The Impact of an Appreciation of the Chinese Yuan on the Global Trade

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Abstract:

Multiple currencies are a troublesome issue in a multi-country model. The GTAP model circumvents this problem by converting values for each country into US dollars. This approach simplifies the model greatly, but it also ignores the role of exchange rates. One may argue that real exchange rates can be calculated based on the bilateral trade volume, but this calculation sheds no light on the predominant influence of exchange rates on international trade, which was demonstrated vividly by the Asian Financial Crisis in 1997, more recently, the GFC, and the Chinese government's apparent determination to keep its exchange rates low even under pressure from the US government. To illustrate the effects of exchange rate policies (e.g., appreciation of the Chinese yuan), the authors add exchange rates into the GTAP model. In doing so, the model technically allows different currencies in different countries while the global aggregation is achieved by converting different current currencies into a global currency (e.g., $US). The simulation results show that a 10% appreciation of the Chinese yuan has a significant impact on China and its major trade partners. Quite unexpectedly, China will gain from a stronger RMB. With a 10% appreciation of RMB, China will increase its imports by 1.199%, exports by 0.522%, terms of trade by 10.263%, and real GDP by 0.02%. Although its income will decrease by 9.337%, real income actually rises by 0.663% if measured in US dollars. The effects of an appreciation of RMB on other countries are mixed and depend

on their trade relationship with China. Exporters to China are likely to be better off, but the countries competing with China in the world market are expected to lose. At the sectoral level, all agricultural sectors and manufacturing sectors in China will be worse off, with the exception of animal production and electronics manufacturing. All service sectors in China would benefit from a stronger RMB. The sectoral effects on other countries are, by and large, opposite to that of China. Payments to factors are expected to reduce significantly in China, but would be marginally positive or negative if measured in a global currency. They are positive for all other countries, with the exception of the US, where payments to capital and labour will drop insignificantly.

1. Introduction.

The exchange rate of the Chinese currency renminbi (RMB) has become a tense issue between China and its trading partners, especially the United States. It is argued that China deliberately manipulates its currency in order to gain unfair trade advantages over its trading partners. On September 29, 2010, the United States House of Representatives passed a Bill (H.R. 2378), which attempted to treat a fundamentally undervalued currency as an actionable subsidy under US countervailing laws (i.e., the US could raise tariffs on certain imported Chinese products), but the Senate did not consider the Bill.

The logic behind this argument is quite obvious: an undervalued Chinese currency means, on one hand, lower prices and thus higher demand for Chinese tradeables, and higher prices and depressed demand for goods from China's trading partners. However, this simple reasoning could not answer the following important questions: to what degree

does China benefit from its current currency setting? How much would China's trading partners gain if it appreciates its currency? To quantify the effect of the RMB exchange rate on international trade, we need to conduct a multicountry modeling. In this paper, we intend to simulate the effect of an appreciation of RMB by employing the GTAP model.

The balance of the paper is as follows: in section 2, we review the relevant literature on China's exchange rate, with an emphasis on general equilibrium modeling. Section 3 describes the changes we made in the GTAP model to enable us to model the effect of exchange rate changes, and then the design of the simulation scenarios. Section 4 is devoted to results interpretation and analysis. Section 5 concludes the paper.

2. Literature review.

There is a large body of literature on Chinese currency. One thread of the studies is to find out if the RMB is undervalued or overvalued. The research in this area is inconclusive. While a number of studies suggest that RMB is undervalued by 15-41% (e.g., Zhang and Pan, 2004[i], Chang and Shao, 2004[ii], Coudert and Couharde, 2005[iii], Goldstein and Lardy, 2006[iv], Chang, 2008[v];Cline and Williamson, 2009[vi], Subramanian, 2010[vii]), other studies conclude that there is little evidence of RMB undervaluation (e.g. Yang and Bajeux-Besnainou, 2004[viii], Funke and Rahn, 2005[ix]; Goh and Kim, 2006[x], Cheung, Chinn, and Fujii, 2007[xi]).

The second thread of studies considers the effect of a revaluation of the RMB. There are two approaches on this topic: econometric and CGE modelling. Examples of the first

approach includes, among others, Suresh (2012)[xii], Soyoung Kim and Yoonbai Kim (2012)[xiii], Jianhuai Shi (2006)[xiv], Xiaohe Zhang (2006)[xv] and Robert A. Blecker and Arslan Razmi (2009)[xvi]. The CGE studies on this topic include Yu, E., Chan, C., and Wan, Z., (2003)[xvii] , Willenbockel (2006)[xviii], Tyres and Yang (2000)[xix], Yang, Zhang and Tokgoz (2012)[xx], and Li and Xu (2011)[xxi]. Since the CGE modelling approach is more relevant to this study, we review them in more detail.

