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Li Wang
John Whalley

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ABSTRACT

Given the rapidly growing reserves in Asia (China, Japan, Korea, Taiwan) and the pressures from trading partners to revalue, there is a need to examine commercial policy in more than a pure barter model. Here we evaluate the joint impacts of exchange rate appreciation on trade flows and country surpluses using a general equilibrium trade model with a simple monetary structure in which the trade surplus is endogenously determined in the exchange rate setting country and the exchange rate is exogenous. We illustrate its application to the Chinese case using calibration to 2005 data. Our results, while elasticity dependent, suggest that the impacts of Renminbi (RMB) revaluation on the surplus are proportionally larger than on trade flows, and that changes in trade flows can be substantial. Different treatments of China's processing trade have small impact on changes in China's trade flow under RMB appreciation, but significant impacts on the change in the surplus. Results are elasticity dependent; larger substitution elasticities in preferences yield larger effects on trade flows and the surplus.

Li Wang
Department of Economics
University of Western Ontario
London, ON
Canada
N6A 5C2
lwang363@uwo.ca

John Whalley
Department of Economics
Social Science Centre
University of Western Ontario
London, Ontario N6A 5C2 CANADA
and NBER
jwhalley@uwo.ca

1. Introduction

Given the rapidly growing reserves and trade surpluses both in major Asian exporters (China, Japan, Korea) and elsewhere (India, Russia) it is clearly unsatisfactory both to analyze commercial policy in these countries in pure barter trade models, and to separately analyze the impacts on trade and reserve accumulation of exchange rate changes. Despite this, currently available literature focuses on either trade policy changes ignoring monetary structure, or trade impacts of exchange rate changes in structures where trade pattern changes do not follow from a trade model. Here, we attempt to bridge this gap using a trade model with simple monetary structure in which the surplus is endogenous. We abstract from all asset holding and intertemporal effects and money is simply a medium of exchange reflecting a transactions demand. Money is non neutral since domestic monetary policy does not accommodate to the fixed exchange rate, and there is excess supply of foreign exchange to the central bank. The central bank accommodates this by making domestic currency inconvertible and absorbing all excess foreign exchange offered.

Nowhere are these issues more pronounced than in Chinese case, where reserves now exceed $1 trillion and annual surpluses approach $20 billion. This has generated intense pressure on China to revalue, and as a result there has been substantial interest in the potential impacts of a significant Renminbi revaluation on trade flows and patterns, as well as in the size of revaluation which might ultimately be needed to restore external sector balance.

Most of the available literature uses econometric models with no explicit trade structure. Park (2005), for instance, using the Oxford Economic Forecasting model, finds that if China revalued by 10% the Chinese trade surplus would fall by $15 billion. Kamada and Takagawa (2005), employing the Asian Economy Model, report that a 10% appreciation of the RMB would cause the aggregate Chinese trade surplus to fall by 0.5% of Chinese GDP. However, as the IMF (2005) notes few of these

studies report changes in China's exports and imports. Marquez and Schindler (2006), using an autoregressive distributed lag model, find that a 10% appreciation of the RMB would reduce China's share of world exports by 0.5% and China's share of world imports by 0.1%.

Other studies of Renminbi revaluation use general equilibrium models in which monetary structure is absent. The IMF (2005), utilizing a partial equilibrium framework, conclude that a 10% Renminbi appreciation would reduce China's trade surplus by $10 billion. Willenbockel (2006), using a general equilibrium model with different fixed labor supply and unlimited labor supply assumptions simulates a revaluation of the RMB by 4%, and finds that a 4% RMB revaluation, would increase China's exports by 10.5% or 13.6%, and exports would fall by 10.7% or 11% depending upon the assumptions used.

Another commonly held view in China is that given China's large processing trade and the importance of FDI inflows for trade performance, trade impacts will be small as most export costs are already effectively foreign currency denominated. FIEs, for instance, which use FDI for platform export production currently account for around 60% of both China's exports and imports, but have wage costs of around $ 30 billion compared to sales of perhaps $400 billion. Trade impacts of RMB revaluation are also acknowledged to be elasticity dependent, but there are no reliable estimates of relevant elasticity parameters for China and estimates for other countries are typically used.

In our model, we characterize reserve accumulation as driven by government or central bank policy which sets non accommodative monetary policy given the exchange rate and simply absorbs any supply of foreign currency it is offered (dollars) at the set exchange rate maintaining inconvertibility of domestic currency. We thus develop a simple monetized extension of a conventional trade model with the added structure that the trade surplus (and surplus induced additions to reserves) is

endogenously determined. To our knowledge this structure, while simple, is novel.

We use a calibrated form of this model using 2005 data[1] forward scaled from both the Chinese 2000 input-output table and international source for earlier years when surpluses were smaller. We thus calibrate to the actual 2005 surplus. We use a 2 country format, and using this calibrated model we are able to compute counterfactuals and assess the potential impacts of both small to relatively mild revaluations of the Renminbi (5%-10%) as well as a larger revaluation (20%). Our results show larger percentage impacts on the trade surplus than on trade flows directly. Trade flow impacts, in turn, depend critically on the elasticity parameters used in the model.

