and $s_1 = 0.06$ with distortionary taxes (blue line = US and red dotted line = China).

Other features that distinguish the economies are the relatively low effective retirement age and low level of government expenditures in China. Low retirement age predicts a positive net foreign assets for the US in the steady state. Low government expenditures imply the opposite, namely a positive net foreign assets position in the steady state. In comparison to the effects of life expectancy and social security, the effects of retirement age and government expenditure are however small.

4.3 Deterministic simulation

In this simulation, the economies are assumed to be initially in a state in which the exogenous variables match the data in 1980, and then converge to a new steady state, in which the the exogenous variables match the data in 2015. During the transition, the exogenous variables follow the path observed in the data.[6]

The steady state analysis suggests that both demographic transition and the low level of social security expenditures could explain the dynamics of the trade balance of China vis-a-vis the US, which is simulated in this subsection. The approach I follow is sequential: first demographic transition is introduced, while all other factors are kept constant; then fiscal policy shocks and differences in public social security spending are introduced; and finally, temporary fluctuations in TFP growth rates are introduced.

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[6]The values of g_1, g_2, s_1, s_2, nw_1, nw_2, x_1 and x_2 match exactly the values in the data, plotted in figures 4, 7 and 8. The life expectancy parameters, γ_1 and γ_2, converge faster than in the data to obtain model convergence.
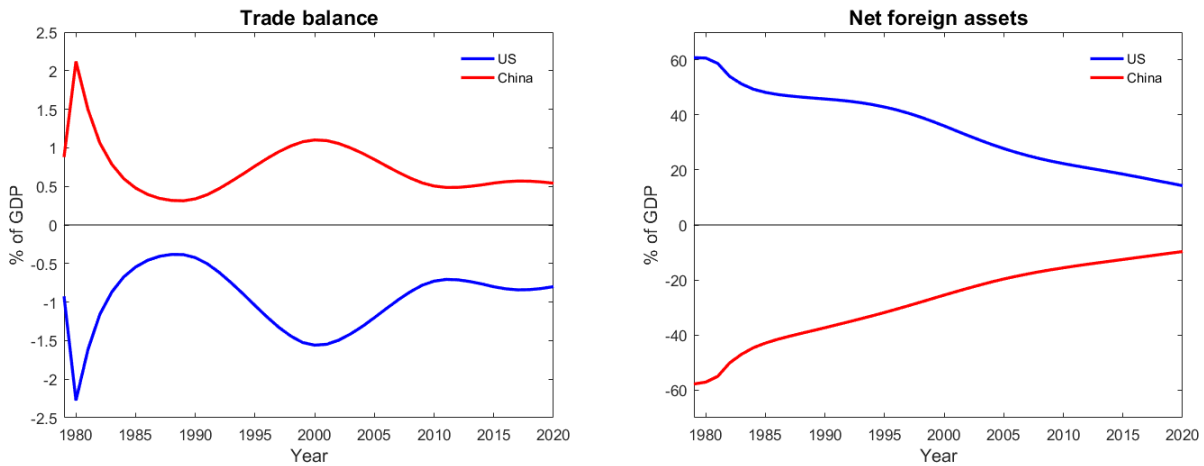
Figure 11: Left panel: Effects of a permanent demographic changes on the trade balance.
Right panel: Effects of a permanent demographic changes on the net foreign asset position.

The dynamic effects of demographic transition The demographic transition captured by this simulation entails a slowdown of population growth and increase of life expectancy in both countries. In the model, we are able to match the population growth rates exactly (see the data in figure 4), but need to assume faster increase in life expectancy than in the data to avoid numerical problems that would otherwise arise in the model solution algorithm. The results of the dynamic simulation for the trade balance and the net foreign asset position are shown in figure 11.

Consistently with the steady state results, higher retirement age and life expectancy together imply a positive net foreign asset position and negative trade balance for the US in the initial state. The size of the net foreign asset position is approximately 60 % of GDP and trade deficit 1 % of GDP for the US. In the initial state, life expectancy is higher in the US than in China, and therefore US has more financial wealth than China, and holds positive amount of foreign assets. China has accumulated a negative foreign asset position and is running a trade surplus in order to repay its debt.

