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Why isn't China exporting automobiles? : A model of technology adoption

Nianchen Han
University of Richmond

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1 Introduction, Motivation & Literature Review

In modern times, the automobile industry has become a relatively labor intensive industry as compared to other industries such as the food processing industry or IT industry. Normally, several people are involved in each process of an automobile production line. However, for a food processing firm such as a bottled water firm, it only takes a few people to control the huge machine in the factory. Under the Heckscher-Ohlin theorem's assumption, a country will operate an industry that is intensive in its abundant resource. That means a labor abundant country will produce labor intensive goods and a capital abundant country will produce capital intensive goods. Then, why is China, a labor abundant country, not producing automobiles and exporting cars?

One explanation for this situation is that a high technology difference exists between countries, which creates comparative advantages based on more than just factor abundance. Even though the automobile industry is a labor intensive industry, the capital abundant countries will still produce automobiles because they have higher technology and the U.S can produce more with the same labor quantities. Thus, to make the world production more efficient, China will have incentive to promote its own technology level and increase the production in the labor intensive industry's production back to itself. Given this incentive of technology adoption, what is the tradeoff tha China faces for the technology adoption? Also, what are the industrial policies that China can pursue to promote its technology level?

Industrial policy is an official strategic effort to encourage the development of the manufacturing industry. In the *Report on subject of Manufactures* by Alexander Hamilton (1791), the idea of the industrial policy was first introduced. Hamilton mainly discussed that to promote early American industry, the U.S. needed to protect the infant manufacturing industry and encourage the development of the industry by promoting its technology level. He specifically discussed that using the tariff revenue to support local firm's innovations and technology development. His idea was expanded by Tilman Altenburg (2011) in *Industrial policy in Developing Country: Overview and Lessons from Seven Country Cases.* Altenburg divided industrial policy into two main categories including functional policies and selective policies. Functional policies encourage support on industry's framework such as power supply and infrastructure construction. Selective policy is direct subsidy from the government to target area such as technology development. In this paper, we will mainly focus on selective policy and industry outcomes if the government supports the technology development. Also, in *The 8th order of National Development and Reform Commission of The People's Republic of China,* we can find direct support evidence that China is using industrial policies to develop its technology level.

In this paper, we are mainly interested in the role of how technology differences matters in a Heckscher- Ohlin model framework and what are the industrial policies' effect on the technology differences. We construct a model which allows us to study this technology adoption problem. This model is a combination trade model of the Heckscher- Ohin model and Ricardo's idea of technology differences. In this model, there are two countries (U.S. and China), two factors (labor and capital) and two industries (a capital intensive industry and a labor intensive industry.) We will study the technology adoption problem by putting different technology levels in the industries from the two countries in this model and examine how technology level changes in China affect the two Countries' utility and production. For simplicity reasons, we will use a simple Cobb- Douglas function for production and utility in this model.

There are three major results in this paper. The first one is that when China increases its technology level, the U.S. welfare may decreases. This result comes because of clearing terms of trade at the beginning stage of adoption technology and the effect this has on the trade direction. The second result incorporates a cost for technology adoption. We study the optimal technology level given the cost function and two different payment methods. Also, we generate the results for interesting when the original technology level in China is not zero. The last result will give us policy outcome. I will show that under some condition, U.S. will pay China to discourage them from adopting more technology in an attempt to prevent welfare loss for them.

I will introduce the set up for the model and solve the model in the second section of the paper. In the third section, I will explain the major results in the detail by using graphs and mathematical tools. Finally, in section 3 I will conclude.

2 Model for the two countries

My model is a two country, two good and two factor model with a simple Cobb- Douglas function. There are several assumptions for this model: First, the model has a constant return to scale production function. Second, the labor and capital resources in both countries are fully hired by the two industries. Household cannot borrow across countries. And for each goods, the sum of production quantities of both countries must equals the sum of consumption quantities of both countries. Based on these assumptions, we have several equations.

(1) $L^{CH} = L^{CH}_{LI} + L^{CH}_{KI}$;

(2) $K^{CH} = K^{CH}_{LI} + K^{CH}_{LI}$;

(3) $L^{US} = L^{US}_{LI} + L^{US}_{KI}$;

(4) $K^{US} = K^{US}_{LI} + K^{US}_{KI}$;

(5) $Q^{CH}_{LI} + Q^{US}_{LI} = C^{CH}_{LI} + C^{US}_{LI}$;

(6) $Q^{CH}_{KI} + Q^{US}_{KI} = C^{CH}_{LI} + C^{US}_{KI;}$

For simplicity, I use Q^{CH} as productions in China and Q^{US} as productions in U.S. L^{CH}_{LI} is the labor factor that is used in the labor intensive industry in China and the L^{US}_{LI} is the labor used in the labor intensive industry in U.S. Similarly, the L^{CH}_{KI} is the labor used in the capital intensive industry in China and L^{US}_{KI} is the labor used in the capital intensive industry in U.S. The same holds true for capital Ks. Correspondingly, the Qs are the quantities of labor intensive goods and capital intensive goods production for China and U.S and Cs are quantity of labor intensive goods and capital intensive goods consumed in China and U.S.

For the labor intensive good, we have the following production functions in China and U.S.,

(7) $Q^{CH}_{LI} = A_{LI} * K^{CH\alpha}_{LI} \mathbf{L}^{\mathbf{C1-\alpha}}_{\mathbf{LI}}$

(8) $Q^{US}_{LI} = A^{US}_{LI} * K^{US^{\alpha}}{}_{LI} \mathbf{L}^{\mathbf{US}^{\mathbf{1-\alpha}}}_{\mathbf{LI}}$

In these functions, the Q^{CH}_{LI} and Q^{US}_{LI} are the productions levels for the labor intensive goods. For China, this industry has a technology level of A_{LI} and for U.S., this industry has a technology level of $A^{US}_{LI.}$ The α is the capital share in this industry. A low α indicates a highly labor intensive industry. An example is the automobile industry.

For the capital intensive good, we have the similar functions with different variables,

(9) $Q^{CH}_{KI} = A_{KI} * K_{KI}^{CH\nu} \mathbf{L}_{\mathbf{KI}}^{\mathbf{CH1-\nu}}$

(10) $Q^{US}_{KI} = A_{KI}^{US} * K^{US^{\nu}}_{KI} \mathbf{L}^{\mathbf{US}^{\mathbf{1-\nu}}}_{\mathbf{KI}}$

In these functions, the Q^{CH}_{KI} and Q^{US}_{KI} are the production level for the capital intensive industry. For China, this industry has a technology level of A_{KI} and for U.S. this industry has a technology level of A^{US}_{KI}. The ν is the capital share of production in this industry. ν should be greater than α because this is a capital intensive industry. One example of this industry is the food processing industry because it is relatively capital intensive industry.

Solving these equations based on first order conditions will give us the nominal wage and rental rate:

(11) $w = P_{LI}*MPL_{LI}$

(12) $w = P_{KI}*MPL_{KI}$

(13) $r = P_{LI}*MPK_{LI}$

(14) $r = P_{KI}*MPK_{KI}$

Since the two countries are under the free trade, the price for each goods is the same in both countries. The nominal wage in both industries is the same in the equilibrium and equals to marginal production of labor. If the wages are different, labor will shift to the higher wage industry and then bring the wage in that industry to equilibrium again. The rental rate in both industries is the same based on the same ideas as above and it is equal to the marginal production of capital.

In this model, to study the welfare of the countries, I will introduce utility functions for the two countries:

(15) $U^{CH} = C_{LI}^{CH\tau} C_{KI}^{CH1-\tau}$ s.t. $P_{LI}*Q^{CH}_{LI} + P_{KI}*Q^{CH}_{KI} = P_{LI}*C^{CH}_{LI} + P_{KI}*Q^{CH}_{KI}$

(16) $U^{US} = C^{US}{}^{\tau}_{LI} C^{US}{}^{1-\tau}_{KI}$ s.t. $P_{LI}*Q^{US}_{LI} + P_{KI}*Q^{US}_{KI} = P_{LI}*C^{US}_{LI} + P_{KI}*Q^{US}_{KI}$

The utility function is a function of consumptions and the maximization is subject to a standard economy – wide one period budget constraint. U is the total utility for China and U^{US} is the total utility for U.S.

Givien all these functions, we need to solve this system of equations to eliminate the variables and express them as parameters of the model. Solving the system's first part which contains the production function, the optimal conditions are:

$L^{CH}_{LI} = \frac{B_F*L^{CH}-K^{CH}}{B_F-B_C}$

$L^{CH}_{KI} = L^{CH} - \frac{B_F*L^{CH}-K^{CH}}{B_F-B_C}$

$K^{CH}_{LI} = B_C * \frac{B_F*L^{CH}-K^{CH}}{B_F-B_C}$

$K^{CH}_{KI} = B_F * \frac{K^{CH}-B_C*L^{CH}}{B_F-B_C}$

$L^{US}_{LI} = \frac{B1_F*L^{US}-K^{US}}{B1_F-B1_C}$

$L^{US}_{KI} = L^{US} - \frac{B1_F*L^{US}-K^{US}}{B1_F-B1_C}$

$K^{US}_{LI} = B1_C * \frac{B1_F*L^{US}-K^{US}}{B1_F-B1_C}$

$K^{US}_{KI} = B1_F * \frac{K^{US}-B1_C*L^{US}}{B1_F-B1_C}$

Where $B = [(\frac{P_{LI}*A_{LI}}{P_{KI}*A_{KI}}) * (\frac{\alpha^{\alpha}}{\nu^{\nu}} * \frac{1-\alpha^{1-\alpha}}{1-\nu^{1-\nu}})]^{\frac{1}{\nu-\alpha}}$

$B_F = \frac{B*\nu}{1-\nu}$

$B_C = \frac{B*\alpha}{1-\alpha}$

B1 is the same as B but with different technology $A^{US}{}_{LI}$ and $A^{US}{}_{KI.}$

Solving for the system's second part with the preference function, the optimal condition becomes:

$$C_{KI} = \frac{(1-\tau)}{\tau} * \frac{P_{LI}}{P_{KI}} * C_{LI}$$

Thus, then combining it with the subjective functions, we have:

$$C^{CH}{}_{LI} = \tau * \left(Q_{LI}^{CH} + \frac{P_{KI}}{P_{LI}} * Q_{KI}^{CH}\right)$$

$$C^{CH}{}_{KI} = (1-\tau) * \left(\frac{P_{LI}}{P_{KI}} * Q_{LI}^{CH} + Q_{KI}^{CH}\right)$$

Correspondingly, we have the similar format for $C^{US}{}_{LI}$ and $C^{US}{}_{KI}$ but with different corresponding variables for U.S.

