

Xing, Yuqing; Detert, Neal

## Article

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# How the iPhone Widens the United States Trade Deficit with the People's Republic of China

Yuqing Xing

National Graduate Institute for Policy Studies

Neal Detert\*

Asian Development Bank Institute

In this paper, we use the iPhone as a case to show that even high-tech products invented by the United States (US) companies will not increase US exports, but on the contrary exacerbate the US trade deficit. The iPhone contributed US\$1.9 billion to the US trade deficit with the People's Republic of China (PRC). Unprecedented globalization, well organized global production networks, the development of cross-country production fragmentation, and low transportation costs all contributed to rational firms such as Apple making business decisions that contributed directly to the US trade deficit. Global production networks and highly specialized production processes apparently reverse trade patterns: developing countries such as the PRC export high-tech goods like the iPhone while industrialized countries such as the US import the high-tech goods they invented themselves. In addition, conventional trade statistics greatly inflate bilateral trade deficits between a country used as export-platform by multinational firms, and its destination countries.

*JEL Codes:* F1

*Keywords:* China, US, Trade deficit, iPhone

## 1 Introduction

The bilateral trade imbalance between the People's Republic of China (PRC) and the United States (US) is at the center of global imbalances. Until now most of the attention has been focused on macro factors, such as low savings in the US, insufficient domestic consumption in the PRC, and the PRC's exchange rate regime. A sharp appreciation of the PRC yuan, it has been argued, is an effective means of mitigating the Sino-US bilateral trade imbalance. Little attention, however, has been paid to the structural factors of economies and global production networks that have transformed conventional trade patterns and the way we look at trade statistics, particularly in calculating the value-added component of traded goods and differentiating between processed and ordinary exports.

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Today's trade is not what was experienced by British economist David Ricardo two hundred years ago (GROSSMAN and ROSSI-HANSBERG 2008). It is almost impossible to define clearly where a manufactured product is made in the global market. This is why on the back of iPhones one can read "Designed by Apple in California, Assembled in China." In this paper, we attempt to explore the effects of some of these factors and attempt to show that production networks, unprecedented globalization and the profit maximization behavior of multinational enterprises play a crucial role in widening Sino-US trade imbalances. We use the iPhone, one of the key technological innovations of recent years created in the US and owned by an American multinational corporation, as an example in this exploration.

## **2 How are iPhones produced?**

iPhones are designed and marketed by Apple, which is one of the most innovative US companies. Apart from its software and product design, the production of iPhones primarily takes place outside the US. Manufacturing iPhones involves nine companies, which are located in the PRC, the Republic of Korea (hereafter Korea), Japan, Germany, and the US. The major producers and suppliers of iPhone parts and components include Toshiba, Samsung, Infineon, Broadcom, Numunyx, Murata, Dialog Semiconductor, Cirrus Logic, etc. All iPhone components produced by these companies are shipped to Foxconn, a company from Taipei, China located in Shenzhen, PRC, for assembly into final products and then exported to the US and the rest of the world. Table 1 lists major suppliers and costs of iPhone components and parts.

By any definition, the iPhone belongs to the high-tech product category, where the US has an indisputable comparative advantage. In effect, the PRC does not domestically produce any products that could compete with iPhones. The US also has an absolute advantage in the smart phone category. Ricardian theory and Hecksher-Olin theory would suggest the US should export iPhones to the PRC, but in fact the PRC exports iPhones to the US. All ready-to-use iPhones have been shipped to the US from the PRC. Foreign direct investment, production fragmentation, and production networks have jointly reversed the trade pattern predicted by conventional trade theories. The manufacturing process of iPhones illustrates how the global production network functions, why a developing country such as PRC can export high-tech goods – at least according to the currently ap-

plied methodology for calculating trade statistics – and why the US, the country that invented the iPhone, becomes an importer.

**Table 1:** Apple iPhone 3G's Major Components and Cost Drivers

<b>Manufacturer</b>	<b>Component</b>	<b>Cost</b>
Toshiba (Japan)	Flash Memory	US\$24.00
	Display Module	US\$19.25
	Touch Screen	US\$16.00
Samsung (Korea)	Application Processor	US\$14.46
	SDRAM-Mobile DDR	US\$8.50
Infineon (Germany)	Baseband	US\$13.00
	Camera Module	US\$9.55
	RF Transceiver	US\$2.80
	GPS Receiver	US\$2.25
	Power IC RF Function	US\$1.25
Broadcom (US)	Bluetooth/FM/WLAN	US\$5.95
Numonyx (US)	Memory MCP	US\$3.65
Murata (Japan)	FEM	US\$1.35
Dialog Semiconductor (Germany)	Power IC Application Processor Function	US\$1.30
Cirrus Logic (US)	Audio Codec	US\$1.15
<b>Rest of Bill of Materials</b>		<b>US\$48.00</b>
<b>Total Bill of Materials</b>		<b>US\$172.46</b>
<b>Manufacturing costs</b>		<b>US\$6.50</b>
<b>Grand Total</b>		<b>US\$178.96</b>