As the life expectancy increases in both of the countries, the mpc's fall for both the retirees and the workers: households need to increase their savings because of the longer time spent in retirement. The households in both countries start to accumulate more financial wealth, and consumption of both retirees and workers initially falls. In China, the fall in mpc's is much larger as its life expectancy increases more. At the same time, as the savings increase, the real interest rate falls, which leads to an

increase in investment, as the adjustment to a new steady state with higher capital stock begins. In China, the increase in savings is larger than investment, and its trade balance temporarily improves. In the US, the increase in savings in smaller than the increase in investment, and the US trade balance weakens. Investments in the US are higher than they would be in autarky, because the increase in Chinese savings pushes down the real interest rate more than the US savings alone would. As the US trade balance weakens, and as the fall in the interest rate causes the returns on its foreign assets to fall, its stock of foreign assets starts to fall.

In both countries, investment gradually returns to the steady state level, which causes the US' trade balance to improve. Investments also fall in China, but the trade balance nevertheless worsens, as its aggregate consumption starts to increase. In the US, consumption remains at a lower level. In both countries, consumption by workers declines, but in China, the increase increase in retirees consumption causes aggregate consumption to increase. This drags down the trade balance in China. At the same time, its net foreign asset position improves. As the age structures between the countries become more similar, the external imbalances become smaller.

The fluctuations in the simulated trade balance, for example the notable fall in the Chinese trade surplus in late 1980s, are caused by the high population growth during the period. Relatively high population growth in China means that investments need to increase to maintain an equal rate of return across countries, which temporarily weakens the trade balance.

The relatively fast population ageing in China therefore causes a slow and continuous decline in the net foreign asset position of the US, which resembles the downward trend observed in the data.

The effect of a permanent difference in social security and fiscal policy I now introduce differences in government expenditures and social security spending, in addition to the demographic transition. Public pension spending is assumed to grow slowly from 6 % to 7 % of GDP in the US. In China, public pensions spending is 2% of GDP during the entire simulation period. Government debt as a share of GDP is at the same level in both countries, since data on Chinese government net debt is not available. The results of the dynamic simulation are shown in figure 12.

The effect of public pension expenditures on the external imbalances is remarkable. Consistently with the steady state results presented in section 4.2, low public pension expenditures in China have a
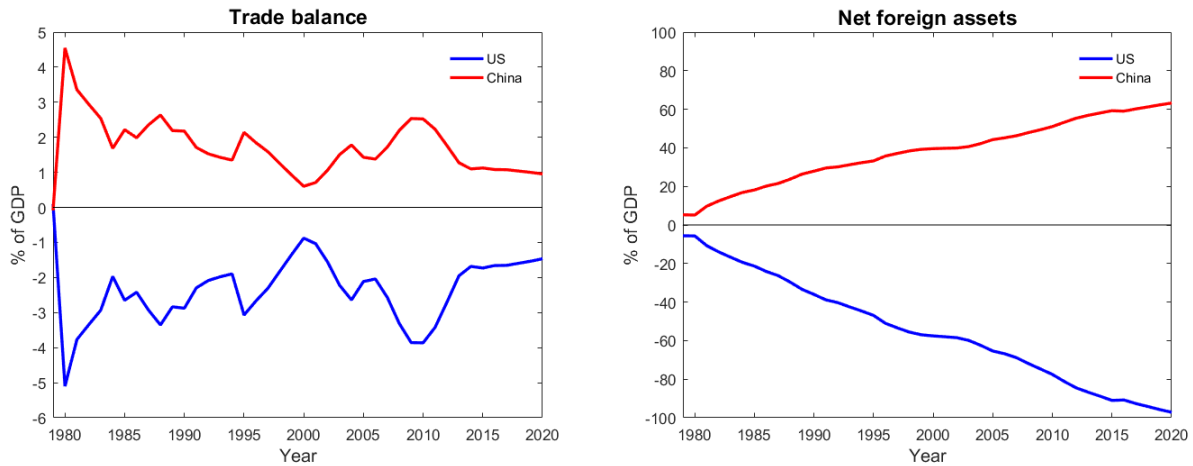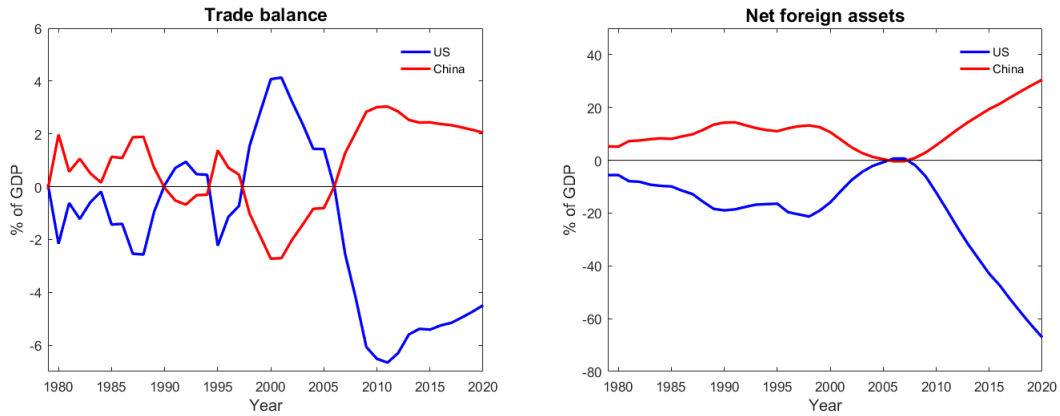
Figure 12: Left panel: Effects of a permanent demographic changes with social security and fiscal policy on the trade balance.
Right panel: Effects of a permanent demographic changes with social security and fiscal policy on the net foreign asset position.