Combining the above equations with equation (15), we can come up with an equation between price and productions:

$$\frac{P_{LI}}{P_{KI}} = P = \frac{\tau}{1-\tau} * \frac{(Q_{KI}^{CH} + Q^{US}{}_{KI})}{(Q_{LI}^{CH} + Q^{US}{}_{LI})}$$

Where we can generate Qs from the equations for Ls and Ks:

$$Q^{CH}{}_{KI} = A_{KI} * B_F^{\nu} * L_{KI}^{CH}$$

$$Q^{CH}{}_{LI} = A_{LI} * B_{LI}^{\alpha} * L_{LI}^{CH}$$

$$Q^{US}{}_{KI} = A^{US}{}_{KI} * B1_F^{\nu} * L^{US}{}_{KI}$$

$$Q^{US}{}_{LI} = A^{US}{}_{LI} * B1_{LI}^{\alpha} * L^{US}{}_{LI}$$

Solving all these equations, we finally get an equation for the price ratio P. P equals to a complicated expression that contains theA_{KI}, A_{LI}, $K^{US}{}_{KI}$, $K^{US}{}_{LI}$, ν , α , τ , L^{CH}, L^{US}, K^{CH}, K^{US}.

Since we solved the equations as functions of the parameters, we can then calibrate each unknown variables by plugging in numbers for them. Our aim is to study the change in the parameter A_{LI} the technology level in China's labor intensive industry. We choose $K^{CH} = 1$, $L^{CH} = 4$ for China because China has a low capital to labor ratio. We choose $K^{US} = 1$, $L^{US} = 2$ for U.S because U.S has a relatively high capital to labor ratio. We set α equals 0.2 because the α is the capital share in production in the labor intensive industry. It should be low. Based on the same idea, we set ν equals 0.8 since it is the capital share in capital intensive industry. To simplify the model, we set the preference coefficient τ equals 0.5. This means that the preference is neutral between the two goods and the utility that you will get from each goods is the same for the same amount of quantity. For the capital intensive industry's technology level in both countries, A_{KI} and $A^{US}{}_{KI}$, I set these two equals to each other and have same value of 1 for simplicity reasons. For the value of the technology level in the labor intensive industry in U.S., $A^{US}{}_{LI}$, I set it to equals to 1. For the value of the technology level for the labor intensive industry in China, A_{LI}, I set a boundary from 0.25 to 1.25 to study the change in this parameter. The numbers for these parameters is showed specifically in table 2.

3 Result and Discussion

(1) The change in variables

As A_{LI} change, the variables in the model change. Graphs 1-4 illustrate these changes. The price ratio $\frac{P_{LI}}{P_{KI}}$ is falling as the technology level in the labor intensive industry in China increases as showed in figure 1. This change in the price ratio makes intuitive sense. When the technology level A_{LI} increases, the production of labor intensive goods increases correspondingly because you can produce more goods with the same labor and capital. As the quantity of supply increases, the price of the labor intensive goods will goes down. Thus the relative price ratio will goes down.

In Figure 2, there are four graphs showing the relationship between unknown variables and A_{LI}. The first graph is a graph that illustrates the increase in capital ratio $\frac{K_{LI}^{CH}}{K_{KI}^{CH}}$ in China when A_{LI} increases. The growth of the capital ratio makes sense because the marginal produced of capital increases as A_{LI} goes up. As the marginal production of capital increases, more capital will be employed in the labor intensive industry due to its higher efficiency. The total capital in China is a constant in this model so when $K^{CH}{}_{LI}$ increases, $K^{CH}{}_{KI}$ must decreases. Thus the capital ratio $\frac{K_{LI}^{CH}}{K_{KI}^{CH}}$ increases in China. Similarly, in second graph, as A_{LI} increases, the MPL in the labor intensive industry increases causing labor to shift from the capital intensive industry from the labor intensive industry in China. Thus the labor ratio $\frac{L_{LI}^{CH}}{L_{KI}^{CH}}$ for China is increasing due to the relative change between each industry's labor forces. However, for U.S., the capital employment ratio $\frac{K^{US}{}_{LI}}{K^{US}{}_{KI}}$ and labor force employment ratio $\frac{L^{US}{}_{LI}}{L^{US}{}_{KI}}$ have the exact opposite trend compared to China's labor employment and capital employment ratio. This opposite trend is based on the relative productivity's change and the effect of the trade. In U.S., the labor intensive industry is becoming increasingly relatively less productive. Thus, U.S. is going to shift both labor and capital resources to the capital intensive industry from the labor intensive industry. The capital employment ratio and labor employment ratio in both industries are decreasing.

In figure 3, we can find out the production ratio $\frac{Q_{LI}^{CH}}{Q_{KI}^{CH}}$ and consumption ratio $\frac{C_{LI}^{CH}}{C_{KI}^{CH}}$ easily from the equations system. For the first graph, I find that the production ratio in China is increasing and the production ratio in U.S. is decreasing. This result can be deducted from the change in the capital and labor employment ratio. In China, the resources are reallocated into the labor intensive industry so that the production in the labor intensive industry will increase whereas the production in capital intensive industry will fall. The U.S. has exactly the opposite situation. For consumption, we have exactly the same consumption ratio in U.S and China. This is due to the preference function. For the preference function, we can generate a relationship between consumption and price ratio: $\frac{C^{US}{}_{LI}}{C^{US}{}_{KI}} = \frac{P_{KI}}{P_{LI}} = \frac{C^{CH}_{LI}}{C^{CH}_{KI}}$. Thus for both countries, their consumption ratio on the two goods are the same. The third and fourth graphs shows the trade quantity's changes in the labor intensive good and capital intensive good separately. The trade quantity is just the difference between the quantity produced and consumed. When the trade quantity is positive, the country is exporting, and the country is importing when the trade quantity is negative. I find that at the beginning, U.S. is exporting the labor intensive goods because of its comparative advantage in the labor intensive industry based on its relatively high technology level while China is exporting capital intensive goods due to its comparative advantage. However, as A_{LI} goes up in China, U.S. starts losing its comparative advantage in the labor intensive industry. Eventually trade direction changes at a certain level of A_{LI}.

In figure 4, we see the relationship between the real GDP and the A_{LI}, as well as the relationship between total utilities in the two countries and the A_{LI}. For the GDP curves, we find that the real GDP in terms of labor intensive goods are increasing for both countries but the real GDP in terms of capital intensive goods are increasing for China and decreasing then increasing for the U.S. We will focus more on this result later. I also find that the utility for China is always increasing. This situation makes sense since the welfare of China as a whole is increasing due to the increasing consumptions in both goods. Increasing consumptions are affected by the total GDP increases. However, for U.S., the utility curve has a decreasing then increasing shape. This is an interesting change that relate to the real GDP's (in terms of capital intensive goods) change. I will discuss the reason for this U –shape curve and dig deeper into this result in the next subsection

Combining the general cases with the specific cases, we can find out that as the technology level increases in China's automobile's industry, there are multiple effects. The price of automobile is lower relative to the price of food due to the change in production. The labor and capital resources will adjust and move into the car industry in China which will create more of automobile and lower the production of food in China. In the U.S., the food industry will gain more capital and labor resources and will have a higher production in this capital intensive good while the production in the labor intensive industry will fall. The increase in the technology level of China's automobile industry will also change the trade direction and generate a higher utility for China. Also, I find this interesting result that a labor abundant country may not produce labor intensive goods, if the technology level in that country is low.

(2) **Why the utility in U.S is decreasing first and then increasing?**

We can explore the utility of U.S. by making a chart that contains the data at different values of the $\frac{A_{LI}}{A^{US}_{LI}}$ ratio to show the effect of A_{LI} increasing in China on the utility and consumption of U.S. As can be seen in the data in the table 1: The Utility of U.S. is decreasing from technology level ratio 0.25 to 0.6594 and is increasing from 0.6594 to 1.25. The utility is at its minimum point of 0.6594. Also, we find that the decrease in utility is due to the sharp decrease in consumption of the capital intensive good and slow increase in consumption of the labor intensive good. The increasing of utility is determined by the sharp increase in consumption of the labor intensive good and slow decrease in consumption of the capital intensive good. From the previous part, we also find that the real GDP for U.S. (in terms of the capital intensive good) is decreasing. Therefore, we can determine that when A_{LI} increases, the consumption of the capital intensive good is decreasing in U.S. What is going on in this situation? The explanation is simple and depends on the direction of trade. At the beginning, the U.S. is exporting labor intensive goods and importing capital intensive goods. As A_{LI} increases, China reallocates its production resources to produce more labor intensive goods and produce less capital intensive goods. P_{LI} falls while P_{KI} is increasing. Thus, the U.S. now gains less from the export and losses on the import. As a result, U.S.'s utility is decreasing due to less welfare gained from trade. However, when A_{LI} keeps increasing, the trade direction will reverse and eventually the U.S. will sell capital intensive goods and gain from the benefit of China's cheaper labor intensive good exports. This result is showed in the figure 5.

(3) **Technology adoption depends on costs**

In the previous study, we assumed the model was no cost on the promotion of the A_{LI} in

China. However, this situation is highly unlikely in the real world. We impose a utility cost on increasing A_{LI}. The equation for the utility function in China now becomes:

$$U = C_{LI}^{\tau} C_{KI}^{1-\tau} - COST * A_{LI}^{2}$$

This cost is a common convex cost. This cost can be interpreted in another way too. Consider $U(C) = C$ & $C = C_{LI}^{\tau} C_{KI}^{1-\tau}$ now we can think of the cost as a cost on the composite good where the composite goods is produced using a Cobb- Douglas function.