[1] This data is discussed in section 5.

2. China's trade flows, foreign exchange reserves and foreign exchange rate regime

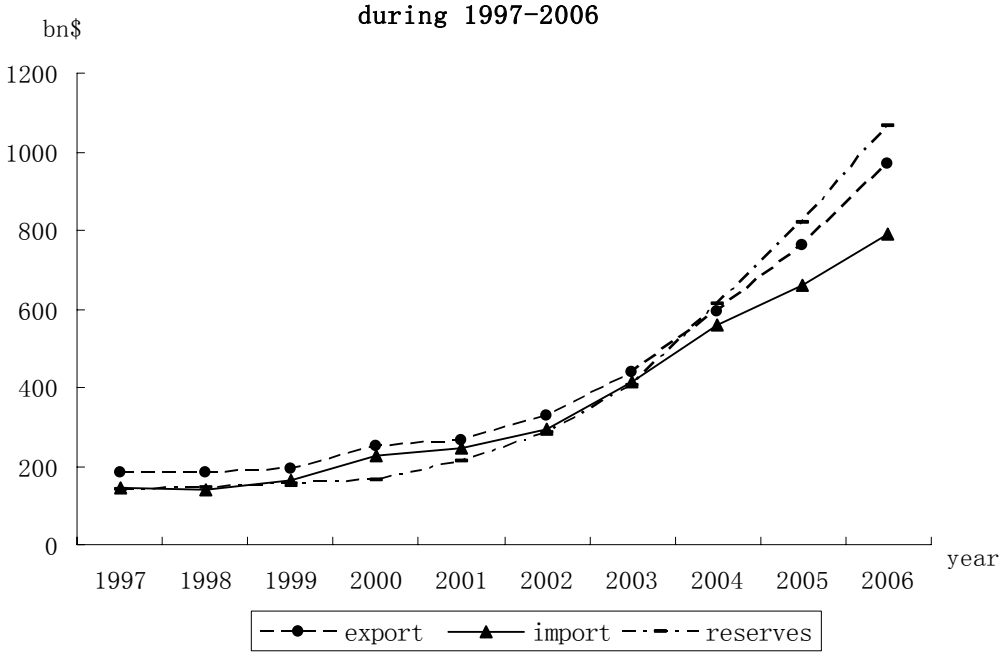
As the more complex model which follows is designed to be reflective of the situation in China, we first discuss relevant background information on China's policy regime. Both reserve accumulation in China and the large trade surplus are a reflection of the joint exchange rate and monetary policies pursued by China's monetary authorities. The RMB was inconvertible and its exchange rate was pegged to the dollar through the 1960's to the early 1990's. With significant domestic inflation, excess demand for foreign exchange resulted with (in the 1980's and early 1990's) associated black market activity. The RMB was devalued to approximately its current level in the early 1990's, and inflation has slowed since. And with sharp growth in exports and inflows of FDI, excess demand for foreign exchange has been replaced by excess supply. This has been absorbed by the central bank through reserve accumulation, with the RMB inconvertible.

The indications are thus of a significant and growing RMB misalignment especially from 2002 on, with the Chinese government maintaining rigid exchange rate regulations and a peg of the RMB against the US Dollar at a fixed rate. In July 2005, when around 70% of the reserves were in US bank notes, under the pressure from the US government, the Chinese government announced an effective 2.4% revaluation of the RMB against the dollar and committed to future exchange rate targets in terms of a trade-weighted currency basket.

Given the potential inflationary consequences of large accumulation of foreign reserves, the Chinese government partially sterilizes its foreign reserve acquisitions by issuing central bank bills and bonds as well as through controls on bank lending. Despite these sterilization efforts, M1 grew by 19% in 2003 and 16.9% in 2005, but given strong Chinese growth, inflation as measured by the CPI rose from 1.2% in 2003 to 1.8% in 2005 (NBS, 2003, 2005).

On the trade side, between 2000 and 2004, the average growth in China's imports and exports exceeded 20% and kept growing in 2005 and 2006[2]. The resulting trade surplus sharply increased China's foreign exchange reserves (See Figure 1). In 2005, the trade surplus also increased due to a slowing down in the growth rate of imports, following restrictions that the Chinese government introduced in 2004 to cool the boom, and a growth in exports of apparel, following the abolition of the multi-fiber agreement (MFA) in January 2005. However, with continuing export growth in many sectors, not just in apparel, by 2006, China's foreign exchange reserves had reached $1 trillion in comparison with only $165 billion in 2000.

Figure 1 China's export, import and reserves during 1997-2006



Data source: China's exports and imports from NBS, "China Statistical Year Book" between 1997 and 2004; and from NBS, "Statistical communiqué of the People's Republic of China on the 2005 (2006) National Economic and Social Development" for 2005 and 2006. Foreign currency reserves are from State Administration of Foreign Exchange, PRC.

[2] The growth rates for China's exports and imports in 2005 and 2006 are: 28.4% and 27.2% for exports, 17.6% and 20.0% for imports.