positive effect on its initial net foreign asset position: whereas the demographic factors would predict a positive net foreign asset position for the US of approximately 50 % of GDP, when differences in social security expenditures are accounted for, the initial net foreign asset position is slightly negative. Despite of life expectancy being lower in China, low pensions raise the aggregate level of non-human wealth in the economy.

The effect of government expenditures is small, but nevertheless the higher government expenditures in the US weaken its net foreign asset position in the steady state. Higher government expenditures increase the tax rate, and lower the labour income of employees in that country. This crowds out private consumption and savings: the steady state trade balance is more positive (because of lower consumption), but the net foreign asset position of the country weakens (because of lower savings).

Social security has a significant effect on the level of external imbalances, but the dynamics are still driven by the demographic changes, as described in the previous section. As life expectancy starts to increase fast especially in China, its net foreign asset position vis-a-vis the US becomes positive, as observed in the data. Together these features predict dynamics that qualitatively match the data well.

Figure 13: Left panel: Effects of a permanent demographic changes, social security, government expenditures and TFP growth on the trade balance.
Right panel: Effects of a permanent demographic changes, social security, government expenditures and TFP growth on the net foreign asset position.

The effects of productivity growth fluctuations   The last shock I introduce now is the temporary TFP fluctuations. The permanent level of productivity growth remains unchanged. Figure 13 reports the resulting dynamics. As expected, TFP shocks have a strong impact on the trade balance. Periods of relatively high productivity growth in China are reflected in relatively high investment and consumption, which weaken its the trade balance and the net foreign asset position. However, due to the underlying demographic trends and differences in social security and government expenditures, there is an increasing trend in the Chinese net foreign asset position. Indeed, only during the period of high TFP growth in China in the mid-2000s the model counterfactually predicts that the net foreign asset position becomes negative. However, the model predicts a positive trade balance for most of the periods in the sample years.