A number of researchers developed single country models for China to gauge the effect of an appreciation of the Chinese Yuan. The benefit of a single country model is that it avoids the complexity of international trade, and the model can include more details about China and be more focused on China's perspectives. There are two drawbacks in this type of study, however. One is that, since the demand for Chinese exports is determined by the price elasticity of foreign demand in a single country model, the modeling results are not accurate due to the omission of an important variable – the income of the foreigners. The second drawback is that there is only one exchange rate in the model because the rest of world is treated as a single entity. This prohibits modeling complex exchange rate policy. Using this single country approach, Yu et al, (2003) modelled the effects of a real exchange rate devaluation sufficient to restore China's competitiveness prior to the Asian Financial Crisis and compared these to the effects of increased rebates of export taxes. The model features two types of firms (ordinary firms and export processing firms), three types of imports (ordinary imports subjected to import tariff and nontariff barriers, duty free imports for producing processed exports, and other duty free imports) and two types of labour (rural labour and urban labour). By comparing

the simulation results of a devaluation of the real exchange rate with those of an increase in the export rebate rate, the paper claimed that a 30% increase in the export rebate rate (or equivalently, a 55% increase in the cost to government of the export rebate) have a similar impact to a 5% real exchange rate devaluation in terms of restoring China's export competitiveness. Willenbockel (2006) used a 17-sector model to simulate the structural effects of a real exchange rate revaluation in China. The real exchange rate shock is realized by a decrease in the saving rate which leads to a decrease in China's trade balance by 4% of GDP in order to restore China's external balance to a sustainable level. The paper concludes that the revaluation of RMB would be associated with fairly moderate intersectoral employment relocation effects.

Most researchers used a multi-country model for this topic. The advantage of this approach is that, not only it will produce more realistic modeling results, it will also reveal the impact on other countries, predominately China's trading partners. Tyres and Yang (2000) used a modified GTAP model to explore the options for China during the Asian Financial Crisis. Three scenarios are designed for this purpose: (1) fiscal expansion, maintaining fixed nominal parity with US$, (2) a nominal wage rise while maintaining fixed nominal parity with the US$, and (3) a nominal devaluation against the US$. The paper concluded that, holding fixed nominal parity with the US$, continued fiscal expansion will raise the home price level and therefore the real exchange rate, harming exports and export-oriented manufacturing industries, but it will reduce the real wage and foster employment growth. The 5% nominal wage rise will also raise the home price level and the real exchange rate and reduced employment causes the return on

installed capital to fall, so investment falls. A 10% devaluation is found to have effects similar to the 5% nominal wage rise. By adopting the mechanism of nominal exchange rates in a single country model, Yang, Zhang and Tokgoz (2012) added nominal exchange rates in the GTAP model and simulated the ex-ante, short-term impacts of an RMB appreciation on the world economy. The paper claimed that, as RMB appreciates, the Chinese economy will be affected negatively, with lower real Gross Domestic Product, lower employment rates, and a decline in the trade surplus. Chinese currency appreciation has a positive impact on the GDP of the major countries and regions, but only by a small margin. With a higher Chinese exchange rate, there is significant improvement in trade balances for other trading partner countries, with the exception of the United States,. Li and Xu (2011) estimated the effects of China's real exchange rate appreciation in the next decade using a recursive dynamic GTAP model. Two different scenarios are simulated against the baseline, one is to adjust the macro-structural imbalance by decreasing the gross national saving rate in China and the other is to adjust the micro-structural imbalance by increasing the real wage rate of Chinese labor. The paper concluded that, compared to the real appreciation created by increasing the wage rate, decreasing the gross national saving rate will help to rebalance China's trade account and improve the Chinese terms of trade in the next decade. In the short run, however, the imbalance is mainly embodied in the trade structure, especially in the bilateral trade of high-technology products between China and US.

3. Model, data, and scenario design

The model used in this paper is the GTAP model. However, significant changes are needed because there is no exchange rate variable in the current GTAP model. There are indeed two attempts to add exchange rates in the GTAP model, but these approaches have considerable limitations and even serious problems in the application of the model.