While China's rapid accumulation of US dollar reserves has been primarily driven by a growing trade surplus over 10 years, other factors have also contributed. One has been net inward FDI flows which, while growing at a relatively moderate pace, average around $60 billion per year. Speculative portfolio and other investment inflows in anticipation of a RMB appreciation are also believed to have played an important role in China's reserve accumulation.

In the last year or so, reserves have increased by more than $100 billion. The pressure on Chinese authorities to revalue the RMB has correspondingly grown, and with it have come concerns over the impact of any significant further revaluation on performance, and especially trade performance. Arguments that little impact will result focus on a significant processing component of trade in which both inputs (imports) and outputs (exports) are foreign currency denominated, and elasticities which have to be unrealistically high for significant impacts to occur. The alternative view that impacts will be larger focuses on a range of factors which will fuel larger impacts including FDI inflows and changes in speculative capital flows.

3. A simple monetary trade model of the Chinese exchange rate and trade regime

To analyze the impacts of RMB appreciation we use a simple trade model with monetary structure. In this impacts on speculative capital flows and FDI inflows are put on one side, and it is the endogeneity of the trade imbalance via reserve accumulation to support a fixed exchange rate. This additional monetary structure is missing in other related modeling work such as Willenbokel (2006).

We depart from classical monetized extensions of real side barter type trade models where money is neutral. In such models, in a two country world each with a national money and a simple fixed velocity transactions money demand, once the domestic money stocks are specified exchange rates are endogenously determined. There are no effects of introducing money on consumption, production or trade. Any change in either or both country money stocks results in a change in the exchange rate between the national monies, but with no impact on real trade flows. Alternatively, if a fixed exchange rate is specified then monetary policy in the two countries has to be accommodative in the sense that the ratio of the two national money stocks must be consistent with the fixed exchange rate.

In these simple models money is only a medium of exchange and no financial assets enter. There is also no time structure and a single period world is assumed. A simple transactions money demand and fixed money stock determines prices of goods in terms of money. In the money neutral case, a strict separation between real and monetary phenomena applies in that relative goods prices are determined by the real side of the international economy and the country price levels (and hence money prices) are determined by the money stock.

Our approach is to specify a monetary regime in a model with monetary non-neutralities reflecting the actual Chinese exchange rate and monetary regime. In

this, model with monetary non-neutralities monetary policy is non accommodative to the chosen fixed exchange rate, and this implies either excess demand for or excess supply of foreign exchange. China was an economy in which up to the mid-1990s there was significant excess demand for foreign exchange with associated rationing and black markets, but from the mid-1990s on the excess demand regime became one of excess supply. By maintaining the inconvertibility of the Renminbi foreigners are prevented from sales of foreign exchange at better rates, and the exchange rate is maintained by the central bank buying foreign currency to absorb this excess supply through additions to reserves. This, in turn, supports the Chinese surplus on trade account. This is equivalent to intervention based stock piling to support a price control (in this case the fixed exchange rate, see Iman and Whalley (1982)).

Later, we use a calibrated numerical model of China with a production side and monetary structure to analyze the impacts of changes of exchange rates in this regime, but we first exposit a simple version of this structure. We consider a simple 2 good (good 1 and good 2) 2 country (country 1 and country 2) pure exchange world, where $\overline{X}_1$ and $\overline{X}_2$ are the initial endowments of goods 1 and 2 in countries 1 and 2. X_1^1, X_2^1, X_1^2 and X_2^2 (X_i^j) denote the demands for good i (i=1,2) in country j (j=1,2).

Each country is assumed to have a representative consumer with a utility function:

$$U^j(X_i^j) \qquad i=1,2, \quad j=1,2 \tag{1}$$

Unlike in a conventional trade model, we incorporate the endogenously determined trade surplus directly into the two country budget constraints. We also assume that the surplus country is predetermined as country 1 (China) and the deficit country as country 2 (the rest of the world) and Country 1 fixes its exchange rate and has non-accomodative monetary policy. Country 2 will be assumed to fix its money stock. This implies that jointly countries 1 and 2 exhibit relative money stocks inconsistent

with the fixed exchange rate and monetary non neutralities result. We assume this to be a reflection of policy choices by country 1.

Denoting $\bar{e}$ as the fixed exchange rate chosen by country 1 (China), and *S* as the endogenously determined surplus denominated in the currency of country 2 (the rest of the world), the budget constraint for country 1 is

$$p_1 X_1^{\,1} + \bar{e}\, p_2 X_2^{\,1} = p_1 \overline{X_1} - eS \tag{2}$$

and, for country 2:

$$\frac{1}{\bar{e}} p_1 X_1^{\,2} + p_2 X_2^{\,2} = p_2 \overline{X_2} + S \tag{3}$$

Unlike in real side models that accommodate trade imbalance as exogenous transfers, here *S* is endogenously determined, given $\bar{e}$ and relative domestic money stocks.