With this new cost, we can construct a new graph for utility with the parameter as technology on the x- axis. In figure 6, we can see that each utility curve has a different maximization point. As a result, when costs changes, the optimal $A_{LI,}$ utility maximizing A_{LI} changes for China. Figure 7 plots out the optimal A_{LI} for each cost value. As cost increases, the optimal A_{LI} falls. This makes intuitive sense because when the cost of adopting technology increases, we will lower the quantity of technology in order to maximize the utility function which now also depends on the $COST*A_{LI}^{2}$.

Figure 7 further plots out two curves for the optimal A_{LI}. These two curves represent two different methods of adopting the technology. First, the temporary method is when we invest in technology to bring up A_{LI} for short period (a single period). The effect of adoption here is temporary and the economy will need to invest again in next period if it wants it to keep technology at that new level. For an infinite period economy, the household will have the cost every period and its utility function will be:

$$U = \frac{C_{LI}^{\tau} C_{KI}^{1-\tau} - COST * A_{LI}^{2}}{1-\beta}$$

Second, the permanent method is when the household invests in technology adoption in the first period and then acquires the technology permanently. In this case, the utility function is the present value of the sum of the utilities in each single period. The resulting utility function is:

$$U = \frac{1}{1-\beta} * C_{LI}^{\tau} C_{KI}^{1-\tau} - COST * A_{LI}^{2}$$

As illustrated by the graph, a household is willing to pay a much higher permanent cost (vs. temporary cost) to acquire the same level of technology. This makes perfect sense because if you buy something permanently, you will be willing to pay more for it.

Combining the two methods together, we can plot a graph of the optimal technology level, A_{LI}, given combination of costs for the two methods. Figure 8 shows this result. In this figure, 0 on the z- axis implies we choose the permanent method and 1 on z- axis implies we choose the temporary method. The graph is in a 3D space because we have two independent costs for the two methods. For most cost combination the economy will choose the permanent method rather than temporary method. The combination of the costs is given by points in the x-y plane. The only situation where the temporary method will be chosen is when we either have an extremely low cost for the temporary method or a relatively high cost on the permanent method.

Figure 9 will expand on the idea developed in the figure 8. Instead of choices on the z-axis, we will plot the optimal technology level A_{LI} for a combination of the costs. Using this graph, we can find the optimal technology level given a combination of the costs for the two methods. Similar to figure 8, I find out that most of the time, the permanent method will be used but when the cost of the permanent method is very high or temporary cost is very low, the economy will switch to the temporary method. The discontinuity in the graph illustrates this shift.

(4) **U.S. intervention in technology adoption choices in China**

Combing the idea from result (2) and result (3), I study wether the drop in U.S. utility will lead to the discouraging China from adopting new technology.

China's gain from the adoption of the technology level equals its new utility minus its original utility. If we assume China's current technology level is A_{LI} = 0.35 (for computational ease):

$Gain^{CH} = U_{CH}$ (optimal A_{LI}) - U_{CH} (0.35)

$Gain^{US} = U_{US}$ (Optimal A_{LI}) – U_{US} (0.35)

W can now plot how China's utility changes as the permanent method cost's change. This is figure 10. In this graph, we see that the gains for China depend on the optimal level of A_{LI} which in turn depends on the cost. The curve is downward sloping because when the cost of technology adoption is too high, China will decrease the technology level and this coupled with higher cost will reduce their gain. Figure 11 illustrates the relationship between optimal A_{LI} and the cost. Notice, the difference between this curve and figure 7 is that when you get to a certain cost level, the technology adoption is no longer optimal and the economy will stay at the current $A_{LI.}$ The reason behind is that China no longer gains anything after this cost level as compared to staying at the current technology level A_{LI} = 0.35.For our parameter vale the critical cost level for this shift approximately equals to 1.5.

In the figure 12, in addition to China's gain I also plot out the loss (negative gain) in utility for U.S. As can be seen, as China's labor intensive industry grows due to the high technology adoption, the utility in U.S. is decreasing because the terms of trade in the U.S. are decreasing. At a high enough cost level, U.S. loss is greater than China's gain, this switching point is given by the intersection of the two curves.

Going back to the optimal technology adoption graph (Figure 11) and adding in U.S.'s policy action to get figure 13. In order to prevent further loss brought upon by the technology adoption in China, the U.S. may intervene and discourage China from adopting new technology. In general such policy of discouragement will not work, however, if gain for China less than the loss for U.S. a beneficial trade can occur where the U.S. pays China, and China accepts payment to stop its technology adoption policies. This is an interesting result because it implies that it is possible that technology adoption may not be favored by the world, even though it would lead to higher production efficiency (but not necessarily welfare increases).

4 Conclusion

In this paper, I combined Heckscher- Ohlin model with idea from a Ricardian model. The eventual framework is a two country, two factor and two good model that allows me to study the tradeoff of technology adoption faced by China's government. I solved the model by solving a system of equilibrium conditions generated by the first order conditions from profit and utility maximization. The equilibrium price is a function of all the parameters. After calibrating the model, I study the effects of changes in A_{LI}, the technology level in the labor intensive sector in China.

I got three interesting results from this analysis. The first one is that when A_{LI} increases, the U.S. can actually experience a loss in utility in some cases. After imcorporating cost into the model, I find the second set of results which study the optimal level of technology adoption. Finally, combining the ideas from the first and second results, I find an interesting policy implication. I find situations where optimal policy suggests that the U.S. pay China to discourage them from adopting new technology and China will accept such payments.

Table 1

$\frac{A_{LI}}{A^{US}_{LI}}$	U^{US}	C^{US}_{LI}	C^{US}_{KI}	$Trade^{US}_{LI}$	$Trade^{US}_{KI}$
0.25	0.90687	0.911437	0.902559	0.495309	-0.49048
0.6594	0.857419	1.055459	0.696538	0.000	0.000
1	0.875099	1.216729	0.629392	-0.40558	0.209797
1.25	0.903073	1.351119	0.603604	-0.70693	0.315818

Table 2

Name	Value	Explanation
K^{CH}	1	Total capital in China.
L^{CH}	4	Total labor in China.
K^{US}	1	Total capital in U.S.
L^{US}	2	Total labor in U.S.
α	0.2	Capital share in production in labor intensive industry.
v	0.8	Capital share in production in capital intensive industry.
τ	0.5	Preference factor.
β	0.5	Discount factor
A_{KI}	1	Technology for capital intensive industry in China
A_{LI}^{US}	1	Technology for labor intensive industry in U.S.
A_{KI}^{US}	1	Technology for capital intensive industry in U.S.

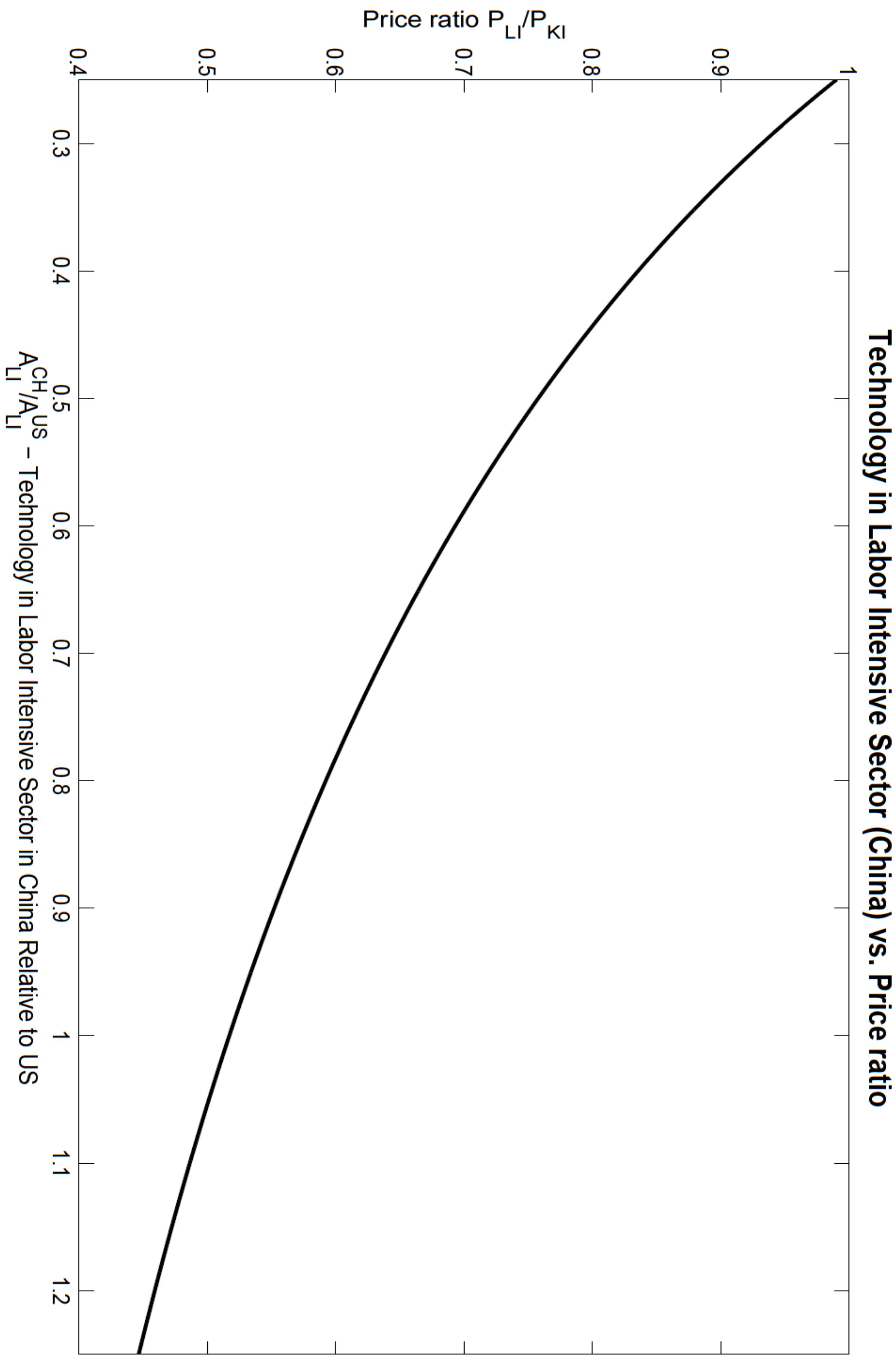

Technology in Labor Intensive Sector (China) vs. Price ratio
Price ratio P_LI/P_KI
0.4
0.5
0.6
0.7
0.8
0.9
1
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
A_LI^CH/A_LI^US – Technology in Labor Intensive Sector in China Relative to US