Source: RASSWEILER (2009)

### 3 iPhones and the US deficit with the PRC

iPhones were introduced to the US market in 2007 to large fanfare, selling an estimated 3 million units in the US in 2007, 5.3 million in 2008, and 11.3 million in 2009. Globally, iPhone sales have been estimated at 3.7 million, 13.7 million, and 25.7 million in 2007, 2008, and 2009, respectively, with the bulk of those sales in advanced markets in Europe, Japan, Singapore, and Korea (HUGHES 2010).

Since all iPhones are entirely assembled in the PRC, the shipment of ready-to-use iPhones from the PRC to the US is recorded as the PRC's exports to the US, thus becoming a part of the US trade deficit with the PRC. Table 2 shows iPhone exports in units and US dollars from the PRC to the US, as well as estimated trade balances in iPhones between the two countries.

Using total unit manufacturing costs as the unit price of iPhones exported to the US, we estimate that in 2007 US\$687 million worth of exports from PRC to the US was attributed to iPhones. In 2009, that amount exceeded US\$2 billion. Since iPhones were not sold in the PRC until late 2009 and the sales of the iPhone were very limited (GAMET 2009), we assume that the iPhone import of the PRC was zero in 2009. Assuming that parts supplied by Broadcom, Numonyx and Cirrus Logic<sup>1</sup> were imported from the US, which were valued at US\$121.5 million, in 2009 iPhones contributed US\$1.9 billion to the US trade deficit, equivalent to about 0.8% of the total US trade deficit with the PRC.

It is estimated that iPhone sales would rise to 21.3 million units in the US by 2011 (HUGHES 2010), almost doubling the current sales. Under the existing production patterns, in which all iPhone are exclusively assembled in the PRC, the contribution of the high-tech product iPhone to the Sino-US trade deficit would be expected to rise further as more and more Americans purchase iPhones.

On the other hand, most of the export value and the deficit due to the iPhone are attributed to imported parts and components from third countries and have nothing to do with the PRC. Chinese workers simply put all these parts and components together and contribute only US\$6.5 to each iPhone, about 3.6% of the total manufacturing cost (e.g., the shipping price). The traditional way of measuring trade credits all of the US\$178.96 to the

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<sup>1</sup> It is also possible that these companies have the components produced outside the US.

PRC when an iPhone is shipped to the US, thus exaggerating the export volume as well as the imbalance. Decomposing the value added along the value chain of iPhone manufacturing suggests that, of the US\$2.0 billion worth of iPhones exported from the PRC, 96.4% in fact amounts to transfers from Germany (US\$326 million), Japan (US\$670 million), Korea (US\$259 million), the US (US\$108 million), and other countries (US\$ 542 million). All of these countries are involved in the iPhone production chain.

**Table 2:** iPhone Trade and the US Trade Deficit with PRC

Year	2007	2008	2009
iPhone Sales in the US* (million Units)	3.0	5.3	11.3
Shipping Price/unit** (US dollars)	229	174	179
PRC's Export to the US in iPhone (million US dollars)	687	922.2	2,022.7
PRC's Trade Surplus with the US in iPhones	N/A	N/A	1,901.2 <sup>1</sup>
PRC's iPhone exports to the US based on value added ( million US dollars)	19.5	34.35	73.45
Value added / total exports	2.8%	3.7%	3.6%
PRC's trade surplus with the US in iPhones based on Value-added	N/A	N/A	73.45 <sup>2</sup>

<sup>1</sup> When calculating trade deficits between the PRC and the US in iPhones, we assume that all parts supplied by Broadcom and Numunyx were imported from the US.

<sup>2</sup> The parts provided by Broadcom, Numunyx, and Cirrus Logic are shipped back to the US inside the ready-to-use iPhones. They are "round tripping" exports, which should not be considered as actual exports in the value added approach.

Sources: \* HUGHES (2010); \*\* RASSWEILER (2009).