Figure 14 shows the simulation decomposed into the effects of demographic transition and the marginal effects of pensions and fiscal policy and TFP. Even though the negative impact of TFP shocks weakens the US trade balance especially in the early 2000s, the opposite effects of demographic factors, social security and fiscal policy predict a trade deficit for the US especially in the beginning of the simulation period. In China, where population is larger and TFP level lower, the effects of demographic factors as well as fiscal policy and social security are more significant. Finally, a key element in the model is social security. Without social security, the model would predict a counterfactual trade deficit
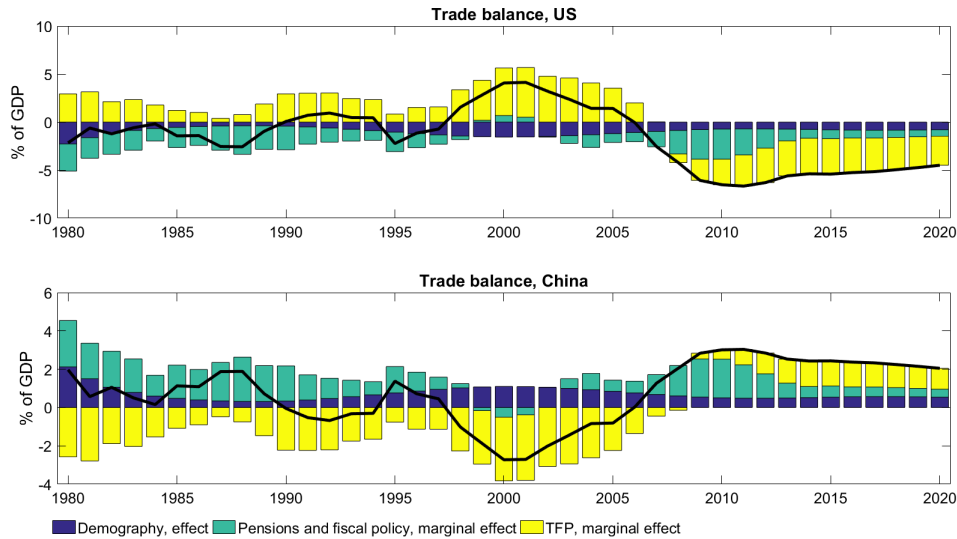
Figure 14: Decomposition of the effects of demographic factors and marginal effect of pensions and fiscal policy and TFP on the dynamics of the trade balance.

and foreign debt for China for almost the entire simulation period.

4.4 Deterministic simulation with learning

A shortcoming of the deterministic simulation used in the previous subsection is that the paths of the exogenous variables are known to the agents at the beginning of the simulation period. This subsection presents an alternative solution to the model, in which a deterministic simulation is performed in every period of the simulation period, but the shocks and paths of exogenous variables are allowed to change. In particular, in each period, the initial values of the exogenous and endogenous variables are given by the simulation in the previous period, and new transition paths are solved based on the updated information. Innovations in exogenous variables are unanticipated unlike in the previous simulation. This approach allows the agents to update their knowledge on the future paths of exogenous variables. The transition paths are constructed as a compilation of values of different rounds of simulation.

The assumptions regarding the future paths of exogenous variables are as follows. In each period, the agents are assumed to know the paths of life expectancy and population growth as given in

the vintage of the UN population forecast (plotted for selected years in figures 5 and 6). TFP and government expenditures are assumed to follow AR(1) processes known by the agents, who estimate the autoregressive parameter given past data in each period. The agents observe the current exogenous realisation of TFP and government expenditures, and forecast the future values given the AR(1) process. Therefore the agents assume that after the temporary shock has occurred, these variables slowly converge to their steady state values. In each period there is a shock to TFP and government expenditures so that the compiled series of these variables exactly match the data (plotted in figures 7 and 8). Therefore, unlike in the deterministic simulation, the agents are not assumed to know the entire path of e.g. productivity growth at the beginning of the simulation. Pension expenditures are assumed to be constant over time.