Figure 1

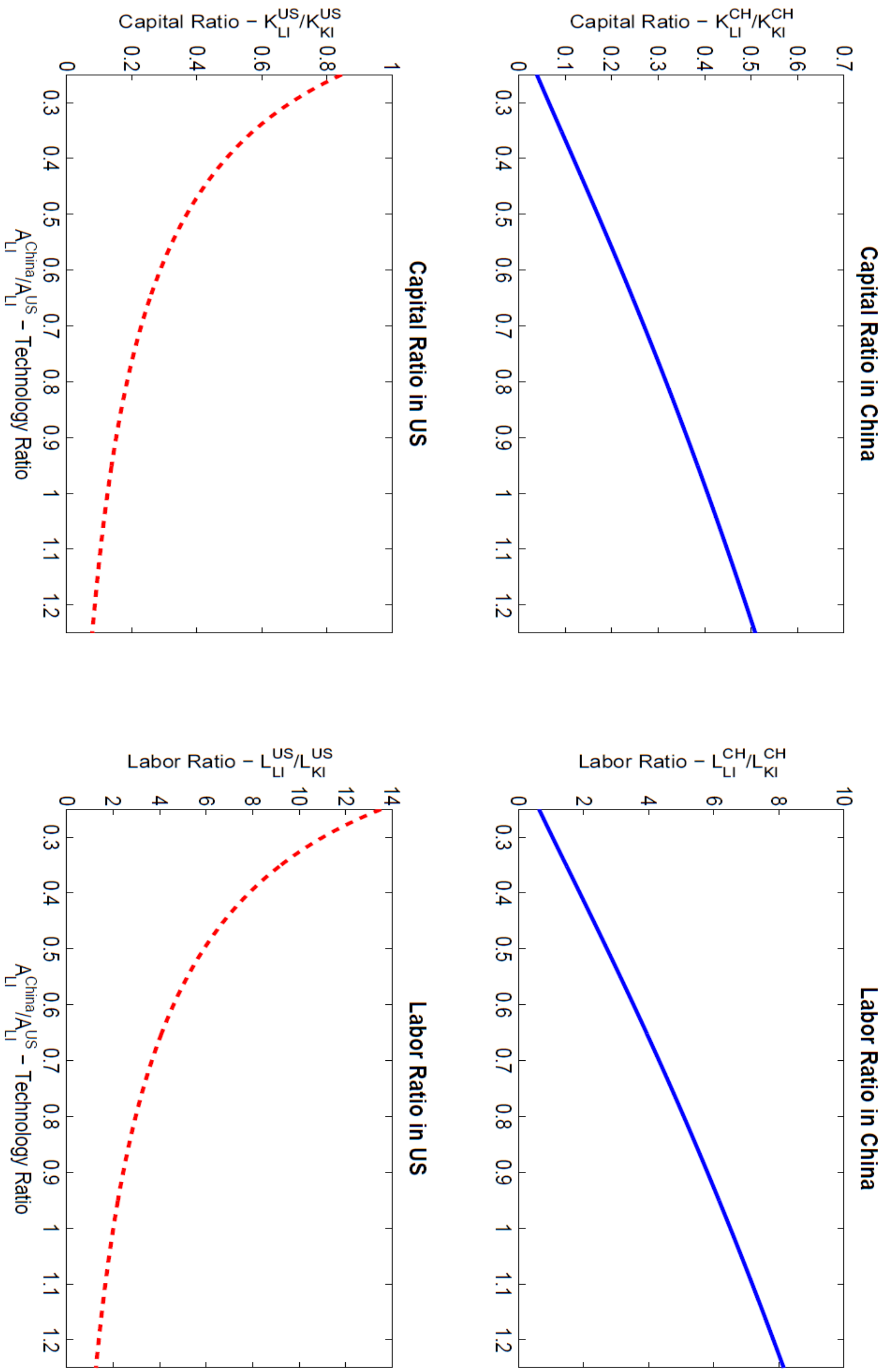

Capital Ratio in China
Capital Ratio – K_{LI}^{CH}/K_{KI}^{CH}
Labor Ratio in China
Labor Ratio – L_{LI}^{CH}/L_{KI}^{CH}
Capital Ratio in US
Capital Ratio – K_{LI}^{US}/K_{KI}^{US}
Labor Ratio in US
Labor Ratio – L_{LI}^{US}/L_{KI}^{US}
$A_{LI}^{China}/A_{LI}^{US}$ – Technology Ratio

Figure 2

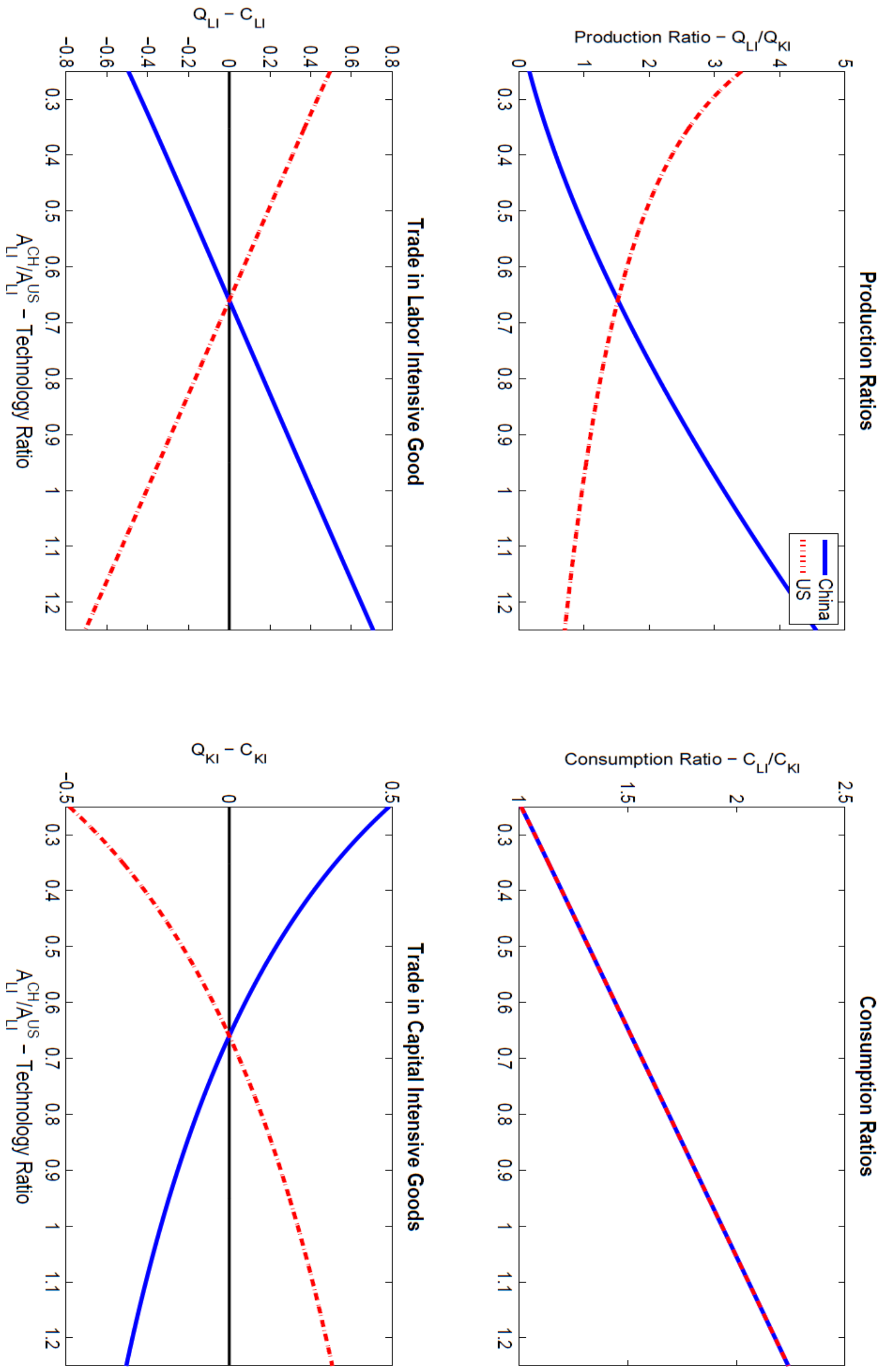

Production Ratios
Production Ratio − Q_LI/Q_KI
China
US
Consumption Ratios
Consumption Ratio − C_LI/C_KI
Trade in Labor Intensive Good
Q_LI − C_LI
Trade in Capital Intensive Goods
Q_KI − C_KI
A_LI^CH/A_LI^US − Technology Ratio
A_LI^CH/A_LI^US − Technology Ratio