If the PRC's iPhone exports were calculated based on the value-added, i.e., the assembling cost, the export value as well as the trade deficit would be much lower, at only US\$73 million, just 3.6% of the US\$ 2.0 billion calculated by using the prevailing method (Table 2). The sharp contrast between the two different trade deficit measurements indicates that conventional trade statistics are not consistent with the trade where global production networks and production fragmentations determine cross-country flows of parts, components, and final products. Bilateral trade imbalances between a country used as a final assembler and its destination markets are greatly

inflated by trade in intermediate products. These statistics provide a distorted picture about bilateral trade imbalances. The Sino-US bilateral trade imbalance has been greatly inflated.

#### **4 iPhone production and the appreciation of the yuan and other Asian currencies**

The yuan's appreciation has been called for by many observers as a means to solve global imbalances, and the Sino-US trade imbalance in particular. The appreciation proponents ignore the fact that the appreciation can only affect a small portion of the cost of "made/assembled-in-China" products. In this section we use the iPhone trade to examine the impact of the yuan appreciation on the high-technology contribution to the trade deficit. The calls for appreciation of the yuan vary from a needed 10% to 40% increase against the US dollar. We will assume here that it appreciates 20% from its current level. We also assume that there is no productivity growth at the PRC assembling factory.

An appreciation of 20% will raise the iPhone assembly cost to US\$7.8 per unit, from US\$6.5, and add US\$1.3 to the total manufacturing costs. This would be equivalent to a 0.73% increase in total manufacturing costs. It is doubtful that Apple will pass this US\$1.3 to US consumers as the increase is negligible and Apple would have little to gain by passing a tiny price increase to iPhone users. Even a 50% appreciation of the yuan against the dollar would not bring a significant change in the total manufacturing costs, as the assembling cost-contribution of PRC workers to a ready-to-use iPhone is very little — only 3.6%. Therefore, the expected pass-through effect of the yuan's appreciation on the price of the iPhone would be zero and US consumers' demand for the iPhone would not be affected. It is unlikely that a yuan appreciation would lower many components of the trade deficit, in this case the portion due to the iPhone trade.

Realizing the limit of the yuan appreciation on the PRC's trade surplus, because of the role played by processing exports, THORBECKE (2010) proposed a joint appreciation of East Asian currencies against the dollar to mitigate the imbalance between the PRC and the US. Below we analyze how the joint appreciation of the currencies of the economies involved in producing iPhone affect iPhone trade. Similarly, we assume that all these currencies — yuan, Korean won, Japanese yen and NT dollar — appreciated against the US dollar by 20%. Excluding parts supplied by Broadcom, Numonyx and

Cirrus Logic, which together costs US\$10.75 per unit, we assume the rest of parts are produced in these Asian economies<sup>2</sup> and there is no technological progress or productivity gains in any factories making these components. Based on these assumptions, the joint appreciation would be expected to raise the unit cost of iPhones by US\$33.64, to US\$212.60. Under the scenario of a 20% joint appreciation, the manufacturing cost could rise by 19%, a much stronger increase than in the case of unilateral appreciation of the yuan.

Apple would be able to cope with the rising cost triggered by the joint appreciation through adoption of one of three strategies: (1) passing the increased cost to consumers by raising the price of iPhone to US\$534 per unit, a 6.8% increase in the retail price; (2) expecting productivity growth cross the production network of iPhones to offset the impact of the joint appreciation; and (3) absorbing the rising cost with profit margin adjustment.

Under strategy (1), a 20% joint appreciation would reduce iPhone imports by 6.8% at most since price elasticities of import demand are generally lower than one. In other words, despite of the assumed complete exchange rate pass-through, the impact of the proposed 20% joint appreciation on PRC's iPhone exports to the US would be relatively small.

On the other hand, under either strategy (2) or (3), the proposed joint appreciation would not affect the demand for iPhones at all, thus the bilateral trade imbalance would not change. It is highly possible that the productivity growth associated with rising global sale volume would mitigate the negative impact of the joint currency appreciation. Economies of scales play a critical role in leading productivity growth in the production of iPhones in the short run. Rising volumes of iPhone shipments continuously lowers the unit cost of the iPhone. It cost US\$265 to produce an iPhone when it was introduced in 2007. Within one year, the unit cost of the iPhone dropped to US\$178 and the functions and memory of newly produced models are much more powerful than of the older models (HESSELD AHL 2008).