Yang, Zhang and Tokgoz (2012) adopted in the GTAP model the approach of using nominal exchange rates in a single country model. They added a nominal exchange rate for each region and adjusted the prices of different types of goods. The nominal exchange rate is added to export prices for foreigners and it is deducted from import prices to domestic users. The nominal exchange rate is also added to the equations of global transportation as well as the prices of world investment goods and savings. There are a number of shortcomings in this approach. First, the exchange rate in this approach does not fit the definition of an exchange rate: the relative price of two currencies. In other words, in the real world, the exchange rate depends on at least two countries, not just one region. So this approach implies that the situation in other countries is unchanged. This will impose a severe constraint on a global model. Secondly, when we allow a country to change its exchange rate in this approach, the degree of change must be the same to all other countries. Apparently, this is because there is only one exchange rate for a region and the other countries are treated as one region (the rest of the world). Thirdly, only one country can change its exchange rate at a time. If two countries change exchange rates at the same time, the c.i,f. imports price will change because the transportation price for imports changes. As the equation for domestic market prices

(*(all,i,TRAD_COMM)(all,r,REG)(all,s,REG) pms(i,r,s) = tm(i,s) + tms(i,r,s) + pcif(i,r,s)-nex(s);*)
violates the homogeneity conditions, the domestic market price for imports does not decrease at the same degree as the domestic currency appreciates. Fourth, the price aggregation in the model is not completed. The change in exchange rates, even in one country, will affect all aggregated prices and nominal values, but only in the aggregated investment price and aggregated saving price, is the impact of an exchange rate change taken into account. Thus, all other nominal aggregations in the model are incorrect.

The approach of Yang and Tyers (2000) also adds a single nominal exchange rate for each region, but they set the exchange rate of the US as unity and thus correctly define the exchange rate of another country as the number of US dollars per unit of the region's currency. The bilateral exchange rate between two regions is correctly defined as the ratio of exchange rates of the two regions. The global savings and transportation margins are correctly converted to US dollars. However, there are two defects in this model. One is that it assumes every currency is pegged with US dollars, which is hardly true. The consequence of this approach is that the model does not allow the direct change of exchange rates between two non-US countries. For example, if the exchange rate between the Australian dollar and the Japanese yen changes, either the exchange rate between the Australian dollar and the US dollar must have changed, or the exchange rate between the Japanese yen and the US dollar must have changed. This pegged regime will make the change in exchange rates very complex in the model. Secondly, the aggregation of global prices and nominal values are not completed. Only savings and international transport in the model are converted to US dollars. All prices and nominal values should be converted

to global currency – the US dollar – otherwise, the nominal global aggregation is incorrect.

The failure of previous approaches is that they try to model the exchange rate in the single currency framework provided by GTAP. To model the exchange rate appropriately, we propose to change the single currency model of GTAP to a multi-currency model. In doing this, we assume that different countries have different currencies (as in the real world) even though all values have been converted to the US dollars in the GTAP database. We add a bilateral exchange rate for any two currencies (regions) and for the base value of each bilateral exchange rate we assign a value of unity (because all base data in the GTAP database are actually in a single currency). In international trade related equations, we use exchange rates to convert the exporting country currency to the importing country currency. In global aggregation, we convert all local currencies to a global currency (e.g., US dollars).

The database used in this paper is GTAP 7 with a base year of 2004. The simulation scenario is designed to demonstrate the effect of a 10% appreciation of RMB to all other countries. That is er("china", nonchina)= 10%. However, because of the bilateral nature of the exchange rates, a 10% appreciation of RMB also means the exchange rates of all other currencies to RMB depreciate by 10%. Namely, er(nonchina, "china")= -10%. The first shock is analogous to an export tax in China and the second shock is analogous to subsidies on exports from other countries to China. We must impose the dual shocks to the model so that the bilateral nature of exchange rates reflects in the simulation (for

exports from China, the prices are 10% dearer and for exports from other countries into China, the prices are 10% cheaper). To show the inappropriateness of imposing only one shock, we also list the macroeconomic results of the first shock for comparison. In short, there are two scenarios in this paper: scenario 1 (S1): the 10% appreciation of RMB affects China's exports to other countries; and scenario 2 (S2): the 10% appreciation of RMB affects both China's exports and imports.

4. Results analysis

The percentage changes of real exports, real imports, terms of trade, income and GDP for each region are shown in Table 1. We consider each of them in turn.