Figure 3

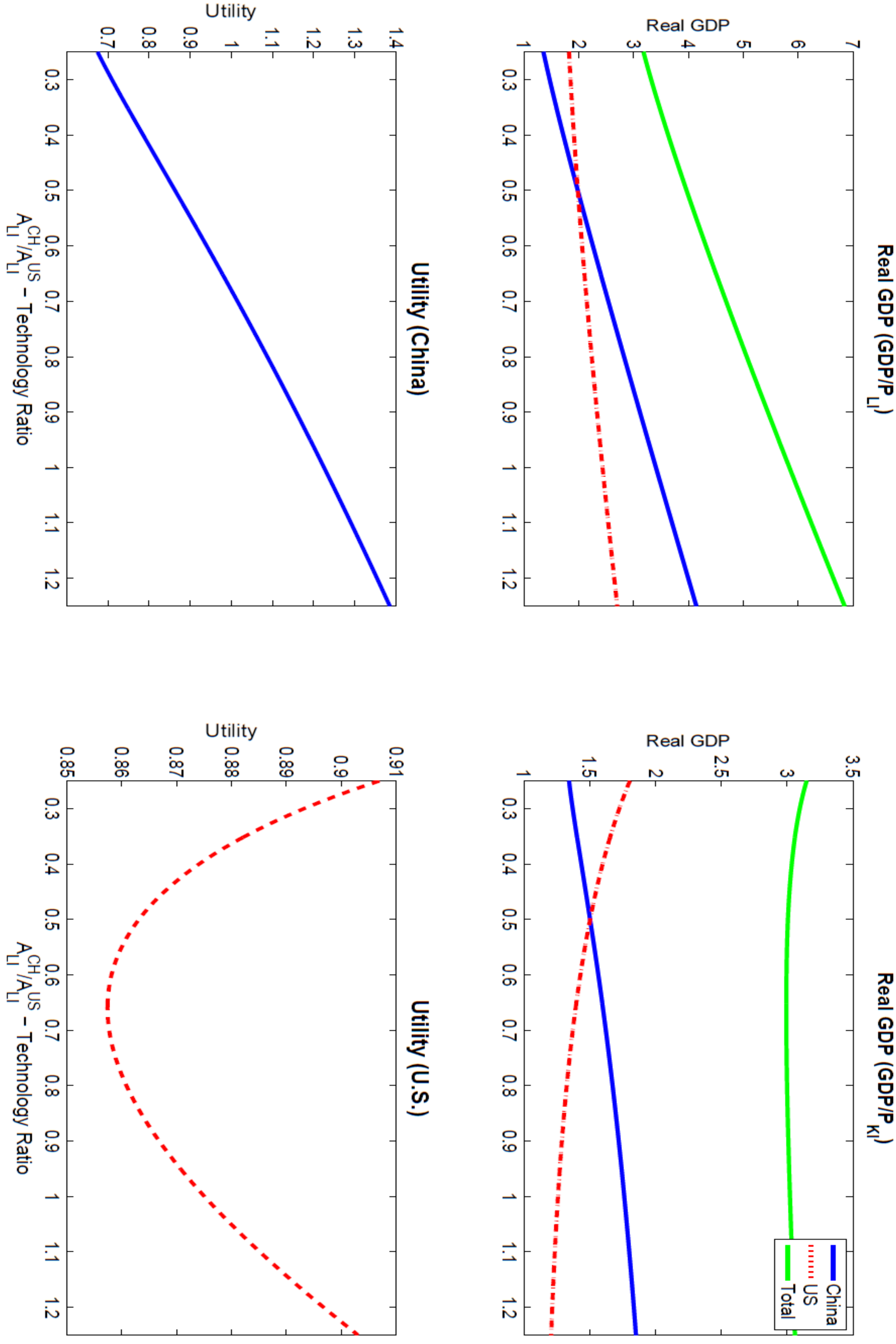

Real GDP (GDP/P_LI)
Real GDP
1
2
3
4
5
6
7
Real GDP (GDP/P_KI)
Real GDP
1
1.5
2
2.5
3
3.5
China
US
Total
Utility (China)
Utility
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
Utility (U.S.)
Utility
0.85
0.86
0.87
0.88
0.89
0.9
0.91
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
A_LI^CH/A_LI^US – Technology Ratio

Figure 4

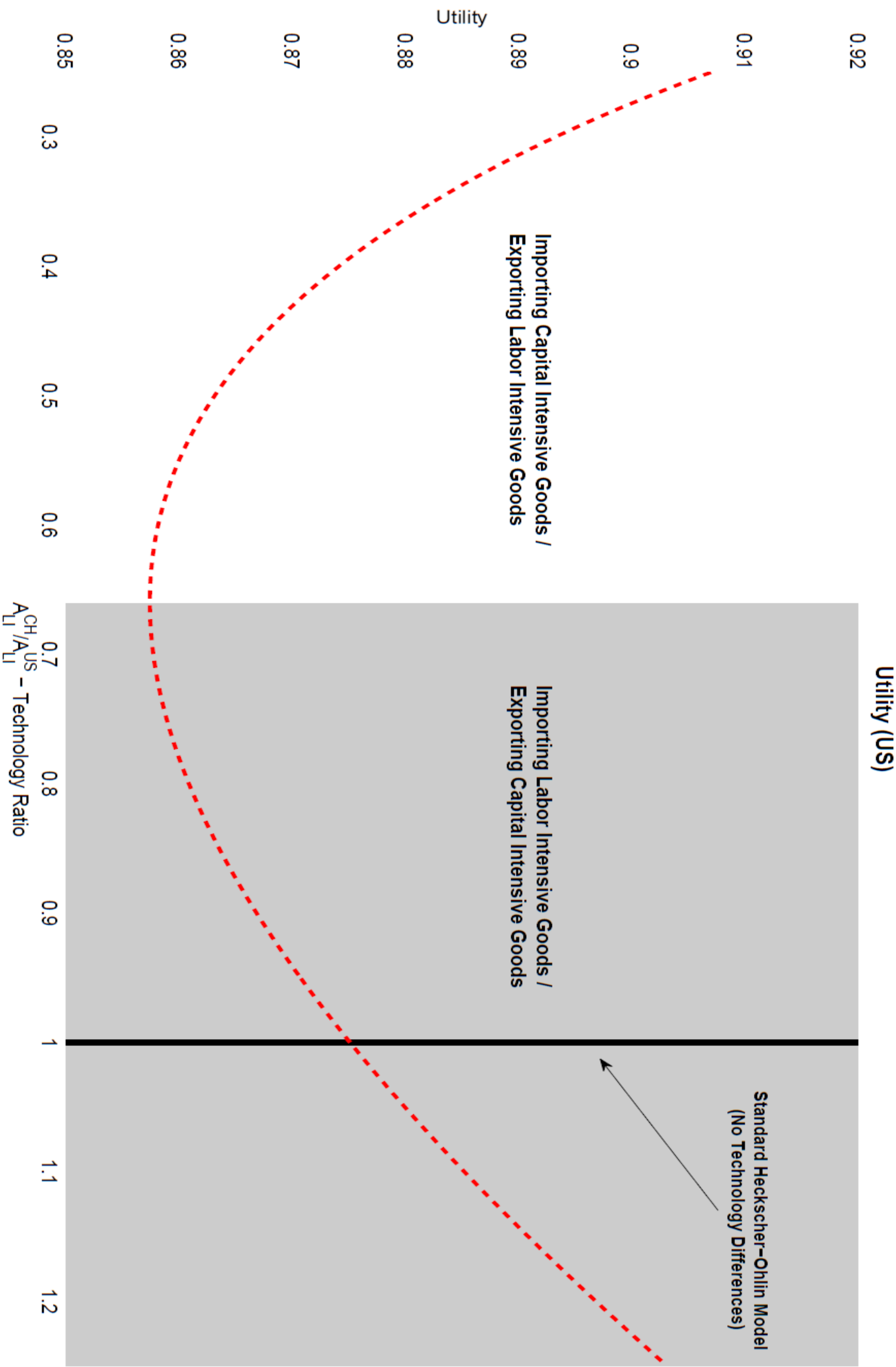

Utility (US)
Utility
0.85
0.86
0.87
0.88
0.89
0.9
0.91
0.92
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
A_{LI}^{CH}/A_{LI}^{US} – Technology Ratio
Importing Capital Intensive Goods /
Exporting Labor Intensive Goods
Importing Labor Intensive Goods /
Exporting Capital Intensive Goods
Standard Heckscher–Ohlin Model
(No Technology Differences)