For country 1, first order conditions for utility maximizing behavior yield

$$\left(\frac{\partial U^1}{\partial X_1^{\,1}}\right) / \left(\frac{\partial U^1}{\partial X_2^{\,1}}\right) = \frac{p_1}{\bar{e}\, p_2} \tag{4}$$

and similarly, for country 2,

$$\left(\frac{\partial U^2}{\partial X_2^{\,2}}\right) / \left(\frac{\partial U^2}{\partial X_1^{\,2}}\right) = \frac{\bar{e} p_2}{p_1} \tag{5}$$

If, for simplicity, we assume a velocity of circulation of unity in both countries, and a money stock in country 1 of $\overline{m}_1$ and in country 2 of $\overline{m}_2$, money demand and supply equations are:

$$p_1 X_1^{\,1} + p_1 X_1^{\,2} = \overline{m}_1 \tag{6}$$

and

$$p_2 X_2^{\,2} + p_2 X_2^{\,1} + S = \overline{m}_2 \tag{7}$$

Adding demand supply equalities in goods gives equation (8) and (9)

$$X_1^{\,1} + X_1^{\,2} = \overline{X_1} \tag{8}$$

$$X_2^{\,2} + X_2^{\,1} = \overline{X_2} \qquad (9)$$

Equation (3)-(9) thus give a system of 7 equations in 7 unknowns ($X_1^{\,1}, X_1^{\,2}, X_2^{\,1}, X_2^{\,2}, p_1, p_2, S$) for which $\bar{e}$ and $\overline{m}_1$ are policy parameters for country 1 given the setting of $\overline{m}_2$ in country 2. Thus, if county 1 is China and it changes the exchange rate for a given $\overline{m}_1$ there will be real side effects. In this model, the exchange rate setting acts as price intervention now supported by stock piling of foreign exchange. Changes in $\bar{e}$ in turn directly impact on *S*, as well as on real side quantities and trade.

We can illustrate how this simple system operates with a simple numerical example. We assume the utility functions in (1) to be Cobb Douglas and use the parameter settings generated by calibration to an artificial data set in Table 1. We then compute an equilibrium for this structure and investigate the impacts of changes in $\bar{e}$ on *S* and other real side variables.

Simulation results outlined in Table 1 shows that with appreciation of the currency in country 1 (exchange rate reductions of 5%, 10% and 20%), country 1's imports increase, while its exports decrease. The trade surplus decreases, and as we suggest earlier, the proportional effects of changes in the exchange rate on the surplus (*S*) are considerably larger than the effects on trade flows (i.e. on $X_2^{\,1}$ and $X_1^{\,2}$).

Table 1
An example of exchange rate revaluation in a simple monetary trade model

A. Artificial benchmark data used to calibrate a simple 2 good pure exchange economy

	Value of consumption in base case in domestic currency price		Domestic currency prices in base case		Endowments	Money stock in *i*
	good 1	good 2	good 1	good 2		
Country 1	80	20	1.0	1.0	110 ($\overline{X}_1$)	110 ($\overline{m}_1$)
Country 2	30	100	1.0	1.0	120 ($\overline{X}_2$)	130 ($\overline{m}_2$)

Base case exchange rate: 1:1
Base case surplus: 10 units of country 2 currency accumulated by country 1

B. Calibrated model parameter Cobb-Douglas preference parameters generated by calibration

	good 1	good 2
country1	0.80	0.20
country2	0.23	0.77

C. Results of changes in the exchange rate and monetary policy

decrease in $\bar{e}$ by	% change in *S*	% change in X_2^1	% change in X_1^2
5%	-14.45	5.95	-4.99
10%	-30.51	12.40	-9.99
20%	-68.65	27.07	-19.98
increase in $\overline{m}_1$ by			
5%	-13.73	5.56	-4.75
10%	-27.46	11.19	-9.08
20%	-54.92	21.89	-16.65

If, instead of changing $\bar{e}$, we instead increase the money stock in country 1 by the same percent as the change in exchange rate, increasing $\bar{m}_1$ causes goods prices in country 1 to fall and this increases country 1 exports, and the trade surplus falls. In this simulation, equal percentage changes in $\bar{e}$ and $\bar{m}_2$ produce similar, but not identical, impacts on trade and the surplus.

4. A simple trade-monetary model structure for China with production and processing trade

We next assess the impacts of RMB revaluation in a more complex model with sectoral detail, production structures, and also consider the role of processing trade. We calibrate the model to 2005 data and again perform counterfactuals. We set out our procedures for constructing a model benchmark data set later. In this, we use data for earlier years which we first scale to 2005 for changes in intervening years. 2005 is used as the base year since the surplus was considerably larger than in earlier years. A key element of this more complex model of China is its treatment of processing trade. Processing trade uses imports as inputs and applies value-added in upgrading for exports. Imports for this purpose are differentiated from those entering final demands. We thus treat a part of imports as for final consumption, and a part for use as intermediate inputs, which are effectively for re-export from China. In 2005, processing trade accounted for 41 percent of China's imports from the world, and 55 percent of China's exports to the world (NBS. 2005). Other imports are dominated by oil and raw materials. The model incorporates a fixed exchange rate regime similar to that in the simple model discussed above. We consider 3 sectors: agriculture and energy, manufactures and other sectors (including services) which account for 12.4%, 47.3% and 40.3% of GDP in 2005, and of 44.8%, 23.8% and 31.4% of employment. We incorporate processing trade into the production structure only in the China part of the model; the rest of the world is scaled to reflect its relative size compared to China, but is modeled in full form as a distinct economy.