Exports in scenario 1 decrease for most countries while they improved remarkably in scenario 2. In scenario 1 the effect of a 10% appreciation of RMB reflects in an increase in the prices for Chinese exports, so it is no surprise that the real exports for China decrease by 10.425%. As Chinese exports decrease dramatically, one would think exports from other countries will increase significantly. But the modelling results show the opposite. The significant decreases in real exports in most countries show that these countries have significant amounts of exports to China. As China's demand for real imports decreases dramatically (due to the import-export linkage), the countries exporting to China will have poorer performance. For instance, exports decrease by 0.606% for Australia, 0.461% for Hong Kong, 1.478% for Japan, 0.591%for Korea, 0.584% for Taiwan, 0.869% for India, 0.883% for Mexico, and 1.14% for the US. However, a few countries benefit (e.g., Malaysia increases exports by 0.046%, Singapore by 0.082% and

Vietnam by 0.191%). This indicates that the latter countries are competitors of China in the exportation market. The higher Chinese currency makes the Chinese exports more expensive and thus gives these countries a price advantage.

Table 1. Macroeconomic results, Percentage changes (%)

	Real exports		Real imports		Terms of trade		Income		Real GDP	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
AUS	-0.606	0.024	-0.262	-0.315	-0.315	0.029	-0.077	0.056	-0.004	-0.001
NZL	-0.323	0.025	-0.043	-0.143	-0.143	0.033	-0.033	0.062	-0.002	0
CHN	-10.425	0.522	-19.184	1.203	1.203	1.199	-12.167	-9.337	-0.579	0.02
HKG	-0.461	-0.03	-1.985	-1.381	-1.381	0.241	-1.814	0.266	-0.002	-0.016
JPN	-1.478	0.114	-0.816	-0.231	-0.231	0.034	-0.055	0.025	-0.001	-0.003
KOR	-0.591	-0.032	-0.953	-0.515	-0.515	0.053	-0.727	0.124	-0.037	-0.01
TWN	-0.584	-0.105	-1.28	-0.747	-0.747	0.086	-1.306	0.267	-0.049	-0.015
KHM	-0.011	0.011	0.521	0.202	0.202	-0.037	0.445	0.035	0.061	-0.002
IDN	-0.17	-0.026	-0.111	-0.258	-0.258	0.032	-0.167	0.097	-0.01	-0.001
MYS	0.046	-0.049	-0.055	-0.24	-0.24	0.008	-0.293	0.153	-0.025	-0.021
PHL	-0.059	-0.036	0.194	0.019	0.019	-0.043	0.12	0.032	-0.007	-0.011
SGP	0.082	-0.031	-0.143	-0.272	-0.272	0.029	-0.689	0.158	-0.032	-0.012
THA	-0.179	-0.103	-0.174	-0.167	-0.167	0.058	-0.296	0.183	-0.023	-0.004
VNM	0.191	-0.059	0.143	-0.264	-0.264	0.008	-0.178	0.133	-0.003	-0.004
IND	-0.869	0.078	0.125	0.136	0.136	0.016	0.29	0.033	0.013	-0.001
CAN	-0.159	0.01	0.097	-0.087	-0.087	0.01	0.197	0.04	0.005	-0.001
USA	-1.14	0.1	-0.019	-0.012	-0.012	-0.038	0.281	-0.002	0.001	-0.001
MEX	-0.883	0.139	0.158	0.149	0.149	0.022	0.505	-0.012	-0.05	0.01
CHL	-0.174	-0.003	-0.248	-0.295	-0.295	0.035	-0.219	0.076	-0.012	-0.001
PER	-0.574	0.067	0.008	-0.106	-0.106	0.054	0.104	0.043	0	0
EU25	-0.336	0.042	0.117	0.014	0.014	0	0.24	0.006	0.028	-0.004
SSA	-0.13	0.01	0.073	-0.202	-0.202	0.03	-0.008	0.058	-0.003	-0.002
RUS	-0.145	0.054	-0.243	-0.318	-0.318	0.037	-0.097	0.018	-0.008	0.002