Figure 5

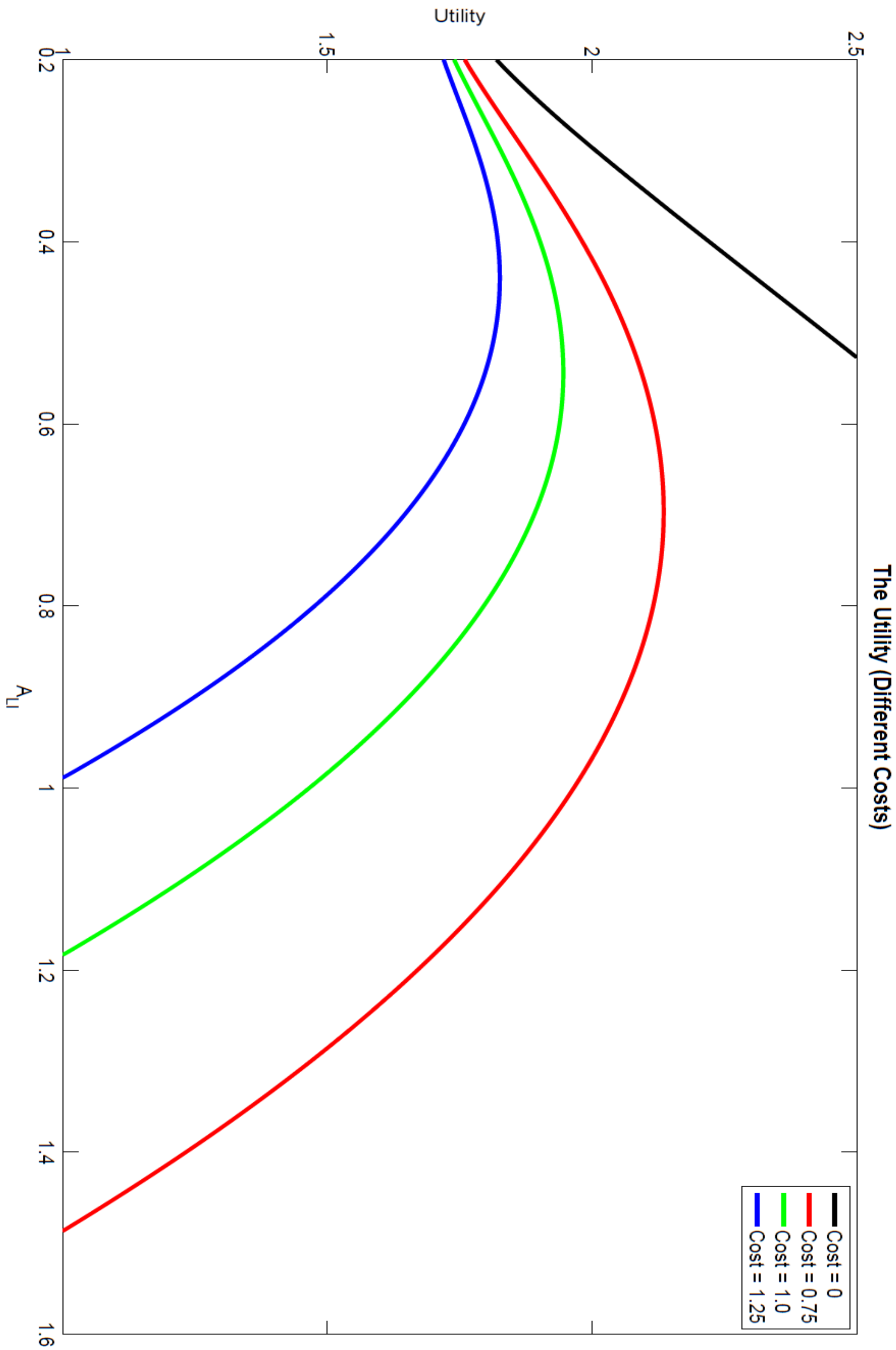

The Utility (Different Costs)
Utility
2.5
2
1.5
1
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
A_LI
Cost = 0
Cost = 0.75
Cost = 1.0
Cost = 1.25

Figure 6

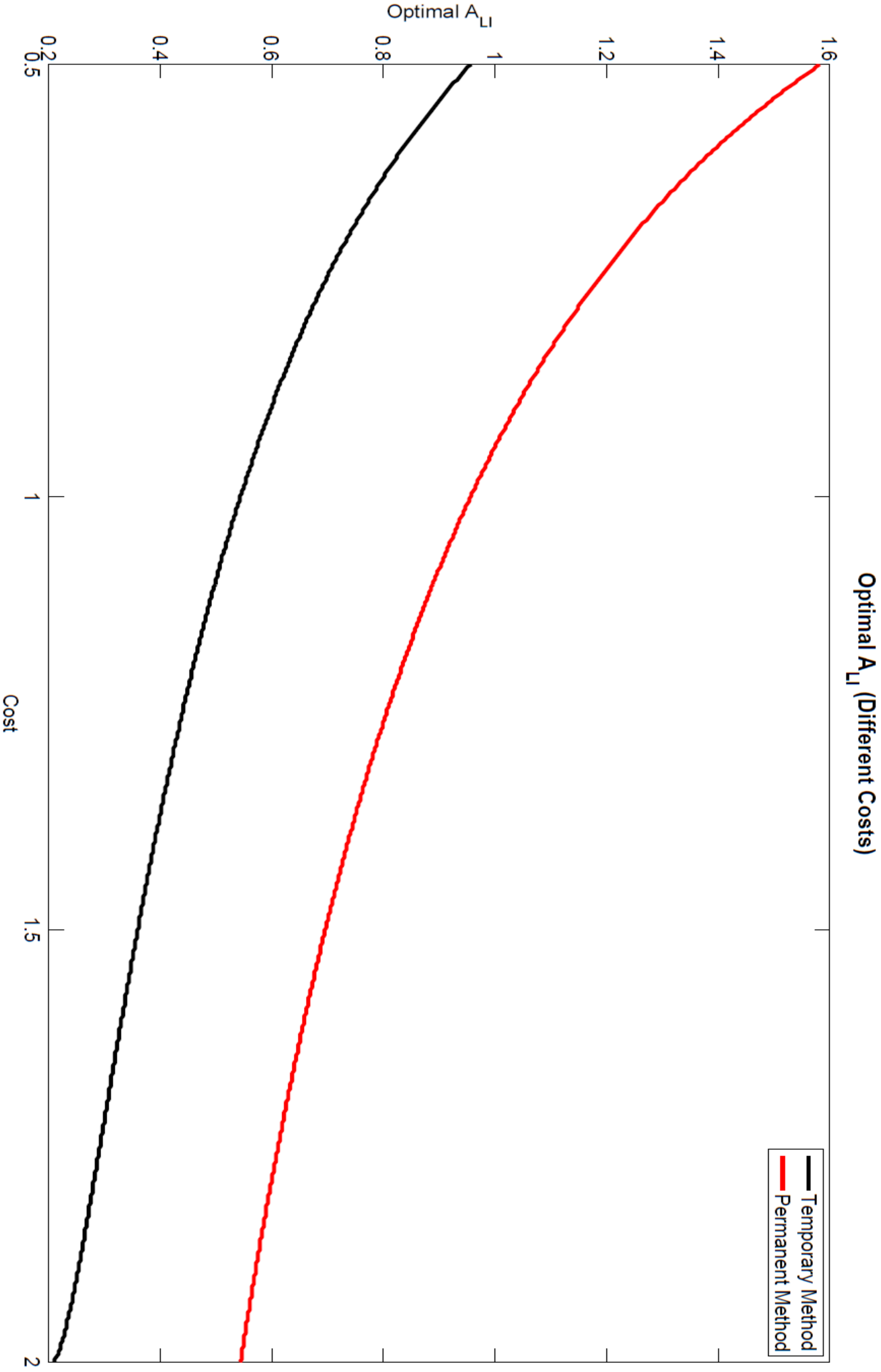
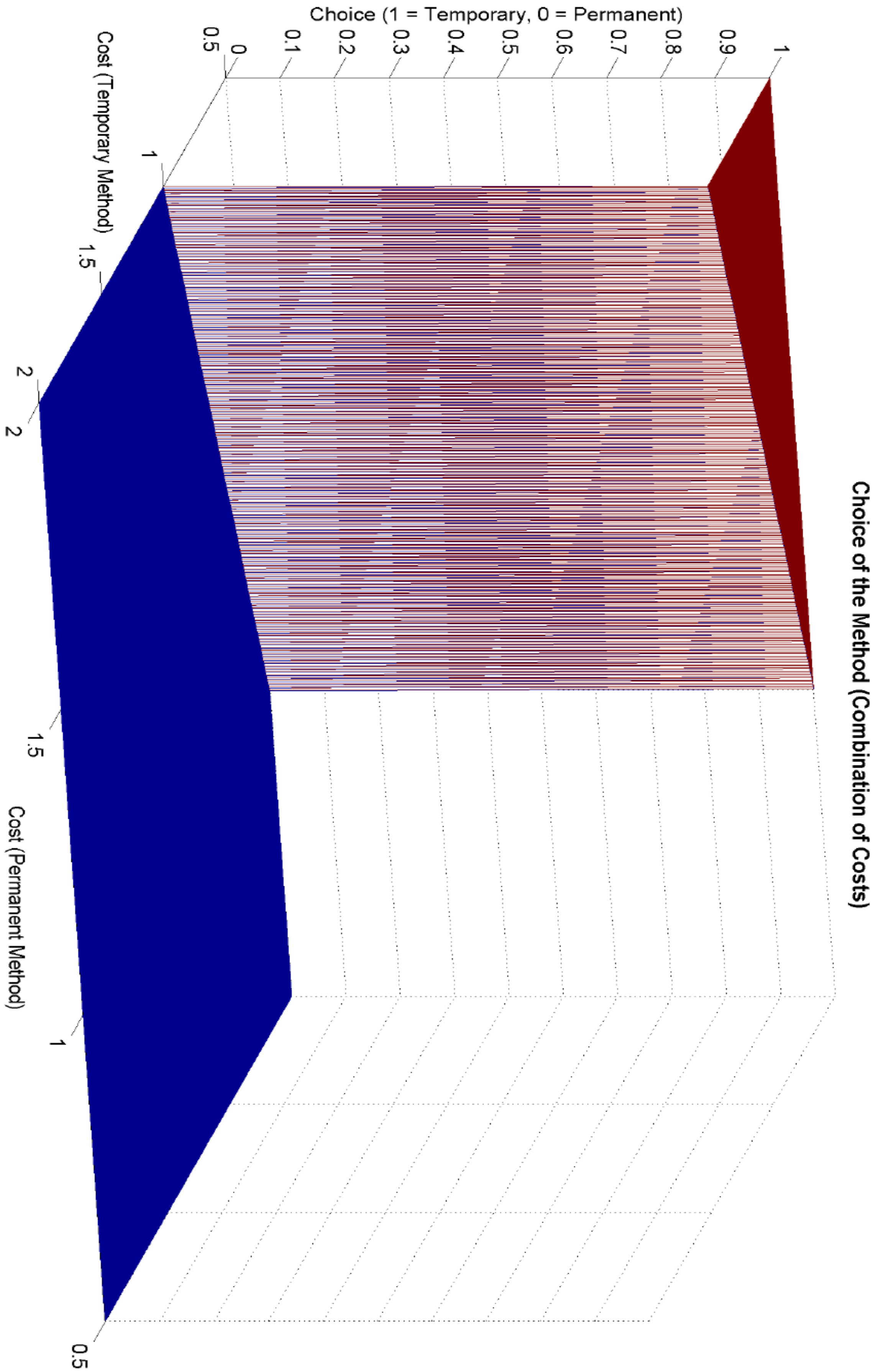

Optimal A_{LI} (Different Costs)
Optimal A_{LI}
Cost
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
0.5
1
1.5
2
Temporary Method
Permanent Method

Figure 7



Choice of the Method (Combination of Costs)
Choice (1 = Temporary, 0 = Permanent)
Cost (Temporary Method)
Cost (Permanent Method)