On the production side in China, we consider a 3 sector system, in which processing trade is specially treated. The production function in each sector in country 1(i) is

$$Y_i^1 = g(L_i^1, K_i^1, N_{2i}^1) \qquad i=1, 2, 3 \tag{10}$$

where i refers to different goods, and Y_i^1, L_i^1, K_i^1, N_{2i}^1 are the outputs of

country 1, labor and capital inputs, and the processing trade input. pl_i^1, pk_i^1, pn_{2i}^1 are the prices of labor, capital and processing trade inputs in country *i*.

First order conditions yields:

$$pl_i^1 = p_{1i}\frac{\partial g}{\partial L_i^1} \tag{11}$$

$$pk_i^1 = p_{1i}\frac{\partial g}{\partial K_i^1}$$

$$pn_{2i}^1 = p_{1i}\frac{\partial g}{\partial N_{2i}^1}$$

Country 2's production involves only labor and capital inputs, with no processing trade input, as follows:

$$Y_i^2 = g(L_i^2, K_i^2)$$

First order conditions are:

$$pl_i^2 = p_{2i}\frac{\partial g}{\partial L_i^2} \tag{12}$$

$$pk_i^2 = p_{2i}\frac{\partial g}{\partial K_i^2}$$

Final demands for commodities in country 1 and country 2 as modeled as derived from CES nested utility functions defined over composites of similar domestically produced and imported goods. This structure allows us to directly incorporate substitution elasticity parameters into the model as the substitution elasticity between similar domestic and imported goods which can then be directly related to import demand elasticities, This yields a relatively conventional Armington type trade model but with different production structures in the two countries.

Maximizing country 1's utility yields demands from the solution to a 2 stage budgeting problem, ie:

$$\max U^1\left\{C_i^1(D_i^{11}, D_i^{12})\right\} \tag{13}$$

$$\text{st.} \sum_i p_{1i} D_i^{11} + \sum_i \bar{e} p_{2i} D_i^{12} = \sum_i p_{1i} Y_i^1 - \bar{e} S$$

where C_i^1 is the CES composite of good *i* in country 1, D_i^{11} (D_i^{12}) is the demand in country 1 for good *i* produced in country1 (2), and *S* is the surplus.

Country 2's demand are similarly derived by maximizing a nested CES utility function defined over CES composites of imported goods from country 1 and domestically produced goods.

$$\max U^2 \left\{ C_i^2 (D_i^{22}, D_i^{21}) \right\} \tag{14}$$

$$\text{st.} \sum_i p_{2i} D_i^{22} + \sum_i \frac{1}{\bar{e}} p_{1i} D_i^{21} = \sum_i p_{2i} Y_i^2 + S$$

As before, we assume each country's money supply is fixed, and each country has a constant velocity transactions demand. In equilibrium, this implies:

$$\sum p_1 D_i^{11} + \sum p_1 D_i^{21} = \bar{m}_1 \tag{15}$$

and

$$\sum p_2 D_i^{22} + \sum p_2 D_i^{12} + S = \bar{m}_2$$

Adding demand supply equalities in goods gives

$$D_i^{11} + D_i^{21} = Y_i^1 \tag{16}$$

$$D_i^{22} + D_i^{12} + N_i^{12} = Y_i^2$$

Finally, factor market clearing conditions are:

$$\sum_i L_i^1 = \bar{L}^1 \tag{17}$$

$$\sum_i L_i^2 = \bar{L}^2$$

$$\sum_i K^1 = \bar{K}^2$$

$$\sum_i K_i^2 = \bar{K}^2$$

An equilibrium can be computed for this system similarly to that for the example above. We build a model admissible data set for 2005 for this structure and perform counterfactual experiments for changes in $\bar{e}$ and /or $\overline{m}_1$. We also incorporate a tariff on imports into the model, and are able to analyze the effects of trade policy changes in the presence of the monetary non-neutralities specified.

5. Data and parameterization

Our model incorporates 2 countries and 3 traded goods (agriculture and energy, manufactures, and other sectors) and we build a model compatible benchmark equilibrium data set for calibration (see Dawkins, Srinivasan and Whalley 2001). We use a base year of 2005 since the surplus in China was larger in that year than earlier and we scale earlier years data to this base. The two countries in our simulations are China and the rest of the world. Due to the multi-country character of the data set, ensuring model consistency of data is a problem in building the benchmark data. We jointly use data from GTAP on trade, production, and consumption as well as China's latest input-output table. We first use sectoral gross output, total import and export for China and the rest of the world from GTAP 5 database for 1997. We use data from China's 2000 input-output table yielding China's gross output, and totals for imports and exports. Using share data from GTAP and China's data from the input-output table, we generate China's sectoral gross output, import and export data for 2000. China's exports are taken as imports by the rest of the world from China. All data is scaled to 2005 as follows. Sectoral exports scaled to 2005 according to the China's exports data from NBS and sectoral share in 2000. Then exports are kept unchanged. In adjusting benchmark data to reflect the 2005 surplus, imports are instead scaled for consistency with the 2005 surplus, this implies aggregate surplus for China is compatible with the surplus actually observed in the year. Gross output for the rest of the world and China are also scaled to 2005 that reflect GDP growth rate from the 2000.