Real exports in scenario 2 improved significantly for most countries. The remarkable improvement of exports in China (from -10.425% to 0.522%) is quite surprising. The difference between the two scenarios is that scenario 2 considers the impact of appreciation of RMB on China's importation while scenario 1 omits it. The unexpected growth in Chinese exports can be explained by the links between Chinese imports and

exports and by the effect of the lower price level in the Chinese economy. Since a considerable portion of imports are used to produce tradables in China, the lower price of imports will make exports cheaper and thus encourage export demand. Moreover, the lower import prices will drag down the prices of domestic goods (if the prices of domestic goods are unchanged, people will switch to imports and the decreased demand for domestic goods will force their prices to fall) and thus spur an economy-wide deflation. This will further drive down the cost of producing exports. The improved performance of other countries is really explained by the increased import demands in China due to the lower imports prices faced by the Chinese. Interestingly, three countries (Malaysia, Singapore and Vietnam) are worse off in scenario 2 – their export growth changes from positive in scenario 1 to negative in scenario 2. This can be explained by the competition in the exportation market and the price effect. As the Chinese exports become cheaper in scenario 2, these countries are disadvantaged because they are competitors of China in export markets.

For the majority of selected countries in Table 1, real imports decrease in scenario 1. The marked decrease in Chinese imports in scenario 1 (-19.184%) is unexpected because the appreciation of RMB is supposed only to affect Chinese exports in this scenario. This result may stem from two factors. One is that Chinese exports are highly linked with imports (i.e., a significant amount of imported inputs are used by firms). However, in considering the substitution effect between the imported and domestically-produced intermediate goods, the degree of decrease in imports should be smaller than that in exports. The greater decrease in imports than in exports in Table 1 suggests that there

must be some other reasons. This leads us to another factor: the income effect. As exports account for a significant amount of final demand for China, the decrease in demand for exports leads to a significant decrease in income for the Chinese, which leads to reduced household consumption, private investment, and public expenditure. This will magnify the reduction in import demand in China. The negative changes in imports for other countries indicate that these countries import significantly from China – their demands for Chinese exports are depressed by the higher price due to a more expensive Chinese currency. Quite a few countries import more in scenario 1 (e.g., Cambodia increases its imports by 0.521%, the Philippines by 0.194% and Mexico by 0.158%). This may indicate that these countries import less from China and more from other countries. As Chinese demand for imports is reduced substantially due to the reduced income stemmed from the reduced exportation, the overall global international trade demand decreases and this will depress the overall price level of international tradables. The lower prices of exports from countries other than China will encourage demands for them. Thus countries importing less from China and more from other countries, will experience an increase in imports.

Compared with scenario 1, real imports increase in scenario 2 for all countries except Cambodia, the Philippines, and the USA. The reason for the substantial increase in Chinese imports is quite straightforward: the stronger RMB means that the prices of imports faced by Chinese people become much lower and this will stimulate Chinese demand for imports. The increase in import demand in other countries in scenario 2 can be attributed to the fact that these countries import more from China and that Chinese

exports become cheaper in scenario 2, as explained previously. The negative growth in imports in a few countries may indicate that they are competitors of China in the importation market. The increase in China's imports pushes up the price of tradables and thus depresses these countries' demand for imports.

The terms of trade change as the prices of exports and imports change. In percentage terms, changes in the terms of trade are the changes in the export price index after subtracting changes in import prices. Thus, the negative changes in the terms of trade for most countries show that either the export price indices decrease or the import price indices increase for these countries, or both. The significant increase in the terms of trade for China is expected because its export prices increase and its import prices decrease following the appreciation of RMB. The large difference between the two scenarios (1.203% in scenario 1 and 10.263% in scenario 2) is because the calculation of the terms of trade is based on local currency: the 10% appreciation is negatively added to import prices in scenario 2, but not added to the export prices (in foreign currency) in scenario 1. Theoretically, the weighted sum of the terms of trade for all countries in the world should be zero (the increase in the terms of trade in one country means a decrease in terms of trade for some other country), so it is reasonable to see that most countries demonstrate negative changes in their terms of trade as a consequence of the large increase in the terms of trade for China.

The income in scenario 1 decreases for the majority of regions listed in Table 1, but in Scenario 2, it increases for all countries except China, USA and Mexico. These results

are consistent with trade theories. Scenario 1 is similar to an export tax scenario. Since a tax on international trade will reduce the trade volume and reduce total welfare, the majority of countries will lose. On the other hand, scenario 2 is comparable to an import subsidy policy, which will stimulate trade and improve welfare. A word of caution is necessary for the income change for China. The large negative changes in both scenarios (-12.167% in scenario 1and -9.337% in scenario 2 do not mean China will suffer greatly. These large changes are changes in nominal value (denominated in Chinese currency). Considering the appreciation of RMB, we need to convert the income of China into US dollars to measure the true income change for China. When adding 10% to China's income changes, we find China is only 2.167% worse off in scenario 1 and 0.667% better off in scenario 2.