The results of the simulation are presented in figure 15. The simulated paths of the trade balance and the net foreign asset position match the data better than those obtained with the deterministic simulation. The Chinese trade balance is positive for almost the entire simulation period, an exception being the year 2007, when the TFP was growing at an average rate of 5.1 % for the sixth consecutive year. In contrast, with the deterministic simulation Chinese trade balance is negative between 1990-1994 (-0.4 % of GDP on average) and 1998-2005 (-1.7 % of GDP on average). Because of these periods of trade deficit, the deterministic simulation predicts China's net foreign asset position to be counterfactually negative between 2006-2007. With the simulation with learning, China is predicted to have a positive net foreign asset position which averages 28 % of its GDP during the simulation period. Also for the US, the simulated trade balance and the negative and deteriorating foreign asset position match the observations in the data well.
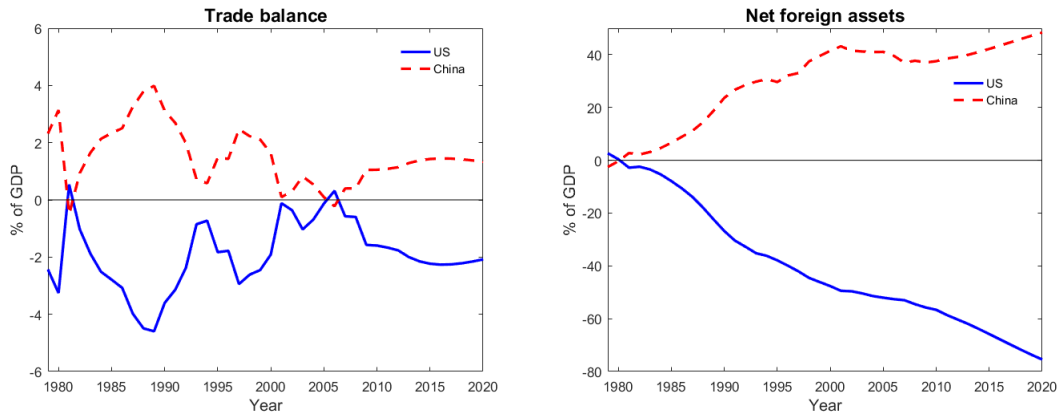
Figure 15: Left panel: Effects of a permanent demographic changes, social security, government expenditures and TFP growth on the trade balance, alternative solution.
Right panel: Effects of a permanent demographic changes, social security, government expenditures and TFP growth on the net foreign asset position, alternative solution.

5 Conclusions

This paper examines whether the relatively fast demographic transition in China combined with its low level of social security can help to explain why China has accumulated a large positive net foreign asset position over the past decades and why the country has been persistently running a positive trade balance vis-a-vis the US. The analysis is done with a model which features a life-cycle structure proposed by Gertler (1999) and a pay-as-you-go pension system along with endogenous labour supply and distortionary taxation.

The results show that demographic transition together with the low level of social security expenditures can help to explain the observed long lasting trade and current account surpluses of China vis-a-vis the US. The fast increase in life expectancy increases Chinese savings and generates current account and trade surpluses. The model predicts a long lasting improvement in China's net foreign asset position and a positive trade balance for most of the simulation period. The role of low social security income in explaining the observed pattern is crucial. Even though the life expectancy grows faster in China, it still remains lower than in the US for the entire simulation period, and therefore without social security, the model would predict a counterfactual negative trade balance and net foreign asset position for China.

Temporary TFP fluctuations remain important drivers of the trade balance, but even after controlling for the effects of productivity growth, the model predicts a positive trade balance and net foreign asset position for China for most of the simulation period. TFP growth rate fluctuations cause more volatility to the trade balance if the model is solved deterministically than when the alternative method is used, in which the temporary shocks are not known in advance and agents learn gradually. Therefore with this method, the impact of the TFP fluctuations is smaller and the results better aligned with data.

As the features in the model are not specific to China, the model could also be used to analyse the relationship between other emerging and industrialized economies. Given the similarities in demographic trends in other emerging economies and the relatively low level of social security commonly observed, the model is likely to predict a similar pattern for several other emerging economies.

Finally, the analysis omits the effects of the Chinese central bank policies including foreign exchange policies, capital controls and trade policies, as well as financial market imperfections. I leave this for future research.