We incorporate processing trade data into the basecase data set as follows. We split total imports of China into final and intermediate demand components. The shares of imports for final and intermediate use are calculated using data from the NBS of China[3]. Intermediate imports are an element of domestic demand. Table 2 reports the

[3] China's customs compiles statistical data on imports for final and intermediate use by good each year. Due to lack of such data for 2005, we use the aggregate share of intermediate imports of the total according to the NBS.

base case data for China and the rest of the world use in our calibration.

For simplicity, we use Cobb-Douglas production functions to represent the technology of the 2 countries with shares calibrated to the 2005 benchmark data. In the case of China, share parameters extend to the use of processing trade inputs. On the demand side, we use CES composites and initially set substitution elasticities to equal to 2 in both countries. We use this as the central case although the literature provides different estimates of this key elasticity. Many of the estimates of domestic and import good substitution are around 2 or greater than 2 (See Betina (2003)). Table 3 reports parameter values in production and preferences generated by calibration, as well as shares of intermediate imports in China's imports that are used in counterfactual analysis.

Table 2
2 Country Base Case Data in 2005 for China and ROW (the Rest of the World) used to calibrate the model

China *(in billion RMB*[4])*	Value of Production	Value of Consumption	Exports to ROW	Import from ROW	Net trade
Agriculture and energy	1537.26	1495.74	41.50	37.79	3.71
Manufacturing	1560.84	1292.77	268.07	177.70	91.37
Other sectors	1028.57	999.47	29.09	22.28	6.81
Surplus	101.9				
Exchange rate	1:1				
$\overline{m}_1$	4126.68				
ROW *(in million US$)*	Value of Production	Value of Consumption	Exports to China	Import from China	Net trade
Agriculture and energy	11567.54	11529.74	37.79	41.50	−3.71
Manufacturing	15665.92	15488.21	177.70	268.07	−91.37
Other sectors	37558.34	37536.05	22.28	29.09	−6.81
Surplus	-101.9				
Exchange rate	1:1				
$\overline{m}_2$	64893.69				

[4] The currency unit used here for Chinese domestic currency is artificial in that we set it to 8.277RMB which is the exchange rate of the US dollar to Renminbi in 2002, this implies that 1 unit RMB* equals 1 US dollar before we scale all the data for 2005. This convention is adapted so that in calibration all equilibrium prices will be unity.

Table 3
Parameters for the model generated by calibration and used in numerical simulation

A. Shares in Cobb-Douglas production functions[5]

	China			Rest of the World		
	Share on capital	Shares on labor	Shares on intermediate	Share on capital	Shares on labor	Shares on intermediate
Agriculture and energy	0.0716	0.1602	0.7682	0.3022	0.3013	0.3965
Manufacturing	0.2328	0.1294	0.6378	0.2097	0.3470	0.4433
Other sectors	0.2579	0.2035	0.5386	0.3000	0.4166	0.2834

B. Share parameters for import and domestic goods in nested CES utility

	China		Rest of the World	
	Imports	Domestically produced goods	Imports	Domestically produced goods
Agriculture and energy	0.1372	0.8628	0.0566	0.9434
Manufacturing	0.2705	0.7295	0.1165	0.8835
Other sectors	0.1299	0.8701	0.0271	0.9729

	Shares of intermediate imports of China used for 2005	Arc estimates of import demand elasticities for China
Agriculture and energy	0.00	-1.965
Manufacturing	56.6[6]	-1.965
Other sectors	0.00	-1.965

[5] The original data are from the GTAP 5 database. We aggregate skilled and un-skilled labor and generate a labor endowment for China and the rest of the world. Land and sector specific resources are not taken into account in the production data used.

[6] Statistical communiqué of the People's Republic of China on the 2002 National Economic and Social Development" (in Chinese) from National Statistical Bureau, PRC reported only a general processing trade volume which is about $276 billion, and share about 41% of the total import. As the processing trade in China is occurred mostly in manufacturing trade rather than in agriculture and services sectors, we shift all processing trade inputs into the manufacturing sector, and thus the share here is 56.6%.

6. Model results for joint trade and surplus impacts of Renminbi revaluation and changes in monetary policy

We have used our calibrated model to simulate the impacts of RMB revaluation jointly on China's trade flows and the trade surplus. We firstly consider appreciations of the RMB by 5%, 10% and 20% respectively with a fixed money stock in both China and the rest of the world. Then we fix the RMB exchange rate and increase the money stock in China to assess the effects of changes in money stocks on trade flows and the surplus. We are also able to analyze trade policy changes in a monetary model.

Results are presented in Tables 4 and 5. Table 4 shows that with appreciations of the RMB of 5%, 10% and 20% respectively, China's imports increase in quantity terms by around 11.8%, 25.7% and 61.5% for these cases, and exports fall in corresponding cases by 9.7%, 18.9% and 35.8%. China's trade surplus falls in larger percentage terms by 12.7%, 25.8% and 53.7% for these cases, mostly due to changes in the quantity of net trades. With Renminbi revaluations of 5%,10% and 20%, the surplus decreases by $12.9 billion, $26.3 billion and $54.6 billion respectively; small changes in prices also influence the change in the surplus. Thus, as in the earlier numerical example, the proportional change in the surplus is much larger than the change in trade flows.