The changes in real GDP are insignificant for most countries in both scenarios. With the exception of China, the magnitude of the change in real GDP in scenario 1 is largely consistent with the magnitude of the change in regional income. The change of real GDP for China is much smaller than the change in income because the former is real value which excludes the effect of deflation caused by appreciation of Chinese currency. Interestingly, the changes in real GDP in scenario 2 are mostly negative while the change in income in this scenario are mostly positive. This difference can be explained by the rise of global prices due to the significantly increased import demand from China in scenario 2. The positive changes in price level overshadows the insignificant decrease in real GDP and thus give rise to positive nominal income.

Table 2 shows the changes in exports by commodity and by region in scenario 2, and provides more detailed information to explain the mystery of the increase in Chinese exports arising from a stronger RMB.

Table 2. Changes in regional real exports at world price, US$ million

Exports	AUS	CHN	JPN	TWN	MYS	THA	CAN	WCR	MEX	EU_25
Rice wheat	3.3	-1.2	0.0	0.0	-0.2	-0.7	7.3	12.9	0.4	9.6
Veggie,fruit,nuts	4.4	-143.0	0.3	0.3	0.5	4.2	5.7	61.7	8.2	20.8
Other crops	1.2	-25.5	0.3	0.0	-0.4	-0.4	0.5	20.9	1.6	19.3
Animal	5.7	5.7	0.3	0.0	-0.2	-0.1	0.3	6.9	1.0	9.0
Forestry	0.2	-7.2	0.0	0.1	0.7	0.0	-0.3	5.8	0.2	4.8
Fishing	1.2	-19.7	2.5	0.4	0.0	0.6	0.5	1.5	0.7	2.2
Coal	11.6	-54.0	0.0	0.0	0.0	0.0	1.9	14.8	0.0	3.9
Oil and gas	17.9	-199.1	4.2	0.6	1.9	-0.3	13.1	18.7	16.2	56.3
Meat products	-3.6	19.1	0.1	-0.4	-0.3	-4.9	-3.1	11.9	1.0	26.5
Other Food	8.8	-224.9	5.8	0.4	16.7	0.5	4.8	52.7	7.7	140.7
Beverage,tobacco	-0.4	-2.0	1.2	0.0	0.5	-0.1	-0.4	3.3	1.9	18.0
Apparel	2.5	-526.8	60.7	7.5	3.0	-9.5	3.3	67.8	42.8	376.6
Wood and print	9.2	-1154.9	27.8	5.8	29.5	11.5	174.1	129.4	47.1	420.8
Petr-coal products	-0.1	-2.4	2.1	-0.8	0.2	-0.7	0.5	20.4	0.3	17.3
Chemicals	4.7	-1113.3	228.8	49.6	32.7	12.4	26.9	314.9	47.7	742.3
Metal products	-2.3	-358.4	149.9	15.3	8.7	2.3	-0.8	77.3	39.0	301.4
Vehicle	-4.7	-48.7	64.3	-13.8	-0.8	-9.1	-60.4	73.7	58.6	114.5
Electronics	-6.2	5849.1	-148.5	-314.1	-152.5	-55.1	-79.5	-248.5	-169.3	-994.0
Other manufacture	-5.9	-419.9	464.1	88.2	4.3	-29.5	-16.6	323.1	147.7	708.8
Electricity	0.0	12.5	0.0	0.0	0.0	-0.1	-1.3	1.0	0.1	4.4
Gas service	-0.1	8.3	0.0	0.0	-0.2	0.0	-0.1	0.0	0.0	-0.3
Water service	-0.1	1.7	0.0	-0.1	0.0	-0.1	0.0	0.5	0.1	0.5
Construction	-0.2	26.7	-3.5	-1.4	-0.4	-0.7	-0.2	-0.1	0.7	-9.2
Trade	-1.4	255.3	11.0	-6.6	-1.0	-5.6	-0.1	12.3	1.5	54.0
Transport	-10.0	733.9	-35.6	-13.6	-7.0	-17.8	-14.4	-36.4	1.6	-272.0
ICT	-0.5	14.0	0.3	-2.1	-0.4	-1.0	-1.5	5.8	0.8	11.2
Finance,insurance	-1.3	18.0	0.8	-7.3	-0.4	-1.0	-2.0	32.5	3.4	55.0
Other business	-3.1	98.6	-0.5	-17.2	-2.1	-10.3	-10.9	52.5	1.2	84.2
Recreation	-1.6	55.1	1.1	-4.1	-2.3	-4.0	-2.1	19.7	0.7	15.1
Public service	-1.7	63.8	0.6	-7.0	-0.2	-1.2	-2.1	49.7	3.2	16.2
Total	27.7	2860.8	838.3	-220.3	-69.9	-120.5	43.2	1106.8	266.1	1958.0