As mentioned above, global sales of iPhones reached 25.7 million in 2009, six times higher than after its inception in 2007. It is projected that the sales of iPhones will continue to rise globally, reaching an estimated 45 million in 2011 (HUGHES 2010). The economies of scales created by the surging sales

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2 Infineon is a German company. Here we assumed all parts provided by Infineon would be produced in its factories in Asia. Therefore, the expected increase presented here represents the upper boundary of the increase associated with the joint currency appreciation.



volume should further reduce the production costs. Hence, the productivity growth along the production chains of iPhones will likely offset at least part of the cost increase due to the proposed joint appreciation.

**Table 3:** Profit Margin of iPhones

	2007	2008	2009
Unit Price*	US\$600	US\$500	US\$500
Unit manufacturing costs*	US\$229	US\$174.33	US\$178.96
Profit margin**	US\$371	US\$325.67	US\$321.04
Profit Margin (%)**	62	65	64

*Sources:*\* iSupply, ; \*\*Calculated by the authors.

Moreover, Apple lowered the price of the iPhone from US\$600 to US\$500 in 2009. Despite a US\$100 reduction in the price, the gross profit margin of the iPhone actually rose to 64% from 62%, thanks to the significant reduction in the production costs (Table 3). The more than 50% profit margin leaves Apple with the flexibility to absorb increased manufacturing costs related to the joint appreciation. With demand for iPhones continuing to climb, both in the US and globally, and potential increases in manufacturing costs likely to be absorbed through productivity increases or through slight reductions in Apple's profit margins, neither a unilateral currency appreciation nor a joint currency appreciation will significantly affect or mitigate the US-PRC trade deficit related to iPhone trade. On the contrary, as more and more iPhones are being shipped to the US from the PRC, the US trade deficits with the PRC continue to grow.

Another possible impact of the yuan appreciation against the US dollar is increasing the purchasing power of PRC consumers for US goods such as iPhones. When PRC consumers purchase iPhones, exports of the US to the PRC increase, thus narrowing the US trade deficit in iPhone trade. Since its official introduction into the PRC market from October 2009 to January 2010, only an estimated 200,000 iPhones had been sold. As a proportion of the mobile and smart phone markets, the iPhone does not command the same market share as it does in the US or Europe, because of the high price. The price of an iPhone at the end of 2009 in mainland PRC was US\$1,000

per unit, double the US unit price. Compared with US\$10,000 GDP per capita in Beijing and Shanghai, the most developed metropolitan cities in the PRC, the iPhone remains relatively more expensive. The iPhone market in the PRC would be limited and much smaller than its counter parts in the US and EU. CHAO, LUK and BACK (2009) estimate that iPhone sales in the PRC will increase to 2.9 million by the end of 2011. Compared with more than 20 million iPhone users in the US, it is highly unlikely that the number of iPhone users in the PRC could match that in the US in the foreseeable future. Hence, trade in iPhones will continue to widen the US trade deficit with the PRC, as iPhones become a mainstream mobile phone in the US.

## 5 Could the iPhone be assembled in the US?

Besides exchange rates, we consider a hypothetical alternative solution for reducing the US trade deficit with the PRC due to the iPhone trade, namely to have all iPhones assembled in the US.

The role of the PRC in the production chain of iPhones is primarily the assembly of all parts and components into the final product for re-shipment abroad. The skills and equipment required for the assembly are very basic and there is no doubt that American workers and firms are capable of assembling iPhones in the US. If all iPhones were assembled in the US, the US\$1.9 billion trade deficit in iPhone trade with PRC would not exist. Moreover, 11.4 million units of iPhone sold in the non-US market in 2009 would add US\$5.7 billion to US exports.

There are two possible reasons for Apple to use the PRC as the assembly center for iPhones. The first could be because of fierce competition in the smart phone sector that forces Apple to find a low-cost assembly location. In such a situation, Apple would be faced with either a profit margin that is too low to be sustainable, or price-setting such that it would not be able to find buyers. The other possible reason would simply be the profit maximization behavior of Apple and the demands of Apple's shareholders.<sup>3</sup>

As shown in Table 3, the gross profit margin of iPhone was 62% when the phone was launched in 2007, before rising to 64% in 2009 due to reductions in manufacturing costs. If the market were fiercely competitive, the expected

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3 The well developed production network in East Asia could also be one of reasons for all iPhones being assembled in the PRC. To make such an argument requires specific technical knowledge we do not have, so we ignore this possibility.

profit margin would be much lower and close to zero in the case of perfect competition. Surging sales and the high profit margin suggest that the intensity of competition is fairly low in the smart phone market, and Apple maintains a relative monopoly position. Therefore, the hypothesis that competition drives iPhones' assembly into the PRC does not hold. It is the profit maximization behavior of Apple rather than competition that pushes Apple to have all iPhones assembled in the PRC. The unprecedented globalization and well developed production networks make it possible for Apple to utilize a much cheaper location outside the US to maximize its profits on iPhones.