We then increase China's money stock $\overline{m}_1$ by 5%, 10% and 20%, the same percentage changes as for the exchange rate. With the resulting increase in the price level in China, China's imports increase by 11.8%, 24.4% and 51.4% , and China's exports fall by 9.7%, 18.1% and 31.8%. The trade surplus falls by 16.7%, 33.1% and 65.1% in these cases. Again, the proportional change in the surplus is considerably larger than the change in trade flows.

Table 4
Simulation results for the impacts of revaluation of the Renminbi on trade flows, China's trade surplus, and China's terms of trade (central case[7])

	Size of RMB* revaluation		
	5%	10%	20%
% change in imports			
In value terms	6.30	13.25	29.50
In quantity terms	11.85	25.71	61.52
% change in imports of			
agriculture and energy sector	11.05	23.98	57.37
manufacturing sector	12.51	27.14	64.93
other sector	10.90	23.64	56.57
% change in exports			
In value terms	-4.95	-9.90	-19.81
In quantity terms	-9.70	-18.91	-35.85
% change in exports of			
agriculture and energy sector	-9.69	-18.90	-35.82
manufacturing sector	-9.71	-18.92	-35.87
other sector	-9.67	-18.85	-35.73
China's trade surplus			
% change compared to base case	-12.68	-25.81	-53.67
Change in $ billion	-12.93	-26.30	-54.69

[7] In the central case model specification, $\sigma = 2$, where σ refers to the elasticity of substitution between comparable domestic and foreign goods.

Table 5
Impacts of variation in China's monetary policies on trade flows, China's surplus and terms of trade (central case $\sigma = 2$)

	Increase in money stock in China		
	5%	10%	20%
% change in imports			
In value terms	11.61	23.84	50.13
In quantity terms	11.84	24.35	51.39
% change in imports of			
agriculture and energy sector	11.04	22.71	47.93
manufacturing sector	12.50	25.70	54.24
other sector	10.89	22.39	47.26
% change in exports			
In value terms	-5.18	-9.90	-18.18
In quantity terms	-9.70	-18.09	-31.80
% change in exports of			
agriculture and energy sector	-9.69	-18.08	-31.79
manufacturing sector	-9.70	-18.10	-31.83
other sector	-9.66	-18.03	-31.71
China's trade surplus			
% change compared to base case	-16.72	-33.07	-65.08
Change in $ billion	-17.03	-33.70	-66.32

We next turn to the impacts of changes in exchange rates that actually occurred in China between 2005 and 2006. China's reforms in the exchange rate regime started in July 2005. From then to the end of 2006, China's RMB appreciation was close to 2.4% (the exchange rate for the US dollar to RMB decreased from 8.27 in 21st July, 2005 to 8.0702 in 30th Dec 2005[8]) and M1 increased by 11.8% in 2005 according to the NBS (NBS,2005). This RMB appreciation together with China's increasing money stock[9] had significant impacts on foreign currency reserves. Our simulations show that without China's jointly using a revaluation of the Renminbi and a monetary loosening, the surplus would have increased by a further 11.4% (Table 6), while imports would increase of further 7.7% and export fall a further 8.2% under the model assumptions.

We also use the model to assess the impacts of tariff rate changes on trade flows and the surplus. We assume different tariff rates on manufactures of 6%, 8%, 10% and 12% and eliminate them. Results are reported in Table 7. With the resulting decrease in import prices, China's imports increase by 6.2%, 8.0%, 9.8% and 11.4%. Exports show very small impacts and in this model, in contrast to a non monetary trade model, the adjustments induced by the import rise are nearly all on the surplus which increases between 4.3% and 7.9%. In contrast to barter economies in which tariff acts as a tax on exports, here the buffer stock of endogenous reserve accumulation removes this effect.

It is not surprising that our simulation results are elasticity dependant, and the key parameter in the model is the substitution elasticity between domestic and foreign products in the utility function. Table 8 provides simulation results under changed substitution elasticities in CES demand functions only for China from 0.5 to 2. Changes in China's import are sensitive to this elasticity, while change in exports to the rest of the world shows almost no change. The resulting changes in China's

[8] Data from The People's Bank of China, accessed at http://www.pbc.gov.cn/huobizhengce.
[9] We adjusted growth rate of money stock in simulation using GDP growth rate.

surplus vary by a factor of 2.

Table 6
Impacts of China's monetary policies in 2005 on trade flows, China's surplus and terms of trade (central case[10])

	Renminbi Appreciation	Increase in money stock in China	Joint effects
	2.40%	1.80%	
% change in imports			
In value terms	1.95	3.08	6.11
In quantity terms	3.39	2.14	7.70
% change in imports of			
agriculture and energy sector	3.03	1.86	7.05
manufacturing sector	3.69	2.36	8.24
other sector	2.96	1.81	6.92
% change in exports			
In value terms	-2.37	-1.92	-4.26
In quantity terms	-4.72	-3.65	-8.21
% change in exports of			
agriculture and energy sector	-4.71	-3.65	-8.20
manufacturing sector	-4.72	-3.66	-8.21
other sector	-4.71	-3.65	-8.18
China's trade surplus			
% change compared to base case	-5.34	-5.36	-11.38
Change in $ billion	-5.44	-5.46	-11.60

[10] See footnote 8.