Focusing on the performance of China, we find that, with the exception of animal production and electronics manufacturing, all agricultural sectors and manufacturing sectors are affected negatively by the appreciation of RMB. The wood and printing sector and the chemical manufacturing sector suffer most with a decrease in exports by US$ 1154.9 million and US$ 1113.3 million respectively. These negative effects can be explained in a straightforward way: the strong Chinese currency makes these Chinese exports too expensive for foreigners and thus depresses foreign demand. The services sectors are generally positively affected. There may be two reasons for this. One is that the deflation caused by the appreciation of RMB may reduce the costs of these sectors' provision of services and goods. The other is that the increased importation stimulated by the strong RMB increases the total trade volume for China which requires more services. This point is vividly illustrated by the substantial increases in trade and transport services (US$ 255.3 million and US$ 733.9 million respectively).

The biggest contributor to the increase in Chinese exports is the electronics manufacturing sector. Without the startling increase in electronics exports (US$ 5849.1 million), total exports would actually decrease by around US$3000 million. So why is the electronics sector so special that it is growing against the trend of all manufacturing sectors? The key is that there is a remarkable amount of imported inputs in this sector. Aside from the substantial importation of other manufacturing goods, this sector imports more than one fifth of the total electronics exports in the world (in other words, there is very strong intra-industry trade in this sector). The strong RMB stimulates importation and substantially reduces production costs for this sector. With the additional help from

deflation in the Chinese economy, electronics exports still have a price advantage and thus can occupy more market share in the world. As Chinese imports of electronics increase substantially, one may expect that electronics exports from other countries should increase. There are indeed some regions showing growth in exports of electronics (e.g., Hong Kong, which we have not listed due to space limits), but most countries experience a decrease in exports as shown in Table 2. The main reason is that the increase in electronics imports in China causes mainly trade diversion rather than trade creation: with the appreciation of RMB, only the Chinese feel that imports are cheaper. As Chinese demand for electronics imports increases, the overall prices of electronics will increase and other countries' demand for them will decrease. As such, increased imports of electronics in China largely come from a decrease in electronics imports in other countries.

Turning our attention away from China, we find that the effects of an appreciation of RMB on exports around the world are mixed. Some countries are negatively affected by an appreciation of RMB. These countries include Taiwan, Malaysia, and Thailand in Table 2 (there are many others which are not listed here). Some benefit significantly. For example, total exports will increase by US$838.3 million for Japan, US$ 1106.8 million for the US, US$266.1 million for Mexico, and US$1958.0 million for the EU. Other countries have positive but mild growth in exports, e.g., US$27.7 growth in exports for Australia and US$43.2 million for Canada. The different effects are largely determined by the industrial structures of these countries. As the Chinese electronics sector increases its exports remarkably, the electronics sectors in almost all other countries reduces

market share significantly. If the growth of exports in other sectors is not able to make up the loss in the electronics sector, then total exports will show negative growth (e.g., Taiwan, Malaysia, and Thailand). Some countries gain substantial ground in the industries where Chinese exports shrink. For example, Japan increases its exports by US$228.8 million in chemicals and US$464.1 million in other manufacturing; the US achieves more exports of US$ 129.4 in wood and print, US$314.9 in chemicals and US$147.7 in other manufacturing; both the EU and Mexico gains significantly in multiple sectors. As the total gain is substantially higher than the total loss, these countries benefit significantly. Although Canada achieves more exports of US$174.1 million in wood and print, its total gain is only moderately higher than its total loss, so its total exports grow by US$43.2 million. Australia is an interesting case. Its electronics sector is quite small, so it loses only US$6.2 million of exports in this sector. Its comparatively larger agricultural and energy extraction sectors benefit significantly from a strong RMB and so they help to obtain US$27.2 million growth in total exports.

The changes in payments to primary factors are shown in Table 3. Since we assume that the endowment of each region is not changed, the changes in factor payments actually reflect changes in factor prices. We consider capital and labour first.