An interesting hypothetical scenario is one where Apple had all iPhones assembled in the US. Assuming that the wages of US workers are ten times as high as those of their PRC counterparts and their productivity would be equal in 2009, if iPhones were assembled in the US the total assembly cost would rise up to US\$68 and total manufacturing cost would be pushed up to approximately US\$240. Selling iPhones assembled by US workers at US\$500 per unit would still leave a 50% profit margin for Apple. As iPhone sales increase globally, that profit margin would also increase. In this hypothetical scenario, iPhones, the high-tech product invented by the US company, would contribute to US exports and the reduction of the US trade deficit, not only with the PRC, but also with the rest of world. More importantly, Apple created jobs for US low skilled workers; those who could not be the software engineers needed by Apple. Giving up a small portion of profits and sharing them with low skilled US workers by Apple would be a more effective way to reduce the US trade deficit and create jobs in the US.

In a market economy, there is nothing wrong with a firm pursuing profit maximization. Governments should not restrict such behavior in any way. However, corporate social responsibility (CSR) has been adopted as a part of corporate values by many multinational companies, including Apple. It may be an effective policy option to practice CSR by creating jobs for low skilled workers, such as using US workers to assemble iPhones.

### **Concluding remarks**

In this paper, we use the iPhone as a case to show that even high-tech products invented by US companies will not increase US exports, but to the contrary exacerbate the US trade deficit. Unprecedented globalization, well organized global production networks, and low transportation costs all con-

tribute to rational firms such as Apple making business decisions that contributed directly to the reduction of the US trade deficit.

Global production networks and highly specialized production processes apparently reverse trade patterns: developing countries such as the PRC export high-tech goods – like the iPhone – while industrialized countries such as the US import the high-tech goods they invented themselves. High-tech products such as iPhones in this context do not help increase US exports, but instead contribute to the US trade deficit. In addition, conventional trade statistics greatly inflate bilateral trade deficits between a country used as export-platform by multinational firms and its destination countries.

In the case of iPhone trade, the PRC actually contributed only 3.6% of US\$2.0 billion export to the US, the rest was simply a transfer from Germany, Japan, Korea, the US, and other countries. Based on value added, the PRC had only a \$73 million trade surplus with the US in iPhone trade, much smaller than the US\$1.9 billion calculated in the traditional way.

PRC workers added a merely \$6.50 to the entire US\$179 manufacturing cost of an iPhone and the appreciation of the yuan would only affect the assembling cost. Therefore, the appreciation of the yuan would have very little impact on the total manufacturing cost as well as the retail price of iPhones. It is unrealistic to expect the appreciation would lower the demand for iPhones in the US. In other words, the appreciation of the yuan would not help mitigate the US deficit due to iPhone trade. If US high-tech companies, such as Apple, were willing to share their profits with low skilled US workers by keeping assembly jobs in the US, it would be a more effective way to reduce the US trade deficit than by targeting the exchange rate policy of the PRC.

Due to the limitation of the data, we are unable to outline a more detailed picture on the distribution of the iPhone value chain cross all countries involved in manufacturing the iPhone. However, adding more countries and parts into the picture would not change the bottom line: the value added created by the PRC accounts for only a small portion of a read-to-use iPhone and current trade statistics greatly inflate the value of PRC's iPhone export to the US as well as the corresponding trade imbalance.

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**Autoren – Authors****Hosuk Lee-Makiyama**

European Centre for International Political Economy (ECIPE)  
Rue Belliard 4–6  
BE-1040 Brussels  
Belgium  
*Hosuk.lee-makiyama@ecipe.org*

**Neil Detert**

Project Manager  
Clean Energy LLC, Newcom Group  
9F, 8 Zovhkis Building  
Seoul Street 21  
Ulaanbaatar 14251  
Mongolia  
*Neal@newcom.mn*

**Yuqing Xing**

National Graduate Institute for Policy Studies  
7-22-1, Roppongi  
Minato-ku  
Tokyo, 106-8677  
Japan  
*Yuqing\_xing@grips.ac.jp*

**Raphael Auer**

Swiss National Bank  
Börsenstrasse 15  
CH-8022 Zürich  
Switzerland  
*Raphael.auer@snb.ch*

**Philip Sauré**

Swiss National Bank  
Börsenstrasse 15  
CH-8022 Zürich  
Switzerland  
*Philip.saure@snb.ch*

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