Figure 8

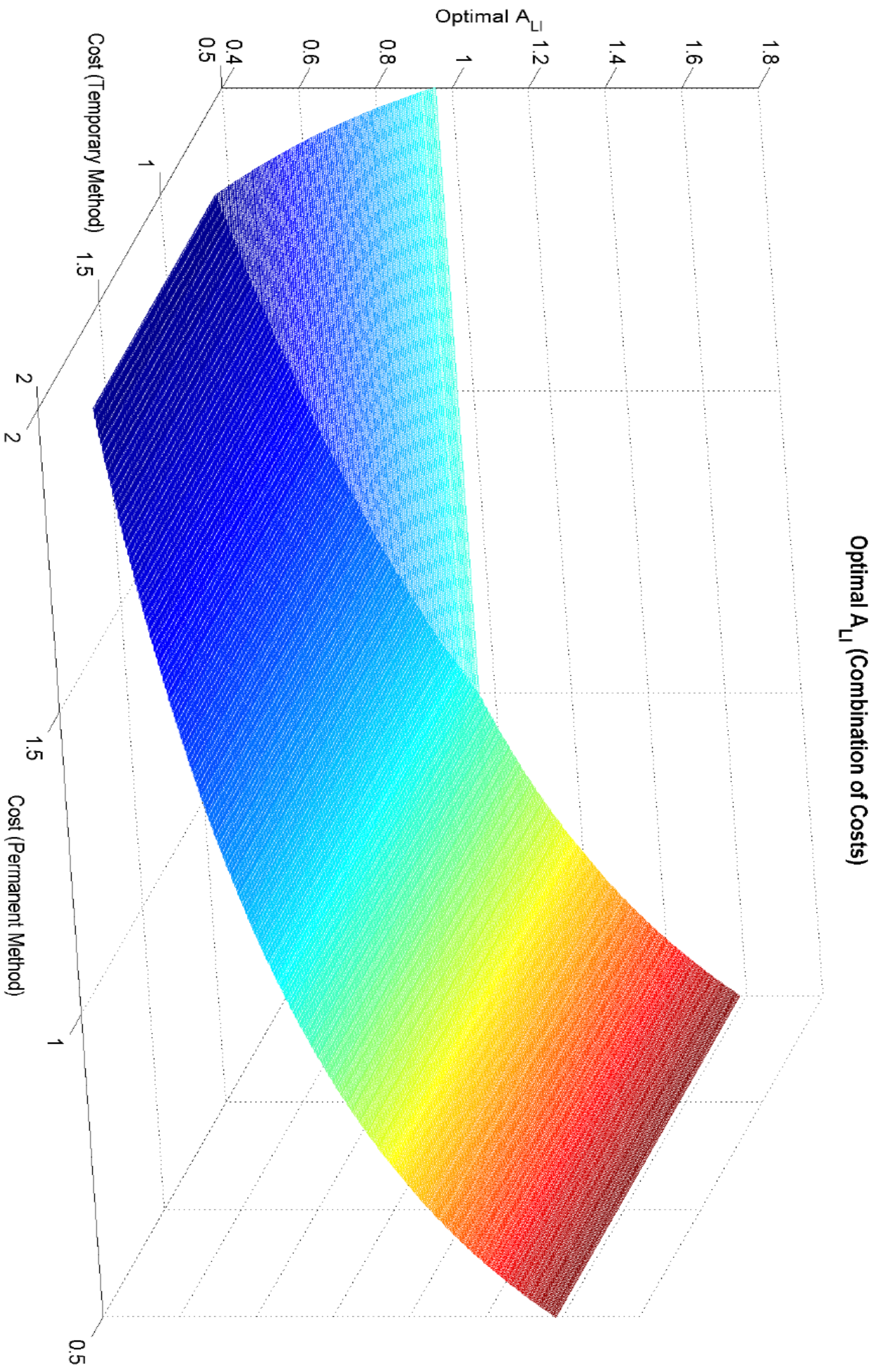

Optimal A_{LI} (Combination of Costs)
Optimal A_{LI}
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
Cost (Temporary Method)
0.5
1
1.5
2
Cost (Permanent Method)
2
1.5
1
0.5

Figure 9

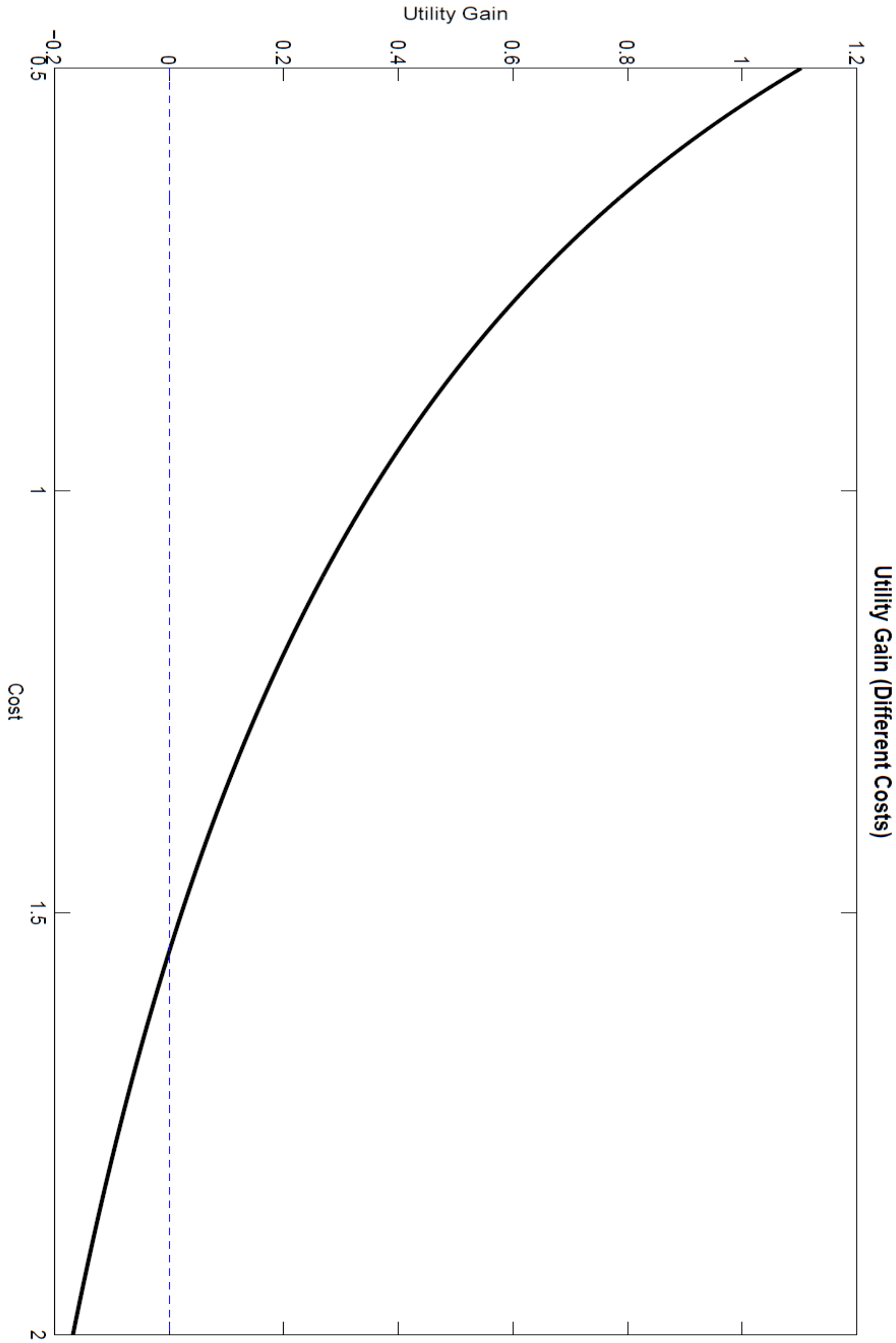
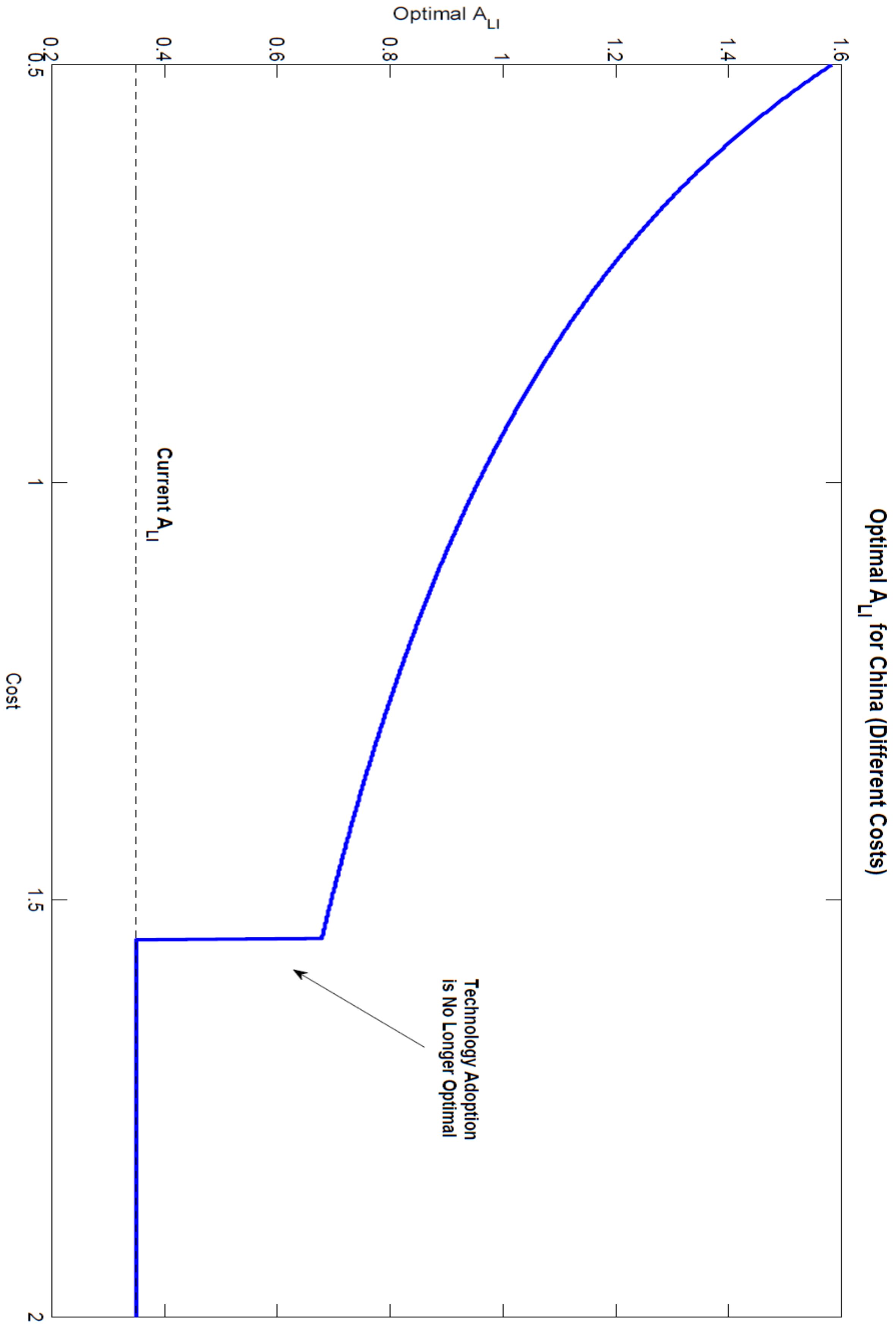
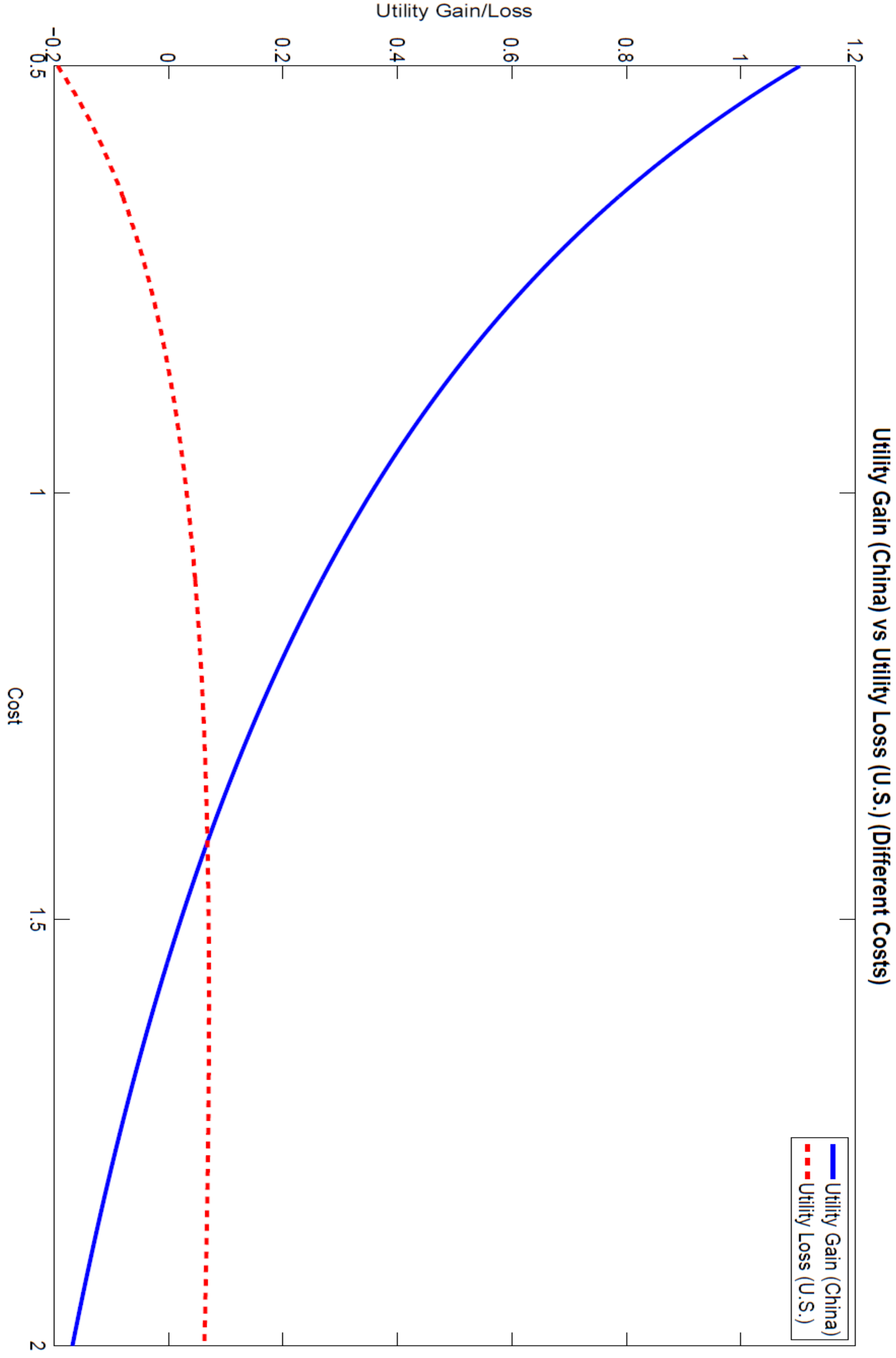