A   Trade balance
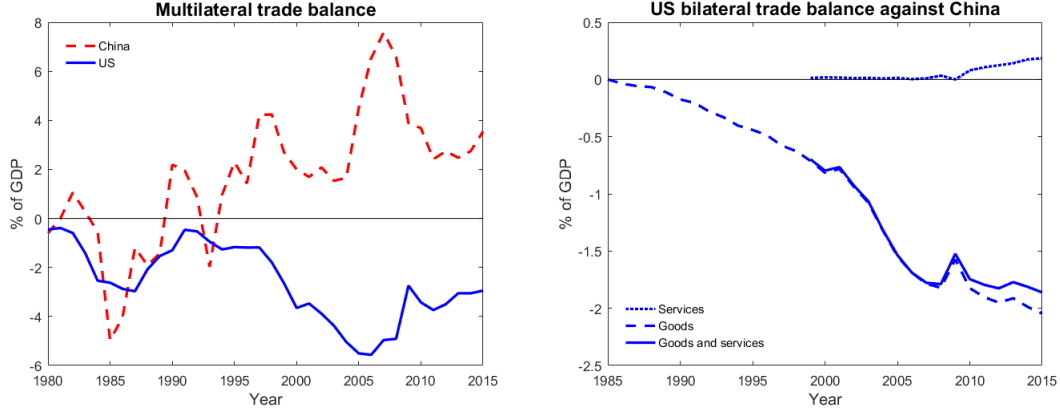
Figure 16: Left: External balance on goods and services 1980-2015 for China and the US. Source: World Bank, World Development Indicators. Right: US bilateral trade balance against China 1985-2015. Sources: US Census Bureau (goods) and Bureau of Economic Analysis (goods and services since 1999).

B   Life-cycle structure

Population in a country at time t consists of two groups of individuals: workers, whose total number is N_t^w, and retirees, whose number equals N_t^r. All agents enter the economy as workers at the age of 20 and remain workers with probability $\omega_{t,t+1}$ and retire with probability $1 - \omega_{t,t+1}$. Every period $(1 - \omega_{t,t+1} + n_{t,t+1}) N_t^w$ new workers are born. Thus the number of workers grows each period at rate $n_{t,t+1}$ and the law of motion for aggregate labour force is

$$N_{t+1}^w = (1 - \omega_{t,t+1} + n_{t,t+1}) N_t^w + \omega_{t,t+1} N_t^w = (1 + n_{t,t+1}) N_t^w \ . \tag{27}$$

At time t, probability of a retiree to survive to the next period is $\gamma_{t,t+1}$. The law of motion for the number of retirees is

$$N_{t+1}^r = (1 - \omega_{t,t+1}) N_t^w + \gamma_{t,t+1} N_t^r \ . \tag{28}$$

The ratio of number of retirees to the number of workers, dependency ratio, is given by $\psi_t = N_t^r / N_t^w$

and can be solved to evolve according to

$$(1 + n_{t,t+1}) \psi_{t+1} = (1 - \omega_{t,t+1}) + \gamma_{t,t+1} \psi_t \ . \tag{29}$$

C Pension systems

China   In the early 1980s, the Chinese pension system covered mostly urban workers in the public sector and state-owned enterprises, and until the early 1990s, all China's pension liabilities were unfunded (Naughton, 2007). After the beginning of the 1980s, the Chinese economy and demographic structure underwent changes that necessitated several reforms in the pension system. The targets of the reforms included increasing the pension coverage to urban employees of private enterprises and eventally, to rural residents, and tackling the challenge posed by the ageing population by setting up a partly funded system.

The current two-tier pension system was introduced in 1998 and revised in 2006 (OECD, 2015). It consists of a public basic pension, which is funded on a pay-as-you-go basis, and a mandatory employee contribution to a second-tier plan. The coverage of the pension system remains mostly limited to urban workers. The second-tier plan, which is a funded individual-account system, was de facto functioning only in 11 out of the 33 Chinese provinces. The pension scheme covers 27.7 % of population aged 15-65 and 33.5 % of the labour force. Depending on individual earnings, the gross replacement rate of the basic pensions system, defined as the pension benefits as a share of individual lifetime average earnings, varies between 30 and 50 % (OECD, 2015). With the defined contribution pillar, the gross replacement rate is approximately 75%.

The US   The public pension system in the United States is called social security and originates in the Social Security Act from 1935. It is a defined benefit, earnings-based public pension scheme. A means tested old-aged pension benefit (Supplemental Security Income) provides additional income for low-income pensioners. The social security covered 71.4 % of population aged 15 to 65 and 92.2 % of the labour force in 2010 (OECD, 2015). The gross replacement rate of the social security varies between 25 % and 45 %, which is low in comparison to the OECD average (OECD, 2015). The

importance of private pensions funds is large in the United States. An approximation by the OECD (2015) shows that if all workers are assumed to contribute annually at the rate of 9% into a voluntary private pension fund throughout their life, the replacement rate of an average earner is 82%.