The imposing feature of Table 3 is that China experiences the largest decrease in payments to primary factors. This largely results from the deflation arising from a more expensive Chinese currency. Since imports are much cheaper to Chinese people, thanks to the stronger RMB, households and firms tend to substitute domestic goods with

imports. This would decrease the demand for domestic goods and thus put downward pressure on the prices of domestic goods. Facing lower demand and lower prices for domestic goods, Chinese firms have to pay lower wages to labour and less rental to capital. The wage decrease for unskilled labour is slightly greater than that for skilled labour. This is consistent with the fact that the sectors employing more unskilled labour are more negatively affected (the sectoral output is not listed here, but it is indirectly reflected in the changes in exports in Table 2). However, if all payments are measured in a global currency, the payments to capital and labour actually increase. (Put differently, taking into account the deflation in the Chinese economy, real wages and real capital rentals increase).

Table 3. Percentage changes in payments to primary factors

Factors	AUS	CHN	JPN	KOR	TWN	SGP	CAN	WCR	EU_25	RUS
Unskilled Labour	0.038	-9.362	0.011	0.07	0.137	0.075	0.031	-0.007	0.005	0.015
Skilled Labour	0.041	-9.262	0.009	0.079	0.174	0.082	0.031	-0.005	0.005	0.013
Capital	0.045	-9.293	0.016	0.068	0.136	0.067	0.036	-0.002	0.004	0.018
Natural Resources	0.446	-11.294	0.381	1.008	0.489	0.829	0.172	0.229	0.241	0.187
Land	0.357	-9.951	0.178	0.257	0.119	0.429	0.381	0.32	0.107	0.072

The changes in payments to capital and labour in other countries are much smaller. For Australia, Korea, Taiwan, Singapore and Canada, there are slight increases in payments to capital and labour; for Japan, EU and Russia, the increase is even less. The US experiences an insignificant decrease in payments to capital and labour. These differing results for different countries are largely determined by their trade linkage with China. The appreciation of RMB increases China’s import demands greatly. This would push up the prices of tradables demanded by China. Countries exporting these types of goods are

expected to increase demand for capital and labour to produce more of these tradables and thus push up factor prices. This is the case for Australia, Korea, Taiwan, Singapore and Canada. On the other hand, the increasing supply of Chinese exports will squeeze the competing industries (e.g. electronics) in the other countries. As demands for products from these industries fall, payments to capital and labour will follow suit. These two factors can affect a country simultaneously, and thus lead to small positive or negative effects.

Compared with returns on capital and labour, the returns on payments to natural resources and land decrease more for China, whilst they increase more for other countries. Land is primarily used by agricultural sectors and natural resources are mainly used by energy extraction sectors (coal, oil, and gas). From Table 2 we see that these sectors in China are hit hard by a stronger RMB, so it is not surprising that the returns on these factors in China decrease further than those on capital and labour. As the Chinese exports using these factors decrease significantly, the demand for these products from other countries increases and this pulls up the prices of these goods as well as the factors producing them. As a result, the returns on natural resources and land in other countries increase significantly.

5. Conclusions

This paper has developed a multiple currency version of the GTAP model and simulated the effects of a10% appreciation of the Chinese currency. Contrary to common wisdom, the simulation results show that China will gain significantly from a stronger RMB.

Following a 10% appreciation of RMB, its imports will increase by 1.199%, exports by 0.522%, terms of trade by 10.263%, and real GDP by 0.02%. Although its income will decrease by 9.337%, real income actually rises by 0.663% if it is measured in US dollars. The unexpected increase in exports following an appreciation of RMB is explained by the strong import-export linkage in some sectors and by the deflation in China caused by its currency appreciation. The effects of an appreciation of RMB on other countries are mixed and depend on their trade relationship with China. Exporters to China are likely to be better off, but the countries competing with China in the world market are expected to lose.

The results on sectoral exports and factor payments give a more detailed picture. At the sectoral level, all agricultural sectors and manufacturing sectors in China are to be worse off, with the exception of animal production and electronics manufacturing. The strong growth in electronics exports underpins the reason for the unexpected export growth in China. The service sectors in China benefit from a stronger RMB. The sectoral effects on other countries are, by and large, opposite to that for China. Payments to factors are expected to reduce significantly in China, but they would be marginally positive or negative if measured in a global currency. Payments to factors are positive for all other countries, with the exception of the US, where payments to capital and labour drop insignificantly.

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