Utility Gain (Different Costs)
Utility Gain
Cost
-0.2
0
0.2
0.4
0.6
0.8
1
1.2
0.5
1
1.5
2

Figure 10



Optimal A_{LI} for China (Different Costs)
Optimal A_{LI}
Cost
Current A_{LI}
Technology Adoption is No Longer Optimal
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
0.5
1
1.5
2

Figure 11



Utility Gain (China) vs Utility Loss (U.S.) (Different Costs)
Utility Gain/Loss
Cost
Utility Gain (China)
Utility Loss (U.S.)

Figure 12

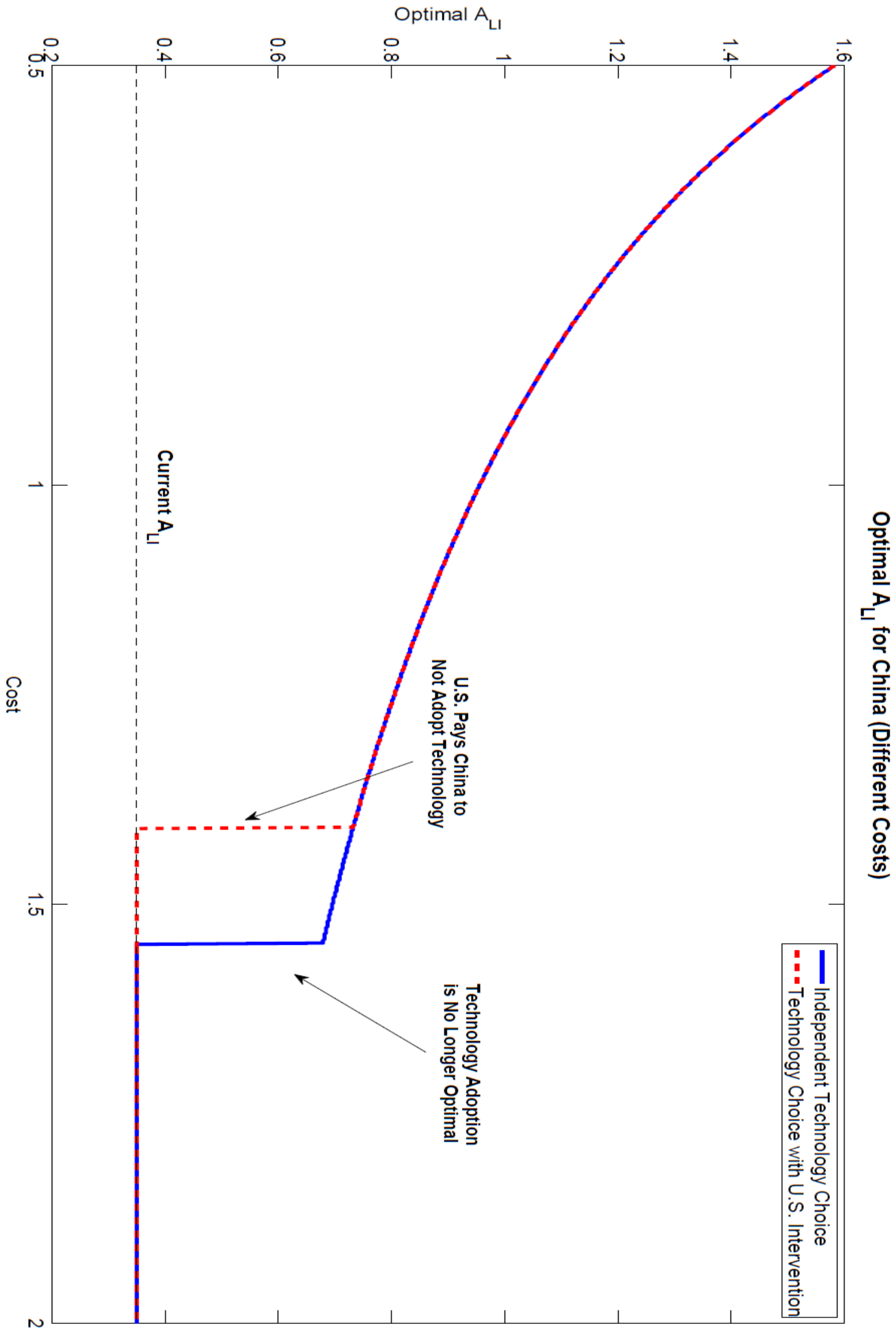

Optimal A_{LI} for China (Different Costs)
Optimal A_{LI}
Cost
Independent Technology Choice
Technology Choice with U.S. Intervention
U.S. Pays China to Not Adopt Technology
Technology Adoption is No Longer Optimal
Current A_{LI}
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
0.5
1
1.5
2

Figure 13

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