The social security system is partly funded. Close to all wage income is subject to FICA-taxes (FICA = Federal Insurance Contributions Act tax) which are administered by the Social Security Trust Funds. The Federal Old-Age and Survivors Insurance (OASI) fund holds the accumulated old-age pension fund assets and pais the benefits (The Board of Trustees, 2016). Any excess income is deposited into the fund and invested into special US government bonds (Special Issue Securities; www.ssa.gov). The OASI funds reserves at the end of 2015 were 2780 billion USD. Income in 2015 was 798 billion USD (of which 679 billion USD consisted of payroll taxes) and costs 776 billion USD (of which benefit payments amounted to 769 billion) (The Board of Trustees, 2016).

References

Bárány, Zsofia, Nicolas Coeurdacier, and Stéphane Guibaud, "Fertility, longevity, and capital flows," Technical Report, Reihe Ökonomie/Economics Series, Institut für Höhere Studien (IHS) 2016.

Caballero, Ricardo J., Emmanuel Farhi, and Pierre-Olivier Gourinchas, "An Equilibrium Model of "Global Imbalances" and Low Interest Rates," *American Economic Review*, March 2008, *98* (1), 358–393.

Carvalho, Carlos, Andrea Ferrero, and Fernanda Nechio, "Demographics and Real Interest Rates: Inspecting the Mechanism," *European Economic Review*, March 2016, *98* (1), 358–393.

Domeij, David and Martin Floden, "Population Aging And International Capital Flows," *International Economic Review*, 2006, *47* (3), 1013–1032.

Eugeni, Sara, "An OLG model of global imbalances," *Journal of International Economics*, 2015, *95* (1), 83–97.

Fair, Ray C. and John Taylor, "Solution and Maximum Likelihood Estimation of Dynamic Nonlinear Rational Expectations Models," 1983.

Ferrero, Andrea, "A structural decomposition of the U.S. trade balance: Productivity, demographics and fiscal policy," *Journal of Monetary Economics*, 2010, *57* (4), 478–490.

Fujiwara, Ippei and Yuki Teranishi, "A dynamic new Keynesian life-cycle model: Societal aging, demographics, and monetary policy," *Journal of Economic Dynamics and Control*, August 2008, *32* (8), 2398–2427.

Gertler, Mark, "Government debt and social security in a life-cycle economy," *Carnegie-Rochester Conference Series on Public Policy*, June 1999, *50* (1), 61–110.

Kilponen, Juha, Helvi Kinnunen, and Antti Ripatti, "Population ageing in a small open economy - some policy experiments with a tractable general equilibrium model," Research Discussion Papers 28/2006, Bank of Finland December 2006.

Mendoza, Quadrini, and Rios-Rull, "Rios-Rull, 2009. Financial Integration, Financial Development and Global Imbalances," *Journal of Political Economy*, 2009, *117* (3).

Naughton, Barry, *The Chinese economy: Transitions and growth*, MIT press, 2007.

OECD, "Pensions at a Glance Asia/Pacific 2013," *OECD Publishing*, November 2013.

_ , "Pensions at a Glance 2015," *OECD Publishing*, December 2015.

Pallares-Miralles, Montserrat, Carolina Romero, and Edward Whitehouse, "International Patterns of Pension Provision II," *A Worldwide Overview of Facts and Figures, Social Protection & Labor Discussion Paper*, 2012, (1211).

Saarenheimo, Tuomas, "Ageing, interest rates, and financial flow," Research Discussion Papers 2/2005, Bank of Finland February 2005.

Song, Zheng, Kjetil Storesletten, and Fabrizio Zilibotti, "Growing like China," *The American Economic Review*, 2011, *101* (1), 196–233.

The Board of Trustees, Federal Old-Age and Survivors Insurance and Federal Disability Insurance Trust Funds, "The 2016 Annual Report of The Board of Trustees, Federal Old-Age and Survivors Insurance and Federal Disability Insurance Trust Funds," 2016.