Table 7
Impacts of elimination of China's tariffs on trade flows, China's surplus and terms of trade

	Assumed Chinese tariff rate on manufacture in the base case			
	6%	8%	10%	12%
% change in import				
In value term	6.21	8.05	9.8	11.45
In quantity	6.19	8.03	9.8	11.43
% change in import of				
agriculture and energy	-0.03	-0.04	-0.04	-0.05
manufacturing sector	10.98	14.24	17.33	20.24
other sector	-0.03	-0.04	-0.04	-0.05
% change in export				
In value term	-0.02	-0.02	-0.03	-0.03
In quantity	-0.02	-0.02	-0.03	-0.03
% change in export of				
agriculture and energy sector	0.03	0.03	0.04	0.05
manufacturing sector	-0.03	-0.04	-0.05	-0.05
other sector	0.03	0.03	0.04	0.05
China's trade surplus				
% change compare to base case	-4.29	-5.56	-6.77	-7.91
Change in terms of trade	-0.02	-0.02	-0.03	-0.04

Table 8
Sensitivity of RMB revaluation impacts to elasticity parameters in demand

	Varying the elasticity of substitution between domestic and foreign products only in China				
	0.5	0.75	1.0[11]	1.5	2.0
Implied import demand elasticity	-0.498	-0.743	-0.988	-1.478	-1.965
% change in imports in value terms					
(Degree of RMB revaluation)					
5%	-1.50	-0.24	1.03	3.64	6.30
10%	-3.18	-0.614	2.00	7.49	13.25
20%	-7.06	-1.76	3.80	15.97	29.50
% change in exports in value terms					
(Degree of RMB revaluation)					
5%	-4.95	-4.95	-4.95	-4.95	-4.95
10%	-9.90	-9.90	-9.90	-9.90	-9.90
20%	-19.81	-19.81	-19.81	-19.81	-19.81
% change in surplus					
(Degree of RMB revaluation)					
5%	-7.32	-8.18	-9.06	-10.85	-12.68
10%	-14.52	-16.29	-18.09	-21.86	-25.81
20%	-28.58	-32.22	-36.04	-44.39	-53.67

[11] Because we use a CES form in the code, we use 0.999 rather than 1 here in execution.

Table 9
Sensitivity of RMB revaluation impacts to assumptions made on the size of China's processing trade

	Varying the assumed fraction of imports in intermediate production in base data (processing trade)			
	0.2	0.4	0.56 (base case)	0.6
% change in imports of China in value terms				
Degree of RMB revaluation				
5%	6.51	6.41	6.30	6.27
10%	13.66	13.45	13.25	13.18
20%	30.35	29.93	29.50	29.36
% change in exports to ROW in value terms				
Degree of RMB revaluation				
5%	-4.95	-4.95	-4.95	-4.95
10%	-9.90	-9.90	-9.90	-9.90
20%	-19.81	-19.81	-19.81	-19.81
% change in surplus				
Degree of RMB revaluation				
5%	-21.84	-15.91	-12.68	-12.01
10%	-44.62	-32.43	-25.81	-24.43
20%	-93.66	-67.76	-53.67	-50.75

As we discussed earlier, processing trade in our model is specially treated and changes in model treatment impact results. We change the share of processing trade by altering the proportion of imports to domestic demand in the base case data used in calibration. Result in Table 9 show cases in which variations in the impacts of RMB revaluation on China's surplus are large, but the variations in impacts on trade flow change are smaller. These results reflect the dampening effect of processing trade inputs on revaluation effects. The larger the processing trade, the more that both inputs and outputs are foreign currency denominated and the smaller the impacts on the surplus.

7. Conclusion

Here we show how the impacts of changes in exchange rates and monetary policy can be analyzed in a trade model with a simple monetary structure in which the trade surplus is endogenously determined and exchange rate policy is exogenous. In this model, money is non neutral. We illustrate the model's application using a calibrated Chinese model incorporating 2005 data. We find that impacts of revaluation Renminbi on the surplus are proportionally larger than on trade flows. Impacts on trade flows and the surplus are both substantial.

A separate treatment of China's processing trade is also incorporated into the model. Varying the fraction of imported intermediate to total imports has little effect on the impacts of trade flow changes under different degree of revaluation, but has a significant influence on the surplus due to changes in net trade. These impacts are also elasticity dependent. Our results show that larger substitution elasticities between domestic and foreign production in demand in China yields larger effects on trade the flow and the surplus.

Since Chinese policymakers implemented current and capital account liberalization measures in 2005 aimed at addressing macroeconomic imbalances, we also analyze these. Our simulations show that these policies had an impact in depressing the growth in the surplus, which would otherwise have been larger.

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